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Transition to a new pension contract

Exploring value transfers in the double transition

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Exploring value transfers in the double transition

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN QUANTITATIVE FINANCE AND ACTUARIAL SCIENCE

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Abstract

In the Netherlands there are advanced plans for a new pension contract. This could require a transfer of existing pension rights from the old to the new contract. This thesis studies the transition to several of the proposed pension contracts, without making a choice for one of the variants. To study the impact of the transition on different generations, the existing pension rights are valued both in the old and the new contract. In this manner the intergenerational redistribution for different transition methods can be quantified. In general a transition based on nominal rights will not reflect the value distribution under the current contract. Working generations would profit most, because they no longer have to pay for building up a buffer. In the proposed new contracts, the system of uniform contribution and uniform accrual (doorsneesystematiek) would be replaced by an actuarially fair contribution scheme. This is studied as a separate transition for which again the loss in value of different generations is calculated. Earlier research has shown that workers in mid career lose most, this is confirmed. It turns out however that the total loss has a maximum in the interest rate and will be lower than the earlier found 100 billion euros. Ultimately, these two transitions are combined to study their joint impact. The double transition works partly in the sense that the two transitions have an opposite effect for the working generations, but that the net effect can still be a significant loss. The double transition will work better for low interest rates than for high ones and will not work when a large buffer is built up in the new contract.

Disclaimer

This thesis has been written during an internship at De Nederlandsche Bank (DNB). The views expressed in this thesis do not necessarily reflect the views of DNB.

Management Summary

Problem definition
There is an ongoing debate in the Netherlands about reforms in the pension system. Since the economic crisis, it has become clear that the nominal rights in the second pillar pension funds are no hard guarantees. This realization has led to major concerns among participants and exposed the conflict of interest between generations. Besides, the current system does not allow for customization, while this could add value because of the different characteristics, risk profiles and risk preferences of individuals. This thesis considers two large reforms in the second pension pillar and the impact of these reforms on the intergenerational distribution.

One reform would be to change the pay-out rules. There are two main contract variants in the discussion, either a contract where participants build up personal property rights instead of pension rights, or a contract where pension rights are explicitly uncertain and no buffers are required. The advantage of the variants with personal property rights is that they allow for more customization and have less discontinuity risk. Another reform would be to abolish the so called doorsneesystematiek, that is to make the pension system actuarially fair in the accrual phase. In this thesis, these reforms are first studied separately after which the joint effect is calculated. This leads to the following research questions:

- What is the distribution of value over generations in the current contract (chapter 4)?
- What is the size of the intergenerational redistribution that takes place in case of a change of contract and can it be restricted by using an alternative transition method (chapter 5)?
- Are the general results sensitive to differences between pension funds (chapter 6)?
- What is the impact of abolishing the doorsneesystematiek on different cohorts and are these results sensitive to changes in parameters (chapter 7)?
- Earlier research suggests that combining these reforms, the double transition, reduces intergenerational redistribution, is this indeed the case (chapter 8)?

Techniques
In this thesis pension benefits are priced using market valuation based on complete markets and the absence of arbitrage; see section 4.1. A pension contract can be modeled as a financial product that pays out benefits with embedded options on cuts or indexation. The value of these options depends on the rules according to which they are executed and the price of risk in the market. When a pension fund invests more in risky equity and less in bonds, both the expected return and risk increase. Through the options the risk and return are distributed over the generations. The total value of the pensions for all generations will stay the same, but value can be shifted between generations by doing so. Hence, in value terms there is a zero sum game between participants.

The driver of uncertainty in the model is equity risk, interest rates are assumed to be fixed. It is assumed that longevity risk is shared in all cases and that there is no macro longevity risk. The benefits are priced using Monte Carlo simulation. In general only existing rights will be valued, except when the contribution rates and doorsneesystematiek are analyzed.

Distribution in the current system
The results (see section 4.3) show that the economic value of pension rights in the current system is in general unequal to the economic value of a nominal guarantee and that the ratio between these two values can significantly differ between cohorts. This outcome is partly driven by the fact that the current contract requires to build up a buffer. Since (old) retirees are better protected against cuts, building up a buffer (assuming the fund has no initial buffer) either requires high contributions or leads to a lower economic value of the existing rights of workers and young retirees.

That a buffer must be built up on average follows directly from the rules for cuts and indexation. Indexation may only be given for funding ratios above 110%, while the MVEV (minimum required own funds) cut prevents a fund from being more than five years below a funding ratio of 104%. A further explanation of the different rules, and the asymmetry between those rules can be found in section 3. It turns out that the cut to MVEV has a much larger impact on the value of pension rights than the cut with recovery plan (see section 4.3.4 and figure 6.1 in section 6.2). Though the cut is painful, it is necessary to protect young cohorts and future generations. Especially gray funds could reach unsustainable funding ratios if there were no cut to MVEV. Therefore, a potential weakness of pension contract variant 1B (see below) is that it does not contain a mechanism similar to the MVEV cut.

In the base case, where we assume there is no initial buffer, old workers pay most for building up the buffer. This finding is in line with earlier conclusions from the CPB.

Apart from cutting in rights, pension funds can use the contribution rate to build up buffers. Though only raising the contributions may not longer be sufficient to solve shortages in the funding ratio, the choice for the contribution rate still is important. This is measured by the funding ratio of the contribution (Dutch: premiedekkingsgraad). The results in section 6.3 show that structurally charging a contribution rate below the value of the new nominal rights (funding ratio of the contribution below 100%), has an eroding effect on the existing rights[1]. Young workers profit if changes in the contribution rate directly lead to an equal change in the wage, while sleepers and retirees lose. It is thus questionable whether charging low contribution rates is a balanced policy. Given the size of the impact in the long run, it could be argued that only funds with a sufficiently high funding ratio should be allowed to lower their contribution rates.

The possibility that the contribution rate is changed in negotiations between social partners, makes it also more difficult to determine the economic value of existing rights under the current contract. That is, because the contract is incomplete in this dimension assumptions must be made on the behavior of the pension fund.

Another incompleteness in the pension contract, is that it is not clearly specified what a pension fund should do in case of extremely high funding ratios. Based on past observations, the standard assumption in this thesis is that this is done through lowering contribution rates. In a sensitivity check (see section 4.3.3), also the alternative assumption that a pension fund would give more indexation instead of lowering the contributions is considered. It turns out that this choice has a relatively small impact on the economic value of benefits for funds with a funding ratio close to 100%. Note that in the determination of the economic value, scenarios are manipulated, such that bonds and equities have the same economic value.

Alternative new contracts

The Social and Economic Council (Dutch: Sociaal Economische Raad, SER) has proposed multiple alternative contracts, of which three are discussed in this thesis. These variants are selected because they are most important in the current policy debate. The variants are described in section 5.1; in short the most important properties are:

- In variants 4A and 4C participants build up property rights instead of pension rights; these variants allow for more customization and life cycle investing. In both these variants future generations are protected, because no debts can be passed on to the future.
  - In variant 4C a non-negative buffer is built up to share equity risk between generations.
  - Variant 4A does not have such a buffer and is in fact rather similar to the new rules for existing defined contribution schemes in the Netherlands (Wet Verbeterde Premieregeling).
- In variant 1B on the other hand, participants keep building up pension rights. However, contrary to the current system these rights can no longer be interpreted as nominal promises plus indexation ambition, but are explicitly presented as variable annuities. In this contract both cuts and indexation will occur more regularly than currently is the case. Furthermore, an important difference is that it is not required to build up a buffer.

Transition to a new contract

The economic value of, for example, one thousand euros in life long annual pension rights for a 45-year old is not the same under the current contract and a potential new contract. When changes in economic value are not taken into account in the transition, it could be the case that some cohorts profit significantly, while others loose. Therefore, an important part of this thesis, is the calculation of the shift in economic value in case of a transition. This depends on the transition method which is used. Chapter 5 considers multiple methods, of which the first is the transition based on nominal rights. In this case people can take their accrued rights to the new system, which means for variant 4A and 4C that participants will receive property rights equal to the present value[2] of the existing pension rights.

A transfer based on nominal rights leads in general to sizable intergenerational redistribution. The results in section 5.3 show that even in case of an initial funding ratio of 100% (and a funding ratio of the contribution of 100%), a transition to 4A or 1B without a transfer in nominal rights is not generation neutral. In this case, the current participants win in economic value because no longer a buffer needs to be built up. Old workers gain most by such a transition, as they would be fully hit by cuts in the current system and have a large amount of existing rights.

In case of a shortage at the time of transition, there are multiple ways to solve this. When a uniform cut is applied on the rights of current participant, retirees are disproportionally hit, because they have protection

[1]This effect depends on the size of the inflow of contributions. For gray funds the impact is smaller.

[2]Based on discounting by the risk free rate.

against cuts in the current contracts. This loss could be limited by spreading the cut over, for example, ten years, as is discussed in section 5.5.

As an alternative it could be considered to base the distribution of rights/assets on the economic value under the current contract; in this case retirees would benefit more from the transition (see section 5.4). This method, namely distributes the benefit of no longer having to build up a buffer more evenly over current participants. The outcomes, however, could be difficult to explain and are model and parameter dependent.

An important difference between the SER variants is to what extent economic value is passed on to the future by building up buffers. In variant 4A there is no intergenerational risk sharing and therefore no positive or negative economic value is passed on to future generations. Variant 1B allows for both having a buffer and a shortage, so some future generations will benefit from an existing buffer while others have to pay for a shortage. In terms of economic value, for a pension fund with initial funding ratio 100%, contract 1B passes neither a shortage nor a surplus on to future generations. In this sense, the ex ante value distribution is the same in variant 4A and 1B with initial funding ratio 100%.

In variant 4C on the other hand, in case of good returns, money is saved in a buffer that cannot become negative. Obviously, future generations expect to receive a positive buffer. Therefore, the economic value of existing rights/capital in this variant lies below the economic value of rights/capital in variant 4A. In absolute sense, the old workers will contribute most to building up this buffer. Hence, for this group it is much less attractive to go to 4C than to go to 1B or 4A. These value effects can be limited by choosing a lower maximum size for the buffer.

Besides the shift in value, also the benefit profiles in the different variants are studied. It turns out that variant 4A can be adjusted to mimic the outcomes in 1B, but because it has more degrees of freedom, it can better be adjusted to the preferred risk exposure at different ages. So, using a better life cycle could be an advantage of 4A over 1B. It lies outside the scope of this thesis what an optimal life cycle would be and to determine the size of this advantage.

A second difference, is that in variant 4A it could be allowed to change the value distribution over the retirement phase of an individual. Due to the existence of personal property rights this can be done without affecting the other participants[3]. Choosing a so-called decreasing annuity could make the transition more attractive for some retirees, because they would directly be able to index their benefits. There will, however, still be a trade-off between the early and later benefits, as there is no free lunch.

Heterogeneity

The conclusions with respect to the value distribution in case of a transition turn out to be strongly fund dependent. The main variables which matter are the initial funding ratio, equity exposure, demography (green versus gray fund) and funding ratio of the contribution[4]. Therefore, in chapter 6 the impact of heterogeneity on the outcomes is studied. This gives an overview of the impact of these respective variables, but it is difficult to give a complete picture as the impact of these variables is interdependent. Therefore, ultimately, the economic value changes due to a transition should be calculated on a per fund basis.

For a fund with no initial buffer, taking high equity exposure is in general disadvantageous for the existing rights of current participants. They lose significantly in economic value as an option on a positive buffer is given to the future, while shortages will be solved by cuts.

The difference between green and gray funds is also relevant. For green funds the funding ratio of the contribution is more important. For gray funds funding ratios far above or below 100% are more likely, as each payment of a benefit magnifies the existing shortage or buffer. This can be prevented by taking less risk.

Abolishing the doorsneesystematiek

Chapter 7 shows that the macro compensation costs for abolishing the doorsneesystematiek are highly sensitive to the risk free rate (which is assumed to be fixed over time), especially when it lies between 0% and 1%, and they reach a global maximum at 3.5%. The often quoted amount of 100 billion euro is based on the assumption of a guaranteed indexation of benefits. Since this would require either structural outperformance of the market or an external risk bearer, this assumption is rejected. Based on the alternative assumption of a nominal guarantee, the *maximum* macro compensation costs are 84 billion euros as can be seen in figure 7.2. Given that interest rates currently lie below 3.5%, the macro compensation costs would now be even lower. How to take into account the term structure and forward rates remains a question for future research. Furthermore, the impact of heterogeneity between funds on the results is non-trivial.

[3]For the sharing of micro longevity risk the choices of other retirees could have some impact, depending on how the sharing of this risk is implemented.

[4]In practice also the interest rate hedge matters, this lies outside the scope of this thesis.

Abolishing the doorsneesystematiek, is a reform which would only affect the accrual phase. Currently young workers pay more than the actuarial fair price for their accrual and old workers less. That is, an implicit subsidy goes from young to old workers. Stopping this system without compensation would be disadvantageous for workers in mid career, as they have already paid subsidies when young, but not yet received them when older.

The main proposed alternative is degressive accrual, all workers pay the same contribution rate but receive the actuarial fair accrual. This means that, given a positive interest rate, old workers receive less accrual than young workers, as is shown in section 7.2. Hence, without compensation, this transition will lead to a lower total pension for workers who are in mid career at the time of transition. When the Aaron condition holds (interest rate > wage growth + population growth), this change would immediately lead to lower contribution rates for the same lifetime accrual.

To determine the compensation costs it is important to decide which definition is used. In line with earlier research a prospective approach is used: instead of the subsidies paid and received in the past, the future subsidies are valued. Furthermore, it must be decided whether changes in the contribution rate are taken into account and how pension rights are valued.

It can be argued that it is not necessary to compensate people for a loss if they in the meantime profit from lower contribution rates. However, a lower contribution rate does not solve a future shortage in pension benefits and these lower contribution rates should be one of the advantages of the new system. Besides, future generations will also fully profit from the lower contribution rates. For these and other reasons, the change in contribution is left out of the definition of compensation costs for abolishing the doorsneesystematiek. Finally note that given the current low interest rates the change in contribution will be much smaller than suggested by the CPB and therefore this choice is relatively less important.

The question, how should pension rights be valued, has already been addressed above: the proper measure would be the market value of the future benefits. This leads however to some technical problems (see chapter 7), which is why the assumption of a nominal guarantee is used as an approximation. This leads to comparable results for a base case fund. An alternative proposed in earlier reports, to assume a guaranteed indexation, is disregarded because this would imply that the pension fund either has a large external sponsor or can structurally outperform the market, quod est non.

For a base case fund, using the value of a nominal guarantee comes close to the outcomes of market valuation. For funds with large positive or negative buffers the nominal guarantee will deviate significantly from the market value, which makes this approximation less suitable.

Using these definitions leads to the above mentioned conclusions for abolishing the doorsneesystematiek. The compensation costs are very dependent on the interest rate, but certainly lower than 100 billion.

Double transition

When both transitions are executed at the same moment in time, without compensation costs, it could be the case that the increase in economic value for some generations offsets their loss in future doorsneesystematiek subsidies. Given a transition based on nominal rights, in chapter 8 indeed some evidence is found for this theory. However, it is not improbable that the compensation will be insufficient for some cohorts.

Especially workers in mid career could lose in a double transition. When for example the interest rate is 1.5% and a base case fund is considered, their net loss is approximately 4% of pension benefits. In general the double transition will work better in case of low interest rates than of high interest rates. Besides, heterogeneity will also in this case have a large impact and calculations on a per fund basis remain necessary.

In my analysis of the double transition I have focused on a transition to 4A or 1B. The difference for a double transition to 4C is that in this case also a buffer must be built up. Most of this buffer will be financed by middle aged and old workers and young retirees. Abolishing the doorsneesystematiek leads to large losses for workers in mid career. When a large buffer is allowed in 4C, middle aged and older workers will face a double loss. Hence, the double transition does not work for a transition to 4C.

Based on these results it is necessary to give explicit compensation for abolishing the doorsneesystematiek in case of a double transition to variant 4C. For a double transition to one of the other variants it depends on the fund specific results and the redistribution which is deemed acceptable, whether explicit compensation is needed.

Contents

1 Introduction

The Netherlands traditionally has large pension savings in the second pillar. The pension funds that manage these savings, have been severely hit by the economic crisis. Persistent low interest rates and shocks in life expectancy have had a negative impact on the funding ratio of the Dutch pension funds. The consequence is that most funds have not been able to index the accrued rights for inflation for multiple years in a row and some funds have even had to cut nominal rights. This did not only have a negative impact on the amount of trust in pension funds, but also raised the question whether risks are fairly shared among the generations. Though the system still has many strong points, critics think it should be reformed to share the risks and benefits in a more transparent and actuarially fair manner over different generations and persons. Furthermore, a new system could allow for more customization, for example a higher risk exposure for young than for old people. There is currently an ongoing policy debate concerning those reforms.

A first reform, which has been discussed during the last years, would be to abolish the doorsneesystematiek. This reform would stop redistribution from young to old workers and make the system more actuarially fair. Furthermore, it would improve labor mobility, by removing the punishment on leaving the pension system in midlife. These points are more extensively discussed in Boeijen et al. (2006)[5]. Abolishing the doorsneesystematiek, would be detrimental to current workers, especially those in mid career, who lose future subsidies. Lever, Bonenkamp and Cox of the CPB Netherlands Bureau for Economic Policy Analysis (Dutch: Centraal Planbureau, CPB) (CPB, 2013)[16] have estimated the costs of compensating the current participants to be 100 billion euros.

A second reform, which is currently being discussed in the Social and Economic Council (Dutch: Sociaal Economische Raad, SER), would be to change the way in which the financial situation of the fund affects the benefits which are paid out. Currently the benefit consists of a nominal promise plus an indexation ambition and with the possibility of cuts; in fact it is a Defined Benefit (DB) system where the promised benefits are no longer hard guarantees. The disadvantage of this system is that people have been promised too much and that the distribution over generations is intransparent. The SER (2015)[8] considered multiple alternatives, which they later brought back to three variants: 1B, 4A and 4C. In variant 1B people still build up nominal rights in a shared pot. Contrary to the existing system, 1B does not require buffers, which will lead to more frequent indexation and cuts. In variant 4A participants save money in a personal pot (which can be invested collectively). The explicit definition of property rights makes this variant more transparent than the current system. Furthermore, it allows for customization and has no intergenerational redistribution. Variant 4C adds a buffer to share investment risks between generations to a system of personal pots. The working of defined contribution plans with personal property rights and the possibility of risk-sharing within these plans is discussed by Bovenberg and Nijman (2015)[6]. They call this type of plans ‘personal pension with risk sharing’.

These two potential reforms are at the center of the current Dutch policy debate. Besides, they are related, as the SER policy options are designed without doorsneesystematiek. Hence, the second reform is conditional on the first.

Whether these reforms are attractive, does not only depend on the respective pros and cons of the current and alternative pension system, but also on the impact that the transition has on different generations. Therefore it is important to study how the transition affects the intergenerational distribution.

Comparing pension benefits in different pension systems is not trivial, because a trade-off must be made between risk and expectation. To make this comparison, I use the technique of economic valuation. This technique from finance gives the market price of a promise, where in this case the possible cuts and indexations are priced as financial options.

In this thesis I will build a model to calculate the economic value of existing rights under the current contract and after a transition to a new contract. These outcomes will be used to determine the impact of a transition on different generations for various transition methods. Besides the shift in economic value, I will also calculate the direct impact of the transition on the benefits of the retirees. The other reform, abolishing the doorsneesystematiek will be analyzed separately with a strong focus on the definition of the problem and the role of the interest rate. Finally, I will consider the question whether there is a synergy advantage to be gained by abolishing the doorsneesystematiek and reforming the system at one point in time, the so-called double transition.

Chapter 2 introduces the Dutch second pillar system and some terminology. The main model used to simulate future benefits in the current system is described in chapter 3. Chapter 4 describes how the economic value of these benefits can be calculated. The transition to a new contract is discussed in chapter 5. Chapter 6 quantifies the impact of heterogeneity on the results presented in chapters 4 and 5. The impact of abolishing the doorsneesystematiek, is the subject of chapter 7. Finally, the two transitions are combined in chapter 8, which discusses the double transition.

2 Dutch pension system

In this chapter the Dutch pension system is introduced. Important properties of the system and relevant terminology are explained.

2.1 The three pension pillars

All inhabitants of the Netherlands receive first pillar pension benefits (AOW), when they have reached the so-called 'AOW-leeftijd' (the age from which one is eligible to receive AOW benefits). These benefits do not depend on working-history[1] and are financed by a premium payed by the current employees.[2] The AOW is a pay-as-you-go system, because no money is saved for this system. The AOW will not play an important role in my analysis, because I will not discuss any possible reforms of the AOW. However, it is important to realize that the AOW guarantees at least a minimum level of subsistence for most retirees in the Netherlands, even if they would get no money in the other pillars.

Most employees save for a second pillar pension in an occupational pension scheme (Dutch: bedrijfstakpensioenfonds). Employees of different companies in an industry participate in such a scheme and in general there is no external risk bearer. Contrary to the AOW, these are funded schemes. Hence, even when no new participants would enter the scheme, current participants would still receive their pensions. All reforms, which I will discuss concern these second pillar pension systems.

The goal of the second pillar pension is to provide people with sufficient benefits to finance their lifestyle, this is often interpreted as that the total pension benefits of a retiree should amount to approximately 75% of his average wage during the working life. The AOW is considered as part of these total benefits; therefore the contributions paid and the rights accrued by an employee are determined as percentage of the wage minus the AOW franchise. The wage minus AOW franchise is called the pension base.

The result of this system is that relative differences in the size of the second pillar pension mainly affect pensioners with a high second pillar income. Poor retirees mainly depend on the AOW and therefore a relative change in their second pillar pension will lead to a much smaller relative change in total benefits.

People who do not build up pension in the second pillar, or want to build up more pension, can save in the third pension pillar. Contrary to the second pillar, buying a third pillar pension product is voluntary.

2.2 Defined benefit and defined contribution

Traditionally the occupational schemes are funded Defined Benefit (DB) systems. The fund promises participants a lifelong nominal annuity based on their average lifetime wage[3]. Since there is no external risk bearer, large shortages have to be solved by raising the pension contribution or cutting benefits. A surplus can be used to adjust the pension promises for price or wage inflation. Due to the maturing system and aging society, it has become increasingly difficult to compensate for shortages by raising the pension contribution. The effect of raising the pension contribution on the financial position of a fund, is smaller in a gray fund compared to a green fund. Furthermore, the contributions measured as percentage of the wage have already been more than doubled since the beginning of this century (Goudswaard, 2013)[11]. Under the current regulations, pension funds are obliged to cut rights when the shortages are too big.

The promise made by the pension fund is viewed as a guarantee by the participants and funds used to communicate it as a guarantee. A guarantee implies that there should be no risk of not being able to pay out the benefits, therefore all accrued rights must be discounted with the risk free interest rate. As a consequence, a decreasing interest rate leads to higher liabilities for the pension fund. Funds can hedge this interest rate risk by buying interests swaps, but most funds did not fully hedge their interest rate risk. As a result most Dutch pension funds currently do not have enough assets to cover their liabilities. These funds cannot longer index the accrued rights with the inflation and some even have had to cut rights. The indexation is important for participants, for in the end the nominal value of the benefits matters less than the purchasing value.

Besides the large defined benefit fund, there are also defined contribution schemes in the Netherlands. Insurers and PPIs (Dutch: premiepensioeninstelling) offer pension products, where individuals pay a fixed

[1] However, persons who have lived multiple years abroad receive less benefits.

[2] A part of the AOW benefits is payed from the government budget, which means that also retired citizens contribute when paying their taxes.

[3] This used to be final wage in the past.

contribution and receive benefits depending on investment returns. These products have similarities to SER variant 4A which will be introduced below.

2.3 Doorsneesystematiek

The pension contributions in the Dutch defined benefit pension schemes are based on the average cost price for all participants in the pension fund. This cost price is lower for young participants, because their contributions can be invested for a longer period of time. Hence, young workers implicitly subsidize old workers.

According to Boeijen et al. (2006)[5] the system was deliberately designed in this way after the war, to enable old workers to build up a reasonable pension in a relatively short amount of time. At that time it was more likely that employees remained at one company for their entire career. In that case they pay a subsidy when young, but also receive one when old.

Currently people have more flexible careers and the doorsneesystematiek makes it less attractive to leave a pension fund in mid career (by for example becoming self employed). This subject will be covered more extensively in chapter 7

3 Modeling cuts and indexation under the nFTK

In a pure defined benefit system, pension funds can only use the contributions of the participants and the company to steer the financial situation of the fund. In the Netherlands, most pension funds cannot demand extra money from an external risk bearer like a company. However, they do have the possibility to cut benefits in bad times and to index them in good times. Also changing the contribution rate has impact on the financial situation.

Indexation and cuts have a direct impact on both the nominal rights of the participants and the financial situation of the pension fund. This leads to a recursive process which is difficult to study analytically, but which can be simulated.

The central variable in the regulatory framework is the funding ratio, which denotes the ratio between assets and liabilities of the fund. In this chapter I will describe the interaction between the funding ratio and cuts and indexation. First the rules according to which the fund may cut or index benefits are introduced in section 3.1. These rules are incorporated in a simulation model for the pension fund, which generates paths for the future pension benefits of the different generations. This model is discussed in section 3.2. Finally some of these paths are presented (section 3.3) and the possible situation of a high surplus is discussed (section 3.4).

3.1 A stylized version of the nFTK

All decisions on cuts and indexation depend directly or indirectly on the funding ratio of the pension fund. The funding ratio of a pension fund is defined as the ratio between market value of the assets and the hard nominal value of the liabilities. The assets of a pension funds consist of investments including stocks, bonds, commodities, real estate, derivatives and more. Most of these assets can be bought and sold at the financial market, so in general the market value is known. On the liability side, the nominal value of the accrual is considered. In a pure defined benefit system the nominal benefits are guaranteed. A nominal guarantee can be replicated by investing against the risk free interest rate and therefore the nominal future benefits must be discounted by the risk free rate to find the market price. In practice, pension funds must use the interest rate term structure published by DNB, which contains the risk free interest rate for different horizons[1]. However, in this thesis, I will assume, for simplicity, a fixed risk free interest rate, and flat term structure, i.e. I use a horizon and time independent parameter r^f. Hence, the equation for the funding ratio looks as follows:

$$F_t := \frac{A_t}{L_t} = \frac{A_t}{\sum_h B_{t+h}/(1+r^f)^h}$$

Where A_t and L_t are the value of assets and liabilities at time t, F_t is the funding ratio[2] at time t, and B_{t+h} are the nominal benefits which have to be paid out at time $t+h$, adjusted for survival probabilities.

The funding ratio is a measure for the financial well-being of the pension fund. The nFTK contains two soft lower bounds for the funding ratio, the required own funds (Dutch: Vereist Eigen Vermogen, VEV) and the minimum required own funds (Dutch: Minimaal Vereist Eigen Vermogen, MVEV). I will alternately use the Dutch abbreviations VEV/MVEV and the English terms, (minimum) required own funds. In general it holds that MVEV<VEV. The MVEV is for most funds equal to 104%, while the VEV depends on the risk exposure of the pension fund. The VEV is modeled in section 3.2.4.

Similar to the funding ratio of the pension fund, the funding ratio of the contribution (Dutch: 'premiedekkingsgraad') can be defined by:

$$F_t^{\text{contr}} := \frac{\Pi_t}{L_t^{\text{in}}}$$

[1]For short horizons this curve consists of current market information (swap rates), for long horizons an Ultimate Forward Rate (UFR) adjustment is used.

[2]In many articles in the press and sometimes also in the literature, the funding ratio is expressed as a percentage. When I take over this convention, I will explicitly use the percentage sign, even though this is not common. In all formulas I will use the funding ratio as a number, i.e. a funding ratio of 1 in my formulas corresponds to the funding ratio of 100% which most people use. To make the interpretation easier, I will in all cases use two decimals for the funding ratio, so 1 will be denoted by 1.00. As a consequence, an indexation of 2% in the text will also correspond to an indexation of 0.02 in the formulas, which means that the liabilities will be multiplied with 1.02.

Hence the funding ratio of the contribution is equal to the total amount of contributions in year t (Π_t) divided by the nominal value of the new accrual which is built up in year t (L_t^{in}). This concept will be discussed more extensively in section 3.2.5. For now, the funding ratio of the contribution is simply the measure which I use to describe the price of new accrual.

The funding ratio of the pension fund tells if the fund has enough assets to cover its liabilities. A pension fund can steer its funding ratio by cutting or indexing benefits, or by changing the funding ratio of the contribution. I assume there is no external risk bearer. In this section I will introduce the rules according to which the pension fund is allowed to index rights or must cut rights. All these rules depend on the funding ratio of the pension fund. A visualization is given in figure 3.1. In this figure the cut and indexation rules are given as a function of the funding ratio at the end of year. However, most of these rules are conditional on multiple variables, as will be explained below.

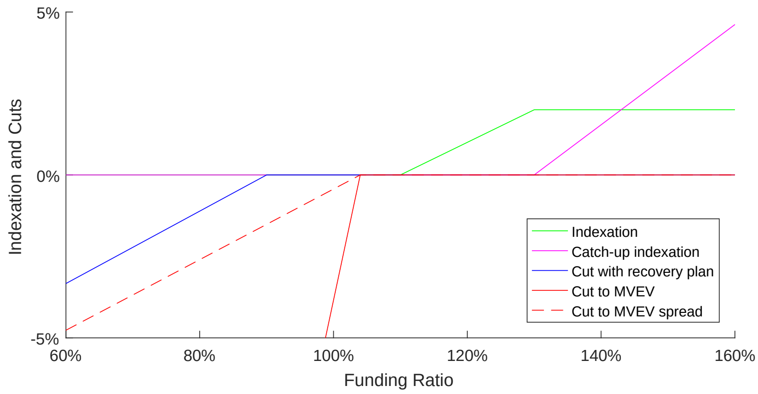

Figure 3.1: *Cuts and indexation as function of the funding ratio.*

3.1.1 Indexation

Funds are not allowed to give indexation when the funding ratio lies below 110%. When the funding ratio lies above this number, indexation may be given, but only an amount that is sustainable to give yearly. This amount is fund specific, but in practice for most funds an increase of 1% in funding ratio allows for approximately 0.1% indexation. This observation can be translated in the following indexation rule for a fund which gives at most the price indexation:

$$i_{1,t}(F_t) = \begin{cases} 0 & \text{for } F_t \leq 1.10 \\ 0.1 \cdot (F_t - 1.10) & \text{for } 1.10 < F_t \leq 1.10 + 10 \cdot i_a \\ i_a & \text{for } 1.10 + 10 \cdot i_a < F_t \end{cases}$$

Here $i_{1,t}$ is the indexation[3] which the fund gives to its participants, i_a is the indexation ambition, i.e. the maximal indexation that can be given in a year, and F_t the funding ratio at time t. If for example the indexation ambition is 2%, while the fund has a funding ratio of 140%, the fund will give the maximal indexation of i_a=0.02, even though it could afford to give 3% indexation. This indexation mechanism is plotted by the green line in figure 3.1 for $i_a = 0.02$.

In practice the rule is slightly more complicated, because the level of the price inflation at time t also has an impact on how much indexation can be given. Pension funds should give less indexation than they can afford structurally if inflation is low and more indexation if inflation is high. I will ignore this complication and assume that the indexation only depends on the funding ratio at time t and a fixed cap (i_a). Furthermore, a pension fund can in some cases compensate for cuts or missed indexation in the past, this so-called catch-up indexation (Dutch: inhaalindexatie) is discussed in the next subsection.

3.1.2 Catch-up indexation

When the fund has missed indexation or given cuts in the past, they may compensate for this by paying out catch-up indexation ($i_{2,t}$), when the funding ratio allows for this. A sufficiently high funding ratio, means that the funding ratio lies above the required own funds (VEV) and is high enough to give full indexation. Denote this lower bound for catch up indexation by $\text{LB}_{i_2} := \max(\text{VEV}, 1.10 + 10 \cdot i_a)$. In a given year, the

[3]The subscript 1 is used to distinguish the different types of indexation.

pension fund is allowed to use at most one-fifth of the surplus over LB_{i_2} for catch-up indexation. Furthermore, the catch-up indexation can not be higher than the indexation backlog. The indexation backlog is denoted by $i_{b,t}$ and is defined as the sum of missed indexation and cuts over the past. This leads to the following recursive formula:

$$i_{b,t} := i_{b,t-1} + (i_a - i_{1,t-1}) - c_{1,t-1} - c_{2,t-1} - i_{2,t-1}$$

Where $c_1 \leq 0, c_2 \leq 0$ are cuts which are defined below. Furthermore, i_{b,t_0} is one of the parameters which must be chosen. The formula for catch-up indexation is:

$$i_{2,t} = \min\left(\frac{F_t - \mathrm{LB}_{i_2}}{\mathrm{LB}_{i_2}} \cdot \frac{1}{5}, i_{b,t}\right) \qquad F_t > \mathrm{LB}_{i_2}$$

In practice there are some complications. According to the regulation catch-up indexation ought only to be given to those individuals who missed out on the indexation/suffered the cuts in rights. This requires a detailed administration, not only in practice but also in the simulation model discussed in this chapter. It would namely require adding an extra dimension to the matrices in Matlab, which would have a negative impact on the amount of scenarios used. Therefore, in the model, $i_{2,t}$ is shared over all existing rights at time t. To prevent that missed indexation is compensated when most of the participants who missed this indexation are already dead, a maximum is put on $i_{b,t}$. The value of $i_{b,t}$ may never be larger than the sum of changes in $i_{b,t}$ over the past 30 years; when this sum is negative, let $i_{b,t} = 0$.

For the implementation of the catch-up indexation the existing indexation backlog at time t_0 needs to be specified. The default assumption will be that at time $t_0 = 2017$ there is an existing indexation backlog of 20% which was built up uniformly over the past 10 years. This corresponds to the observation that since the economic crisis indexation has been scarce and also some cuts in rights have taken place.

The catch-up indexation, based on $i_{b,t} = 0.2$ and $\mathrm{LB}_{i_2} = 1.3$, is plotted by the pink line in figure 3.1.

3.1.3 Ten-year recovery plans

When the funding ratio of a fund lies below the VEV, it should make a recovery plan which shows how it will reach the VEV in 10 years. In case of a big shortage, the recovery plan may not be sufficient and the fund would expect still to have a funding ratio below the VEV after 10 years. This can be solved by applying a cut on the existing rights, such that the VEV will be reached within 10 years. However, this cut may also be spread out over the next 10 years, where the future cuts are conditional on the future funding ratio.

In practice only the cut for the first year must be executed with certainty. After the second year, the funding ratio will probably still be below the VEV[4] and the fund will have to make a new recovery plan. The new recovery plan replaces the old one, so whether a cut is needed in the second year solely depends on the new recovery plan. Note that for the new recovery plan again a 10-year horizon is allowed.

The possibility to make different choices within such a recovery plan makes the pension contract by definition incomplete. The fund can for example raise the contribution rate to support the recovery or it can take voluntary cuts. However, there is also an important limitation, the pension fund is not allowed to increase its exposure to equity risk when recovering. Furthermore, the leeway to adjust the contribution rate is limited by agreements with the social partners. Hence, there is a lower bound on the shortage from which a pension fund can recover without cuts. This lower bound is called the critical funding ratio (CFR). The CFR differs per fund and a formula is given below, but for most funds it lies between 80% and 100%.

Cutting the current accrual is only needed when the funding ratio lies below the CFR. Only the cut in the first year matters, because this cut will be executed. The size of this cut can be approximated by:

$$c_{1,t}(F_t) = \frac{(F_t - \mathrm{CFR})}{\mathrm{CFR}} \cdot \frac{1}{10} \qquad \text{for } F_t < \mathrm{CFR}$$

The first fraction calculates the size of the total cut which is needed to reach the CFR immediately, the second fraction spreads the shock over 10 years[5].

The cut with recovery plan is plotted by the blue line in figure 3.1, with the assumption CFR = 0.9.

3.1.4 Model for the critical funding ratio

The critical funding ratio (CFR) is the lowest funding ratio for which the pension fund can make a recovery plan that leads to a funding ratio equal to the required funding ratio (VEV) after 10 years. To calculate

[4]If somehow the funding ratio lies above the VEV after one year, the cuts are not necessary anymore.

[5]In this formula for the cut it is necessary to divide by the CFR, because it is the relative distance between the funding ratio and the CFR which matters, and not the absolute distance. This can best be seen when the factor $\frac{1}{10}$ is ignored. When a pension fund with a CFR of 90% has a funding ratio of 80% and cuts its liabilities by 10%, the new funding ratio will be $\frac{0.8}{0.9} \approx 0.89 < 0.90$. Hence, taking the absolute distance between the CFR and the funding ratio leads to an underestimation of the cut.

whether the VEV will be reached, funds must simulate the funding ratio over a 10 years period, based on their proposed policy. The simulation is based on one (deterministic) scenario with a certain yearly return of 7% on equity. Pension funds who have to make a recovery plan are not allowed to increase their risk compared to last year. The CFR then depends on multiple factors, of which the most important are the following:

- First of all a fund with a higher equity exposure can recover faster because in the recovery plan it is allowed to assume a 7% return on equity, without taking the risk into account. However, the risk on equity plays a role in the calculation of the VEV; funds with more equity exposure have a higher VEV (ceteris paribus). For interest rates far below 7% the impact of the return on equity premium prevails, i.e. funds with a higher equity exposure currently have a lower CFR.
- Secondly, a higher interest rate will lower the positive impact of equity returns in the recovery plan, because the equity premium is assumed to be smaller for higher interest rates (the recovery plans use a fixed equity return instead of a fixed risk premium).
- Thirdly, a low funding ratio of the contribution will have a negative impact on the recovery, this effect will be stronger for green funds than for gray funds.

To estimate the size of these effects, I make use of an internal DNB model which can calculate the critical funding ratio for each pension fund, for different interest rates and different funding ratios of the contribution. This model is calibrated on existing recovery plans of the different pension funds. Note that the outcomes of this model are an approximation of the 'true' CFR.

The model does not offer the possibility to change the equity exposure of the fund and it does not contain a measure for the 'grayness' of a pension fund (though it is possible to compare manually some funds which are known to be green or gray). Therefore, my possibilities to find the impact of these variables are limited. The impact of these variables is estimated as follows:

Assume that the equity exposure (ϕ), the interest rate (r^f) and the funding ratio of the contribution (F^{contr}) impact the CFR independently of each other. The internal DNB model is used to calculate the CFR for all pension funds for $F^{\text{contr}} = 1.00$ and a flat interest rate of 0.7%[6]. First, I take different values for the interest rate and calculate its impact on the CFR, it turns out that the relation is approximately linear and that the coefficient is 8.5. Secondly I make three groups of representative funds (green, standard and gray) and for each group the CFR is calculated for different values of F^{contr}. Also this relationship turns out to be linear and the coefficient is larger (more negative) for green funds than for gray funds, which is in line with the expectations. Finally, to estimate the impact of the equity exposure, the internal model does not allow a change in this variable. Instead I make use of the variation in equity exposure between pension funds. After checking that the relationship is indeed linear, a regression of the dependent variable CFR on the independent variable equity exposure is used to determine the impact of equity exposure on the CFR. This regression gives a coefficient of -0.25 for the equity exposure.

Combining these three effects leads to the following linear model for the CFR:

$$\text{CFR} = 0.96 - 0.25\phi + 8.5(r^f - 0.007) - \beta(F^{\text{contr}} - 1.00)$$

Where ϕ is the fraction of the assets invested in equity, r^f the flat risk free interest rate and β is a parameter which depends on the grayness: $\beta(\text{gray}) = 0.1, \beta(\text{standard}) = 0.2, \beta(\text{green}) = 0.3$.

This model of the CFR is not able to take into account cross-effects between the different variables. When for example the interest rate becomes much higher, this could change the impact of equity exposure. However, for reasonable parameter choices the model is a big improvement compared to using a fixed CFR. Furthermore, it is not necessary to have the perfect model for the CFR, because the cut to MVEV (see below) in general has more impact on the value of the accrual, than the cut which depends on the CFR.

Finally, one constraint is added to the model: the CFR cannot be larger than the VEV. This makes sense, because if the funding ratio lies above the VEV no recovery plan is needed. Note that this constraint is only relevant for extreme parameter choices. The value of the VEV is given by the formula in section 3.2.4.

3.1.5 Cut to MVEV

The nFTK contains a second cutting rule to prevent that pension funds have a structural shortage. For this rule, the MVEV (Minimaal Vereist Eigen Vermogen, minimum required own funds) is used, which lies below the VEV. The size of the MVEV differs per fund and changes over time, but the variance between

[6]This flat interest rate gives on average the same CFR as the current interest rate term structure, and for most funds the difference between the CFR for the interest rate term structure and a flat rate of 0.7% is less than one percentage point.

the large pension funds is negligible. Given the observed values for the large pension funds, a reasonable approximation for the MVEV is 104%.

The nFTK does not allow funds to have a Funding Ratio below the MVEV for a long period of time. If the Funding Ratio lies below the MVEV for 5 years (6 observations at the end of year) in a row, the pension fund must apply a cut to reach the MVEV immediately. This can be modeled using the following formula:

$$c_{2,t}(F_{t-5},..,F_t) = \frac{F_t - \text{MVEV}}{\text{MVEV}} \qquad \text{if } F_{t-5},..,F_t < \text{MVEV}$$

Funds are allowed to spread out the cut over 10 years. But these future cuts are *unconditional* and are only applied on accrual which exists at the time of the cut. The cuts are unconditional in the sense that they are executed regardless of the development of the funding ratio, even if it will get higher than the MVEV or VEV. For the cut which is spread out, the yearly cut should lie above one-tenth of the direct cut; the higher cuts are necessary to afford the lower cuts on benefits which are paid out during the first ten years. This is worked out in subsection 3.1.6.

Finally, for this rule the year 2015 is considered as starting point, because the regulation was altered in that year. Many funds already had a Funding Ratio below the MVEV in 2015, which means that these funds might have to cut in 2020.

The MVEV cut is plotted by the red line in figure 3.1, for a pension fund which has been below the MVEV for 5 years in a row already. The solid line is the cut when it is not spread out.

3.1.6 Spread out cut to MVEV

Assume that a fund must execute a cut to MVEV of size c_{2,t_1} and decides to spread it out over 10 years. Let t_1 be the year in which the MVEV shock would take place if it was not spread out. Furthermore, denote by $\alpha_{2,t}$ the size of the benefits which are yearly paid out, relative to the total amount of liabilities, hence $\alpha_{2,t} := L_t^{\text{out}}/L_t$, where L_t^{out} denotes the size of the outflowing[7] benefits in year t. Assume that $\alpha_{2,t} = \alpha_2$ is constant over the 10-year period over which the shock is spread.

The shock only impacts existing accrual, so new contributions in the spreading period are exempted from this shock. Because the benefits which are paid out within ten years, receive only a part of the shock, the yearly shock should be larger than one tenth of the original shock. To spread the shock evenly, assume that the yearly cut is a fixed percentage of the accrual at time t_1, i.e. the nominal cut size for an individual is the same each year while the relative cut size increases.

The absolute amount of liabilities consisting of existing accrual at time t, decreases approximately with $100 \cdot \alpha_2\%$ of the original amount each year due to benefits that are being paid out. So the relative size of the liabilities that can be cut in the 10-year period is $(1, 1-\alpha_2, .., 1-9\alpha_2)$. To get a total shock of the same size, as when the shock was taken at once, a correction factor is needed.

$$\theta = \left(\frac{1 + 1 - 9\alpha_2}{2}\right)^{-1} \cdot \frac{1}{10}$$

Because $\alpha_2 > 0$, it holds that $\theta > \frac{1}{10}$ and θ is increasing in α_2, i.e. θ is higher for gray funds. The yearly nominal shock size is $\theta \cdot c_{2,t_1} \cdot B_t$, where B_t are the accrued rights/benefits at time t. Indeed, ten yearly shocks sum up to a higher shock than if it would be taken at once.

For the model, also the relative cut size is needed. The relative cut size increases as the nominal benefits are diminished by the earlier cuts. This can be seen in the following formula:

$$c_{2,t_1}^{\text{Spread}}(h) = \theta \cdot c_{2,t_1} \frac{1}{1 + (h-1) \cdot \theta \cdot c_{2,t_1}} \qquad 1 \le h \le 10$$

The denominator is the factor by which the current accrual has decreased due to earlier cuts. Cuts are always a negative number, so the denominator is smaller than one and the relative shock (relative to the accrual in year $t_1 + h$) indeed increases over time.

The first year of the spread out MVEV cut is plotted by the dashed red line in figure 3.1, for $\theta = 0.11$ (which corresponds to $\alpha_2 = 0.025$).

3.1.7 Lower contribution in case of high buffers

When a pension fund has high buffers, they can either give extra indexation, or ask a lower contribution for the same accrual. In practice most funds will probably lower the contribution rate in this case. This can be concluded based both on agreements between the social partners and on observations from the past.

[7]This idea is extended in section 3.2.5.

Furthermore, it is fiscally unattractive for a pension fund to raise the indexation above the inflation, which makes it more attractive to lower the contribution rate instead. As the contributions are paid partly by employers and partly by employees, both could benefit from a lower contribution rate.

Consider the following rule to determine the contribution: let the funding ratio of the contribution decline linearly from 100% to 0% for a funding ratio between 150% and 200%. Not all funds have the same funding ratio of the contribution to start with, so a more general formulation would be:

$$F_t^{\text{contr}}(F_{t-1}) = \begin{cases} F^{\text{contr}} & F_{t-1} \leq 2 \cdot (2.00 - F^{\text{contr}}) \\ 2 \cdot (2.00 - F_{t-1}) & 2 \cdot (2.00 - F^{\text{contr}}) < F_{t-1} \leq 2.00 \\ 0 & 2.00 < F_{t-1} \end{cases}$$

In this formula F^{contr} is the default funding ratio of the contribution of the pension fund. The mechanism is visualized in figure 3.2 for different values of F^{contr}.

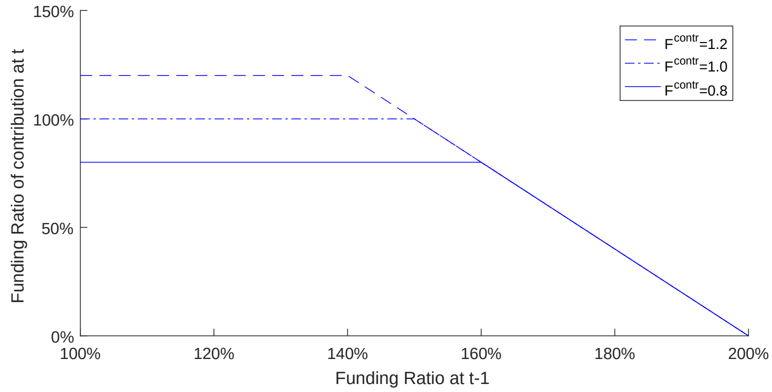

Figure 3.2: *Next period funding ratio of the contribution as function of the funding ratio.*

3.1.8 Summary

Looking back at figure 3.1 it turns out that the cut and indexation mechanisms are difficult to compare, because they are conditional on different variables. Furthermore, the figure does not contain the assumed contribution discount for high funding ratios.

Figure 3.1 shows that he cut to MVEV is in general larger than the cut with recovery plan. Even though the cut to MVEV requires a low funding ratio for five years in a row, which is not the case for the cut with recovery plan, it will turn out that the cut to MVEV is most important for the value of pension benefits. The figure also shows the asymmetry of the nFTK; the MVEV cut is much steeper than both types of indexation and when the indexation backlog is empty the indexation is even bounded, while this is not the case for cuts.

3.2 Behavior of the funding ratio over time

The funding ratio of a fund can change for multiple reasons. First of all, changes in the markets can affect the value of assets and in case of the interest rate also the liabilities. Secondly, incoming accrual and outgoing benefits can impact the funding ratio. For example, when the funding ratio is high and contributions only cover the new nominal liabilities, incoming accrual gets a share in the buffer for free, which negatively affects the funding ratio. Thirdly, cuts and indexation change the value of the liabilities and therefore also the funding ratio.

In this section I will build the model which describes the behavior of the funding ratio over time. First, the market risks are discussed. After that, I will present equations for the behavior of the funding ratio, which take into account the impact of market developments and cuts and indexation. Finally, incoming accrual and outgoing benefits are added to the model.

3.2.1 Market risk

A pension fund is exposed to multiple forms of market risk, including equity risk, interest rate risk, and inflation risk.

Equity risk is the risk on stocks, in which the pension fund invests. I model this risk using a single stock, which represents a diversified market portfolio.

Interest rate risk is mainly liability driven. When the interest rates go down, the value of future benefits increases, which has a negative impact on the funding ratio. When a pension fund invests in bonds and interest rate swaps, the value of the assets will also go up when the interest rate goes down. These assets can thus be used as a hedge against interest rate risk. When a pension fund is fully hedged, movements in the interest rate do not affect the funding ratio. Though in practice most Dutch pension funds are not fully hedged, it can still be useful to assume there is no interest rate risk. This assumption limits the complexity of the model and makes the results easier to interpret.

Inflation risk is the risk of high inflation, which has a negative impact on the purchasing power of the benefits. Because the Dutch pension funds made a nominal promise, inflation risk is not directly relevant here. Therefore, assume there is also no inflation risk.

3.2.2 Financial market

Consider a financial market with a single risky stock, S, which represents equity risk and a risk free bond[8], M. The variables are observed in discrete time, and for the assets time index t denotes the beginning of year t. For the return on an asset, time index t denotes the return made during year t. The assets behave according to the following equations:

$$\begin{aligned} S_{t+1} &= (1+r_t^s)S_t,\ t>0 \qquad & S_0 &= 1 \qquad & (1+r_t^s) &\sim \ln\mathcal{N}(\mu^s,\sigma^s) \\ M_{t+1} &= (1+r^f)M_t,\ t>0 \qquad & M_0 &= 1 \end{aligned}$$

Where r^f is the return on the risk free bond and r^s is the return on the risk free stock, which follows a lognormal distribution. Assume that there is a fixed risk premium λ, so $\mathbb{E}^{\mathbb{P}}[1+r_t^s] = 1+r^f+\lambda\ \forall t>0$. The parameters for the lognormal distribution can be calculated, using the following standard formulas:

$$\mu^s = \ln\left(\frac{\mathbb{E}[1+r_t^s]^2}{\sqrt{\text{std}[1+r_t^s]^2+\mathbb{E}[1+r_t^s]^2}}\right) \qquad \sigma^s = \ln\left(1+\frac{\text{std}[1+r_t^s]^2}{\mathbb{E}[1+r_t^s]^2}\right)$$

When choosing parameters, I will report the mean and the standard deviation of the return; μ^s and σ^s will be used in the calculations but not reported.

If a pension fund would only invest in risk free bonds, then the funding ratio would not change due to investment throughout the year. Both assets and liabilities would namely grow with the risk free rate. When the fund also invests in equity, the funding ratio will change if the return on equity lies below or above the risk free rate. Therefore, define $\tilde{S}_t := S_t/M_t$, which denotes the excess return. The following equations hold:

$$\tilde{S}_{t+1} = \frac{1+r_t^s}{1+r^f}\tilde{S}_t,\ t>0 \qquad \tilde{S}_0 = 1 \qquad \frac{1+r_t^s}{1+r^f} \sim \ln\mathcal{N}(\mu^e,\sigma^e)$$

It can be shown that under the real world probability measure $\sigma^e = \sigma^s$ and $\mu^e = \mu^s - \ln(1+r^f)$. Furthermore note that the expected excess return is given by the following expression:

$$\mathbb{E}^{\mathbb{P}}[\tilde{S}_{t+1}] = \frac{1+\lambda+r^f}{1+r^f}\tilde{S}_t \approx (1+\lambda)\tilde{S}_t$$

This means that under the real world measure the risk free interest rate does have an impact on the funding ratio in this model. However, for small values of r^f the impact is small.

3.2.3 Model equation

The funding ratio can be modeled as a function of the results on investment and the impact of cuts and indexation.

Decisions on cuts and indexation are based only on the funding ratio at the end of year[9]. Therefore the development of the funding ratio throughout the year is irrelevant. Superscript 'e' and 'b' are used to distinguish the end of year (December 31) from the beginning (January 1). For the cut and indexation these superscripts can be omitted, because they only take place at the end of the year. The assets are only observed at the beginning of the period and their value at the end of year t is equal to their value at the beginning of year $t+1$. Let ϕ be the exposure to equity risk of the fund and let c_1, c_2, i_1, i_2 be the cuts and

[8]In the literature B is often used for a risk free bond, but this can be confused with benefits.

[9]In practice the average funding ratio over the past 12 months (Dutch: Beleidsdekkingsgraad) also plays a role in some cases, this complication is ignored here.

indexation introduced in the previous section (3.1). Using this notation, the evolution of the funding ratio over time can be described by the following two equations:

$$F_t^e = \left(\phi \frac{\tilde{S}_{t+1}}{\tilde{S}_t} + (1-\phi)\right) F_t^b \tag{3.2.1}$$

$$F_{t+1}^b = F_t^e \Big/ \left[(1+c_{1,t}(F_t^e)) \cdot (1+c_{2,t}(F_{t-5}^e, .., F_t^e)) \cdot (1+i_{1,t}(F_t^e)) \cdot (1+i_{2,t}(F_t^e))\right] \tag{3.2.2}$$

Note that the results on investment change the value of the assets, which is why multiplication is used in equation 3.2.1. On the other hand, the cuts and indexation are applied on the rights and therefore change the liabilities of the pension fund, which is why division is used in equation 3.2.2.

For the behavior of the funding ratio in this model it does not matter whether the cut to MVEV is spread out or not. If the cut is spread out, it must immediately be put on the balance of the pension fund. Therefore, the funding ratio will also in this case directly after the cut be equal to the MVEV. For the value of the benefits and the cuts on the benefits, spreading out will make a difference.

3.2.4 Required own funds (VEV)

The model for the funding ratio can be used to calculate the required own funds. The required own funds or VEV is defined as follows. If the fund has a funding ratio equal to the VEV, the probability of having a funding ratio above 100% at the end of the year is 97.5%, that is:

$$\mathbb{P}[F_t^e \leq 1.00 | F_t^b = \text{VEV}] = 0.025$$

This equation can be rewritten to:

$$\mathbb{P}\left[\left(\phi \frac{1+r_t^s}{1+r^f} + 1 - \phi\right) F_t^b \leq 1.00 | F_t^b = \text{VEV}\right] = 0.025 \Rightarrow \mathbb{P}\left[\phi \frac{1+r_t^s}{1+r^f} + 1 - \phi \leq \frac{1}{\text{VEV}}\right] = 0.025$$

To solve this equation, use $1+r_t^s \sim \ln \mathcal{N}(\mu^s, \sigma^s)$. The cumulative density function of a lognormal distribution is $\Phi\left(\frac{\ln(x)-\mu}{\sigma}\right)$, where Φ is the cumulative density function of the normal distribution and $\Phi^{-1}(0.025) = -1.96$. This leads to the following equation for the VEV:

$$\text{VEV} = \left(\phi \frac{e^{-1.96\sigma^s + \mu^s}}{1+r^f} + 1 - \phi\right)^{-1}$$

This expression gives a VEV of 118% for a fund with the parameters as given in table 3.2 below. Note that the VEV of the most Dutch pension fund currently lies between 110% and 130%. In their calculations also other risks like interest rate risk are taken into account.

Finally, take the MVEV as lower bound for the VEV. This is only relevant for funds with an equity exposure close to 0%.

3.2.5 Add in- and outflow to the model

To analyze the difference between green and gray funds, it is necessary to take the effect of inflow of contributions and outflow of benefits into account. Besides, the inflow is needed to analyze the impact of using different contribution rates, for example when funds lower their contribution rate as discussed in section 3.1.7, or when a fund structurally makes use of a low or high contribution rate. Assume that the in- and outflow take place at the end of a year and therefore they are not multiplied by the profit on investment.

To determine the impact of the inflow on the funding ratio, two variables must be defined. First the size of the new accrual relative to the total size of the liabilities $\alpha_1 := L_t^{\text{in}}/L_t$, where L_t is the nominal value of the liabilities before in- and outflow. And second the so-called 'premiedekkingsgraad' (funding ratio of the contribution), which is defined as the total amount of contributions divided by the value of the total value of new accrual: $F_t^{\text{contr}} := A_t^{\text{in}}/L_t^{\text{in}}$.

For the outflow define the relative size of the benefits, $\alpha_2 := L_t^{\text{out}}/L_t$, and the funding ratio of the benefits, F_t^{out}, in a similar manner. Note that $F_t^{\text{out}} = 1.00$ by definition, because cuts and indexation take place at a different point in time and the rights are adjusted directly.

Finally, replace the notation 'e' for end of period by 'e_1' (after investment results, before in- and outflow) and 'e_2' (after in- and outflow). Let $F_t^{e_1}$ be defined by equation 3.2.1 and use the following equation to add the in- and outflow:

$$F_t^{e_2} = \frac{F_t^{e_1} + \alpha_1 F^{\text{contr}} - \alpha_2 F^{\text{out}}}{1 + \alpha_1 - \alpha_2} \tag{3.2.3}$$

The derivation of this equation can be found in appendix B. Note that the in- and outflow have no impact in the special case that both $\alpha_1 = \alpha_2$ and $F^{\text{in}} = 1.00 = F^{\text{out}}$. This case means that the size of in- and outflow is equal, and that the contribution is put equal to the value of the new liabilities.

Impact of in- and outflow
When a pension fund has a funding ratio above 100% and benefits are paid out, this has a positive effect on the funding ratio because the part of the buffer which corresponds to these benefits remains in the fund. In Dutch this effect is called 'buffervrijval'. When on the other hand the funding ratio lies below 100%, paying out benefits has a negative effect on the funding ratio. So in short, one could say that paying out benefits leads to divergence of the funding ratio from 100%.

When a pension fund has a funding ratio above F^{contr}, then inflow has a negative impact on the funding ratio, the new accrual gets a share of the existing buffer; in Dutch this is called 'verwatering'. On the other hand when the funding ratio lies below F^{contr}, then inflow has a positive impact on the funding ratio. Hence, inflow leads to convergence of the funding ratio towards F^{contr}.

The impact of the inflow is stronger in a green fund, while the impact of the outflow is stronger in a gray fund. To distinguish between these funds, I use different values for α_1 and α_2 as given in tabel 3.1. These values are based on observations of Dutch second pillar pension funds. In practice the demography of a fund can change over time. However, for easy interpretation of these effects, assume that α_1 and α_2 are fixed over time.

	Standard fund	Green fund	Gray fund
α_1	0.025	0.035	0.015
α_2	0.025	0.015	0.035

Table 3.1: *Weights of in- and outflow used for different funds.*

3.2.6 Assumptions

The model as written down in equations 3.2.1, 3.2.2 and 3.2.3 implies multiple assumptions. The most important (i.e. most likely to have a material impact on the results) assumptions are:

- There are no macro risks except for market risk (i.e. no macro longevity risk, discontinuity risk, etc.).
- Investments in risky assets can be simplified to one risk factor.
- There is no interest rate risk on the market or interest rate risk is fully hedged by the pension fund.
- Indexation decisions are independent of the current inflation or the inflation is fixed.
- Gray funds remain gray and green funds remain green for the entire horizon which I study.

Most of these assumptions have already been clarified above. They are listed here to give a quick and transparent view of the main modeling choices.

3.3 Scenarios

In this section I will illustrate the behavior of the funding ratio, under the model described in section 3.2, by showing some simulated scenarios. The parameters for the simulation are given in table 3.2 and the real world probability measure is used.

Without cuts and indexation the process will follow an upward trend, because of the risk premium. The cuts will have a positive impact on the funding ratio in bad scenarios, while the indexation will lead to a lower funding ratio in good scenarios. The in- and outflow has no impact in this case, because

An example of two different random scenarios can be found in figure 3.3. The solid lines are the funding ratios and the dashed lines show the nominal impact of cuts and indexation on existing rights in the same scenarios. The years on the horizontal axis denote the beginning of a year, so if for example a cut takes place at the end of 2020, this is visible in the graph near the number 2021. For both scenarios the funding ratio is plotted from the beginning of 2017 (start at value 100%) to the end of 2036 (the cut/indexation at the end of 2036 is omitted).

The green line shows a scenario with many good years in which indexation can be given. Good returns on investments lead to an increasing funding ratio during the year. When the funding ratio lies above 110% at the end of the year, indexation is given, which has a negative impact on the funding ratio, this is represented

Description	Symbol	Value
Indexation ambition	i_a	2.0%
Indexation backlog at begin	i_{b,t_0}	20%
Risk free rate	r^f	1.5%
Risk premium	λ	3.5%
Equity volatility	$\text{Std}(1+r^s)$	20%
Equity exposure	ϕ	50%
Starting year	t_0	2017
Funding ratio at begin	F_{t_0}	100%
Funding ratio contribution	F^{contr}	100%
Weight liabilities inflow	α_1	2.5%
Weight liabilities outflow	α_2	2.5%
Critical funding ratio	$\text{CFR}(\phi, r^f, \beta, F^{\text{contr}})$	95%

Table 3.2: *Parameters for simulation, base case.*

by the small vertical parts of the lines at the end of some years. In the same years the dashed line goes up, because the benefits are indexed. At the end of 2032 the green line has an indexation far above 2%, this is the impact of the catch-up indexation. In this scenario, the existing rights of an individual would have been indexed by 40% between the beginning of 2017 and the end of 2036.

The red line represents a scenario with a bad start. In this scenario both types of cut are visible. I assumed that the funding ratio was already below the MVEV at the end of 2015 and 2016, therefore the first cut to MVEV takes place at the end of 2020, when the funding ratio has been below MVEV at the end of six subsequent years. Furthermore, the cut with recovery plan is visible at the end of 2018, and 2019. This shock is quite small, because only one-tenth of the gap between the funding ratio and the CFR (95%) has to be bridged by the cut.

Again the dashed line shows the impact on the existing accrual. I assume that the cut to MVEV is spread out over 10 years. This is indeed visible, as the red dashed line goes down for multiple years, while the funding ratio is already above the MVEV. At the end of 2025 the funding ratio has recovered and is even high enough to give indexation. In these years both the indexation and the spread out MVEV cut are given, which in 2025 and 2026 still leads to a cut, while in 2028 and 2029 the net result is positive. 2030 is the first year without the spread out cut to MVEV. In this scenario, the net change of the existing rights of an individual would have been -7% between the beginning of 2017 and the end of 2036.

In case of a yearly inflation of 2%, the purchasing power of the benefit would have decreased in both these scenarios. In the green scenario the change in purchasing power would have been -4% and in the red scenario -36%.

$\alpha_1 = \alpha_2$ and $F^{\text{contr}} = 1.00$.

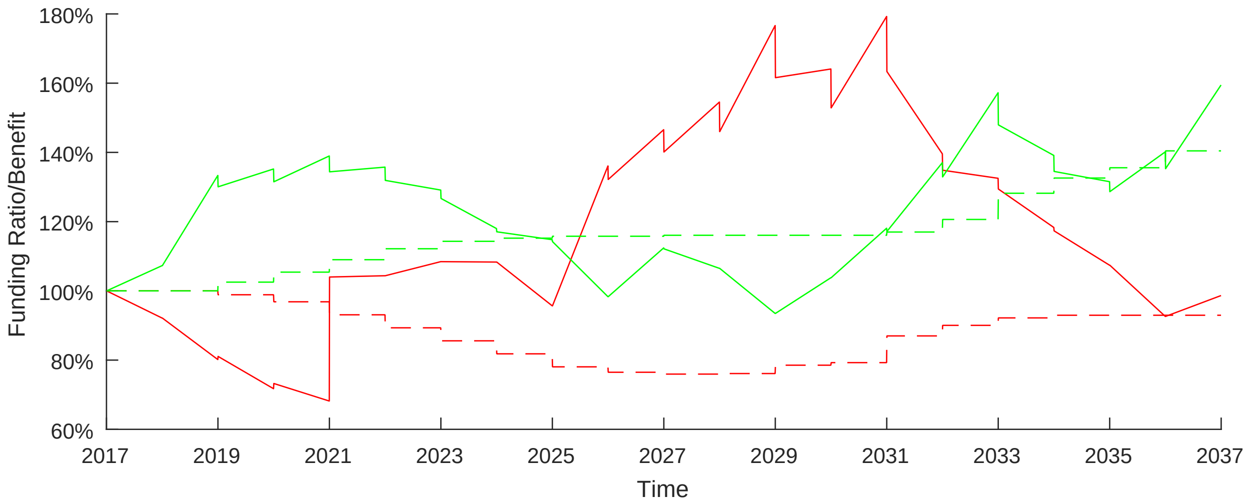

Figure 3.3: *Different scenarios of the development of the funding ratio under $\mathbb{P}$. Base case parameters. The solid lines show the funding ratio, the dashed lines show the impact of cuts and indexation on the nominal value of the benefits.*

In figure 3.4 the mean, and percentiles of the funding ratio are plotted over a fifty year period. Also in this picture the impact of the cuts and indexation is visible. In 2020 the cut to MVEV has a big upward impact on the fifth and first percentile, and also the mean and median go up after this cut. Still the fifth percentile lies below the MVEV after the cut in 2020, this must be caused by some scenarios which had a funding ratio above the MVEV in one of the earlier years (2017, 2018, 2019) and below the MVEV in 2020.

The drift of the funding ratio is positive, under the real world measure, which is visible in the upward trend of the mean and median throughout the year. The downward shocks at the end of the year are caused by indexation.

Furthermore, this picture shows that the funding ratio can grow boundlessly, apparently the indexation mechanisms and lowering the contribution are not effective enough to bound the funding ratio from above. On the other hand, the cutting mechanisms manage to keep the funding ratio bounded from below. Negative outliers are still possible, but the first and fifth percentile do not have a negative drift.

It is difficult to tell which funding ratios will be unsustainable in practice. Based on these results for the first and fifth percentile, it can be assumed that the impact of discontinuity risk on the results is limited. Therefore it is acceptable not to model discontinuity risk. However, it seems less likely that pension funds would keep a buffer of 200%. Thus, the good scenarios lead to improbable outcomes. This problem will be addressed in section 3.4.

But first the impact of demographics on the behavior of the funding ratio will be analyzed.

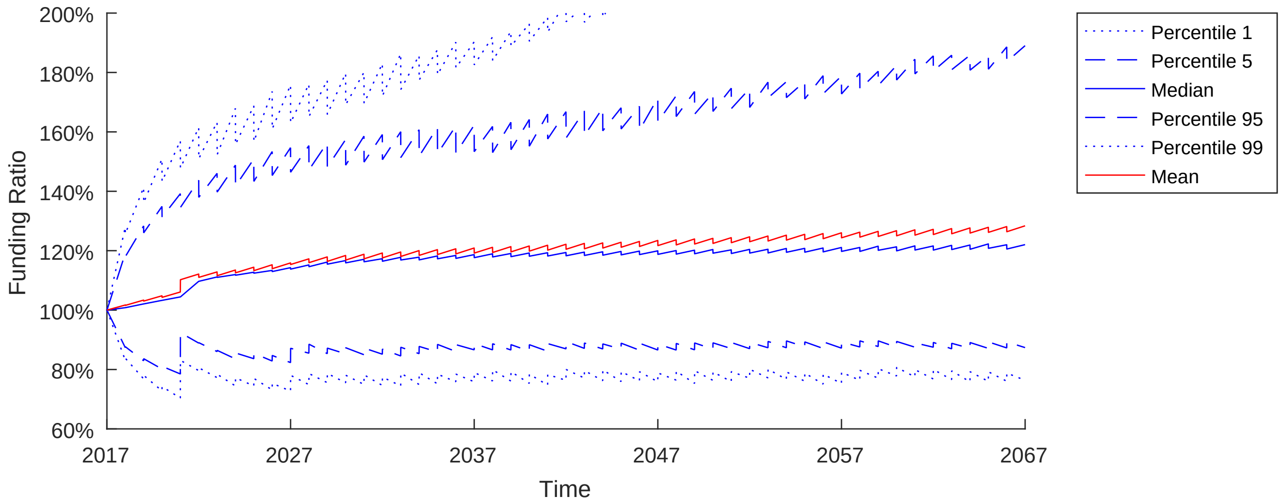

Figure 3.4: *Statistics of the development of the funding ratio under $\mathbb{P}$. Base case parameters.*

3.3.1 Compare green and gray fund

Consider a green fund and a gray fund, where the only differences are the size of the in- and outflow. The values for α_1 and α_2 can be found in table 3.1. For the other parameters, use the values in table 3.2.

In figure 3.5 the percentiles of the funding ratio for a green fund (green line) and a gray fund (gray line) are given. In section 3.3.1 it was predicted that the gray fund would show more diverging behavior from a funding ratio of 100% than the green fund. This indeed is the case for the ninety-fifth and the fiftieth percentile, however for the fifth percentile there is not much difference. This can be explained by the fact that a pension fund can remain at most five years in a row below a funding ratio of 104%, due to the MVEV shock. For funding ratios above 100%, the gray fund has a higher upward drift, which means that in less scenarios it will remain close to 100%. Hence, also for the fifth percentile the behavior above a funding ratio of 100% matters, and therefore the fifth percentile of the gray fund does not lie below that of the green fund.

Note that in the first few years of the simulation, the fifth percentile of the gray fund does lie below that of the green fund, because all scenarios start at 100% and therefore the fifth percentile will in the first few years mainly consist of scenarios that have not been above a funding ratio of 100% yet.

The funding ratio of the green fund is more sensitive to the funding ratio of the contribution than the funding ratio of the gray fund. Therefore the option to lower this funding ratio of the contribution when the funding ratio is high, has more impact on the green fund than on the gray fund. Still, even without this rule, the funding ratio of the gray fund has more upward potential. For high funding ratios, contributions with $F^{\text{contr}} = 1.00$ still have a strong negative effect on the funding ratio, while paying out benefits has a strong positive effect.

In conclusion, the simulations of green and gray funds show that the same risk profile leads to significantly different outcomes for different funds. Gray funds will have more extreme outcomes for the same equity exposure. Given that older people are in general more risk averse, gray funds should mitigate this effect by choosing a lower equity exposure.

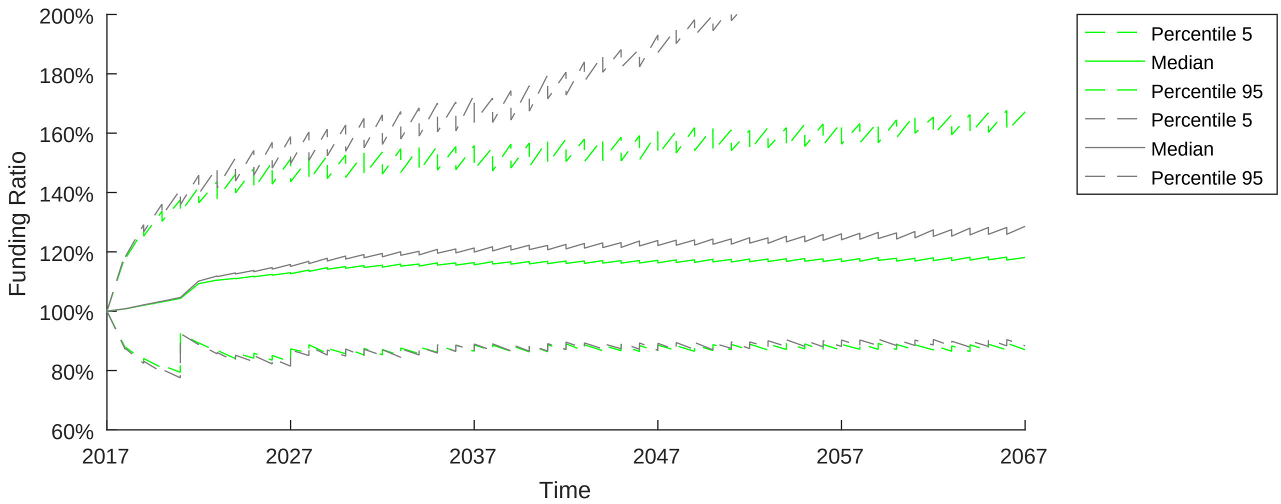

Figure 3.5: *Scenarios of the development of the funding ratio under* $\mathbb{P}$ *for a green pension fund (green lines) and a gray pension fund (gray lines). Difference between green and gray fund modeled by adjusting the parameters for in- and outflow, other parameters are base case,* $F^{contr} = 1.00$.

3.4 Bonus indexation

Even when contributions are lowered as described in section 3.1.7, the funding ratio can grow to a level far above 200%, as can be seen in figure 3.4 and figure 3.5. It could be argued that such a funding ratio is unrealistic, because rules could be changed to give extra indexation to current participants. In their quantitative analysis of the current and possible new pension contracts, Pensioenfederatie (2016)[20] presents results for two interpretations of the current contract: one where extra indexation is given in case of large buffers and one where individuals cannot receive more than full indexation. In that paper the rule to give extra indexation is not explicitly specified. There are many plausible mechanisms that limit the buffer in good scenarios. Of these possibilities, I use the following mechanism.

Let F^{high} be the funding ratio, below which the pension fund follows the nFTK and gives no extra indexation. Assume that when $F_t > F^{\text{high}}$ the pension fund gives extra indexation, such that in expectation $\frac{1}{y}$ of the surplus is gone after one year, where y is the number of years over which the bonus indexation is spread. That is, the pension fund solves the equation:

$$\mathbb{E}_t^{\mathbb{P}}[F_{t+1}^e - F^{\text{high}}] = \left(1 - \frac{1}{y}\right)(F_t^e - F^{\text{high}}) \qquad F_t^e > F^{\text{high}}$$

This mechanism takes the expected return on investment in year $t+1$ into account, which is necessary because the returns can have a large impact on the funding ratio. If the expected return on investment is 2% and the funding ratio is 300%, then the expected funding ratio after one year is 306%. While a fund with funding ratio 100% only has an expectation of 102% for the next year. A linear indexation would not take this into account and might therefore be too low in case of high funding ratios. For a fund without in- and outflow, which has a high funding ratio, the funding ratio of the next period is given by[10]:

$$F_{t+1}^e = \left(\phi\frac{\tilde{S}_{t+1}}{\tilde{S}_t} + (1-\phi)\right) \cdot \frac{F_t^e}{1 + i_t(F_t^e)} \qquad F_t^e > F^{\text{high}}$$

Where i_t is the total indexation (normal indexation + catch-up indexation + bonus indexation). Therefore, the total indexation that is needed to keep the funding ratio bounded is:

$$i_t(F_t^e) = \frac{F_t^e \cdot \mathbb{E}_t^{\mathbb{P}}\left[\phi\frac{\tilde{S}_{t+1}}{\tilde{S}_t} + (1-\phi)\right]}{\left(1 - \frac{1}{y}\right)F_t^e + \frac{1}{y}F^{\text{high}}} \qquad F_t^e > F^{\text{high}} \qquad (3.4.1)$$

[10] The in- and outflow is omitted to keep the formulas easy to read. In the calculations where this mechanism is used, the in- and outflow is taken into account.

Bonus indexation will only be applied, when it leads to more indexation. Therefore define the bonus indexation $i_{3,t}$ by:

$$i_{3,t} = \max(i_t - i_{1,t} - i_{2,t}, 0) \qquad F_t^e > F^{\text{high}}$$

Where i_t is given by equation 3.4.1. Hence, the normal indexation and catch-up indexation are given first and only when these are insufficient to get back at F^{high} in y years, bonus indexation is given.

Equation 3.4.1 is quite complicated. For a better understanding, consider the special case $y = 1$, i.e. the bonus indexation is not spread over multiple years. Then:

$$\mathbb{E}_t^{\mathbb{P}}[F_{t+1}^e - F^{\text{high}}] = 0 \qquad \Rightarrow \qquad i_t(F_t^e) = \frac{F_t^e}{F^{\text{high}}} \mathbb{E}_t^{\mathbb{P}}\left[\phi \frac{\tilde{S}_{t+1}}{\tilde{S}_t} + (1 - \phi)\right] \qquad F_t^e > F^{\text{high}}$$

A total indexation of F_t/F^{high} would bring the funding ratio back to F^{high}, but the returns would lead to a higher expected funding ratio at the end of year $t+1$, therefore the expectation of the return is also included in the calculation.

The parameter choice for the bonus indexation determines how high the funding ratio can become. Based on tests with different values, I decide to use $y = 3, F^{\text{high}} = 1.50$. These choices are rather arbitrary, but that cannot be prevented because it is unknown which decisions will be made in case of high funding ratios. This combination of model and parameters works in the sense that given reasonable parameter choices, the 99-th percentile of the funding ratio remains below 200% over a 75 year horizon.

The bonus indexation is not implemented as default choice in the calculations below, but it will be used for a robustness check.

3.5 Conclusion

In this chapter the financial framework for a pension fund under the current rules has been introduced. This discussion has shown that the current rules for cuts and indexation are quite complex, buffers can grow boundlessly, and that there is an asymmetry between the cuts and indexation.

The complexity of the nFTK is caused by the multiple different rules that depend on different variables, and the interdependence between the funding ratio and cuts and indexation. This complexity makes it impossible to solve the model analytically, which is why I use simulation techniques.

Furthermore, buffers can grow boundlessly as there is no indexation mechanism that prevents extremely high funding ratios. Even when the contribution rate is lowered to zero, the funding ratio can keep growing. This is caused by the buffervrijval (retirees only get 100% of their benefits, even if the funding ratio is 200%), which is especially strong for gray funds. Therefore, it is important that the behavior of the pension fund in case of high funding ratios is clearly defined.

Finally, a consequence of the asymmetry of the cuts and indexation is that pension funds have a tendency to build up a buffer in most scenarios. This means that in the current system on average a buffer is given to future generations, as will be visible in the results of the next chapter.

4 Value existing rights

In the previous chapter it has been shown that benefits can be indexed and cut based on the funding ratio of the pension fund. In this chapter I will quantify the impact of this uncertainty on the value of existing pension rights. To do that, the concept of 'value' must be clearly defined. In the literature two types of value are typically distinguished: the legal value and the economic value.

The term 'legal value' often indicates the value of the nominal rights when there is no possibility of indexation or cuts. I will use the term 'hard nominal contract' or 'nominal guarantee' to indicate the value of a contract which pays out the nominal rights without any probability of indexation or cuts and I keep aloof from the discussion whether this is indeed the legal value. A nominal guarantee consists of a cashflow of future benefits, so to get the value of the hard nominal contract the nominal benefits must be adjusted for survival probabilities and discounted by the risk free rate. This corresponds to a pension fund that has no risk; i.e. a pension fund that invests such that changes in the liabilities are matched by equal changes in the assets.

Contrary to the hard nominal value, the economic value does take into account the impact of a mismatch between assets and liabilities on the benefits which participants will receive. The economic value is defined as the amount of money needed to replicate the entitlement which the participant currently has, by investing in the market. The economic value can be computed as the expected value of future benefits under the so-called risk-neutral measure (this concept is explained below).

The aim of this chapter is to calculate the economic value of existing rights, i.e. new accrual is not valued though the impact of new contributions and accrual of *other* participants on the funding ratio is taken into account. To do this the concept of economic value is explained in section 4.1. Section 4.2 contains the formulas for the economic value of an annuity and in section 4.3, the results are presented. This chapter focuses on a base case fund with initial funding ratio 100% and funding ratio of the contribution 100%; the impact of heterogeneity is addressed in chapter 6 below.

The application of the economic value on the transition questions will be addressed in the next chapters.

4.1 Valuation

Calculating the economic value, or 'valuation', is a technique in mathematical finance that can be used to price financial derivatives under the assumption of frictionless markets and no arbitrage. An arbitrage is a strategy which has cost price zero and yields a positive probability of a profit (positive cashflow) before infinity, without any probability of a negative cashflow. This implies for example, that if two trading strategies (or financial products) yield the same (stochastic) cashflows, then they must have the same price. If this would not be the case, a trader could short the more expensive strategy and buy the cheaper strategy and in this manner make a profit without risk.

Why is this relevant for pensions? The benefit which an individual receives is an uncertain cashflow which largely depends on movements in the financial markets. High investment returns lead to a high funding ratio, which allows for more indexation. Or to state it differently, the benefit which an individual receives is a nominal amount plus an option (long call) on indexation and an option (short put) on cuts. This contract could be sold at the market as a nominal benefit plus embedded options. Valuation gives the price that the market would pay for this contract, this is called the economic value of the contract.

Now, assume that the pension fund does not add or take away money, but only invests money on behalf of the participants and distributes the pay-off. Besides, ignore non-market risks. Then the economic value of all current and future participants of the pension fund must be equal to the amount of assets. This implies that there is a zero-sum game between the participants: no value can be created, if one generation gets a higher economic value, another generation must pay for this.

As a consequence, a pension fund cannot create value by allocating more money to equity. The economic value of 100 euro of stocks is the same as the economic value of 100 euro of bonds; the former has a higher expected return but also a higher risk.

When on the other hand calculations are based on expected returns only and there is assumed to be a positive equity premium, then it will turn out that the investments in stocks have a higher expected return than the investments in bonds. This suggests that there would be an arbitrage opportunity, which is problematic. Using valuation instead solves this problem, as will be explained below.

Finally, note that this does not mean that investing in risky assets cannot help to give people a better pension. People can still find the combination of higher risk and a higher return attractive. Valuation does not help to make this trade-off, to do that other tools are available (for example utility functions), but in all cases it is essential that both risk and reward are taken into account. What valuation does tell is that when a contract becomes more risky without a higher reward, the owner of this contract loses value. This may seem obvious, but it cannot be stressed enough, because this effect is often difficult to observe in calculations based on expected returns. The economic value on the other hand does take this into account, and is therefore a powerful tool to show how different generations are affected by decisions about risk and reward.

In the remainder of this section the technical aspects and the limitations of valuation will be discussed.

4.1.1 Risk neutral pricing

To calculate the market price of the embedded options, I use the risk neutral pricing method, which is based on the so-called 'risk-neutral (probability) measure', $\mathbb{Q}$. To understand this concept, first consider its counterpart, $\mathbb{P}$.

Every outcome of the stochastic variables (state of the world) has a probability, which is assumed to be known. All these probabilities together are called the 'real-world (probability) measure' or $\mathbb{P}$. On average stocks have a higher return than bonds, i.e. the expectation of their return is higher. In mathematics this can be denoted, for a stock S and a bond M, by: $\mathbb{E}^{\mathbb{P}}\left[\frac{S_{t+1}}{S_t}\right] > \mathbb{E}^{\mathbb{P}}\left[\frac{M_{t+1}}{M_t}\right] = r^f$. Here $\mathbb{E}$ is the symbol for the expectation and $\mathbb{P}$ tells that the expectation is taken under the real-world measure.

Mathematically speaking it is possible to change the probabilities of certain outcomes/states of the world, this is called 'a change of measure'. To take risk into account, a lower probability is given to good outcomes (high stock returns) and a higher probability is given to bad outcomes (low/negative stock returns). The risk-neutral measure $\mathbb{Q}$ is defined such that for all existing assets the expected return is exactly equal to the risk-free rate. In mathematics: $\mathbb{E}^{\mathbb{Q}}\left[\frac{S_{t+1}}{S_t}\right] = \mathbb{E}^{\mathbb{Q}}\left[\frac{M_{t+1}}{M_t}\right] = r^f$. This definition implies that there is no risk premium on the stock under the risk-neutral measure.

As a consequence, assets that give a high return in bad scenarios are under the risk-neutral measure more valuable than assets that give a high return in good scenarios. What good and bad scenarios are is determined based on the prices for different risky assets that exist in the market. When the risk free interest rate is fixed, a new asset C, which has a stochastic payoff in the next period, can be priced by the risk-neutral valuation formula:

$$C_t = \frac{M_t}{M_{t+1}}\mathbb{E}^{\mathbb{Q}}[C_{t+1}] = \frac{1}{1+r^f}\mathbb{E}^{\mathbb{Q}}[C_{t+1}] \tag{4.1.1}$$

This formula can be used to price derivatives on the financial market, or in this case the embedded options of pension benefits[1].

4.1.2 Closing rule

In general valuation leads to a zero-sum game over the generations. However, this does include future generations (and future accrual of current generations). Hence, the economic value of the existing rights is not necessarily equal to the amount of assets in the pension fund. The remaining surplus or shortage is the total economic value of future accrual.

Sometimes, when relatively short simulation periods are used, a closing rule is used to distribute the remaining buffer or shortage at the end of the simulation period over the people who are then still alive. The disadvantage of such a rule is that it does not take into account that a part of this buffer could go to future generations.

To avoid this problem, I use a simulation period of 75 years, which means that all people who have existing rights at time t_0, will have passed away at the end of the simulation period (start working at age 25, maximum age is 100). This means that a closing rule at the end of the simulation period would spread the buffer or shortage over future generations only. However, I will not present results for these generations and therefore there is no need to use a closing rule.

Besides the closing rule, also the maximum size of the buffer does matter. The pension contract is incomplete in the sense that it does allow for large buffers which may not be sustained in practice. One could argue that it is likely that those buffers are spent on lower contributions, on extra indexation, or both. I have argued before in section 3.1.7 that it is fiscally more attractive to lower the contributions than to raise indexations and that this is more in line with observations from the past. Hence, the base case assumption will be that contributions are lowered while no bonus indexation is given. However, given the importance of this subject it is necessary to test if the economic value of an annuity is robust to a change of this assumption.

[1]To show that risk-neutral pricing can indeed be applied in this case is non trivial, but it turns out that in this model no problems occur.

4.1.3 Limitations

Valuation only works under a set of assumptions and has some limitations. How important these limitations are, depends on the application.

The most important limitation in the application of valuation on a pension fund, is that contracts are incomplete. The contribution rate can be changed in negotiations between the social partners. Furthermore, the board of the fund can change the exposure to different risk factors (equity risk, interest rate risk, inflation risk, etc.). These decisions shift value between generations. It is necessary to make some assumptions on the behavior of the pension fund, but there exists a large set of plausible assumptions.

Another source of incompleteness is political risk. Politicians can change the rules of the nFTK, which will impact the probability and size of cuts and indexation.

Furthermore, valuation is also model and parameter dependent. It is for example possible to use a model in which the interest rate has a tendency to go up from the current (low) rates. On the other hand, one can also choose a model which gives more weight to a so-called 'Japan scenario' with structural low interest rates. In my model, I use a fixed interest rate. This also has an impact on the result and is important to take into account when interpreting the results.

Finally, valuation can only be used to value market risks. In a pension fund also other risks are shared, e.g. longevity risk. When there is no market price available it is not possible to calculate the economic value of exposure to this risk.

This list of limitations is not exhaustive, but it captures the main points for the application of valuation on a pension fund.

4.1.4 Existing rights

The non-retired participants of a pension fund can be divided in two groups, the workers who build up new accrual in the fund (short 'active workers') and the so-called sleepers (Dutch 'slapers'), people who still have rights at the fund but currently do not build up new accrual at this particular fund. This can be either because they build up new accrual at a different pension fund, or because they do not build up new pension accrual at all.

The interests of these two groups are not always aligned, both benefit from higher future indexations, but only the active workers benefit from a discount on the contribution rate (without a change in the accrual rate).

In the calculations below I will focus on the valuation of existing rights, which is relevant for both active workers and sleepers. For young active workers this might only concern a small part of the value of their total pension at this pension fund. Therefore, this will be important to keep in mind when interpreting the results. Note that though only existing rights are valued, it is still assumed that contributions and new accrual of other working people are added each year.

Finally, note that for retirees this distinction is irrelevant. In general it can reasonably be assumed that retirees do not build up new accrual anymore.

4.2 Calculating the economic value

This section only gives formulas for the valuation of existing rights. The formulas for the valuation of new accrual can be found in appendix C. The equations in this section build further on the model presented in the previous chapter, the central part of the model is found in section 3.2.

To calculate the economic value of the benefits, I use risk-neutral valuation. Assume that at time t_0 a participant has a nominal accrual of B_{t_0} euro and that at year $t_0 + h$ he will receive a benefit of B_{t_0+h}. The size of the benefit B_{t_0+h} is given by:

$$B_{t_0+h} := B_{t_0} \prod_{t=t_0}^{t_0+h-1} (1 + i_{1,t})(1 + i_{2,t})(1 + c_{1,t})(1 + c_{2,t})$$

Let $h > 0$ and denote the value of this benefit at time $t \in [t_0, t_0 + h]$ by V_t^h for a participant who certainly does not die in the meantime. The value at time $t_0 + h$ is equal to $V_{t_0+h}^h = B_{t_0+h}$, because at that point in time there is no uncertainty left and the value of the benefit must be exactly equal to the amount which the participant gets. The value of this benefit can be calculated using the risk neutral pricing formula which is given in equation 4.1.1. This leads to[2]:

$$V_{t_0}^h = (1 + r^f)^{-h} \mathbb{E}_{t_0}^{\mathbb{Q}}[B_{t_0+h}] \qquad h > 0 \tag{4.2.1}$$

[2]Note that $t_0 + h$ must denote the end of period, because I assumed benefits are paid at the end of period. I assume t_0 is also end of period; if it is begin of period, an extra year of discounting is needed.

The economic value depends on multiple parameters, including the type of contract and the funding ratio at time t_0. Consider for example a hard nominal contract (is the same as a nominal guarantee, abbreviation 'NG'). In this contract there is no risk for the participant, hence the nominal benefit is guaranteed and the economic value can be simplified to:

$$V_{t_0}^h(\text{NG}) = (1+r^f)^{-h}\mathbb{E}_{t_0}^{\mathbb{Q}}[B_{t_0+h}] = (1+r^f)^{-h}B_{t_0} \qquad h>0$$

Note, that the economic value of benefits is decreasing over the maturity if this hard nominal contract is used and $r^f > 0$. This is not necessarily the case for all contracts, but for example the economic value of benefits in a pension fund under the nFTK will also follow a downward trend in h.

For a pension fund under the nFTK, equation 4.2.1 cannot be simplified, but must be solved using simulation.

4.2.1 Indexation and cut factor

The current pension contract contains embedded options on cuts and indexation. To determine the value of these options relative to the nominal guarantee, I introduce the variable ξ in this section, which I call the 'indexation and cut factor'. I will use ξ mainly on the background, but it has one useful interpretation. This variable shows namely directly whether the cut or the indexation option prevails. Furthermore, it can be used to show at which points in time the options to cut or to index have a relatively higher value.

Define the indexation and cut factor, ξ, under the risk neutral measure for contract C with starting funding ratio F_{t_0} and for $h>0$ by:

$$\xi_{t_0}^h(\text{C}, F_0) := \frac{V_{t_0}^h(\text{C}, F_{t_0})}{V_{t_0}^h(\text{NG})} = \frac{V_{t_0}^h(\text{C}, F_{t_0})}{(1+r^f)^{-h}B_{t_0}} = \mathbb{E}_{t_0}^{\mathbb{Q}}\left[\frac{B_{t_0+h}(\text{C}, F_{t_0})}{B_{t_0}}\right] \tag{4.2.2}$$

In the contracts which I consider, benefits are only changed by indexation or cuts. Hence, ξ must be equal to the product of the indexation and cuts between t_0 and t_0+h. To define ξ in this manner, I first introduce the stochastic variable Ξ:

$$\Xi^h(\omega) := \prod_{t=t_0}^{t_0+h-1}(1+i_{1,t}(\omega))(1+i_{2,t}(\omega))(1+c_{1,t}(\omega))(1+c_{2,t}(\omega)) \qquad h>0 \tag{4.2.3}$$

Cuts and indexation take place after benefits are paid out, therefore the cuts and indexation at t_0+h are not included in this value. Now ξ is equal to the expectation of Ξ under the risk neutral measure:

$$\xi_{t_0}^h := \mathbb{E}_{t_0}^{\mathbb{Q}}[\Xi^h] \qquad h>0$$

Note that for a nominal guarantee ξ_t^h is by definition equal to one. In the formulas which I will use throughout, ξ contains the difference in value between contracts.

4.2.2 Economic value of an annuity

In the Dutch second pillar pension funds, participants cannot choose for a lump-sum, but are obliged to take an annuity. Here, annuity must be interpreted as a variable annuity, i.e. a stream of yearly payments between retirement and death, where the size of the payments depends (for example) on investment returns. Under the current contract the possibility of cuts and indexation makes the annuity a variable annuity.

Consider a participant who has a nominal accrual of B_{t_0} euro at time t_0, which will be paid out in the form of a yearly annuity after his retirement. Use notation A_{t_0} for the value of this annuity at time t_0. The formula for the value of existing accrual, for an individual of age j_0 at t_0, is:

$$A_{t_0}(j_0) = \sum_{i=j_r-j_0}^{j_d-j_0} V_{t_0}^i \cdot \mathbb{1}[\text{alive}]$$

Where j_r is the retirement age and j_d the maximum age. Use ${}_kp(j)$ to denote the probability for an individual of age j to live another k years. When the value is taken at the beginning of year t_0, then the formula for the value of an annuity becomes:

$$A_{t_0}(j_0) = \sum_{i=j_r-j_0}^{j_d-j_0}(1+r_f)^{-(i+1)}\mathbb{E}_{t_0}^{\mathbb{Q}}[B_{t_0+i}]\ {}_ip(j_0) \tag{4.2.4}$$

In case of a nominal guarantee $\mathbb{E}_{t_0}^{\mathbb{Q}}[B_{t_0+i}] = B_{t_0}$, in that case equation 4.2.4 is simply the standard formula to calculate the value of an annuity: the sum over retirement of the payments discounted by the interest rate and multiplied by the probability to be still alive. Then, the variable $A_{t_0}(j_0)$ can also be interpreted as the annuity factor, i.e. the amount of euros that is needed to buy an annuity of one euro.

In case of the current contract $\mathbb{E}^{\mathbb{Q}}_{t_0}[B_{t_0+i}]$ is not longer necessarily equal to B_{t_0}, but instead depends on certain characteristics of the pension fund, for example the funding ratio at t_0.

4.3 Results

In this section I will calculate the value of an annuity, for an individual who has an existing accrual of $B_{t_0} = 1$, using the formulas above. Furthermore, I will express the value of an annuity under the current contract as a percentage of the value of a nominally guaranteed annuity. To make these calculations first the parameter choice must be discussed. After that the results will be presented and the impact of the interpretation of the contract and the economic parameters will be discussed.

The main goal of these results and the subsequent sensitivity analysis, is to get a better understanding of how the current contract distributes value over generations. To find out if a transition to a new pension contract leads to redistribution between generation, first the starting point must be known, i.e. the distribution of value under the current contract.

4.3.1 Parameters

I use the parameters in table 4.1. The model equations can be found in section 3.2 and the equations of the cut and indexation options are given in section 3.1. Because the focus of this chapter will be on the impact of cuts and indexation on the economic value, changes in life expectancy are less relevant. Therefore, assume that all cohorts have the same survival probabilities, namely those of the cohort born in 1974[3] and assume the maximum age is 100 years.

As can be seen in table 4.1 my basis interpretation of the existing contract is that in case of a high funding ratio the contribution is lowered, but no bonus indexation is given. For the lower contribution, I use the mechanism and parameters as described in section 3.1.7. Furthermore, it is assumed throughout that the MVEV cut is spread out over 10 years.

Description	Symbol	Value
Indexation ambition	i_a	2.0%
Indexation backlog at begin	i_{b,t_0}	20%
Risk free rate	r^f	1.5%
Equity volatility	$\text{Std}(1 + r^s)$	20%
Equity exposure	ϕ	50%
Funding ratio at begin	F_{t_0}	100%
Funding ratio contribution	F^{contr}	100%
Weight liabilities inflow	α_1	2.5%
Weight liabilities outflow	α_2	2.5%
Lower contributions if high F_t?		Yes
Give bonus indexation if high F_t?		No
Spread cut to MVEV?		Yes (over 10 years)
Years below MVEV at t_0		2

Table 4.1: *Parameters for base case assumptions.*

4.3.2 Results in the base case

First of all I have calculated the value of an annuity for a nominal guarantee and the current contract, these results can be found in table 4.2. The results for the nominal guarantee are in line with the expectations. Below age 65 the value of the annuity is increasing in the age, because of the positive discount factor (risk free rate). Above age 65 the value of the annuity is decreasing in the age, because the benefits that have already been received are no longer part of the value.

The value of an annuity under the nFTK can best be interpreted in comparison with the nominal guarantee. For this fund the cut options have more impact than the indexation options, which leads to a value of the annuity below the value of the nominal guarantee. Furthermore, the older participants are better protected against cuts and lose less in value than young participants when compared with the nominal guarantee. Since no cohort has an economic value above the nominal guarantee and the starting funding

[3] I used the data and forecasts of the Koninklijk Actuarieel Genootschap (AG, 2016)[2]

ratio is 100%, the total economic value of the existing rights must be lower than the available assets in this pension fund. Therefore the total economic value for future accrual must be positive.

The finding that the economic value for future generations is positive, is plausible given the design of the current contract. There is namely an asymmetry between cuts and indexation. Indexation is bounded, while cuts are unbounded and there is no indexation mechanism which mirrors the MVEV cut. Hence, on average the current system has the tendency to build up a buffer.

This tendency to build up a buffer is also in line with the terminology which is used in the rules of the nFTK. The minimum required own funds and the required own funds are both higher than 100%, while these terms suggest that funds ought to have a funding ratio above these values.

From the assumption that new contributions only cover the new liabilities, but do not add to the buffer (funding ratio of the contribution is 100%), it follows that the value of this buffer must come from existing rights. The results in table 4.2 show that indeed a part of the value of the existing rights is used to build up these buffers.

	25	35	45	55	65	75	85	95
Nominal guarantee	10.4	12.1	14.1	16.7	20.2	14.2	8.1	3.5
nFTK	8.9	10.6	12.6	15.4	19.4	13.8	8.0	3.5
nFTK/Nom guar	86%	88%	89%	92%	96%	97%	99%	100%

Table 4.2: *Economic value of existing accrual under base case assumptions.*

4.3.3 Interpretation of the contract

This subsection analyzes the robustness of the results for a change in the way high buffers are handled, as discussed in section 4.1.2. To do this, I use the mechanism for lower contributions as described in section 3.1.7 and the mechanism for bonus indexation as described in section 3.4.

The results in table 4.3 show that the impact of the interpretation of the contract on the economic value of existing accrual is relatively small. For the young generations it does matter more than for the old, which can be explained by the longer duration of their savings and the low starting funding ratio (100%) compared to the funding ratio from where bonus indexation is given (150%).

The option on bonus indexation has a (small) positive impact on the value of existing rights, while the option on lower contributions has a (small) negative impact on the value of existing rights. However, for young workers who also pay contributions to build up new pension accrual, the option on lower contribution will also have some value. This value is not taken into account in table 4.3.

The impact of these two embedded options on the value of the benefits, is relatively small because they only end up in the money in very good scenarios. However, the valuation technique weights the outcomes in bad scenarios relatively higher than those in good scenarios, to take the risk into account. Embedded options that first require a significant increase in the funding ratio, therefore have a relatively small impact on the total value of the benefit. When the starting funding ratio is higher, i.e. the embedded option is less far out of the money, these embedded options will have more impact.

	25	35	45	55	65	75	85	95
Neither (G=G)	87%	88%	90%	92%	96%	97%	99%	100%
Lower contribution (base case)	86%	88%	89%	92%	96%	97%	99%	100%
Bonus indexation (G<>G)	88%	89%	90%	92%	96%	97%	99%	100%
Both	87%	88%	90%	92%	96%	97%	99%	100%

Table 4.3: *Economic value of existing accrual relative to nominal guarantee, for different interpretations of the current system. All parameters, except for the buffer sharing mechanism, are the base case. The value of lower contributions for young generations is not included in these numbers. In case both the contribution is lowered and bonus indexation is given; the lower contribution is applied first. The notation 'G=G' and 'G<>G' refers to the two contract interpretations used by Pensioenfederatie (2016)[20] (they probably use a different bonus indexation mechanism).*

Comparison of results with Pensioenfederatie

Pensioenfederatie (2016)[20] also considers two different interpretations of the current contract, one with no buffer sharing mechanism (called 'G=G') and one with a mechanism to give extra indexation in case of high buffers (called 'G<>G'). Their relative results for these two cases are difficult to compare, because they take in both cases the value of the median scenario as 100%, while this value depends on the interpretation of the contract. That is, the results for the two interpretations are not displayed on the same scale. Still the relative differences suggest that in their calculations the interpretation of the contract does have a large impact on the median scenario (under $\mathbb{P}$), but a relatively small impact on the 5-th percentile scenario (under $\mathbb{P}$). The relatively large impact on the median scenario which they find is surprising, because it suggests that their economic scenarios already generate excessive buffers in a median scenario.

The paper contains results of multiple pension funds, which have all used different economic models and/or parameters. Since these economic assumptions are not published, it cannot be said with certainty which assumption explains these good outcomes. It could be the case that their scenarios contain some mean reversion of interest rates (to a level above the current rates). Given that interest rates are not modeled in this thesis, this would explain why I cannot replicate those findings[4].

Finally, for a fund which has a high starting funding ratio and a high equity exposure, these embedded options are likely to have a larger impact on the economic value of the benefits. When such a fund is studied, it is worthwhile to generate results for different interpretations. However, given the low funding ratios which most Dutch pension funds currently have, the impact of the interpretation of the contract on the value of existing accrual is relatively small. Therefore, I prefer to limit the amount of results and will for the remainder focus on one case, namely the base case where contribution is lowered in case of high buffers but no bonus indexation is given.

4.3.4 Impact of the cut to MVEV

An interesting property is that the current system requires funds to build up a buffer. This explains why in a fund which starts without a buffer ($F_{t_0} = 1.00$) the economic value of existing accrual for young generations lies far below the value of a nominal guarantee. It turns out that the cut to MVEV is the main driver behind these results. To show this, I have also calculated the value of an annuity when there is no cut to MVEV. Given the importance of the cut to MVEV, the decision to spread out the shock or not could also be relevant. Finally, the starting year does matter. Assuming that the fund had a funding ratio below the MVEV at the end of 2015, the first cut to MVEV could take place in 2020. Therefore, I also consider the case that the simulation starts in 2020 and faces a cut to MVEV at the end of the year if the funding ratio ends below 104%.

The results in table 4.4 confirm that the cut to MVEV has a large impact on the results. Without the cut to MVEV, the economic value of existing accrual is much higher. In that case the contract is more symmetric, while with the MVEV cut shortages must be solved relatively quickly (which is not the case for buffers above 100%).

Though the existing rights are vulnerable to the MVEV cut (also partly due to the low starting funding ratio of 100%), it does have a positive impact on the value of future accrual, which is not visible in these results. The loss of the current generations on existing rights, will lead to a higher value of new accrual, which benefits young workers and future participants.

In general spreading the cut to MVEV is beneficial for retirees, who will receive multiple benefits with a smaller cut, and disadvantageous to younger generations because the total cut is larger. This statement is also confirmed by the results in table 4.4. For the 55-year old, spreading is also advantageous because it is assumed that not only the first cut to MVEV, but also later cuts to MVEV are spread out. Furthermore, the amount of time left before the first possible cut to MVEV matters most for retirees.

	25	35	45	55	65	75	85	95
No cut to MVEV	98%	99%	100%	100%	100%	100%	100%	100%
Cut to MVEV spread, $t_0 = 2017$	86%	88%	89%	92%	96%	97%	99%	100%
Cut to MVEV not spread, $t_0 = 2017$	87%	88%	89%	90%	93%	94%	96%	99%
Cut to MVEV spread, $t_0 = 2020$	86%	87%	89%	92%	95%	96%	98%	99%
Cut to MVEV not spread, $t_0 = 2020$	87%	88%	89%	90%	92%	93%	94%	96%

Table 4.4: *Economic value of existing accrual relative to nominal guarantee, for the current system with and without the cut to MVEV. All parameters are the base case. In case of a cut to MVEV it is assumed that the fund had a funding ratio below the MVEV at the end of 2015 and the subsequent years (until t_0).*

[4]The results in table 4.3 are generated under $\mathbb{Q}$ and cannot directly be compared to the results of Pensioenfederatie. But also when I calculate the median under $\mathbb{P}$, I do not find significant differences in the outcomes.

4.3.5 Impact economic parameters

In this model the most important economic parameter is the equity volatility. A higher equity volatility leads to more risk and a redistribution of value. However, this effect is similar to a change in equity exposure, which is discussed in section 6.2. The equity premium does not play any role at all, because it disappears under the risk-neutral measure.

Though the value of an annuity strongly depends on the interest rate, the ratio between the value of a variable annuity under the nFTK and a fixed annuity (nominal guarantee) is very insensitive to the interest rate. It turns out that changing r^f with one percentage point does not have a material impact on the results presented in this manner.

In a more extensive model, where stochastic interest rates are used, the interest rate model would probably have a material impact on those results. In that case, the model choice would namely impact the likelihood of cuts and indexation. However, in case of a fixed interest rate, this effect does not occur. Modeling stochastic interest rates could be an interesting topic for future research.

Moreover, also non market risks, for example macro longevity risk, that are shared in the current contract could have impact on the value distribution. These risks are more difficult to price, because no market price is available. This could also be a topic for future research.

4.4 Conclusion

In this chapter it has been shown that the current pension contract shifts economic value to the future. The main driver of this redistribution is the cut to MVEV. Furthermore, it has been shown that the interpretation of the contract is of secondary importance when valuing benefits for a pension fund with an initial funding ratio of 100% and an equity exposure of 50%. Given that many large Dutch pension funds currently indeed have funding ratios at or below 100%, this is an important finding.

In the next chapter the impact of the value distribution on the transition to a new contract will be considered. For that application the results in this chapter are a relevant starting point.

5 Transition to a new system

In the previous chapter it has been shown that the economic value of existing rights relative to a nominal guarantee of the same size is age dependent. When these differences are not taken into account in the transition to a new pension contract, there will be a redistribution of economic value between generations. This observation leads to two questions. First of all, what is the size and direction of redistribution when a transition takes place without changing the amount of rights that people have built up. And secondly, how can a transition be performed without redistribution between generations?

The intergenerational redistribution is measured in economic value in this thesis. However, to participants this is an abstract measure. In the end people want to know what the impact of the transition is on their benefits; will indexation become more likely, or will there be more cuts? Therefore, I will quantify the size and risk of future benefits both before and after the transition. Throughout this chapter it is assumed that no compensation is given for abolishing the doorsneesystematiek, which is considered in chapter 7. The transition to a new contract and the compensation for the doorsneesystematiek will be discussed together in chapter 8.

Just as in chapter 4, the term 'annuity' is used to refer to a variable annuity. Besides, the impact of the ultimate forward rate (UFR) on the value of the liabilities in the current system could have an impact on the transition. Because the interest rate is not modeled, this is ignored in this thesis.

In section 5.1 the different pension contracts which are under consideration are introduced. Section 5.2 discusses the extensions to the model needed for the transition. Section 5.3 considers the first case, the value impact of a transition without a change in nominal rights. Section 5.4 considers the second case, a transition based on economic value. Section 5.5 considers two different methods to solve a shortage in case of a transition based on nominal rights. Finally, also the direct impact of the transition on the benefits of the retirees is relevant, this is considered throughout for both cases.

5.1 Different pension systems

In the Dutch pension debate, many different types of pension contracts have been discussed. In 2015, the SER published an analysis of four main variants, each with some sub variants, see SER (2015)[8]. Since then, some of these options have been rejected. In the current policy debate, the focus lies on variants 1B, 4A and 4C[1]. The names of these policy options may sound cryptic, but the variants itself can in fact be linked to existing pension systems in the Netherlands. An overview of existing and proposed variants can be found in table 5.1.

The upper row of table 5.1 shows some properties of the current contract, the nFTK. This system does contain intergenerational risk sharing and has the possibility to shift debts to the future in the form of negative buffers. To protect future generations, funds are required to build up a buffer, in practice this means that they are not allowed to index at a funding ratio below 110%, i.e. before they have a buffer of 10%, and that the funding ratio is not allowed to be structurally below 104% (MVEV).

SER variant 1B keeps the risk sharing possibilities of the current contract, but does not require to build up a buffer. Therefore indexation can be given for all funding ratios above 100%. Due to the symmetry of the contract, it will turn out to be the case that this variant does not shift economic value to the future.

In SER variant 4C future generations are protected by not allowing negative buffers, i.e. deficits cannot be shifted to the future. Even though buffers are not required, the system is designed such that on average a positive buffer will be passed on to the future. This means that variant 4C will shift economic value to the future. An important difference between SER variant 4C and 1B is that in variant 4C property rights are explicitly defined and the exposure to risk factors can be differentiated between individuals. One example of differentiation is life cycle investing, where young participants have a higher equity exposure than old participants.

In SER variant 4A it is not possible to share investment risk between generations through buffers, thus no economic value is shifted to the future. Furthermore, personal property rights are also in this variant explicitly defined and life cycle investing is possible. According to Klijnsma (2016)[12] this variant is already possible within the framework of a new law called 'Wet Verbeterde Premieregeling (WVP)'.

In the remainder of this section, each of the SER variant will be discussed more extensively.

[1] The number refers to the main variant and the letter to the sub variant; sometimes also the roman numerals are used, i.e. I-B, IV-A, IV-C.

Name	Inter gen RS	Macro long RS	Negative buffer	Buffer required[2]	LC investing
nFTK	Yes	Yes	Yes	Yes	No
SER 1B	Yes	Yes	Yes	No	No
SER 4C	Yes	Yes	No	No	Yes
SER 4A/WVP	No	Possible	N/A	No	Yes

Table 5.1: *Properties of different pension systems. Abbreviations: WVP = wet verbeterde premieregeling (existing Dutch defined contribution system), RS = risk sharing, gen = generational, long = longevity LC = lifecycle.*

5.1.1 SER variant 4A

This variant is a defined contribution (DC) system, which is in fact identical to the existing DC systems in the Netherlands (commonly known as: 'beschikbare premieregeling') when investing after retirement is allowed, as is the case according to a new law (September 2016) called 'Wet Verbeterde Premieregeling' (WVP). In this contract participants pay a fixed contribution and all risks are borne by changes in the benefits. Property rights are explicitly defined and therefore the risk exposure can be differentiated between individuals or cohorts. There is no intergenerational risk sharing; only the micro longevity risk is shared (and there is the possibility to share macro longevity risk). Assuming there is no heterogeneity in survival probabilities, this has as a consequence that the economic value of an individual is equal to the size of his property rights, i.e. the amount of assets in his personal pot.

A theoretical discussion of this type of pension systems and the possibilities for risk-sharing can be found in Bovenberg and Nijman (2013)[6]. Furthermore, there is an extensive literature on the optimal investment policy for personalized pensions, starting with Merton (1969)[18]. The general consensus is that it is optimal to have decreasing equity exposure over the pension wealth when getting older, this is called a lifecycle policy. Furthermore, it could be attractive to smooth financial shocks over time, instead of immediately absorbing those in the next payment. This is formalized by Balter and Werker (2016)[3] following the methods used in Nijman et al. (2013)[19]. Since the volatility of benefits over different years of retirement is not discussed in this thesis, I will not consider smoothing to limit complexity.

To simulate the benefits after the transition, it is necessary to model how benefits are adjusted in case of financial shocks. Assume there is no longevity and interest rate risk and only consider equity risk. Let the pension fund follow a life cycle investment policy without smoothing of financial shocks.

To determine the yearly payments after retirement, it is still useful to think in terms of assets and liabilities. Assume that the liabilities of the individual consist of equally sized yearly payments between his retirement and death. These payments are discounted by a discount factor; if the return in a year is lower or higher than the discount factor, the liabilities are adjusted by the difference between the discount factor and the return. Therefore, differences between assets and liabilities are immediately solved and the budget constraint remains valid. This leads to the following formula that determines adjustments:

$$1 + i_t = \frac{\phi(j)(1 + r_t^r) + (1 - \phi(j))(1 + r^f)}{1 + r^f + \phi(j)\lambda - i_a} \tag{5.1.1}$$

In this equation the numerator is the realized return in year t, where $\phi(j)$ is the age-dependent equity exposure. The denominator contains the discount factor, which I have chosen to be equal to the expected return minus a fixed indexation ambition. Due to the personal property rights and the absence of guarantees, there is no obligation to use the risk free rate as discount factor. However, to prevent front loading of the benefits, the government will probably put a maximum on the discount factor. Under the current rules for defined contribution (WVP) it is indeed allowed to use a discount factor which is higher than the risk free rate, this is called a decreasing benefit.

The expected adjustment each year is (by design) approximately equal to the indexation ambition:

$$\mathbb{E}_t^{\mathbb{P}}(1 + i_{t+1}) = \frac{\phi(j)\lambda + 1 + r^f}{1 + r^f + \phi(j)\lambda - i_a} \approx 1 + i_a$$

Note that when $i_a = 0$ the second relation holds exactly. That is, when the maximal discount factor is used, the benefit is in expectation flat (under the real-world measure). However, the economic value of the earlier payments is higher, because these are less risky. The term 'decreasing benefit' thus refers to the value of the benefit that is decreasing.

To make sure that the budget constraint holds, the initial yearly payment must be determined by dividing the assets by the annuity factor. In this case the annuity factor for a person of age $j < j_r$ is given by:

$$\delta(j) = \sum_{l=j_r}^{j_d} \frac{{}_{l-j}p(j)}{\prod_{i=j}^{l}(1 + r^f + \phi(i)\lambda - i_a)}$$

The annuity factor for retirees can be calculated in a similar manner, but then the summation starts at their current age.

5.1.2 SER variant 4C

SER variant 4C (see SER (2016)[9]) is the same as variant 4A plus a buffer for intergenerational risk sharing. Individuals still have a personal pot of pension assets which they can invest with a life cycle. The difference is that in case of high returns a part of their return is put in a buffer, which can be used to compensate a part of the losses in bad years. Contrary to the current contract the buffer in variant 4C cannot be negative. Furthermore, there is an upper limit on the buffer, Pensioenfederatie (2016)[20] for example assumes 20% of total pension assets.

The interpretation of 4C which is currently used in the discussion, is 4C-R, which means that only equity risk is shared through this buffer, while interest rate risk is not shared. The boundaries, above which excess returns have to be transferred to the buffer or excess losses may be taken from the buffer, are based on percentiles of the distribution of the equity returns. In SER (2016)[9] the lower bound is the 20th percentile and the upper bound the 80th percentile.

Valuation

For the valuation of rights/savings in 4C the buffer can be interpreted as a combination of two options, a short call option and a long put option. However, these options are non-standard in the sense that the call option is not executed when the buffer is full and the put option is not executed when the buffer is empty. Therefore they cannot be valued analytically, and a simulation model is used instead.

When the maximum buffer size is larger than zero, the economic value of the benefits depends on the maximum size of the buffer, the initial size of the buffer, the bounds that determine when money is put in or taken out of the buffer, the age of the participant and the life cycle which is used. Assume that the fund uses the following life cycle (for a discussion, see section 5.2.4):

$$\phi(j) = \begin{cases} 0.9 & \text{if } j \leq 35 \\ 0.35 + 0.55 \cdot \frac{65-j}{30} & \text{if } 35 < j \leq 65 \\ 0.15 + 0.2 \cdot \frac{90-j}{25} & \text{if } 65 < j \leq 90 \\ 0.15 \cdot \frac{100-j}{10} & \text{if } 90 < j \end{cases} \tag{5.1.2}$$

Furthermore, let the equity exposure of the collective be the average equity exposure of all individuals weighted by their assets ($\bar{\phi}_{t_0} = 0.42$). Then the amount of assets of the collective grows with $\bar{\phi}_t(1 + r^s) + (1 - \bar{\phi}_t)(1 + r^f)$. Assume that the buffer is invested against the risk free rate[3]. Finally, note that the bounds for using the buffer are based on the distribution of the stock under the real-world measure (the 20th and 80th percentile), also when the risk-neutral measure is used to generate the scenarios.

Results

Table 5.2 shows the economic value of the assets which an individual has accrued at t_0 compared to the nominal guarantee which he could buy from those assets (note that this value is equal to the nominal value of the assets). When there is no buffer (variant 4A, upper row in the table) there is in value terms no difference terms between investing in equity (according to the life cycle in equation 5.1.1) and buying a nominal guarantee. The risk profile and expected return do change.

In case of a buffer on the other hand, an individual could win or lose in terms of economic value by interacting with the buffer. Note that table 5.2 only shows the value of available assets at time t_0, new accrual which might be built up is not valued. The second row shows that the existing assets lose in value when there is no initial buffer. The participants lose value because they have to contribute to the buffer in good scenarios, while in bad scenarios they cannot benefit from the buffer when it is empty. Only when bad years follow good years, an individual can take money out of the buffer, but even then it will in general not be more than he put in.

In bad years following good years, the amount which the participants can take out together is limited by how much they (or former participants) put in in the good years. For an individual who participates from the beginning, it is only possible to profit if his total equity exposure relative to the total equity exposure of the collective increases. Then he contributes relatively less in the good years and profits relatively more in the bad years. This is possible in a gray fund as each time when a benefit is paid out a part of the buffer is left behind. Alternatively, an individual can attain this by continuing to work. Raising his total amount of

[3]The optimal investment policy of the buffer is not in scope of this thesis. Since the buffer will be needed in times of low/negative returns on equity, it intuitively makes sense not to invest the buffer in equity.

assets will namely positively affect his total equity exposure. In table 5.2 the focus lies on existing rights, so the latter is not measured.

It could also be considered to start with a buffer of 10%. Financing this buffer by a uniform cut on existing accrual would hurt the retirees. To finance a buffer of 10%, namely a cut of $10/110 \approx 9\%$ is needed, which is larger than the increase in economic value according to table 5.2. In case of a buffer of 20% which is financed by a uniform cut, the elderly are even worse off.

For the youngest generations this could be beneficial, both because their existing rights are more sensitive to the buffer size and because they might build up new accrual. The new accrual has more value in a fund with an initial buffer of 20% than in a fund with an initial buffer of 0%, while it will not be hit by a uniform cut on existing rights to finance the buffer.

For the remainder of this chapter, assume that in case of SER variant 4C the initial buffer has size 0% and the maximal buffer 20% of the total amount in the personal pension pots.

Initial buffer size	25	35	45	55	65	75	85	95
No buffer (4A)	100%	100%	100%	100%	100%	100%	100%	100%
0% (max 20%)	87%	87%	89%	93%	96%	97%	99%	100%
10% (max 20%)	105%	103%	101%	101%	100%	100%	100%	100%
20% (max 20%)	122%	117%	111%	107%	103%	102%	101%	100%

Table 5.2: *Economic value of assets in variant 4A and 4C for different cohorts when the life cycle in equation 5.1.2 is used relative to the nominal guarantee which could be bought of those assets, depending on the size of the initial buffer. Maximal buffer size is 20%. Costs of the initial buffer are not taken into account. No new accrual is built up.*

5.1.3 SER variant 1B

SER variant 1B is a contract without personal property rights, and with intergenerational risk sharing. The main differences with the current contract are that it does not require a buffer and that it has degressive accrual instead of the doorsneesystematiek. Also of variant 1B, different sub variants exist. In line with the Pensioenfederatie (2016)[20], I will only consider sub variant 1B-RTS (and abbreviate it to 1B). In this contract liabilities are discounted with the risk free term structure excluding UFR. The funding ratio is defined in a similar manner as in the current system, except for the discounting of the liabilities (the current system uses the risk free term structure including UFR).

The cuts and indexations are symmetric around a funding ratio of 100%, each year one-tenth of the deviation from a funding ratio of 100% is solved by cutting or indexing benefits. I use the same formula for indexation as Pensioenfederatie (2016)[20]. The formula for indexation (if i is negative, it is a cut), is:

$$i_t(F_t^{1B}) = (F_t^{1B} - 1.00) \cdot \frac{1}{10}$$

Compared to the current system, variant 1B will lead to a higher value for existing rights because no buffers have to be built up.

Intuitively, when a fund has a funding ratio of 100% in variant 1B, the value of the cut and indexation option should be equal due to symmetry. Therefore, I would expect the expectation under the risk-neutral measure of existing accrual in case of a funding ratio of 100% to be equal to the value of a nominal guarantee for all cohorts. This hypothesis is difficult to prove analytically, but is confirmed by simulation.

Finally, one of the most important differences between variant 1B and the existing contract, is that it does not contain a rule comparable to the cut to MVEV. This means that in bad times deficits can be indefinitely shifted to the future. Especially for gray funds, this could lead to high discontinuity risks.

5.2 Parameters and Model

In this section the parameters for the base case are given. Furthermore, the definition of the numbers that are presented later is discussed. In line with the previous chapter, only equity risk is considered. It is assumed that micro longevity risk is fully shared and there is no macro longevity risk.

5.2.1 Parameters

The base case parameters stated in table 4.1 are also used as base case in this chapter. This leads to a consistency between the results presented in chapter 4 and this chapter. These parameters are sufficient to value the existing rights per cohort, but to calculate the division of assets/rights in a transition the size of each cohort must be known. Therefore, some extra assumptions on the population and the existing rights must be made.

Let the pension fund consist only of people who have saved for their pension within this fund during their entire career, up till the moment of transition. The cohort sizes are proportional to the existing Dutch population. The parameters needed to calculate the existing rights for an individual can be found in table 5.3. The sum of the discounted nominal future benefits of individuals gives the liabilities of the pension fund. The assets of the pension fund are determined by multiplying the liabilities with the starting funding ratio.

Finally, to simulate the benefits under the real-world measure after the transition, one extra parameter is needed, namely the risk premium on equity. Take an equity risk premium of 3.5%.

Description	Symbol	Value
Wage inflation	i_w	2.0%
Career profile	m	1.0%
Historic uniform accrual	α_h	2.0%
Starting salary	$w_s(t_0)$	30,000
Franchise	$f(t_0)$	12,500

Table 5.3: *Parameters needed to determine the existing accrual for an individual who worked full-time between age 25 and 65.*

5.2.2 Valuation based on existing accrual

Similar to chapter 4, the valuation will only concern the existing rights. Taking this perspective is favorable for sleepers. Valuing future accrual could be relevant for workers who remain active within a fund. However, from the perspective of a transition, there are some strong arguments to give less attention to the value of new accrual.

The goal of a pension reform is to create a new system in with individuals can build up a good pension. Taking into account the value of new accrual in transition, would imply that there is a longer period of time in which the old system still influences the outcomes. Assuming that the new system is favored over the old one, this should only be considered when generations who are active during the transition either have less opportunity to build up a sufficiently large pension or lose a future subsidy which they have earned by paying a subsidy in the past. This is both the case for abolishing the doorsneesystematiek which is discussed in chapter 7.

Furthermore, at some point a cut must be made. If current participants are compensated for value changes in future accrual, then new participants could also demand this compensation. Ultimately this leads then to the question whether all future generations should be compensated.

5.2.3 Distribution of the benefits

Besides the economic value of the benefits, it can also be relevant to consider the size and risk of the benefits. This can be done by calculating the percentiles of the distribution of the benefits under the real-world measure ($\mathbb{P}$). To summarize all benefits which an individual receives during his retirement in one number, define the average benefit (AB) as the sum of payments over retirement weighted by the survival probabilities.

In the results, the average benefit in the different variants is compared to the average benefit in case of a nominal guarantee. The size of this nominal guarantee is based on the nominal size of the existing rights in the *old* system.

The average benefit can be calculated for existing rights only, or for a person who builds up pension rights during his entire working life. The difference between these two options is that in the second case investment risks in the working years are mitigated by risk free new accrual. The life cycle investment policy is explicitly based on this assumption (see Merton (1969)[18]). When no new accrual is added, life cycle investing leads to more risky outcomes due to the high equity exposure at young ages. I will here focus on the case in which new accrual is built up during the remaining working years.

These results can therefore be used to judge whether participants still receive a good pension after the transition and by how much their benefits/rights will be changed in the transition. To only analyze this transition, it is assumed that the doorsneesystematiek would also be abolished in the scenario where the nFTK is kept in place.

A consequence of using the average benefit is that volatility during the retirement phase is not measured. This is an important aspect to take into account in the design of a pension system, but lies outside the scope of this thesis which focuses on the transition.

5.2.4 Life cycle

In SER variant 4A and 4C life cycle investing is used. The exposure to equity can be differentiated between age groups, in general the exposure is a non-increasing function of age.

The large variability of potential life cycles, makes it possible to approximate the probability distribution of benefits in a different system. The Pensioenfederatie (2016)[20] chooses a life cycle such that the outcomes of SER system 1B are replicated.

Analogous to this, I have designed (by trial-and-error) a life cycle, under which the outcomes of 4A give an approximation of the outcomes of 1B. This match is based on an individual who keeps accruing new rights during the remainder of his career, and calibrated on the model used in this thesis. For SER variant 1B, a starting funding ratio of 100% and an equity exposure of 50% are assumed. The matching life cycle is given above in equation 5.1.2.

The resulting life cycle is in principle not optimal for the risk preferences of the individuals. Finding a more optimal life cycle lies outside the scope of this thesis.

When only the existing accrual is considered, the resulting benefits in variant 4A are more volatile than in variant 1B for young participants. This can be explained by the high equity exposure during their working life, which is not compensated for by risk free new accrual.

5.3 Transition without transfers in nominal rights

One possible way to arrange the transition, is that individuals keep their nominal rights, even though the system is changed. This assumption is for example used in Pensioenfederatie (2016)[20]. It turns out that this choice leads to a redistribution in economic value, as will be shown in this section.

Consider a fund which goes from the current system to one of the SER variants. Assume that the fund wants to start with a funding ratio of 100% in the new system; this is necessary in case of variants 4A and 4C and optional in case of 1B. The fund can then perform the transition in two steps. First, apply a uniform cut (or indexation in case of a rich fund) on the existing rights, such that the funding ratio is 100% in the old system. Second, change the system: in case of 1B this means that individuals keep their nominal rights and the new funding ratio is still 100%, in case of variant 4A or 4C individuals receive property rights to a pot with which they can buy a nominal guarantee of equal size as their nominal rights.

Distribution of the average benefits

For a fund with a funding ratio of 100%, I have calculated the percentiles of the average benefit. Table 5.4 contains the results when there is no transition and the results after a transition to 1B, 4A or 4C without a transfer of rights. In all cases it is assumed that non-retired participants keep accruing rights[4] until their retirement.

Table 5.4 shows that this transition leads to an improvement in average benefits, both in bad and in good scenarios, for all *current* generations. The intuition behind this result is that in 1B and 4A it is not required to build up a buffer for future generations. As a consequence of the zero sum condition, future generations loose compared to the current generation. However, in variant 4A the value of their accrual will be equal to the value of their contributions. So even though they loose the subsidy of current generations, they will still get an actuarially fair pension. In case of variant 1B some generations will profit from entering in a fund with a positive buffer, while others will pay as they enter in a fund with a negative buffer.

By design of the life cycle, the reported percentiles of the benefits in 4A and 1B are similar. The results in 4C, however, are different and cannot be put equal to the outcomes in the other variants, due to the buffer which is built up in 4C. This buffer results in lower outcomes compared to 4A and 1B, not only in the good scenarios, but also when the median is considered. Even when the 5-th percentile is considered, the older cohorts loose compared to 4A, because the initial buffer is zero. This may seem counterintuitive because 4C is designed to protect people in times of bad equity returns. However, the old workers and retirees already have a large accrual at the time of the transition. Therefore it is difficult for them to get more out of the buffer than they put in. During retirement the exposure to equity is namely decreasing due to the benefits which are paid out. They have a higher total equity exposure in the good years when the buffer is built up, then in the bad years when the buffer works (only bad years that happen when a buffer exists are relevant). Also for the old workers these retirement years play a large role in the results.

Immediate indexation

An important difference between variant 1B on the one hand and variants 4A and 4C on the other hand, is that the latter allow for more customization in the pay-out phase. As explained in section 5.1.1, it could be allowed to create a decreasing benefit (in value terms, under $\mathbb{Q}$) by choosing a higher discount rate, which

[4] With degressive accrual instead of doorsneesystematiek.

	Percentile	25	45	65	85
nFTK	5%	-27%	-32%	-20%	-8%
nFTK	50%	44%	28%	7%	1%
nFTK	95%	106%	98%	46%	14%
1B	5%	-21%	-24%	-15%	-7%
1B	50%	48%	34%	11%	2%
1B	95%	204%	156%	58%	16%
4A	5%	-20%	-23%	-16%	-7%
4A	50%	47%	33%	11%	3%
4A	95%	212%	149%	51%	15%
4C	5%	-20%	-25%	-18%	-8%
4C	50%	37%	21%	5%	1%
4C	95%	150%	99%	33%	10%

Table 5.4: *Percentiles of the average benefit relative to a nominal guarantee in case of no transition and after a transition to 1B, 4A or 4C without a transfer in rights. All parameters base case, starting funding ratio 100%. Workers build up new accrual until their retirement.*

is assumed to be limited by the risk free rate plus equity exposure times risk premium. Table 5.5 shows the impact of different discount rates on the first payment that retirees will receive after a transition based on nominal rights. For young retirees the sensitivity to the discount factor is higher, because their benefits have a longer duration. Furthermore, they can reach a higher maximal direct indexation because they have a higher equity exposure. However, even though a direct indexation of benefits may make a transition more attractive, this direct indexation will make future indexation less likely. The interpretation of $i_a = 0$ is that for the remainder of their retirement, retirees will only receive an increase in benefits in years with above average equity returns and face a decrease in benefits in years with below average equity results. That is by choosing a higher discount factor they directly use the equity premium of future equity risk, i.e. value is shifted from the future to the moment of transition. Because in 4A the pension capitals are separated, this can be done without intergenerational redistribution.

By changing the direct indexation, the results in table 5.4 will not be significantly altered. This choice namely only changes the distribution of payments over an individual's retirement, which does not have much impact on the average benefit that is shown in that table.

Note that similar results can also be created for the immediate indexation of existing rights for the working generations. However, these results are less relevant because they can be mitigated by future accrual. Furthermore, the working generations have a longer duration than retirees which makes the cumulative impact of inflation larger. Because the working generations do not yet receive benefits and the changes in benefits due to the transition have already been reported in table 5.4, the immediate indexation for these generations is omitted.

System	65	75	85	95
1B	0%	0%	0%	0%
4A/4C (risk-free DF)	0%	0%	0%	0%
4A/4C ($i_a = 0$)	13%	7%	3%	1%
4A/4C ($i_a = 0.01$)	-0%	-2%	-3%	-2%
4A/4C ($i_a = 0.02$)	-13%	-11%	-8%	-5%

Table 5.5: *Immediate indexation for retirees of different ages in case of a transition based on nominal rights. Results for 4A and 4C are the same, because an initial buffer of 0% is assumed, and it is assumed that the buffer does not impact the choice for the discount factor. Base case parameters, starting funding ratio 100%.*

Redistribution of economic value

The improvement in benefits in both bad and good scenarios observed in table 5.4, suggests that the benefits of current generations have a higher value after the transition. Table 5.6 gives an overview of the economic value of existing rights under the nFTK for a base case fund and after a transition, without a transfer in rights, to the different SER variants. Note that contrary to table 5.4, in table 5.6 new accrual plays no role.

Indeed the benefits in variants 4A and 1B have the highest value, because (on average) no buffers are built up for future generations. In 4C (initial buffer 0%, max buffer 20%) the economic value is accidentally similar to the value under the nFTK for a base case fund. Both systems shift value to the future and apparently the value of these buffers is approximately equal in this case. Note that with a smaller maximal buffer, variant 4C will shift less economic value to the future.

All current generations win (in case of this particular fund) if the transition takes place without a transfer in rights, but the younger generations win more in terms of economic value, than the older ones. Note that in absolute terms the advantage for the 45-year old is likely to be bigger than for the 25-year old, since the size of existing accrual is larger for the former.

Hence, the consequence of this transition method, is that the gains of no longer building up a buffer for the future, are distributed unequally over the generations. In this case none of the current generations is worse of due to the transition. However, when a fund has a shortage, this is no longer the case, as will be shown next.

	25	45	65	85
nFTK	86%	89%	96%	99%
1B	100%	100%	100%	100%
4A	100%	100%	100%	100%
4C (max buffer 20%)	87%	89%	96%	99%
4C (max buffer 10%)	95%	94%	97%	99%

Table 5.6: *Economic value of existing accrual under the nFTK (no transition) and the SER variants (transition without transfer of rights), expressed as percentage of the value of a nominal guarantee. All parameters base case, starting funding ratio 100%. In case of variant 4C the initial buffer is 0%.*

5.3.1 Solving a shortage using a direct cut

When a pension fund with a starting funding ratio of 90% is considered, a cut of 10% in benefits is needed to start with a funding ratio of 100% after the transition. This cut can for example be applied uniformly on all benefits without smoothing. This method is analyzed in this subsection. The alternative of spreading the cut over time is analyzed in section 5.5.

Distribution of the average benefits

Table 5.7 shows the distribution of the benefits with and without this transition, for a fund with starting funding ratio 90%. For the old retirees (represented by the 85-year old), the direct cut leads to worse outcomes in all three SER variants, than if there would be no transition. The younger generations on the other hand, are better off after the transition. The difference between the age groups, can be explained by the timing of the cuts. Without a transition a large cut is likely in case of starting funding ratio 90%, but would only take place after some years. After this cut the fund would still have to build up a buffer, which is unattractive for the younger generations. For the older retirees postponing the cut is very valuable, because of their high mortality rate. Younger generations do not benefit from postponing cuts, when they still build up new accrual it is even harmful because the earlier the cut is taken, the smaller is their accrual which is exposed to the cut.

	Percentile	25	45	65	85
nFTK	5%	-29%	-37%	-26%	-11%
nFTK	50%	41%	19%	-0%	-2%
nFTK	95%	109%	96%	38%	9%
1B	5%	-21%	-26%	-23%	-16%
1B	50%	48%	29%	0%	-8%
1B	95%	204%	144%	42%	4%
4A	5%	-20%	-26%	-25%	-16%
4A	50%	47%	28%	-0%	-8%
4A	95%	212%	137%	36%	3%
4C	5%	-20%	-28%	-26%	-17%
4C	50%	37%	16%	-6%	-9%
4C	95%	150%	90%	19%	-1%

Table 5.7: *Percentiles of the average benefit relative to a nominal guarantee in case of no transition (nFTK) and after a transition to 1B, 4A or 4C without a transfer in rights. All parameters base case, starting funding ratio 90% for nFTK. For 1B, 4A and 4C immediately a uniform 10% cut is applied after which the starting funding ratio is 100%. Workers build up new accrual until their retirement.*

Redistribution of economic value
Table 5.8 shows that also in terms of economic value of the existing accrual the young cohorts win and the old retirees loose if the transition is executed in this manner.

This method of performing the transition hurts the retirees disproportionally, they face a significant loss in economic value while other generations win in economic value. In order to design a transition which makes none of the current participants worse off, it is necessary to consider an alternative transition method.

	25	45	65	85
nFTK	77%	80%	89%	96%
1B	90%	90%	90%	90%
4A	90%	90%	90%	90%
4C (max buffer 20%)	78%	81%	86%	89%
4C (max buffer 10%)	95%	94%	97%	99%

Table 5.8: *Economic value of existing accrual under the nFTK, 1B, 4A and 4C expressed as percentage of the value of a nominal guarantee. All parameters base case, starting funding ratio 90% for nFTK. For 1B, 4A and 4C immediately a uniform 10% cut is applied after which the starting funding ratio is 100%. In variant 4C the initial buffer is 0%.*

5.4 Transition based on economic value

In the previous section it has been shown that a transition without a transfer in rights leads to significant intergenerational redistribution in terms of economic value. In this section I will propose an alternative method, where the transition is executed such that the distribution in economic value between the generations remains constant. This is by definition the only way of having a generation neutral transition[5].

The economic value of the existing accrual does not necessarily sum up to the amount of assets in the fund, because a part of the economic value can go to building up a buffer. In the current system the total economic value is in general lower than the amount of assets, except when the funding ratio of the contribution lies (far) above the current funding ratio. The remaining surplus will be divided evenly over the existing accrual.

5.4.1 Base case

In the interpretation of the results, I will first focus on the transition to 1B and 4A, because neither of these systems builds up a buffer for the future.

Redistribution of economic value
Table 5.9 contains the economic value of the existing accrual before and after the transition for a base case fund with starting funding ratio of 100%. Even though the funding ratio is 100% for this fund; all current cohorts have under the nFTK an economic value smaller or equal to 100% of a nominal guarantee. Therefore, the amount of assets must be larger than the total economic value of participants. This matches the finding that the current contract builds up buffers for the future. Because in the base case it is assumed that the funding ratio of the contribution is 100%, this buffer must be largely paid from the value of existing rights.

The second row shows that when the assets are divided based on economic value, all current generations indeed get an improvement in economic value of the existing rights. This is the case, because no longer economic value is passed on to the future, in the form of building up a buffer.

	25	45	65	85
nFTK	86%	89%	96%	99%
Division (1B and 4A)	91%	95%	102%	105%
Division (4C, max buf 20%)	99%	100%	100%	101%
Division (4C, max buf 10%)	93%	98%	101%	103%

Table 5.9: *Economic value of existing rights under the nFTK (upper row) and economic value after the transition when assets are distributed based on economic value. The division depends on the chosen SER variant; in case of variant 4C the initial buffer is 0%. Numbers expressed relative to the value of a nominal guarantee. All parameters base case, starting funding ratio 100%.*

[5]The transition is generation neutral with respect to the existing rights. In all cases, future generations are affected because in the current system in expectation a buffer is passed on to them, while in variant 1B and 4A this is no longer the case. This, however, is not a consequence of the transition method, but of the design of the new pension system.

Immediate indexation

Depending on the new system the amount of nominal rights will change for each cohort. In SER variant 1B (with funding ratio 100%), the economic value of a nominal right of 1 euro is equal to the economic value of a nominal guarantee of 1 euro, even though it has a different risk profile. Thus, if a 45-year old gets only 95% of the value of a nominal guarantee (with the size of his existing rights) after a transition to 1B, he will have to accept a direct cut of 5% in rights. Based on table 5.9 the economic value of his rights will have improved despite of the cut, because the new rights are more valuable than the old rights. For this pension fund, only working people will face a nominal cut in rights in case of a transition based on economic value to 1B. Retirees on the other hand will get an immediate raise in benefits, as can be seen in table 5.10.

In variant 4A the consequences for working people are similar, but less visible, because they get claims on assets rather than pension rights. The retirees also receive a direct indexation in this case. When risk free discounting is used in 4A, the immediate indexation for retirees will be the same as in case of a transition to 1B. When on the other hand a higher discount factor is used, the immediate indexation will be higher. The immediate indexation in case of distribution based on economic value can be found in table 5.10.

Compared with the nominal transition in table 5.5, retirees receive a higher immediate indexation. This difference is financed by cuts in nominal rights of the working generations.

System	65	75	85	95
1B	2%	4%	5%	7%
4A (risk-free DF)	2%	4%	5%	7%
4A ($i_a = 0$)	15%	11%	9%	7%
4A ($i_a = 0.01$)	2%	1%	3%	4%
4A ($i_a = 0.02$)	-11%	-8%	-3%	1%
4C (risk-free DF)	-0%	0%	1%	1%
4C ($i_a = 0$)	13%	7%	4%	1%
4C ($i_a = 0.01$)	-0%	-2%	-2%	-2%
4C ($i_a = 0.02$)	-13%	-11%	-8%	-4%

Table 5.10: *Immediate indexation in different systems in case of a transition based on economic value. Base case parameters. In case of 4C the maximum buffer is 20% and the initial buffer is 0%.*

Distribution of the benefits

Finally, table 5.11 shows the distribution of benefits. When the results are compared with table 5.4, it turns out that the differences between the transition methods have most impact for the retirees and the old workers.

The average benefits shown in these tables are namely based on a full working life. For a 25-year old, the existing rights are only a small part of his lifetime accrual, which is why the differences between those two methods barely impacts those results.

System	Percentile	25	45	65	85
nFTK	5%	-27%	-32%	-20%	-8%
nFTK	50%	44%	28%	7%	1%
nFTK	95%	106%	98%	46%	14%
1B	5%	-21%	-25%	-13%	-2%
1B	50%	48%	32%	13%	8%
1B	95%	204%	150%	61%	22%
4A	5%	-20%	-24%	-15%	-2%
4A	50%	47%	31%	13%	8%
4A	95%	212%	144%	54%	21%
4C	5%	-20%	-25%	-18%	-7%
4C	50%	37%	21%	5%	2%
4C	95%	150%	99%	33%	10%

Table 5.11: *Percentiles of the average benefit relative to a nominal guarantee in case of no transition and after a transition to 1B or 4A based on economic value. All parameters base case, starting funding ratio 100%. Workers build up new accrual until their retirement. In case of 4A and 4C, $i_a = 0$ is assumed; this parameter has a relatively small impact on the results. In case of 4C maximal buffer is 20% and initial buffer 0%.*

Variant 4C

Until now the focus of the interpretation has been on variant 1B and 4A. For variant 4C the same analysis is mostly valid, but there are some important differences. Contrary to the other variants, variant 4C requires a buffer and therefore shifts economic value to the future. This means that the increase in economic value due to the transition is smaller when variant 4C is chosen, as can be seen in table 5.9. In case of a maximal buffer of 20% (base case) the profit in economic value for current generations compared to the current system, is negligible. In case of a maximal buffer of 10%, current generations win in economic value compared to the current contract, but less than in case of a transition to 4A or 1B.

As can be seen in table 5.2 the young generations lose relatively[6] most economic value when an initially empty buffer is added to the system. If the transition is based on economic value, this loss must be taken into account, and a compensation is given in the form of a higher amount of initial assets. The consequence is that compared to a transition to 4A, the young generations receive more in assets but less in economic value. For the older generations both the amount of assets and the amount of economic value is lower in case of a transition to 4C compared to a transition to 4A.

To calculate the immediate indexation after a transition to 4C, the same discount rate is used as in variant 4A. This may not be the proper discount rate because the buffer is not taken into account. The buffer leads namely to an adjustment of returns before those are added to the personal account. To limit complexity, this problem is ignored.

The immediate indexation in case of a transition to 4C with a risk-free discount factor (see table 5.10), is calculated under the assumption that the participants still would apply life cycle investing. If this were not the case, the value of starting with an empty buffer would change. For example, when all participants invest against the risk free rate, the buffer will never grow and adding the empty buffer does not change the economic value of the existing accrual of the participants. In that case we would be virtually back in variant 4A, thus 4C is only considered with life cycle investing.

Due to the buffer, the economic value of individuals in 4C depends also on their investment policy. When people are given the freedom to choose their equity exposure in variant 4C, there is an incentive to let the exposure depend on the size of the buffer. Individuals can increase the economic value of their existing accrual by taking more risk in case of high buffers and less risk when the buffer is empty.

Finally, there is a difference in the economic value of new accrual between variant 4C and 4A. In variant 4A the economic value of adding one euro to a pension account, is one euro. In variant 4C this depends on the size of the existing buffer. In case of high buffer, new accrual has a higher economic value and in case of a low or no buffer, the economic value of new accrual lies below one. There is a size of the buffer where this effect is zero, but this is not the same size for all generations. See for example the impact of starting with a buffer of 10% on existing accrual, in table 5.2.

When variant 4C starts with an empty buffer, also the value of the contributions in the first few years will be lower because of the buffer that needs to be built up. This is also the case in the current system, but would not be the case in variant 4A or 1B.

5.5 Alternative transition methods

In section 5.3 it has been shown that a transition based on nominal rights leads to a sizable redistribution in economic value between current cohorts. Especially in case of a shortage that is solved using a direct uniform cut, this leads to undesirable outcomes. Section 5.4 has shown that a transition based on economic value solves these problems. However, there are also alternative mechanisms conceivable that solve shortages more in line with the existing value distributions than a uniform cut, while being easier to communicate than a transition based on economic value. In this section two of such mechanisms will be discussed: a transition to 1B with an initial funding ratio unequal to 100% and spreading the existing shortage over a period of 10 years.

5.5.1 Start with a funding ratio unequal to 100% in 1B

Similar to the current system, variant 1B allows for negative buffers. This means that a potential mechanism to a transition could be to keep the existing negative buffer in place. That is, all participants keep their existing rights and the starting funding ratio in 1B is the same as the funding ratio in the nFTK was before the transition[7].

Consider for example a fund with starting funding ratio 90%. Then after the transition, the funding ratio will still be 90%, which makes cuts in the first years after the transition more likely. The value distribution for existing rights after such a transition is given in table 5.12.

Compared to the method with a uniform cut (see table 5.8) the rights of retirees are indeed better protected. However, workers still profit more from this transition, in terms of economic value, than retirees.

[6]In absolute terms the old workers will in general lose more, because they have already built up more rights.
[7]Ignore the UFR.

This can be seen by comparing the results in table 5.12 with the value distribution without transition, which is also given in table 5.8.

It is important to realize that when the transition is performed in this manner the total economic value of the current participants lies above the amount of available assets. This means that future contributions of workers and new participants contribute to solving the shortage. Therefore value of the new accrual is lost, compared to a transition where the shortage is immediately solved as discussed above. Compared to the initial situation, the new accrual will still increase in value, because when a funding ratio of 100% is reached a buffer no longer needs to be built up.

An important disadvantage of this transition method is that in the first few years after the transition, there is a high probability of cuts. Even though these could also have occurred in the existing system, this does not help to show participants the advantages of the new system.

	25	45	65	85
1B	90%	91%	94%	96%

Table 5.12: *Economic value of existing accrual after a transition to 1B when individuals keep their nominal rights, but the starting funding ratio in 1B is 90%. All other parameters base case.*

5.5.2 Spread shortage over 10 years

Instead of a uniform cut, a pension fund with a shortage could choose to use a smoothing period of 10 years. But to protect future accrual, this smoothed cut could be directly put on the balance, such that only current generations are exposed. This is in fact equivalent to spreading the cut to MVEV, as described in section 3.1.6 with as only difference that the target funding ratio is now 100% instead of 104%.

The consequence of this method is that retirees are partly protected, because all benefits with a duration below 10 years receive a smaller cut. The cut has the same size for all generations below 55 years because they have no benefits that are paid out within 10 years.

After the transition this method would lead to 10 years of an unconditional cut. This cut would be combined with the yearly adjustment of the benefit in the new system. Variant 4A offers in this case the most possibilities to distribute the funds over the remaining lifetime.

Finally, note that in this method the existing rights face in total a larger cut, then when variant 1B is started with funding ratio 90%. This is the case because new contributions are not cut. Therefore, the fact that retirees face a smaller cut, means that workers face a larger cut.

Both these methods do not lead to outcomes exactly equal to the economic value distribution under the nFTK. However, they do reflect the protection which retirees have against cuts.

	25	45	65	85
1B	89%	89%	92%	95%
4A	89%	89%	92%	95%

Table 5.13: *Economic value of existing accrual after a transition to 1B or 4A when the existing shortage (of 10%) is spread over the existing rights, with a spreading period of 10 years. Starting funding ratio after the transition 100%. All other parameters base case.*

5.6 Conclusion

As has already been shown in the previous chapter, the nFTK requires building up a buffer. When this buffer is not financed by high contribution rates, the economic value of all existing rights lies below the amount of assets in the pension fund. In variant 4A and 1B no buffer is built up, which means that in a transition to one of these systems there is a surplus of economic value to distribute.

This chapter shows that a transition based on nominal rights is in general not in line with the value distribution of the current contract. As an alternative it is proposed to distribute the assets based on economic value. This method is in general more beneficial to retirees, because it takes into account the protection which they have against cuts in the current system.

When a fund has a shortage at the time of transition, applying a uniform cut to solve this shortage in the transition disproportionally hurts retirees. In this case they would even prefer not to have a transition at all. Not solving the shortage (in case of a transition to 1B) or spreading the cut over 10 years, better reflects the interest of the retirees, but still leads to redistribution in economic value.

The benefits which a retiree receives do not only depend on the economic value. It is shown that variant 4A offers more possibilities to distribute the benefits over the retirement than variant 1B. Furthermore, variant 4A has more degrees of freedom to determine the optimal risk exposure at each point in time by adjusting the life cycle. Finally, there could be discontinuity risk in variant 1B because it does not have a mechanism similar to the MVEV cut, while in variant 4A there is no discontinuity risk. These last two differences between those SER variants are not included in the results of this chapter, but could be very important. This is therefore an interesting topic for future research.

Variant 4C differs from variants 4A and 1B in the sense that on average a buffer is given to future generations. Because of the costs of building up this buffer, there is a smaller or no surplus to distribute in the transition. Based on the costs of building up a buffer of maximal 20% of the total amount of assets, the alternative of a smaller maximum is worth considering. Finally, a potential risk in 4C is that there is an incentive to adjust the risk exposure to the size of the buffer, if allowed.

5.6.1 Comparison with CPB

The CPB (2016)[17] has performed an ALM analysis on the current contract and multiple SER-variants, including those described in this chapter. Their model contains both interest rate risk and equity risk. Their results also show that building up a buffer in the current contract or 4C has a negative value for current generations, and that the value distribution in variant 4C and variant 1B (starting funding ratio 100%) is very similar. This is in line with the results of this and the previous chapter.

6 Heterogeneity between funds

In the previous chapter benefits in the current contract have been valued and the shifts in value caused by a transition have been discussed. These results however, are dependent on the properties of the pension fund. Given the existing heterogeneity between Dutch pension funds, it is necessary to analyze the impact of some key parameters on the value distribution of the current system and the transition.

To limit the amount of results, I will only consider the value of benefits and not show the immediate indexation or percentiles under the real-world measure. Furthermore, it is assumed that the transition will go to variant 4A. These results also apply to the case of a transition to variant 1B with starting funding ratio 100%. The economic value of existing rights is namely the same in these variants. In case of a transition to 4C the distributional effects are different, because similar to the current system, variant 4C shifts value to the future. Finally, note that in case of a transition based on nominal rights, the economic value after the transition is the same for all generations, namely $100 \cdot F_{t_0}\%$ of a nominal guarantee.

In section 6.1 the impact of the initial funding ratio on the value of existing rights and on the distribution in case of a transition is calculated. Section 6.2 answers the same questions but now for the impact of the equity exposure. Section 6.3 studies the impact of the funding ratio of the contribution on the value of existing rights and the value of building up new accrual. Finally, section 6.4 analyzes the difference between green and gray funds. When referring to the base case parameters in this chapter, this concerns the parameters given in tables 4.1 and 5.3.

6.1 Initial funding ratio

First, let's consider the impact of the initial funding ratio. In table 6.1 the value of an annuity under the nFTK is compared for different values of F_{t_0}. Obviously, everyone is better of with a higher funding ratio at t_0, but the effect is not the same for all generations.

The existing accrual of a 25 year old is much more sensitive to F_{t_0}, than the accrual of an 85 year old. This is not surprising either, because the nFTK protects the elderly against large shocks and F_{t_0} contains the effect of (recent) shocks of the past. For the cohorts between 25 and 55 years old, the sensitivity of the value of their benefits is almost one to one, a ten percentage point change in the funding ratio corresponds approximately to a nine percentage point change in the value of the existing accrual for these cohorts. For higher initial funding ratios (for example 150%) this effect is smaller, because the indexation which can be given is bounded.

Furthermore, the cases with a positive buffer shows an interesting outcome. In all these cases there is a peak in economic value at some age, for $F_{t_0} = 1.10$ the cohorts between age 65 and 85 and for $F_{t_0} = 1.20$ and $F_{t_0} = 1.30$ the cohort of the 55-year old. At first, the positive buffer makes the indexation options more valuable than the cut option, especially because from this starting position cuts are less likely. However, in the long run the probability of cuts increases and due to the asymmetry of the contract (unbounded cuts, bounded indexation) the value of cuts will again be higher than the value of indexation. This explains why the economic value of young cohorts can lie below the economic value of middle aged cohorts in case of a positive initial buffer. This effect becomes smaller when the interpretation of the contract is changed. However, even then it does not completely disappear. Finally, it is important to realize that only existing rights are considered. When young generations profit of lower contributions in scenarios with high buffers, that is not included in these results.

	25	35	45	55	65	75	85	95
$F_{t_0} = 0.80$	67%	69%	70%	73%	82%	86%	92%	98%
$F_{t_0} = 0.90$	77%	78%	80%	83%	89%	92%	96%	99%
$F_{t_0} = 1.00$	86%	88%	89%	92%	96%	97%	99%	100%
$F_{t_0} = 1.10$	95%	97%	99%	101%	102%	102%	102%	101%
$F_{t_0} = 1.20$	103%	105%	107%	109%	108%	107%	105%	102%
$F_{t_0} = 1.30$	111%	113%	115%	116%	113%	111%	108%	104%

Table 6.1: *Economic value of existing accrual relative to nominal guarantee. All parameters, except for the starting funding ratio, are the base case.*

Impact on the transition

When the transition to variant 4A is based on the distribution of economic value, then not only the economic value of the existing rights of each generation matters, but also the difference between the available assets and the economic value of all individuals together. If a fund has an initial funding ratio of 80%, then the participants can on average get an economic value of 80% of a nominal guarantee with the size of their existing rights. The average is weighted by the amount of liabilities, which means that the old workers and young retirees get a relatively high weight.

The results of a distribution based on economic value can be found in table 6.2. These numbers are in all cases higher than those in table 6.1 because the current contract shifts value to the future. Compared to these results, a transition based on nominal rights (with a direct cut/indexation to get the funding ratio back at 100%) leads to significant intergenerational redistribution in case of an initial funding ratio equal to or below 100%. Especially the retirees lose value in this case. For higher funding ratios the differences between a transition based on economic value and based on nominal rights is relatively smaller.

	25	35	45	55	65	75	85	95
$F_{t_0} = 0.80$	69%	70%	72%	74%	84%	88%	94%	99%
$F_{t_0} = 0.90$	80%	82%	83%	86%	93%	96%	100%	103%
$F_{t_0} = 1.00$	91%	93%	95%	98%	102%	104%	105%	107%
$F_{t_0} = 1.10$	103%	105%	107%	110%	111%	111%	111%	110%
$F_{t_0} = 1.20$	115%	117%	119%	121%	120%	119%	117%	114%
$F_{t_0} = 1.30$	127%	129%	131%	133%	129%	127%	124%	118%

Table 6.2: *Economic value of existing accrual relative to nominal guarantee after the transition, in case a transition to 4A is performed based on economic value. All parameters, except for the starting funding ratio, are the base case.*

6.2 Equity Exposure

The embedded options in the pension contract are more likely to end up in the money when the funding ratio is more volatile. This could be caused by investing more in equity. Therefore, it is expected that the equity exposure will have an impact on the economic value of existing benefits. To be more specific, given the asymmetry of the current contract, a high equity exposure is likely to be unattractive in value terms for current generations.

The results in table 6.3 show a pension fund with the same parameters as before, only different values for the equity exposure are considered and a starting funding ratio of 104% is assumed instead of 100%. This means that the starting funding ratio is equal to the MVEV and cuts are not necessary, unless the fund looses money, for example due to bad investment results. If no risk is taken, the pension fund can with certainty pay out the benefits and the contract is equal to a nominal guarantee, as can be seen in the upper row. When risk is taken, there is a positive probability of both cuts and indexation. Table 6.3 shows that for most current generations the cut option has a higher value than the indexation option. When the pension fund takes more risk, this leads to a buffer for future generations in good scenarios and severe cuts in bad scenarios, i.e. by taking risk the pension fund shifts value to future accrual. Only for the oldest generations the risk is attractive, because they are better protected against cuts (assuming the MVEV cut is spread out), but can still profit from indexation and catch-up indexation.

	25	35	45	55	65	75	85	95
$\phi = 0.00$	100%	100%	100%	100%	100%	100%	100%	100%
$\phi = 0.25$	94%	95%	96%	97%	98%	99%	100%	100%
$\phi = 0.50$	90%	91%	93%	96%	99%	100%	100%	100%
$\phi = 0.75$	79%	83%	87%	93%	98%	100%	101%	101%
$\phi = 1.00$	64%	69%	76%	85%	94%	98%	100%	101%

Table 6.3: *Economic value of existing accrual relative to nominal guarantee. All parameters, except for the equity exposure and the starting funding ratio, are the base case. The starting funding ratio is 104% (MVEV).*

Impact of the options

To get a better understanding of the working of the embedded options, I have plotted the cut and indexation factor ξ (see equation 4.2.2) as function of the equity exposure in figure 6.1 for a benefit with a horizon of 30 years. The cut and indexation factor is the amount by which the nominal benefit is multiplied in expectation under $\mathbb{Q}$. If the cut and indexation factor is 1, the benefit has the same value as a nominal guarantee and the net impact of the embedded options is zero. The cyan line contains all options in the model, while the other lines show the separate impact of the options[1].

Both indexation options are bounded, the normal indexation by the maximal indexation which may be given and the catch-up indexation by the existing backlog. This explains why the growth in value of these options is decreasing over ϕ for high ϕ. The cut options on the other hand show an almost linear decline. In the end, the value of these options is also bounded, since the benefits paid out to a participant are non-negative.

Using figure 6.1 the loss in value in case of extra equity exposure can be split in two effects. The first effect is that before indexation can be given a buffer must be built up (the funding ratio must increase from 104% to 110%), while a small decrease in the funding ratio can lead to cuts (the maturity of the plotted benefit is 30 years, so even when spread out the MVEV cut has a large impact). This is visible at the left part of the graph, the red line immediately goes down, while the green line needs more equity exposure to go up. Between an equity exposure of approximately 10% and 50% the decline of the value of the benefit is relatively slow. The second effect is that the value of the indexation option flattens when it approaches its upper bound, which leads to a stronger decline in the value of the contract for high ϕ, in the graph this is best visible between 50% and 100% equity exposure. Different parameter values lead to different pictures, but in general building up the buffer and a decreasing growth of the value of the indexation option can explain most of the results.

Another interesting observation from figure 6.1 is that it once again confirms that the value of the cut to MVEV prevails over the value over the cut with recovery plan.

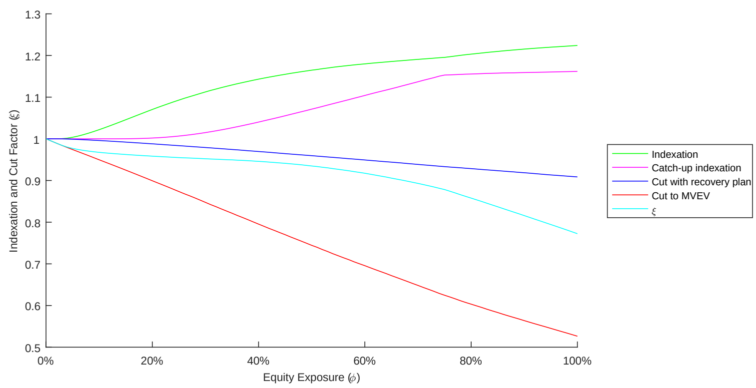

Figure 6.1: *Relative value of the different embedded options on a benefit with a horizon of 30 years. Parameters are the base case, except for the starting funding ratio which is 104% and the equity exposure that is changed.*

Impact on the transition

Also for funds with different equity exposure, the transition based on economic value can be calculated. This leads to the results stated in table 6.4. In case of a transition based on nominal rights, all participants would get 104% of the nominal size of their existing rights, which is the same as the result in the upper row with zero equity exposure. The rest of the table shows that the intergenerational redistribution of a transition based on nominal rights is larger when the equity exposure of the fund is higher.

Finally, it is important to realize that the impact of equity exposure also depends on the other characteristics of the pension fund. When a fund already has a buffer, then it is more attractive for current generations to take some risk, as can be seen in table A.1 (see appendix) where the starting funding ratio is 120%. In these results, for all current generations the economic value of existing rights is higher for $\phi = 0.25$ than for $\phi = 0.00$, while this was not yet the case for $F_{t_0} = 1.04$. However, also for higher funding ratios we observe the pattern that for the oldest participants it is more attractive to take some extra risk than for young participants, in the sense of economic value of the existing rights. In the current system a part of their risk premium goes to future accrual and older generations, which is why the existing accrual of young participants loses in value when more risk is taken.

The results after the transition for $F_{t_0} = 1.20$ can be found in table A.2. In this case the intergenerational redistribution of a transition based on nominal rights is still largest for the maximal equity exposure, but is in this somewhat higher for $\phi = 0.00$ than for $\phi = 0.50$.

[1] All results are generated in one run, so I consider the value of a certain option given that the other options also exist.

	25	35	45	55	65	75	85	95
$\phi = 0.00$	104%	104%	104%	104%	104%	104%	104%	104%
$\phi = 0.25$	101%	101%	102%	103%	105%	106%	106%	107%
$\phi = 0.50$	96%	98%	100%	103%	106%	107%	108%	108%
$\phi = 0.75$	87%	91%	96%	102%	107%	110%	111%	111%
$\phi = 1.00$	74%	81%	89%	99%	110%	114%	118%	118%

Table 6.4: *Economic value of existing accrual relative to nominal guarantee after the transition, in case a transition to 4A is performed based on economic value. All parameters, except for the equity exposure and the starting funding ratio, are the base case. The starting funding ratio is 104% (MVEV).*

6.3 Funding ratio of the contribution

Another important variable to consider, is the funding ratio of the contribution. There is a large heterogeneity in this parameter between funds, and it could have a significant impact on the value of the rights in the fund. In practice the funding ratio of the contribution is regularly changed, but in this analysis a fixed funding ratio of the contribution will be assumed to better understand the impact in the long run[2]. Note that the focus at first lies on the impact of the contribution which *other* people pay on the existing rights of an individual.

Many experts claim that the contributions cannot longer be used to compensate for shortages in mature pension fund, because contributions are small compared to the existing liabilities (In Dutch people say 'Het premie instrument is bot geworden'). This is true in the short run. However, even if the impact of the contribution rate is smaller than it used to be, a structural low contribution rate (relative to the accrual) could still have a significant negative impact on the current funding ratio, as will be shown below.

According to the Dutch regulation, the contributions should be equal to the value of the new accrual plus a share of the required buffer. This can be translated to F^{contr} =VEV, where the VEV is the fund specific required own funds (see section 3.2.4). This is called the cost effective price of new accrual (Dutch: 'kostendekkende premie'). However, the regulation also contains an exemption which allows pension funds to discount the new accrual against expected returns in the calculation for the contributions (but not for the funding ratio), this is the 'reduced cost effective price' (Dutch: 'gedempte kostendekkende premie')[3]. The expected return depends on the exposure to equity of the pension fund, and funds are allowed to assume a return of 7% on equity as advised by the parameter committee, Langejan et al. (2014)[14].

In practice most funds use a funding ratio of the contribution which lies between the cost effective price and the reduced cost effective price. Therefore it is not necessary to calculate the reduced cost effective price. Instead, I will consider different values for the funding ratio of the contribution that lie within these bounds. Furthermore, assume accrual is fixed, i.e. a pension fund would have to demand more contributions to raise the funding ratio of the contribution instead of lowering the accrual. The results for a standard fund (i.e. neither green nor gray, $\alpha_1 = \alpha_2 = 0.025$) are printed in table 6.5.

These results show that the funding ratio of the contribution indeed has a significant impact on the value of the existing rights for different generations. Because these results only concern the value of existing rights, they do not show the advantage which the lower contribution rate gives to young workers. Hence, the results in table 6.5 are most relevant for sleepers.

	25	35	45	55	65	75	85	95
$F^{\text{contr}} = 0.60$	56%	62%	70%	78%	89%	93%	97%	99%
$F^{\text{contr}} = 0.80$	70%	74%	79%	85%	92%	95%	98%	100%
$F^{\text{contr}} = 1.00$	86%	88%	89%	92%	96%	97%	99%	100%
$F^{\text{contr}} = 1.20$	104%	102%	100%	99%	99%	99%	100%	100%

Table 6.5: *Economic value of existing accrual relative to a nominal guarantee. All parameters, except for the funding ratio of the contribution, are the base case.*

Impact through the contribution

In this case it is also relevant to consider the value of a lower contribution rate for a participant who keeps building up new accrual in the fund until his retirement. As argued before, the value of a lower contribution

[2]The assumption of a lower funding ratio of the contribution in case of a high buffer is kept. However, this has only a small impact on the results given the starting funding ratio of 100%.

[3]The terminology is contradictory, because the reduced cost effective price does not cover the costs (new liabilities) of the new accrual.

for an individual is not self-evident. Therefore, it is interesting to consider the two extreme cases that an individual either fully profits from contribution discounts, or not at all. Intermediate cases can then be considered by interpolation.

To do so, the size of the contributions and the existing and future accrual must be known. The parameters in table 5.3 are used to calculate the existing and future accrual for participants of different ages. Future accrual is added, both in case of the nominal guarantee and the current contract; the value of new accrual under the nFTK can be found in appendix C. In all cases uniform accrual and uniform contribution (doorsneesystematiek) is assumed as contribution mechanism. The contribution rate, $\pi_U(t)$, is then given by equation 7.2.2 below (see next chapter). Denote the value of a lower contribution by V_c and let j_0 be the age of a working individual at time $t = 0$. Then the value of a lower contribution for this individual is given by the discounted sum over the remaining working years of the wage times the contribution rate times one minus the funding ratio of the contribution:

$$V_c := \sum_{j=j_0}^{j_r} w_{pb}(j,t) \cdot \pi_U(t) \cdot (1 - F^{\text{contr}}) \cdot (1 + r_f)^{-t} \qquad j_0 < j_r \qquad (6.3.1)$$

Hence, $F^{\text{contr}} = 1.00$ is taken as reference point; for lower funding ratios of the contribution there is a profit and for higher funding ratios of the contribution there is a loss.

The first case which is considered, is that an individual keeps accruing new rights until his retirement, but does not profit from a low contribution rate, i.e. $V_c = 0 \quad \forall F^{\text{contr}}$. These results are given in table 6.6. The new accrual has a shorter duration than the existing rights and therefore, the total pension of a worker who remains active is less sensitive to the funding ratio of the contribution than the total pension of a sleeper (which was given above in table 6.5.

The second case which is considered, is that an individual keeps accruing rights until his retirement and fully profits from a low contribution rate, i.e. one euro less contribution leads to an increase of one euro in the wage[4]. For this case V_c is given by equation 6.3.1 and the results are given in table 6.7.

If one believes that the employer takes a part of the advantage from the lower contribution rate, then the value for the employee can be found by making a linear interpolation between tables 6.6 and 6.7.

Note that for retirees the results are the same in all three tables.

For the sake of argument, assume that the employer fully charges the pension contributions in the wage of the employee. Then the results in table 6.7 are leading for workers who remain active and the results in table 6.5 are leading for sleepers.

Under this assumption, changing the funding ratio of the contribution leads to redistribution from retirees and sleepers to (new) workers: the retirees and sleepers lose value when the contributions are too low and do not benefit from the low contribution rate, because they do not build up new accrual anymore. Especially young workers and workers who recently joined the pension fund benefit, because they have to pay less for their new accrual while they have relatively little existing rights which will lose value.

Consider for example a worker of age 25 who has no existing rights and is about to work a full career. According to table 6.6 the value of the total accrual which he will build up over his career is decreasing in the funding ratio of the contribution. If the funding ratio of the contribution is 100%, then the value of his total lifetime accrual is only 92% of a nominal guarantee, because a part of it is necessary to build up a buffer. Now, when the funding ratio of the contribution is structurally lowered to 60%, the value of his total lifetime accrual decreases by approximately 20% of the value of a nominal guarantee to 72% of this value. However, the lower contribution saves him money. He could for example use this money (40% of his contribution) to buy a nominal guarantee. This explains why the difference between the results for a 25-year old in table 6.6 and table 6.7 is equal to 40 percentage points.

For the older generations the difference between table 6.6 and table 6.7 is smaller, because the contributions paid in the past are not taken into account and therefore the value of the contribution on which they get discount is smaller relative to the total accrual over life. Therefore, these results cannot directly be applied on old workers who joined the pension fund late in their career.

Taking all results together, the impact of a structural change in the funding ratio contribution is quite complicated, but it is definitely economically significant. In general a low funding ratio of the contribution benefits young employees, as long as their wage is sufficiently elastic to the pension contributions.

Furthermore, a structural low funding ratio of the contribution has a detrimental impact on the value of existing rights. Which funding ratio of the contribution is necessary to keep the value at 100% of a nominal

[4]The impact of taxes is ignored in the pay-out phase and must therefore also be ignored in the contribution phase, for the sake of consistency.

	25	35	45	55	65	75	85	95
$F^{\text{contr}} = 0.60$	72%	72%	74%	79%	89%	93%	97%	99%
$F^{\text{contr}} = 0.80$	82%	82%	82%	86%	92%	95%	98%	100%
$F^{\text{contr}} = 1.00$	92%	91%	91%	92%	96%	97%	99%	100%
$F^{\text{contr}} = 1.20$	102%	101%	100%	98%	99%	99%	100%	100%

Table 6.6: *Economic value of existing and new accrual (based on a full career) relative to a nominal guarantee. All parameters, except for the funding ratio of the contribution, are the base case. Advantage of cheaper contribution for individual not taken into account.*

	25	35	45	55	65	75	85	95
$F^{\text{contr}} = 0.60$	112%	105%	97%	91%	89%	93%	97%	99%
$F^{\text{contr}} = 0.80$	101%	97%	94%	91%	92%	95%	98%	100%
$F^{\text{contr}} = 1.00$	92%	91%	91%	92%	96%	97%	99%	100%
$F^{\text{contr}} = 1.20$	84%	87%	89%	93%	99%	99%	100%	100%

Table 6.7: *Economic value of existing and new accrual (based on a full career) relative to a nominal guarantee. All parameters, except for the funding ratio of the contribution, are the base case. Advantage of cheaper contribution for individual is taken into account relative to base case* $F^{contr} = 1.00$.

guarantee (which is a reasonable requirement given the nominal promise) depends on the initial funding ratio of the fund and the demography. For a fund which starts without a buffer, the rule $F^{\text{contr}} = \text{VEV}$ works quite well based on these results (the VEV is in this case 118%, which lies close to 120%).

For funds with a higher funding ratio, the funding ratio of the contribution is less vital. These funds can namely also profit from the buffervrijval which occurs when benefits are paid out. For very green funds the buffervrijval is smaller and the funding ratio of the contribution remains relevant. From a policy point of view, these results suggest that stricter rules for applying the reduced cost effective price in case of a funding ratio below the required capital, are needed to protect the interests of existing participants in the fund.

It is not straightforward to apply these results on the transition, because in practice the funding ratio of the contribution is changed regularly. These changes depend for example on negotiations between the social partners and changes in the interest rate. A possible solution would be to first determine more narrow rules for the contribution rate that are deemed fair in the current system and then use the economic value based on these rules for the transition calculations. This topic is left for further research.

6.4 Grayness

In section 3.3.1 above it has been shown that the demography of a pension fund affects the behavior of the funding ratio. In this section the impact of the demography of the fund on the value of the benefits is examined. To do this it is assumed that a fund can remain green or gray for 75 years (the simulation horizon). In practice this may not be the case, but this assumption is the best way to show the impact of the demography in the long run.

Table 6.8 contains the results for a green and a gray fund, compared to a standard fund. The parameters for the in- and outflow of these different funds are given in table 3.1 above. According to this table the effects of the demography matter mainly in the long run. This can be explained by the starting situation. When the starting funding ratio is 100% and the funding ratio of the contribution is also 100%, then in- and outflow both have no effect. When the funding ratio deviates from this starting position, the demography will have an impact. The gray fund will in this case show more diverging behavior from 100%, while the green fund will show converging behavior towards a funding ratio of 100%.

Pension funds build up a buffer on average. For the older generations the demography does not matter, they lose value for building up a buffer. After a certain amount of time, there will be a buffer on average. In the green fund this buffer will be eroded by a large inflow with funding ratio of the contribution 100%. In the gray fund on the other hand, the large outflow will magnify the buffer. Therefore, the rights of the younger generations have a higher value in a gray pension fund.

This story depends thus on the initial situation of the pension fund. When for example the pension fund has an initial positive buffer, also the old generations will profit from being in a gray fund, as can be seen in table 6.9.

At a starting funding ratio of 120%, indexation can immediately be given. This is beneficial for retirees in all cases. However, in the green fund the funding ratio is eroded by more inflow than in the gray fund, which means that the younger retirees get on average less indexation in the green fund than in the gray fund. The

	25	35	45	55	65	75	85	95
Green	84%	86%	89%	92%	96%	97%	99%	100%
Standard	86%	88%	89%	92%	96%	97%	99%	100%
Gray	89%	90%	91%	92%	96%	97%	99%	100%

Table 6.8: *Economic value of existing accrual relative to a nominal guarantee. All parameters, except for the in- and outflow, are the base case. Thus initial funding ratio is 100% and funding ratio of the contribution is also 100%.*

economic value of younger generations in the green fund lies below this of older generations, which suggests that the younger generations must use a part of their economic value to keep the buffer in place. In the gray fund this difference is smaller, because the buffer can be maintained largely by the outflow, as each time a benefit is paid, the part of the buffer corresponding to the paid out liability is left in place and distributed over the remaining liabilities.

	25	35	45	55	65	75	85	95
Green	98%	101%	104%	107%	106%	106%	105%	102%
Standard	103%	105%	107%	109%	108%	107%	105%	102%
Gray	110%	110%	111%	111%	109%	108%	106%	102%

Table 6.9: *Economic value of existing accrual relative to a nominal guarantee. All parameters, except for the in- and outflow and initial funding ratio, are the base case. The initial funding ratio is 120% and funding ratio of the contribution is 100%.*

When the pension fund starts with a shortage, the effects are reversed, as can be seen in table 6.10. At the initial funding ratio of 80%, inflow with a funding ratio of the contribution of 100% diminishes the shortage, while in case of outflow paying out the full benefit magnifies the shortage for the remaining liabilities.

This leads to larger cuts for a gray fund, mainly the old workers and young retirees are worse off compared to a green fund. However, in the long run, the cuts will on average lead to a buffer, in which case again the gray fund is more attractive. This explains why for the 25-year old in this case the difference between a green and a gray fund is relatively small.

	25	35	45	55	65	75	85	95
Green	68%	70%	72%	75%	84%	88%	93%	98%
Standard	67%	69%	70%	73%	82%	86%	92%	98%
Gray	68%	68%	69%	71%	81%	85%	91%	98%

Table 6.10: *Economic value of existing accrual relative to a nominal guarantee. All parameters, except for the in- and outflow and initial funding ratio, are the base case. The initial funding ratio is 80% and funding ratio of the contribution is 100%.*

Besides on the initial funding ratio, this analysis also depends largely on the funding ratio of the contribution. The analysis is therefore repeated for a funding ratio of the contribution of 120% and for a funding ratio of the contribution of 80%, these results can be found in tables A.3 and A.4 (see appendix).

In case of a high funding ratio of the contribution it is relatively more attractive to be in a green fund, especially in case of a low initial funding ratio. When the fund has an initial funding ratio of 120% and the funding ratio of the contribution is 120%, the green and gray fund perform equally well. For a yet higher initial funding ratio, the gray fund offers more upward potential.

When on the other hand the fund has a low funding ratio of the contribution, the green fund will perform worse. The contributions do not longer contribute to the recovery[5] and therefore it becomes even in case of a shortage more attractive to be in a gray fund. Furthermore, it is interesting to see that in a green fund with initial funding ratio of 120%, this low funding ratio of the contribution has an enormous negative impact on the value of the existing rights of young participants.

Taking everything into account, the impact of demography cannot be seen independently of the initial funding ratio and the funding ratio of the contribution. When one happens to be in a green fund, the funding ratio of the contribution is very important, even more so than based on the results of the previous section.

[5]Except when even lower initial funding ratios are considered, but this would really require a model for the discontinuity risk.

6.5 Conclusion

The results in this chapter show that for the value distribution in a transition, heterogeneity matters. Therefore, it is necessary, in case of a transition, to perform these calculations for each pension fund separately.

When instead of a transition based on economic value, it will be decided to perform a transition based on nominal rights, there are in some cases risks of large intergenerational redistribution. Especially in case of a negative or empty buffer, or in case of a high equity exposure, a transition based on nominal rights does not reflect the value distribution in the current system.

It turns out that the funding ratio of the contribution still has a considerable impact on the value of the rights in a pension fund. To protect the interests of retirees and sleepers it is advised to raise the lower bound for the funding ratio of the contribution for pension funds with a funding ratio below the VEV. Limiting the leeway of the pension fund to set the contribution rate is especially important in case of a transition based on economic value. In these calculations, namely, not only the policy for the upcoming years matter, but also the contribution rate for the upcoming 75 years.

Finally the effects of different variables often need to be considered together. Green funds are obviously more sensitive to the funding ratio of the contribution than gray funds. Besides, the differences between a gray and green fund are more material when the initial funding ratio differs from the funding ratio of the contribution.

7 Abolishing the doorsneesystematiek

The transition discussed in chapter 5 implies abolishing the doorsneesystematiek, because this is assumed in all SER variants. Moreover, in variant 4A and 4C it would be very difficult to keep the doorsneesystematiek, then the subsidies between generations would namely have to be made explicit. In variant 1B keeping the doorsneesystematiek would be possible.

In this chapter the costs of compensating participants for abolishing the doorsneesystematiek will be discussed. In section 7.1 the properties of the doorsneesystematiek and the consequences of abolishing it will be discussed. Section 7.2 contains the model used in this chapter. Then, in section 7.3 the loss for individuals and the compensation costs are defined. Section 7.4 contains the results for multiple definitions of the compensation costs and in section 7.5 the sensitivity of those results is analyzed. Finally, in the conclusion the pros and cons of the different definitions will be discussed to choose one definition for the next chapter, which concerns the double transition.

7.1 Doorsneesystematiek

The pension contributions in the Dutch occupational pension schemes are determined according to the principle of uniform contribution and uniform accrual (Dutch: doorsneesystematiek). This means that within a fund all participants pay the same percentage of the pension base as contribution and receive the same percentage of the pension base as accrual, regardless of age. This system is not actuarially fair, since the contributions of the young participants can be invested for a longer period of time. Or to put it differently, because the benefits of the young participants lie further in the future, the present value of these benefits is smaller. In fact the younger participants subsidize the older participants. The doorsneesystematiek can be seen as a pay-as-you-go element in the funded pension schemes. In a 'standard' pay-as-you-go scheme, working people pay for the current retirees. In this specific case younger workers pay a part of the accrual for older workers. In both cases the system is dependent on new inflow. Furthermore, the relative size of different generations can have a significant impact on the costs and benefits for those generations

When employees work their entire life for companies which use the doorsneesystematiek for the pension contribution, they will be compensated for this subsidy when they are older workers themselves. However, employees who leave the system around age 45, will not get compensated for their subsidy and only face the downside of the doorsneesystematiek. In the past people used to work their entire life for the same company, but currently this is no longer the case. Also more people get self-employed. Besides the redistribution from younger to older participants, there is also redistribution from employees with a relatively flat salary profile to employees with a steeply increasing wage profile, see CPB (2013)[16]. The intuition behind this result, is that employees with a steep wage profile pay subsidizing contributions over a wage which is relatively low compared to their career average, and receive extra accrual based on a wage which is relatively high.

The current Dutch cabinet is in favor of abolishing the doorsneesystematiek to stop these cases of ex-ante redistribution, to make the system more transparent and to create opportunities for reforming the pension system and introducing more freedom of choice within the system (Klijnsma, 2016)[12]. However, Klijnsma stresses the importance of sharing the costs of abolishing the doorsneesystematiek in a fair and balanced manner over different generations.

There are multiple alternative accrual mechanisms which could be considered to replace the doorsneesystematiek, see appendix D. In this chapter I will only consider a transition from doorsneesystematiek to degressive accrual. In case of degressive accrual, all participants pay the same contribution, but young participants build up more rights (assuming the interest rate is positive).

A transition from doorsneesystematiek to degressive accrual without compensation, would imply a loss for current workers, especially those in mid-career. They have paid subsidies when young, but do not longer get the subsidies when old. The costs of compensating the current workers are the transition costs, which will be calculated in this chapter.

7.2 Model

Central in the analysis of the doorsneesystematiek stands the value of the subsidy which is received or paid by different generations. To quantify these subsidies, a model is needed which focuses on the contribution phase instead of on the value of the benefits. Therefore it is necessary to introduce some extra equations.

The lost subsidies due to abolishing the doorsneesystematiek can be calculated either retrospectively or prospectively. The retrospective view considers the subsidies paid and received in the past due to the doorsneesystematiek, while the prospective view considers the subsidies which will be received when the individual keeps working in the pension fund with doorsneesystematiek until retirement. These approaches are not equivalent when relevant parameters (demographics, financial position of the fund, interest rate etc.) have changed. I will use the prospective approach, which takes the current situation as status quo and redistribution from the past as given. This choice is in line with earlier research by for example CPB (2013)[16].

Before I can define the loss per generation in case the system is changed, I will first introduce the model of the pension fund, some notation, and explain how the premium is calculated in case of respectively doorsneesystematiek and degressive accrual.

7.2.1 Notation

I use the following notation: The pension fund is observed at time $t = 0$, where t is the time in years.. The probability for an individual of age j to live for another k years is denoted by ${}_kp(j)$. The number of participants of age j at time t is $N(j,t)$. The wage of a participant is given by $w(j,t)$ and the franchise by $f(t)$ and both are indexed by the wage inflation i_w. The pension base is the wage minus the franchise: $w_{pb}(j,t) = w(j,t) - f(t)$. Furthermore, the wage of an individual also increases with age, this factor is denoted by m.

People start working at age j_s, retire at age j_r and die at or before age j_d. The accrual and contribution as percentage of the *current* wage are respectively denoted by α and π; subscript U and D are used to distinguish between uniform accrual & uniform contribution (doorsneesystematiek, U) and degressive accrual (D).

Each year only workers of age j_s enter the fund, the amount of workers which enters the fund in year $t+1$ is $1+n$ times the amount of new workers in year t. So n can be interpreted as the population growth.

7.2.2 Assumptions

Similar to chapter 3, assume that there is only equity risk on the financial market. Interest rates and inflation are fixed and have a flat term structure, the equity risk is represented by a stock of which the returns follow a lognormal distribution.

For the population I make the following assumptions. The career profile is fixed over time and does not depend on age. Assume that all generations of the pension fund have the same survival probabilities and retire at age 65. In practice the life expectation increases over cohorts, but this is compensated by later retirement. I abstract from mismatches in case the retirement age grows too fast or slow compared to life expectancy and therefore assume fixed survival probabilities. The fixed survival probabilities which I use, are based on the realizations (until 2015) and expectations for the cohort born in 1974. I used the data and forecasts of the Koninklijk Actuarieel Genootschap (AG, 2016)[2]. I do not distinguish between male and female workers and therefore took the average of their respective survival probabilities. Using the increasing life expectations and retirement date, would better match reality, but also adds complexity while it is only of secondary importance for the problem at hand.

For the population of the fund, assume that the career profile is the same for all participants, people start working at age 25, only new workers of age 25 enter the fund and that people live at most 100 years.

7.2.3 Calculating the contribution rate in case of doorsneesystematiek

The calculation of the uniform contribution rate in case of doorsneesystematiek consists of two steps. First the annuity factor (price of a life long annuity of one euro) for a person of age j at time t is the sum over retirement of the probability to be alive discounted by the risk free rate:

$$\delta(j) = \sum_{l=j_r}^{j_d} \frac{{}_{l-j}p(j)}{(1+r^f)^{l-j}} \tag{7.2.1}$$

Secondly the costs of all accrued rights are added up and shared over the participants, which leads to a fixed contribution as percentage of the pension base:

$$\pi_U(t) = \frac{\sum_{j=j_s}^{j_r-1} N(j,t) \cdot w_{pb}(j,t) \cdot \alpha_U \cdot \delta(j)}{\sum_{j=j_s}^{j_r-1} N(j,t) \cdot w_{pb}(j,t)} \tag{7.2.2}$$

Both the contribution and accrual do not depend on age (j), by definition of the doorsneesystematiek, while the annuity factor is age-dependent. Given uniform contribution $\pi_U(t)$ the fair accrual for an individual of age j would be:

$$\alpha_F(j,t) = \frac{\pi_U(t)}{\delta(j)}$$

For positive interest rates (or a zero interest rate and non-zero probability to die before retirement), $\delta(j)$ is increasing over j. Therefore it holds that $\alpha_F(j,t) > \alpha_U$ for young workers and $\alpha_F(j,t) < \alpha_U$ for old workers.

7.2.4 Calculating the contribution in case of degressive accrual

For a fair comparison between the two mechanisms, the degressive accrual should be chosen such that the total accrual over an individual's working life is equal to the total accrual in case of doorsneesystematiek. Furthermore, in a system with degressive accrual, the contribution is the same for employees of all ages. Assume that the contribution is also fixed over time. Given an unknown, uniform contribution for degressive accrual, the actuarially fair accrual for each age is given by:

$$\alpha_D(j) = \frac{\pi_D}{\delta(j)}$$

In this formula both the accrual and the premium are expressed as a percentage of the *current* wage. So, when comparing the total accrual in the two systems, the wages should be used as weights, to ensure that the total accrual as percentage of the *average* wage is the same. Denote the weights by:

$$v(j) := w_{pb}(j,t_0) \cdot (1+i_w)^{j-j_s}$$

Where $w_{pb}(j,t_0)$, which is the pension base of a person of age j at time t_0, takes the career profile into account, and i_w models the growth of the pension base over time. These weights can be used to put the lifetime accrual in both systems equal:

$$\sum_{j=j_S}^{j_r-1} \alpha_D(j) \cdot v(j) = \sum_{j=j_S}^{j_r-1} \alpha_U \cdot v(j)$$

Plugging in the formula for $\alpha_D(j)$ gives:

$$\sum_{j=j_S}^{j_r-1} \frac{\pi_D \cdot v(j)}{\delta(j)} = \alpha_U \sum_{j=j_S}^{j_r-1} v(j)$$

Solving for the contribution rate π_D gives:

$$\pi_D = \alpha_U \sum_{j=j_S}^{j_r-1} v(j) \Bigg/ \sum_{j=j_S}^{j_r-1} \frac{v(j)}{\delta(j)} \tag{7.2.3}$$

It is interesting to see that the time index does not play a role in this formula. The cause of this, is the assumption that survival probabilities, career profile, wage inflation, and interest rate are fixed over time. If one of these assumptions would be relaxed and $\delta(j)$ or $v(j)$ would become time dependent, then the calculation of the contribution for degressive accrual would become more complicated. The set of requirements of a fixed contribution rate over time, a fixed contribution rate over age and the same total accrual over a full career as in the old system, would lead to an empty solution set. This problem lies outside the scope of this thesis

A comparison of the accrual for each age between doorsneesystematiek and degressive accrual can be found in figure 7.1.

7.3 Loss per generation

To calculate the costs of abolishing the doorsneesystematiek, a clear definition of the compensation costs is needed. Ultimately, it will be a political decision whether and by how much individuals will be compensated. However, there are also important economic arguments why some calculation methods are better than others. In this section, I will discuss different possible compensation mechanisms and choose a proper definition based on economic arguments. After that, I will give the formulas which are needed for this method.

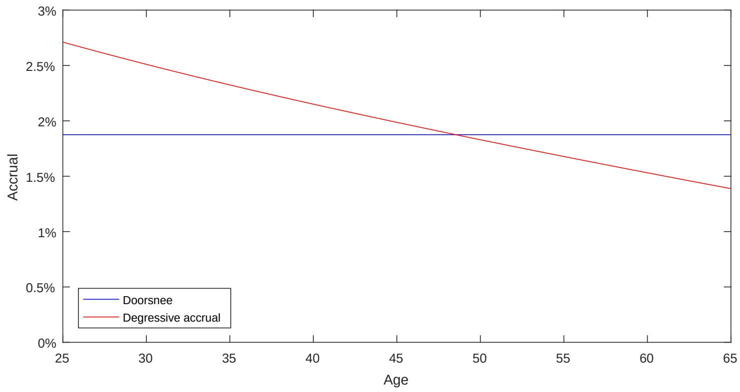

Figure 7.1: *Accrual for doorsneesystematiek and degressive accrual over age when* $r^f = 0.015,\ i_w = 0.015,\ m = 0.01$.

7.3.1 Definition

When the doorsneesystematiek is abolished at a certain point in time, and replaced by a system of degressive accrual, both the amount of rights which workers build up and the contribution rate will change.

Due to the fact that in the new system more rights are accrued in the beginning of the career and less at the end, current workers will build up less rights over their remaining working life than without abolishing the doorsneesystematiek. The loss of an individual in benefits can be defined as the total accrual on which he misses out due to the change of system. That means consider the value of the sum of $\alpha_U - \alpha_D(j,t)$ over all future working years for the current employees.

The change in contribution occurs, when $\pi_D \neq \pi_U$, which is in general the case. Abolishing the doorsneesystematiek is equivalent to replacing a pay-as-you-go system by a funded system. The difference in contribution between those systems has been discussed by Aaron (1966)[1]. He finds that the difference depends on the return in a pay-as-you-go system, which is wage growth plus population growth, and the return in a funded system, which is the risk free interest rate. I use the Aaron condition as follows: the contribution is lower in a funded system than a pay-as-you-go system if the risk free interest rate is higher than the sum of the wage growth and population growth[1], i.e.: $(1 + r^f) > (1 + i_w) \cdot (1 + n)$. This condition holds for mature systems, transition costs are ignored.

Hence, when the Aaron condition holds, we have $\pi_D < \pi_U$, i.e. current and future workers pay less contribution when the doorsneesystematiek is abolished. This change in contribution is called 'premievrijval' in Dutch (as long as the contribution decreases), which is difficult to translate in English, but release of contribution may come closest. However, if the Aaron condition does not hold, the contribution will rise after the transition. In general it is assumed, often without saying, that the Aaron condition holds and the premievrijval is positive, see for example CPB (2015)[15]. Assume, that there is indeed a significant positive premievrijval. Then the policy question becomes: should we fully compensate people for the future accrual they miss, when in the meantime they also benefit from lower contributions?

The main problem here is that it is unknown what the value of the premievrijval is for the individual. There are some arguments, why the individual is likely to profit much less from the premievrijval than its nominal size suggests. First of all many pension funds currently have a contribution rate which lies below the cost price of the new accrual, therefore the premievrijval may be partly (or fully) used to reduce this gap. Secondly, even if the contribution rate is lowered, the individual may not fully profit from this change: the marginal tax rate is for many workers higher during their working life than during retirement and also the employer could take a part of the change in contribution. Thirdly, even if the participants would fully profit from the premievrijval, they would receive this money at a different point in time. Thus, if they would not save the premievrijval, they would still face a loss in the retirement phase.

Besides these problems concerning the value of the premievrijval, there is also an argument about intergenerational fairness. Given that future generations will fully profit from the premievrijval, it is contradictory to take the benefit of a premievrijval for the remaining years from the current working generations.

Finally it can be argued that the premievrijval in CPB (2015)[15] is overestimated. The often quoted result of an 8% lower contribution rate[2] is based on a real wage growth of 1% and a real return of 3%. They also show that when the real return is 2% instead, the contribution can be lowered by only 2.5%. In the current system, the contribution rates ought to be based on the risk free interest rate. Given the current low interest rates, it would be optimistic to assume an interest rate 1% over the wage growth after the transition, let alone 2%. Therefore, the often quoted 8% is not in line with the current economic reality.

[1] Aaron stated the condition the other way around, but my formulation is more in line with the recent literature.
[2] Percent, not percentage point.

For many pension funds, the premievrijval may even be negative. This depends on the demography of the specific funds, but it can be shown that for the Netherlands as a whole the Aaron condition is violated at this moment. The wage growth (based on collective labor agreements) in the Netherlands in 2016 namely was 1.9% according to the CBS[3], while the interest rates were far below this amount throughout 2016. The population growth is positive in the Netherlands, but this may be partly explained by the increasing life expectancy, therefore I assume that this factor is zero. This indicates that the Aaron condition indeed did not hold in the Netherlands in 2016. It does matter whether this is only for a short period of time the case, or whether the Aaron condition can be violated for a long period of time (which seems unlikely). In the latter case, one should first seriously consider what the optimal combination of funded and pay-as-you-go pensions is. This could be a relevant policy question, but it lies outside the scope of this thesis. However, these observations support the choice not to use the premievrijval to pay (a part of) the compensation costs.

Taking everything into account, I conclude that only the future accrual which an individual misses should be considered and that the change in contribution can be ignored when determining the compensation costs. This definition is in line with CPB (2013)[16] and CPB (2015)[15].

7.3.2 A formula for the loss for an individual

As explained above, for the compensation only the difference between the accrual with doorsneesystematiek and with degressive accrual must be considered, this is the loss for an individual. To determine this loss it will be necessary to value the accrual. The value of the accrual depends on the interpretation of the contract, i.e. whether cuts and indexation should be taken into account, and will be addressed later.

Assume that at $t = t_0$ a pension fund changes the accrual system from doorsneesystematiek to degressive accrual without a transition period. This change takes place before the contributions of year t_0 are paid. Consider an individual who has age $j_0 \in [j_s, j_r)$ at time t_0. First calculate the difference in accrual for one future working year. Let $x_1 \in [0, j_r - j)$ and $t = t_0 + x_1,\ j = j_0 + x_1$. Denote by $L_{t_0}(j,t)$ the value at time t_0 of the accrual on which a person of age j misses out on time t. This loss (there is a loss if $L_{t_0}(j,t) > 0$) is given by the following formula:

$$L_{t_0}(j,t) := \mathbb{E}_{t_0}\left[\sum_{x_2=j_r-j}^{j_d-j} \Xi^{t,t+x_2}(\alpha_U(t) - \alpha_D(j,t)) w_{pb}(j,t)(1+r^f)^{-(x_1+x_2)} \mathbb{1}[D \geq j + x_2 | D \geq j_0]\right]$$

In this formula the summation runs over the retirement period (x_2 is the number of years forward from year t). The accrual built up in year t is multiplied by cuts or indexation (Ξ as defined in equation 4.2.3), discounted by the risk free rate and only counted if a person is still alive (D denotes the stochastic year of death).

Under the assumption that within the pension fund as a whole there is no longevity risk, i.e. micro longevity risk is diversified and macro longevity risk is zero, and the assumption that there is no discontinuity risk, this equation can be simplified to:

$$L_{t_0}(j,t) = \sum_{x_2=j_r-j}^{j_d-j} (1+r_f)^{-(x_1+x_2)} (\alpha_U(j,t) - \alpha_D(j,t)) w_{pb}(j,t) \cdot {}_{x_1+x_2}p(j) \cdot \mathbb{E}_{t_0}^{\mathbb{Q}}\left[\Xi^{t,t+x_2}\right] \tag{7.3.1}$$

Now the total loss for the individual due to abolishing the doorsneesystematiek is given by the sum of the loss per working year:

$$\Lambda_{t_0}(j_0) = \sum_{x_1=0}^{j_r-j_s} L_{t_0}(j_0 + x_1, t_0 + x_1) \tag{7.3.2}$$

In this equation, Λ can be interpreted as the economic value of the loss for an individual of the cohort which has age j_0 at t_0.

7.3.3 Macro compensation costs

When people are compensated for their loss in future subsidies, Λ, it is interesting to calculate the sum of this compensation over all participants. I will call this the macro compensation costs. To calculate the macro compensation costs, I assume that current workers will be fully compensated for their loss in accrual. Furthermore, I assume that if abolishing the doorsneesystematiek will lead to an increase in accrual for some participants, they will not be taxed but instead receive zero compensation. The question how this compensation will be financed and whether future generations should pay a part of this price, is left open.

[3] See https://www.cbs.nl/nl-nl/nieuws/2017/01/in-2016-grootste-cao-loonstijging-sinds-2009

To calculate the compensation costs for abolishing the doorsneesystematiek in the entire Dutch second pillar, I make use of the total pension base for the Dutch second pillar. Based on DNB data the total pension base was 112 billion euros in 2015. To use this number I introduce a multiplier, M, which is defined such that in the first year the total pension base in the model matches the real total pension base. That is, M is the solution of this equation:

$$M \sum_{j=j_s}^{j_r-1} w_{pb}(j,t_0)N(j,t_0) = 112 \cdot 10^9$$

The macro compensation costs can be calculated as the sum of the loss of all individuals times the multiplier:

$$\text{MCC}_{t_0} = \sum_{j=j_s}^{j_r-1} \Lambda_{t_0}(j) \cdot \mathbb{1}[\Lambda_{t_0}(j) > 0] \cdot N(j,t_0) \cdot M \tag{7.3.3}$$

7.4 Results

In this section I will calculate the loss due to the change of accrual system for the different generations who are active at time t_0. I will distinguish different types of contract.

7.4.1 Parameters

The parameters which I use in this chapter are consistent with the previous chapters. However, which parameters are important differs between the chapters and some new parameters must be added. A complete overview of the base case parameters can be found in table 7.1.

Description	Symbol	Value
Wage inflation	i_w	2.0%
Risk free rate	r_f	1.5%
Risk premium	λ	3.5%
Equity exposure	ϕ	50%
Equity volatility	$\text{Std}(1+r^s)$	20%
Uniform accrual	α_U	1.875%
Career profile	m	1.0%
Starting salary	$w_s(t_0)$	30,000
Franchise	$f(t_0)$	12,500
Transition year	t_0	2017
Funding ratio	F_{t_0}	100%
Age people start working	j_s	25
Retirement age	j_r	65
Population growth	n	0.0%

Table 7.1: *Parameters base case*

The assumptions on survival probabilities can be found in section 7.2.2. Furthermore, I assume that the inflow remains equal, i.e. there is no population growth. For the initial population I use the population of the Netherlands based on CBS data. For the rest of the years, I assume that yearly of each cohort the expected amount of people dies. I ignore the different labor participation of different generations and simply assume that it is the same for every generation between age 25 and 65. Due to the use of the multiplier, only the relative size of the generations matters, the absolute size is irrelevant.

For the valuation of the cut and indexation option in the nFTK, the same base case parameters are used as in chapter 5.

7.4.2 Different contracts

The compensation costs depend on the method that is used to value future benefits. The three main options to be considered are the nominal guarantee, the economic value (under the nFTK) and the real guarantee. Furthermore two hypothetical interpretations are added to build the intuition needed for understanding the results of the economic value under the nFTK.

Nominal guarantee
The pension fund gives no indexation, but the nominal benefits are guaranteed, so there will also be no cuts.

This is the so-called hard nominal contract.

Nominal + indexation
The pension fund gives indexation when the funding ratio allows this according to the nFTK 2015. There is no possibility for the pension fund to cut benefits.

Nominal + cuts
The pension fund cuts benefits when the funding ratio requires this according to the nFTK. There is no possibility for the pension fund to index benefits.

nFTK
The pension fund follows the rules of the nFTK and can both cut and index benefits when necessary/allowed.

Real guarantee
The pension fund guarantees indexation and the participants bear no financial risk. This situation is comparable to the model used by CPB (2013)[16]. Let the size of the yearly indexation be 2.5%.

The different results in the different interpretations, are caused by different values for $\mathbb{E}_{t_0}^{\mathbb{Q}}\left[\Xi^{t,t+x_2}\right]$ in equation 7.3.1. In case of the economic value Ξ contains the cuts and indexations under the nFTK, which is how it is defined. The same holds for 'nominal + indexation' and 'nominal + cuts', only in this case either the cutting rules or the indexation rules are abolished. This means that 'nominal + indexation' has a large discontinuity risk and is therefore unrealistic.

In case of the nominal guarantee, Ξ is 1 at all times with probability 1. This can be achieved if the fund has a starting funding ratio of 100% and does not take any risks. When this is not the case, the value for the nominal guarantee can still be calculated, but cannot be interpreted as economic value.

In case of a real guarantee, a yearly fixed indexation of 2.5% is needed. This means that similar to the nominal guarantee, Ξ is deterministic, but in this case $\Xi^{t,t+x_2} = 1.025^{x_2}$. This result cannot be achieved with certainty by a fund without a large external risk bearer.

7.4.3 Compensation costs

Given the parameters in table 7.1 I have calculated the loss per generation due to the transition from doorsneesystematiek to degressive accrual, according to equation 7.3.2. The loss per generation is reported in table 7.2.

The loss for an individual of each generation is reported as the percentage of his current pension giving wage, i.e. his wage excluding the franchise. The advantage of this measure is that it can be applied both on high income and low income workers. A disadvantage is that the results are more difficult to compare between age groups, because their wages are unequal in case of an increasing career profile (which is a base case assumption).

In case of a nominal guarantee a person who is about to enter the fund should have a loss of exactly zero. Due to the fact that all relevant economic parameters are fixed over time and there are no cuts or indexation of the benefits, the value of the future subsidies paid when young should be equal to the value of those received when older. This is indeed the case, the 25 year old namely represents a participant who is about to start working and the value of his loss is 0. The older generations have already paid subsidy for some years, so over the upcoming years they will pay more subsidies than they will get back. Therefore the 35, 45, and 55 year old have a positive loss $\Lambda_{t_0}(j_0)$. The 65 year old has by definition a loss of zero, because he will not pay contributions anymore.

The real guarantee is different from the nominal guarantee in one important respect: participants can make a higher return inside the pension fund, than outside the fund. In fact in this case it is assumed that the pension fund gives them a free lunch in the form of guaranteed indexation. The result is that it is more attractive for participants to accrue money when young, compared to when old because of the difference in duration. Hence, paying a subsidy when young and receiving one when old is not attractive. Therefore, the 25 year old has in this case a negative loss, he wins in economic value if the doorsneesystematiek is abolished, before he enters the fund. The losses for the 45 and the 55 year old are higher than in case of the nominal contract, because the subsidy which they will receive is indexed by the pension fund. The macro compensation costs are also higher, because it is assumed (see equation 7.3.3) that the young generations will not have to pay negative compensation but simply receive zero instead. Finally, this variant can only be considered if a (large) external risk bearer guarantees the indexation. Because this is in general not the case, this case ought to be excluded. Note that a risk premium cannot be used to finance the indexation, because the indexation is supposed to be guaranteed, while the risk premium is accompanied by risk.

The 'nominal + indexation' contract offers the possibility to index benefits, but guarantees there will be no cuts. This means that it contains a positive option, on top of the nominal contract. Comparing the nominal indexation contract with the nominal contract leads to the same interpretation as comparing the real guarantee to the nominal guarantee. The size of the effect is smaller though, because indexation is only given when the fund can afford it.

The 'nominal + cut' contract cuts benefits if necessary, but never gives indexation. The embedded option has a negative value and therefore the effects are opposite to the real guarantee. For a 25 year old it is attractive to pay a subsidy now and receive one back later, because the rights can not be cut in between. Therefore the loss of a 25 year old is positive, he loses in economic value when the doorsneesystematiek is abolished. Furthermore, the loss for the 45 and the 55 year old lies below their loss in case of a nominal guarantee. This is because the subsidies which they receive, might be cut and therefore have a lower economic value.

The results for the nFTK lie between 'nominal + indexation' and 'nominal + cut', but for most ages closer to 'nominal + cut'. Apparently, the cut option prevails over the indexation option, which is no surprise given the assumption that the funding ratio at time 0 is equal to 100%.

These results look interesting, but before it is possible to make any hard conclusions with respect to the macro compensation costs, it is necessary to perform a sensitivity analysis.

	25	35	45	55	65	MCC_{t_0}
Nominal guarantee	0%	65%	87%	67%	0%	$67 \cdot 10^9$
Nominal + indexation	-21%	64%	94%	73%	0%	$70 \cdot 10^9$
Nominal + cut	29%	63%	72%	55%	0%	$60 \cdot 10^9$
nFTK	10%	64%	81%	62%	0%	$64 \cdot 10^9$
Real guarantee	-198%	57%	136%	104%	0%	$91 \cdot 10^9$

Table 7.2: *Loss of future subsidies for different generations when doorsneesystematiek is abolished, expressed as percentage of their current pension giving wage. Macro compensation costs expressed in euros. All parameters base case.*

7.5 Sensitivity analysis

For most of the sensitivity analysis I will focus on the nominal guarantee. Results for a sensitivity analysis compared to the nFTK would give similar results, with changes in the same direction.

Career profile

First of all consider the impact of the career profile. The base case assumption is a yearly increase of 1%, which will be compared to a flat career profile and a 2% increase. Furthermore, I will consider a quadratic wage profile. Deelen (2012)[10] has shown that the relation between wage and tenure is not linear, but at least quadratic, i.e. wages grow faster for young workers than for old workers. Chen (2015)[7] has translated this idea into a formula. In my notation, and without the wage inflation, this formula looks as follows: $w(t,j) = (1 + (j - j_s)b_1 + (j - j_s)^2 b_2) w(t, j_s)$. I use the same coefficients as Chen, namely $b_1 = 0.0063$ and $b_2 = -0.00011$. These parameters lead to a maximum wage of 9% more than the wage of a starter at age 54 and approximately 7.5% more wage than a starter at retirement, i.e. the wage decreases after age 54. In the table with results, this variant is called 'Quadratic car prof'.

	25	35	45	55	65	MMC_{t_0}
$m = 0.00$	0%	63%	88%	71%	0%	$68 \cdot 10^9$
$m = 0.01$	0%	65%	87%	67%	0%	$67 \cdot 10^9$
$m = 0.02$	0%	66%	84%	63%	0%	$65 \cdot 10^9$
Quadratic car prof	0%	61%	85%	69%	0%	$67 \cdot 10^9$

Table 7.3: *Loss of future subsidies for different generations when doorsneesystematiek is abolished, expressed as percentage of their current pension giving wage. Macro compensation costs expressed in euros. All parameters base case, except for the career profile. Benefits valued as if they are a nominal guarantee.*

The results for this sensitivity analysis can be found in table 7.3, the row '$m = 0.01$' corresponds to the nominal guarantee in table 7.2. When the career profile for all participants is steeper, there are multiple effects. The older workers have a relatively higher wage, which means that the pension fund becomes more gray. This effect works through the contribution and does not have an impact on the reported measure.

Besides that, the future received subsidies are larger because they are given over a larger wage. On the other hand more of the wage is earned at the end of the career which means that the duration of the pension savings is lower and therefore a higher degressive accrual is needed at all ages, which means that the future received subsidies are lower. The net effect differs for the age groups, but given the large changes in career profile which are considered the changes in outcomes are relatively small.

Finally, the outcomes are sufficiently robust against a quadratic career profile. Given the sensitivity of the results to other parameters which will be shown below, the choice between career profiles is relatively unimportant.

Wage inflation

A similar test can be performed on the sensitivity with respect to the wage inflation. These results can be found in table 7.4.

The impact on the results is again relatively small. Also in this case a higher percentage of degressive accrual is needed each year when the wage inflation is higher and future subsidies are calculated over a higher wage. Those effects are similar to a steeper career profile. However, changing the wage inflation does have a much bigger impact on the premievrijval. Higher wage inflation requires higher contributions in case of degressive accrual, but does not impact the uniform contribution. The contributions are not taken into account in this measure for the compensation costs, therefore the impact on the 'premievrijval' is not visible in table 7.4.

	25	35	45	55	65	$MMC_{t_0}(\cdot 10^9)$
$i_w = 0.01$	0%	63%	88%	70%	0%	$68 \cdot 10^9$
$i_w = 0.02$	0%	65%	87%	67%	0%	$67 \cdot 10^9$
$i_w = 0.03$	0%	66%	86%	65%	0%	$66 \cdot 10^9$

Table 7.4: *Loss of future subsidies for different generations when doorsneesystematiek is abolished, expressed as percentage of their current pension giving wage. Macro compensation costs expressed in euros. All parameters base case, except for the wage inflation. Benefits valued as if they are a nominal guarantee.*

Demography

The next variable which must be considered, is the demography of the fund. It turns out that changing the inflow of young workers in the pension fund has no impact at all on this measure for the transition loss. The inflow works through the contribution which matters for the premievrijval and the Aaron condition, but in case of a nominal guarantee it does not matter for the loss per generation as defined in this chapter.

Changing the initial demography also does not have an impact on the loss per cohort, it does however change macro compensation costs because workers of 45 or 55 years old require more compensation than workers of 35 or 60 years old. When I assume a flat initial population instead of an approximation of the real Dutch population, the macro compensation costs decrease with approximately 1 billion euro. The Dutch population namely has relatively many people in their fifties who require a high compensation. Hence, for the Netherlands as a whole the demography is not a key variable for this problem, but on pension fund level it can have a significant impact.

Risk free interest rate

The last variable of which I consider the impact on the transition in case of a nominal guarantee, is the risk free interest rate. For the impact of the interest rate, I also consider the real guarantee contract, because this method is used in the analysis of the CPB (2015)[15]. A plot of the macro compensation costs for different fixed interest rates (flat term structure) can be found in figure 7.2. The red line is based on a nominal guarantee and the assumptions in table 7.1. The blue line is based on a real guarantee (fixed indexation of 2.5%) and the base case parameters, except for $i_w = 0.03$ and $\alpha_U = 0.01825$. These adjusted parameter values match the report of CPB (2015)[15].

The most important observation from figure 7.2 is that the macro compensation costs have a maximum in the interest rate. In a simplified version of the model, it can be proven analytically that this maximum indeed exists and that the location of the maximum in this figure is plausible. For the proof see appendix E.

For the nominal guarantee the maximum is approximately 84 billion euros and lies at 3.5%. This result deviates somewhat from the 4.5% which was found in the simplified model in the appendix. However, given the fact that this figure contains forty working generations instead of two, this difference is not surprising and the results based on forty working generations should be seen as the main results. Furthermore the figure shows that the macro compensation costs are most sensitive to the interest rate for low interest rates, while around the maximum the sensitivity is low. This also explains the conclusion of the sensitivity analysis in CPB (2015) [15], which claims that the results are relatively insensitive to the interest rate; they simply

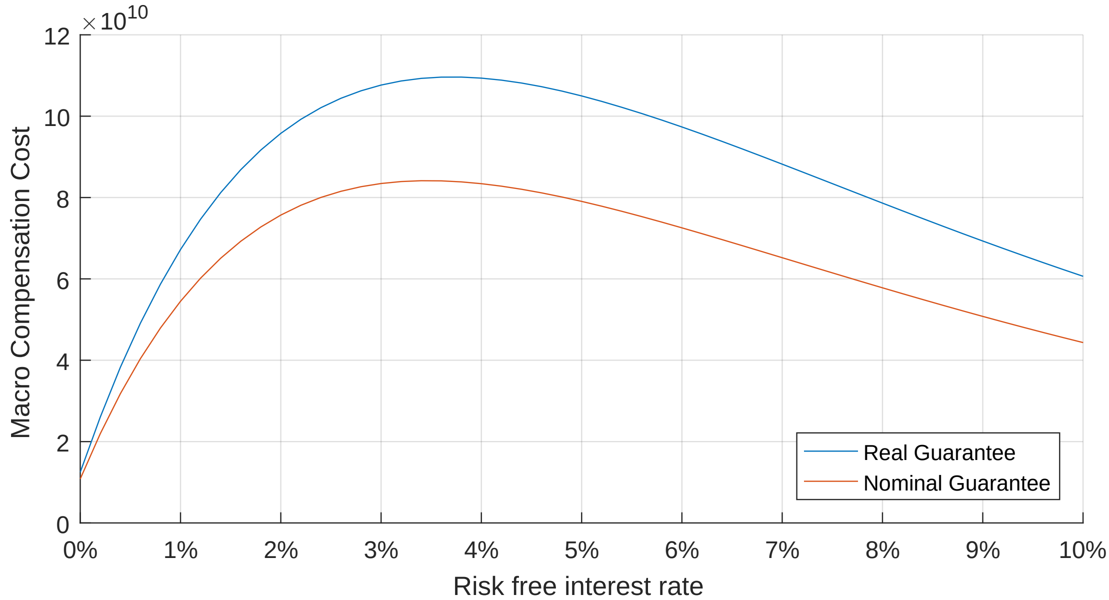

Figure 7.2: *Macro Compensation Costs as function of the interest rate. All parameters base case, except for the interest rate.*

did not consider low values for the interest rate.

The blue line in figure 7.2 corresponds to the CPB analysis, because they assumed a guaranteed indexation. It is difficult to tell from this paper which methodology is used for valuing the accrual and discounting future cashflows and whether it corresponds to the methods used in this chapter. Furthermore, it is difficult to interpret from the paper whether they discount by 3% or 5%, but in either case the values in figure 7.2 lie not too far from their estimate of 102 billion euros.

Finally, it is noteworthy that the macro compensation costs are not zero when the interest rate is zero. This can be explained by the non-zero probability of dying before retirement, which makes accrual cheaper for a 25-year old than for a 64-year old. When it is assumed that people can only die after retirement, then the macro compensation costs become indeed equal to zero in case of an interest rate of 0%.

To find out how the impact of the interest rate is divided over the different generations, I plotted the loss for each age group for different interest rates in figure 7.3. This graph shows that the age group which has the greatest transition loss does depend on the interest rate, but that the pattern remains roughly the same. For very high interest rates (five and six percent), the top shifts more to high ages due to the strong

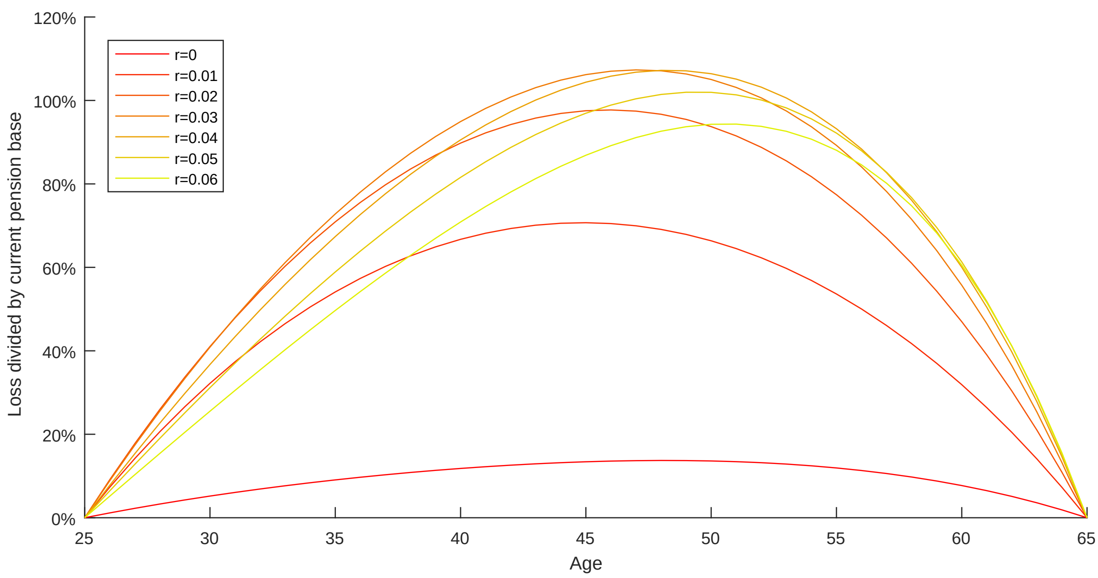

Figure 7.3: *Loss expressed as percentage of average lifetime wage for different ages and interest rates*

effect of discounting. The distance between the lines shows again that the sensitivity to the interest rate is much larger for low interest rates, than for high interest rates.

Presenting the results in euros would present the same picture, with different values on the y-axis. The current pension giving wage namely, is independent of the interest rate in my model.

7.5.1 Sensitivity to the starting funding ratio

Instead of valuing the nominal guarantee, it is also possible to use the value of the accrual under the nFTK. This methodology requires more assumptions and is more fund specific. Table 7.5 shows the impact of the funding ratio on the compensation to different generations. The starting funding ratio has only a small impact on the macro compensation cost, but the distribution of the costs over the cohorts changes significantly.

Old workers only receive subsidies, those are more valuable in case of a higher starting funding ratio. Young workers on the other hand first have to pay subsidies and only receive subsidies later. The subsidies which they receive in the future are relatively insensitive to the starting funding ratio, due to the converging impact of the nFTK on the funding ratio. The subsidies which they pay are sensitive to the starting funding ratio, and therefore abolishing the doorsneesystematiek is less attractive for young participants in case of a low funding ratio.

Using the value of accrual under the nFTK can therefore lead to very high compensations for individuals who have paid yet little or no doorsneesystematiek subsidies at all.

	25	35	45	55	65	MMC_{t_0}
$F_{t_0} = 0.80$	22%	70%	80%	54%	0%	$63 \cdot 10^9$
$F_{t_0} = 0.90$	15%	67%	81%	58%	0%	$64 \cdot 10^9$
$F_{t_0} = 1.00$	10%	64%	81%	62%	0%	$64 \cdot 10^9$
$F_{t_0} = 1.10$	4%	61%	82%	66%	0%	$65 \cdot 10^9$
$F_{t_0} = 1.20$	-1%	59%	83%	69%	0%	$65 \cdot 10^9$

Table 7.5: *Loss for different generations expressed as percentage of their average lifetime wage*

7.6 Conclusion

In this chapter the compensation costs for abolishing the doorsneesystematiek have been discussed. This discussion has shown that there are multiple definitions possible for the compensation costs and that the outcomes depend strongly on parameters, especially on the interest rate. In this section I will highlight the most important findings and discuss the pros and cons of different compensation techniques or definitions of the loss.

I have already argued (see section 7.3) that the compensation costs for abolishing the doorsneesystematiek ought to be defined as the value of the sum of the missed future accrual and that the change in contribution should be ignored. Within this definition the question remains, how to value these rights? Three alternatives have been considered, the nominal guarantee, the economic value and the real guarantee. Based on the results of this chapter, the nominal guarantee is the most practical measure to value the rights.

The nominal guarantee has some useful properties: it is easy to calculate, easy to explain and it is in line with the nominal promise which has been made by the pension funds. A disadvantage of the nominal guarantee is that it does not take the financial position of the fund into account. An alternative which does take this into account is the economic value of the subsidies.

Technically, using the economic value of the subsidies is the best option when purely the prospective approach is considered. However, a consequence of this alternative, is that the loss for a 25-year old may deviate significantly from zero (see for example table 7.5). Taking into account that one of the main reasons to compensate people if the doorsneesystematiek is abolished, is to compensate individuals for subsidies paid in the past, this outcome is undesirable. In other words, the retrospective approach should not be entirely ignored and therefore someone who has not yet paid any, or only very little, subsidies (the 25-year old in this model) should not receive a positive or negative compensation when the doorsneesystematiek is abolished. And, if one would give this compensation to the 25-year old, should not also the 24-year old who is not yet in the fund receive a compensation?

The real guarantee is included because it is considered in multiple reports, see for example CPB (2013)[16]. However, from a technical point of view it is problematic. The real guarantee namely implies that either the pension fund can structurally outperform the market or it has a large sponsor. When this is indeed the case, abolishing the doorsneesystematiek is very attractive for young participants, but if the guarantee does not hold this method could therefore give a strong overestimation. Given that most pension funds in the Netherlands have barely been able to give indexation over the past decade, that most of them do not have an external sponsor and that they in general have an ambition instead of a promise to index rights, the real guarantee does not seem to match the current practice.

Hence, considering these alternatives, the nominal guarantee is the preferred choice. The decisive argument is that it does not create a discontinuity between the young people who are about to start working and those who have just started working. In the meantime it still gives a good approximation of the economic value.

Based on this definition for the compensation costs, the macro compensation costs for the sector can be calculated. The main conclusion from these calculations is that the compensation costs for the doorsneesystematiek have a maximum in the risk free rate of approximately 83 billion at 3.5%. the sensitivity of the compensation costs to the risk free rate is very low near the maximum and relatively high between a risk free rate of 0% and 1%. In any case, the calculations show that the often quoted amount of 100 billion euros is an overestimation. This overestimation is caused by assuming a real guarantee instead of a nominal guarantee and choosing an interest rate very near to the maximum.

In the next chapter, the nominal guarantee will be the default choice when the compensation for doorsneesystematiek is considered. In that chapters the insights of both transition problems will be put together, to find out if there are any advantages to combining the two transitions in a double transition.

8 Double Transition

In the chapters above I have discussed two transition problems separately. If indeed both transitions will take place, then it would be interesting to consider the impact of taking them together. This is the so-called double transition.

The main research question with respect to the double transition is: does a transition to one of the discussed SER variants compensate for the losses due to abolishing the doorsneesystematiek, assuming that the transition takes place without transfers in rights? The underlying hypothesis behind this question is that the new contract would be beneficial to the generations that suffer most from abolishing the doorsneesystematiek. In chapter 5 it has been shown that a transition to a new pension contract indeed leads to a value increase for current generations, when in the new contract less buffers will be built up. In case of a transition without transfers in nominal rights the value changes are distributed unequally. This chapter will compare this distribution with the distribution of the losses due to abolishing the doorsneesystematiek.

In this chapter the focus lies on a transition to 4A or 1B based on nominal rights. These results will in general not hold for a transition to 4C. For that case the value of rights under the new contract will be lower due to the buffer which must be built up in variant 4C.

Section 8.1 will discuss the double transition for a base case fund, after which in section 8.2 the sensitivity to economic parameters and heterogeneity between funds will be analyzed.

8.1 Base case

In this section the transition will be considered for the base case.

8.1.1 Assumptions and definitions

The assumptions made in the previous chapters still hold and also the definition of the transition costs is in line with the conclusions from these chapters.

For the transition to a new contract, as discussed in chapter 5, only the transition based on nominal rights is considered. The value redistribution caused by the transition will only be calculated for existing rights; this choice is consistent with chapter 5.

To calculate the loss for an individual when the doorsneesystematiek is abolished, the prospective approach based on nominal rights is chosen. Based on the conclusion of the previous chapter, nominal rights is the only alternative which treats the youngest workers and new young workers equally. The prospective approach is contradictory to the choice to calculate only the change in economic value of existing accrual. However, because it is in essence still a compensation for subsidies paid in the past, this contradiction will be left in place.

8.1.2 Parameters

The same base case parameters are used as in the previous chapters (see tables 4.1, 5.3 and 7.1)[1]. Based on these parameters both the value transfer in case of a transition based on nominal rights and the compensation costs for abolishing the doorsneesystematiek can be calculated. Both results are expressed in euros.

A consequence of denoting the outcomes in euros is that the same results as presented earlier will look different. A large relative change for young workers turns out to be small in absolute terms because they have not built up that many rights yet.

8.1.3 Results

Figure 7.3 shows both the loss due to abolishing the doorsneesystematiek and the increase in economic value due to a transition without transfer in nominal rights. The yellow line shows the net impact of the double transition.

Hence, this graph shows that the benefits of the transition to a new system do not perfectly match the loss due to abolishing the doorsneesystematiek. The retirees for example are by definition not impacted by abolishing the doorsneesystematiek, but win in this case from the transition to a new contract. Workers are affected by both transitions, but for most of them the loss of abolishing the doorsneesystematiek is in this

[1] Some parameters occur in multiple of these tables, but in that case the values are consistent.

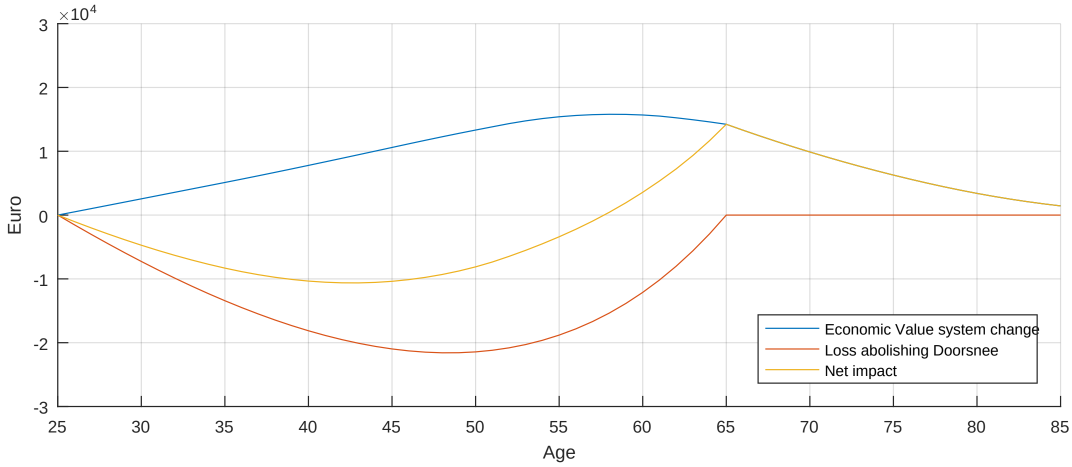

Figure 8.1: *Impact of the two transitions on different generations expressed in euros. The blue line is the improvement in economic value of existing accrual of an individual in a transition from nFTK to 4A or 1B in a base case fund. The red line is the loss of an individual when the doorsneesystematiek is abolished and the yellow line the net impact of the double transition. Base case parameters for both transitions.*

case larger than the benefits of a transition to a new contract. For old workers the impact of the change of contract is largest, because they have already built up a large amount of accrual, but do not have much protection against cuts yet. As explained in the previous chapter, the workers in mid career are hurt most when the doorsneesystematiek is abolished. The net impact (present value) for workers between 40 and 45 years is in this case a loss of 10000 euros and this is an economically significant amount as it represents approximately 4% of the total pension benefit (assuming a full career) for these individuals.

Thus, the conclusion in the base case is that the double transition is able to mitigate the negative impact of abolishing the doorsneesystematiek, but that there still is significant intergenerational redistribution. Based on these results it is necessary to give an explicit compensation for abolishing the doorsneesystematiek. Whether this compensation ought to be financed by higher contributions, the profits of the transition to a new contract, or an external sponsor is left for future research.

This conclusion could be different for other economic parameters and the double transition may work better for some funds than for others. This is the topic of the next section.

8.2 Sensitivity analysis

The results in figure 7.3 depend on multiple parameters. This section examines the robustness of the conclusions to changes in these parameters. To limit the amount of results, and given that multiple effects could occur at the same time, I will focus on the intuition and not publish tables or figures in all cases.

8.2.1 Interest rate

One of the most important variables in this case is the interest rate. It has been shown that the loss in case of abolishing the doorsneesystematiek is increasing in the interest rate[2]. This means that the red line will lie closer to zero for low interest rates and will be more negative for high interest rates.

For the transition to a new contract, the interest rate only matters as discount factor, but does not affect the probabilities of cuts and indexation in this model. Given the long duration of the benefits, this is especially for young participants an important factor. In case of a lower interest rate, all future benefits increase in value. Hence, the blue line will lie higher for low interest rates and lower for high interest rates. This means that the interest rate has an opposite effect on both transitions. As a consequence, the double transition works better for low interest rates than for high interest rates.

The size of these effects can be seen in figure 8.2, which shows on the left the case $r_f = 0.5\%$ and on the right $r_f = 2.5\%$. These two results deviate significantly from the base case presented in figure 8.1. When $r_f = 0.5\%$ the change of contract fully compensates the losses due to abolishing the doorsneesystematiek. Some generations profit more from the double transition than others, but this can partly be explained by the larger accrual which they have. So in this case the double transition yields more balanced results than

[2]Given the current low interest rates the maximum of the compensation costs is not relevant now as it lies above 3%.

when $r_f = 1.5\%$. When on the other hand $r_f = 2.5\%$, the losses for the working generations are even higher than when $r_f = 1.5\%$ and the double transition therefore leads to more intergenerational redistribution.

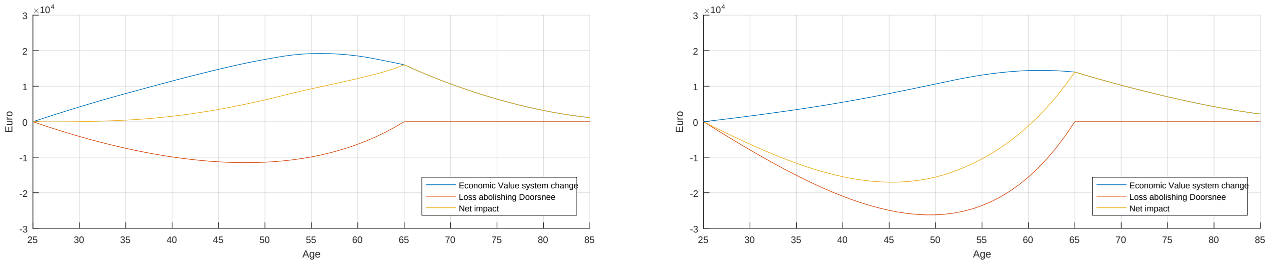

Figure 8.2: *Impact of the two transitions on different generations expressed in euros. The blue line is the improvement in economic value of existing accrual of an individual in a transition from nFTK to 4A or 1B in a base case fund. The red line is the loss of an individual when the doorsneesystematiek is abolished and the yellow line the net impact of the double transition. Base case parameters for both transitions, except for interest rate. In the left graph* $r_f = 0.5\%$ *and in the right one* $r_f = 2.5\%$

8.2.2 Initial funding ratio

A consequence of using the nominal rights approach for the compensation costs of abolishing the doorsneesystematiek, is that the initial funding ratio does not impact the compensation cost. For the redistribution in case of a change of contract, the initial funding ratio does have a large impact. That means that when the initial funding ratio is changed, the blue line moves, while the red line remains in place. Similarly, also the equity exposure of the fund and the funding ratio of the contribution only affect the blue line.

For the impact of these variables, see chapter 6. These results are not denoted in euros, but they give the intuition in which direction the blue line will move.

Based on calculation of the double transition for different values of these parameters, the qualitative conclusions with respect to the effectiveness of the double transition turn out to be strongly fund dependent. This is in line with the results presented in chapter 6.

8.2.3 Demography

The demography of the fund can impact both transition problems. This subject has been briefly touched upon in earlier chapters, but does require more extensive research for hard conclusions.

Note, however, that given the definition of the compensation costs for abolishing the doorsneesystematiek used in this thesis, the compensation for an individual does not depend on the demography of the fund. In this definition, the contribution rate namely plays no role. Hence, the red line will be the same for funds with a different demography, ceteris paribus. It could be the case, though, that funds might have to change their contribution rate when the doorsneesystematiek is abolished. Green funds will need to raise their contribution rate, while gray funds can lower it.

8.3 Conclusion

This chapter has shown that the intuition behind the double transition makes sense, but that the match between the two transitions is not perfect and depends both on the interest rate and on the characteristics of the pension fund.

In general, the double transition will work best in case of low interest rates, because in that case the compensation costs for abolishing the doorsneesystematiek are relatively low and the value of future benefits is relatively high. In case of higher interest rates, the double transition is in general insufficient and explicit compensation for abolishing the doorsneesystematiek would be needed.

However, knowing the interest rate is necessary but not sufficient information to judge whether the double transition will work. The redistribution of economic value due to the change of contract is strongly fund specific, which implies that the double transition cannot be judged on the sector level.

To decide the exact impact of all fund specific parameters it will be necessary to calculate both the compensation costs for abolishing the doorsneesystematiek and the value distribution due to the change of contract for each fund separately. Else, making use of the double transition could accidentally lead to significant intergenerational redistribution, even when this would not be the case for the average fund.

9 Conclusion

The outcome of the pension discussion is still uncertain, but if the reforms that are considered would be executed, the Dutch pension system would change substantially.

This thesis has shown that regardless of which pension system is chosen, the transition could lead to significant redistribution between generations. Analyzing the outcomes and compensating the losers could help to create a more balanced transition. Given the size of the potential reforms and the distributional impact these choices deserve serious deliberation.

Distribution of value in the current contract

Building up the required buffer in the current contract costs value for the current participants. Old workers pay the largest share of these costs, since retirees are better protected against cuts and young workers have built up less rights yet. This conclusion is based on a pension fund which has no initial buffer and where the contributions do not contribute to building up a buffer. Then, the current participants will in good times only get indexation after the buffer is built up, while in bad times the shortage will be fully solved with cuts. That is, they have full downside, but limited upside from risk taking. Calculations show that this indeed leads to an economic value of existing rights which lies below the economic value of a nominal guarantee with the same size.

In building up the buffer, the cut to MVEV plays a crucial role. Without this rule, shortages could be sustained for an indefinite period of time. Though discontinuity risk is not modeled in this thesis, it is likely that this risk would be higher without the cut to MVEV. This is also a potential weakness of SER variant 1B, since this system has no mechanism similar to the cut to MVEV. To find out whether this is indeed the case, more research is needed.

The Pensioenfederatie (2016)[20] found a large sensitivity of their results to the interpretation of the contract in good scenarios. In this thesis it is argued that high buffers (above 150%) in the current system, will most likely be used to lower the contribution rate. Alternative assumptions could be that they are used for bonus indexation or not at all. The value of the benefits in this thesis turns out to be relative insensitive to this assumption. This difference with the findings of the Pensioenfederatie could depend on multiple factors. First, adding stochastic interest rates as risk factor could make the outcomes more volatile and thereby high funding ratios more likely. Secondly, their scenarios contain risk premiums which make high buffers much more likely.

Transition to a new contract

In SER variants 4A and 1B there is no longer the obligation to build up a buffer, while in variant 4C it is still necessary to build up a buffer. Therefore, a transition to 4A or 1B is more attractive for current participants than a transition to 4C. How the advantage of not longer building up a buffer is distributed over the generations, depends on the transition method. In case of a transition based on nominal rights, old workers benefit most. This is a direct consequence of the fact that they pay most for building up the buffer.

The impact of a transition to 4C largely depends on the maximum size of the buffer. When for example the maximum size is 20% of total assets, current generations will not benefit in value terms from the transition. In case of a smaller buffer the transition will be more beneficial to current generations, while building up a larger buffer leads to a loss. Note that it is assumed that the initial buffer is empty. When a pension fund has a high funding ratio at the transition date, it could consider to start with a positive buffer in 4C, this would lead to different results.

When there is an initial shortage, the transition would become more difficult. In variant 1B it is possible to start with a shortage, but in 4A this is not the case. Solving the shortage by a direct uniform cut in rights would lead to much bigger transition losses for retirees than for younger participants. An alternative could be to spread the cut over multiple years. In this case retirees would be better protected and the value distribution would be more in line with the distribution under the current contract.

It is also possible to adjust the rights after the transition based on the value distribution in the old and new contract. This is a relevant benchmark as it is by definition the method which minimizes redistribution in economic value.

Finally, also the impact on the next benefit for retirees can be calculated. This does of course depend on the initial funding ratio and how the assets are distributed. In variants 4A and 4C, it is possible to customize the benefit profile over retirement, which can lead to a higher immediate indexation. The trade-off is that this leads to lower expectations for future pension increases, as there is no free lunch.

Heterogeneity

The impact of heterogeneity on the results is substantial. The main variables which matter are the initial funding ratio, equity exposure, demography (green versus gray fund) and funding ratio of the contribution[1]. Not only the separate effect of these variables matters, but there are also consequences of certain combinations. For example, in a green fund the impact of a low funding ratio of the contribution will be larger than in a gray fund. This thesis gives some of the largest effects, but in the end an analysis for each fund separately will be needed.

Perhaps the most interesting result from this analysis is that the funding ratio of the contribution does matter in the long run. Structurally charging a low contribution rate erodes the existing rights. This policy favors young and new participants at the expense of old workers and retirees. To better balance the interests of different generations, one could consider to make stricter contribution rules for funds that are in recovery.

Abolishing the doorsneesystematiek

The total compensation costs for abolishing the doorsneesystematiek will be less than 100 billion euros. First of all, it has been shown that these costs are highly sensitive to the risk free rate, and that using a risk free rate closer to the current interest rates will lead to substantially lower estimates. Secondly, the often quoted amount of 100 billion euro is based on the assumption of a guaranteed indexation of benefits. Since this would require either structural outperformance of the market or an external risk bearer, this assumption is rejected. Assuming a nominal guarantee instead, or applying market valuation, will lead to lower compensation costs. These two effects can be seen in figure 7.2. How to take into account the term structure and forward rates remains a question for future research. Furthermore, the impact of heterogeneity between funds on the results is non-trivial

The calculations with respect to the doorsneesystematiek explicitly do not take the change in contribution rates into account. Abolishing the doorsneesystematiek could lead to lower contribution rates. When these are used to make the transition cheaper, the transition will take longer in the sense that current generations will not benefit of the lower contribution rates. Besides, given the current low interest rates, the difference in contribution rates with and without doorsneesystematiek is likely to be small. In practice it may for many funds also be needed to repair the above mentioned funding ratio of the contribution.

Double transition

The double transition reduces the redistribution for a transition to 4A or 1B, though the loss for participants in mid career could still be significant. The double transition does not work for a transition to 4C.

When the transition to variant 4A or 1B is based on nominal rights and the doorsneesystematiek is abolished without compensation for working participants, the impact of both transitions works in opposite directions. The increase in value of not longer having to build up a buffer partly compensates for the loss of future doorsneesystematiek subsidies. The compensation works best in case of low interest rates (for example 0.5%), but is probably insufficient in case of higher rates. Besides, heterogeneity will also in this case have a large impact and calculations on a per fund basis remain necessary.

Especially workers in mid career could lose in a double transition. When for example the interest rate is 1.5% and a base case fund is considered, their net loss could amount up to 4% of pension benefits.

The difference for a double transition to 4C is that in this system also a buffer must be built up. Most of this buffer will be financed by middle aged and old workers and young retirees. Abolishing the doorsneesystematiek leads to large losses for workers in mid career. When a large buffer is allowed in 4C, middle aged and older workers will face a double loss. Hence, the double transition does not work for a transition to 4C.

Based on these results it is necessary to give explicit compensation for abolishing the doorsneesystematiek in case of a double transition to variant 4C. For a double transition to one of the other variants it depends on the fund specific results and the redistribution which is deemed acceptable, whether explicit compensation is needed.

Considerations

Consider a smaller buffer in variant 4C

The Pensioenfederatie (2016)[20] assumes a buffer which has a maximum size of 20% of the total assets in the pension fund. Based on the calculations in this thesis, the intergenerational effects of building up such a buffer are substantial. Therefore, it could be considered to use a smaller buffer, for example maximal 10%, to

[1] In practice also the interest rate hedge matters, this lies outside the scope of this thesis.

balance the interests of different generations. Besides, it seems counterintuitive to define a buffer for equity risk as the percentage of total assets in the fund. The exposure to equity will differ between funds. Instead, the maximum buffer could be chosen as a percentage of the amount invested in equity.

Put a higher minimum on the contribution rates
In the current system pension funds are allowed to set the contribution rate below the cost price of new rights. This has a direct negative impact on the funding ratio and when this policy is sustained, it leads to a significantly lower value of existing rights. In short, this policy is not in line with the nominal promise made by the pension fund. Therefore, it could be considered to limit the ability of pension funds that are in recovery to lower the contribution rates.

Future Research
Multiple risk factors
This thesis has focused on one risk factor, namely equity risk. With this approach the working of the embedded options of the current contracts and the SER variants have been shown. However, it is unknown what the impact of taking into account multiple risk factors would be. Therefore, future research on this topic, and especially interest rate risk could be very interesting.

Term structure of the interest rate for doorsneesystematiek calculations
With respect to the doorsneesystematiek it has been shown that the interest rate has a large impact on the results. Therefore, future research could consider how interest rate term structures and forward rates should be implemented. For these calculations, an important question is how the contribution for degressive accrual is determined when interest rates change over time. Should generations who face different interest rates during their life pay the same contribution rate?

Fund specific calculations
To determine the value distribution under the current contract, more fund specific calculations are needed. Especially in case of a deviating demography, or path specific policy of the pension fund this could lead to new insights. When this is done for multiple pension funds, it is essential that all funds use the same economic assumptions and parameters (preferably the same scenario set). Else it will not be possible to distinguish the impact of economic assumptions and heterogeneity. Also for the impact of the double transition more fund specific calculations are needed.

Discontinuity risk
This thesis has shown that the MVEV cut is a strong mechanism to prevent structural deficits. Without such a mechanism shortages may be sustained for a longer period of time, which could lead to a much larger discontinuity risk. Since SER variant 1B does not contain a mechanism similar to the MVEV cut it could be worthwhile to research the discontinuity risk in this system. This research should especially look at gray funds, since these are most vulnerable to a downward spiral: when the funding ratio lies below 100%, paying out benefits has a negative impact on the funding ratio, which makes the impact of the next pay out even larger. An illustration of this effect can be found in Kocken and Potters (2010)[13].

References

[1] H. Aaron, "The social insurance paradox", Canadian Journal of Economics and Political Science/Revue canadienne de economiques et science politique **32**, 371–374 (1966).

[2] Actuarieel Genootschap, *Prognosetafel ag2016*.

[3] A. Balter, and B. Werker, "Variable annuities in the dutch pension system", Netspar Industry Papers (2016).

[4] I. van den Berg, J. van Egmond, M. Tielen, S. Vermeulen, and H. Vleeming, *Afschaffen van de doorsneesystematiek*, tech. rep. (Netspar, 2014).

[5] T. Boeijen, C. Jansen, C. Kortleve, and J. Tamerus, "Leeftijdsolidariteit in de doorsneepremie", in *Kosten en baten van collectieve pensioensystemen*, edited by F. Van der Lecq, and O. Steenbeek, (Kluwer, 2006), pp. 147–165.

[6] L. Bovenberg, and T. Nijman, "Personal pensions with risk sharing", Netspar Discussion Papers (2015).

[7] D. Chen, and W. Romp, "Modelling pension fund regulation and stability", PhD thesis (University of Amsterdam, 2015).

[8] Commissie Toekomst Pensioenstelsel, *Advies toekomst pensioenstelsel*, tech. rep. (SER, 2015).

[9] Commissie Toekomst Pensioenstelsel, *Persoonlijk pensioenvermogen met collectieve risicodeling*, tech. rep. (SER, 2016).

[10] A. P. Deelen, "Wage-tenure profiles and mobility", De Economist **160**, 141–155 (2012).

[11] K. Goudswaard, "Hoe ziet het nederlandse pensioenstelsel er in de toekomst uit", Tijdschrift voor Openbare Financiën **45**, 61–74 (2013).

[12] J. Klijnsma, "Perspectiefnota toekomst pensioenstelsel", Kamerbrief (2016).

[13] T. Kocken, and J. Potters, "Sinking giants", Life & Pensions, May (2010).

[14] T. Langejan, G. Gelauff, T. Nijman, O. Sleijpen, and O. Steenbeek, *Advies commissie parameters*, tech. rep. (Technical report, SZW, 2014).

[15] M. Lever, and J. Bonenkamp, *Transitie doorsneesystematiek: een kwantitatieve analyse*, tech. rep. (CPB, 2015).

[16] M. Lever, J. Bonenkamp, and R. Cox, *Voor- en nadelen van de doorsneesystematiek*, tech. rep. (CPB, 2013).

[17] M. Lever, and T. Michielsen, *Ser-varianten toekomstig stelsel: een alm-analyse*, tech. rep. (CPB, 2016).

[18] R. C. Merton, "Lifetime portfolio selection under uncertainty: the continuous-time case", The review of Economics and Statistics, 247–257 (1969).

[19] T. Nijman, S. Van Stalborch, J. Van Toor, and B. Werker, "Formalizing the new dutch pension contract", Netspar Occasional Papers (2013).

[20] J. Tamerus, and et al. (Commissie Toekomst Pensioenstelsel), *Financieel pensioenresultaat*, tech. rep. (Pensioenfederatie, 2016).

[21] Werkgroep Doorsneepremie, *Doorsneesystematiek, veranderen of behouden?*, tech. rep. (AG, 2014).

A Extra tables and graphs

	25	35	45	55	65	75	85	95
$\phi = 0.00$	109%	109%	109%	108%	106%	105%	103%	102%
$\phi = 0.25$	110%	110%	110%	110%	107%	106%	104%	102%
$\phi = 0.50$	103%	105%	107%	109%	108%	107%	105%	102%
$\phi = 0.75$	90%	94%	99%	104%	106%	107%	106%	103%
$\phi = 1.00$	72%	78%	85%	94%	101%	103%	104%	102%

Table A.1: *Economic value of existing accrual relative to nominal guarantee. All parameters, except for the equity exposure and the starting funding ratio, are the base case. Starting funding ratio is* $F_0 = 1.20$.

	25	35	45	55	65	75	85	95
$\phi = 0.00$	123%	123%	122%	121%	119%	118%	116%	114%
$\phi = 0.25$	122%	122%	123%	122%	119%	117%	115%	113%
$\phi = 0.50$	115%	117%	119%	121%	120%	119%	117%	114%
$\phi = 0.75$	103%	108%	114%	120%	122%	123%	122%	118%
$\phi = 1.00$	89%	97%	106%	117%	125%	128%	129%	127%

Table A.2: *Economic value of existing accrual relative to nominal guarantee after the transition, in case a transition to 4A is performed based on economic value. All parameters, except for the equity exposure and the starting funding ratio, are the base case. Starting funding ratio is* $F_0 = 1.20$.

	F_{t_0}	25	35	45	55	65	75	85	95
Green	80%	88%	86%	84%	83%	88%	90%	94%	99%
Standard	80%	82%	81%	79%	79%	86%	89%	93%	98%
Gray	80%	77%	76%	75%	75%	83%	86%	92%	98%
Green	100%	107%	104%	102%	100%	100%	100%	100%	100%
Standard	100%	104%	102%	100%	99%	99%	99%	100%	100%
Gray	100%	101%	99%	97%	97%	98%	98%	99%	100%
Green	120%	124%	121%	118%	116%	110%	108%	106%	102%
Standard	120%	123%	120%	118%	116%	111%	109%	106%	102%
Gray	120%	124%	121%	118%	116%	111%	109%	106%	102%

Table A.3: *Economic value of existing accrual relative to a nominal guarantee. All parameters, except for the in- and outflow, initial funding ratio and the funding ratio of the contribution, are the base case. The initial funding ratio is 80% in the upper part, 100% in the middle and 120% in the lower part. The funding ratio of the contribution is 120%.*

	F_{t_0}	25	35	45	55	65	75	85	95
Green	80%	51%	55%	61%	67%	79%	84%	91%	97%
Standard	80%	54%	58%	62%	67%	79%	84%	91%	97%
Gray	80%	59%	61%	63%	67%	79%	84%	90%	97%
Green	100%	63%	69%	75%	83%	91%	94%	97%	100%
Standard	100%	70%	74%	79%	85%	92%	95%	98%	100%
Gray	100%	78%	81%	84%	88%	93%	96%	98%	100%
Green	120%	75%	82%	90%	97%	102%	103%	103%	102%
Standard	120%	85%	90%	96%	102%	104%	105%	104%	102%
Gray	120%	98%	100%	104%	107%	107%	107%	105%	102%

Table A.4: *Economic value of existing accrual relative to a nominal guarantee. All parameters, except for the in- and outflow, initial funding ratio and the funding ratio of the contribution, are the base case. The initial funding ratio is 80% in the upper part, 100% in the middle and 120% in the lower part. The funding ratio of the contribution is 80%.*

B Add in- and outflow to funding ratio

In this appendix equation 3.2.3 is derived. The notation is the same as in the main text: F_t is the funding ratio, A_t the assets, L_t the liabilities, α_1 the relative size of the inflow and α_2 the relative size of the outflow. The superscripts 'in' and 'out' are used to distinguish the in- and outflowing assets and liabilities from the existing ones (the only exception is that instead of F_t^{in}, F_t^{contr} is used. The formula for the alphas is:

$$\alpha_{1,t} := \frac{L_t^{\text{in}}}{L_t} \qquad \alpha_{2,t} := \frac{L_t^{\text{out}}}{L_t}$$

The funding ratio is defined as the ratio of assets and liabilities, so after in- and outflow the new funding ratio will be:

$$F_t^{\text{new}} = \frac{A_t + A_t^{\text{in}} - A_t^{\text{out}}}{L_t + L_t^{\text{in}} - L_t^{\text{out}}}$$

The funding ratio of the in- and outflow is also as the ratio between assets and liabilities. Therefore $A_t^{\text{in}} = L_t^{\text{in}} \cdot F_t^{\text{contr}}$ and $A_t^{\text{out}} = L_t^{\text{out}} \cdot F_t^{\text{out}}$. Plugging this in gives:

$$F_t^{\text{new}} = \frac{L_t \cdot F_t + L_t^{\text{in}} \cdot F_t^{\text{contr}} - L_t^{\text{out}} \cdot F_t^{\text{out}}}{L_t + L_t^{\text{in}} - L_t^{\text{out}}}$$

The next step is to make use of the definition of α_1 and α_2 and to replace L_t^{in} and L_t^{out}:

$$F_t^{\text{new}} = \frac{L_t \cdot F_t + \alpha_{1,t} L_t \cdot F_t^{\text{contr}} - \alpha_{2,t} L_t \cdot F_t^{\text{out}}}{L_t + \alpha_{1,t} L_t - \alpha_{2,t} L_t}$$

Now L_t can be taken out of the numerator and denominator and cancels out. This leads to the following formula for the new funding ratio:

$$F_t^{\text{new}} = \frac{F_t + \alpha_{1,t} F_t^{\text{contr}} - \alpha_{2,t} F_t^{\text{out}}}{1 + \alpha_{1,t} - \alpha_{2,t}}$$

This result is indeed equal to equation 3.2.3. Finally, note that when $\alpha_{1,t}, \alpha_{2,t}, F_t^{\text{contr}}, F_t^{\text{out}}$ are given, then this means that $L_t^{\text{in}}, L_t^{\text{out}}, A_t^{\text{in}}, A_t^{\text{out}}$ are no free variables, but follow uniquely from the chosen parameters and the value of L_t.

C Value new accrual

In this appendix the formulas for the economic value, the cut and indexation factor and annuities of new accrual are given. These formulas form an extension of those used in section 4.2 and are necessary to calculate the economic value of benefits under the nFTK in chapter 7.

Let $t_0 \leq t_1 \leq t_2$ and assume that an individual contributes to the pension fund at time t_1 and will receive his benefits at time t_2, then the formulas below will give the value of this benefit at time t_0. Note that t_1, t_2 must be end of period. Assume t_0 is end of period as well (and use a year extra discounting if not). The intuition behind the results is omitted and can be found in section 4.2. Denote by $B_{t_2}^{t_1}$ the size of a benefit at $t_2 \geq t_1$, when the contribution is paid at t_1. Denote the value of such a benefit which is paid out at t_2 by $V_{t_0}^{t_1,t_2}$ Again use the risk neutral pricing formula:

$$V_{t_0}^{t_1,t_2} = (1+r_f)^{-(t_2-t_0)}\mathbb{E}_{t_0}^{\mathbb{Q}}[B_{t_2}^{t_1}] \qquad t_0 \leq t_1 \leq t_2$$

This leads to the following formula for the value of benefits under a hard nominal contract (NG):

$$V_{t_0}^{t_1,t_2}(\text{NG, 100}) = (1+r_f)^{-(t_2-t_0)}\mathbb{E}_{t_0}^{\mathbb{Q}}[B_{t_2}^{t_1}] = (1+r_f)^{-(t_2-t_0)} \qquad t_0 \leq t_1 \leq t_2$$

The indexation and cut factor, ξ, is defined by:

$$\xi_{t_0}^{t_1,t_2}(\text{Contract}, F_0) := \frac{B_{t_0}^{t_1,t_2}(\text{C}, FR_0)}{V_{t_0}^{t_1,t_2}(\text{NG, 100})} = V_{t_0}^{t_1,t_2}(\text{C}, F_0)\cdot(1+r_f)^{-(t_2-t_0)} = \mathbb{E}_{t_0}^{\mathbb{Q}}[V_{t_2}^{t_1,t_2}(\text{C}, F_0)]$$

Alternatively, I can again find ξ by first defining Ξ:

$$\Xi^{t_1,t_2}(\omega) = \prod_{t=t_1}^{t_2-1}(1+i_t(\omega))(1+c_{1,t}(\omega))(1+c_{2,t}(\omega)) \qquad t_1 < t_2$$

And then taking the risk neutral expectation:

$$\xi_{t_0}^{t_1,t_2} := \mathbb{E}_{t_0}^{\mathbb{Q}}\Xi^{t_1,t_2} \qquad t_0 \leq t_1 < t_2$$

Finally, consider the economic value of an annuity, in this case t_2 is omitted, because the annuity is paid out over multiple years. Assume that the individual has age j_0 at t_0 and that contributions are all paid before retirement (age j_r) The value of the annuity is then given by:

$$A_{t_0}^{t_1} = \sum_{i=j_r-j_0}^{j_d-j_0} V_{t_0}^{t_1,t_0+i}\cdot\mathbb{1}[\text{alive}] = \sum_{i=t_1}^{j_d-j_0}(1+r_f)^{-(i+1)}\xi_{t_0}^{t_1,t_0+i}\ {}_ip(j_0)$$

So, all formulas become slightly more complicated due to the use of extra time indices, but the intuition remains the same.

D Alternative accrual mechanisms

There are multiple alternative accrual systems which could replace the doorsneesystematiek, the CPB (2013)[16] mentions four possible alternatives :

- Uniform contribution and degressive accrual: all employees pay a uniform contribution and receive an actuarial fair accrual. In case of positive interest rates, this implies a degressive accrual over age.
- Uniform accrual and progressive contribution: all employees receive a uniform accrual and pay an actuarially fair contribution for this accrual. When the discount curve is increasing, this implies a progressive contribution.
- Lower accrual, higher indexation: this is also called the ‘indexation alternative’. In this variant the doorsneesystematiek remains in place. However, the accrual is lowered while the contribution remains the same and indexation becomes more important. The young employees profit more of the indexation, because their time horizon is longer.
- Individual Defined Contribution (IDC): all employees pay a uniform contribution, but no fixed accrual is promised. Instead the individual will receive a pension based on the accumulated contributions and returns.

Each of these alternatives has its pros and cons. A potential disadvantage of the progressive contribution, is that it might make it more expensive to hire older employees and worsen their position on the labor market. Van den Berg et al. (2014)[4] argue that in practice this has no impact on the hiring policy of companies. Furthermore, they note that there is currently no research which proofs that older employees who currently are part of pension scheme with progressive contributions, are worse off than older employees within an occupational pension scheme.

With respect to the degressive accrual, Van den Berg et al. (2014)[4] argue that it is not possible to have both pension funds with uniform accrual and progressive contribution and pension funds with uniform contribution and degressive accrual within one country. They expect that this would lead to fiscal problems and people saving either too much or too little. This arguments has its merits, but it is important to realize that the occupational pension schemes represent a huge fraction of the pension wealth in the Netherlands. Therefore it does make sense to take the policy choice for the occupational schemes as new standard. Hence, the existence of pension schemes with progressive contribution in the Netherlands, is not necessarily an argument against considering degressive accrual.

Finally Van den Berg et al. (2014)[4] note that uniform contribution and degressive accrual is not allowed according to the current European laws for equal treatment. Though, this may be a hurdle in the reform, I will abstract from this problem in this thesis.

The indexation alternative can have very similar outcomes to the case with degressive accrual, but is less transparent. Furthermore, the conditional indexation could have less value than extra rights. However, this depends on the more detailed design of this variant.

The choice for an IDC scheme would imply an extensive reform of the pension system. In an IDC scheme the pension of an individual would depend directly on the returns on his/her contribution. In DB and CDC schemes on the other hand, the pension depends on the accrued rights and the financial position of the pension fund. From the perspective of the individual, this alternative is very similar to degressive accrual. In both cases the contribution is fixed and the accrual is actuarially fair. Therefore, the conclusions of a transition to a system of degressive accrual can directly be applied in this case as well.

Finally, the AG (2014)[21] considered a fifth alternative, which implies differentiating between the contribution-franchise and the accrual-franchise. However, this approach does not correspond to completely abolishing the doorsneesystematiek, it only mitigates the effects. Therefore I will not consider this alternative.

Summarized, the most relevant variants to consider are the progressive contribution and the degressive accrual, which both have its pros and cons. I will focus on the degressive accrual variant, for two reasons. First of all, because it is currently the most popular variant in the policy debate. And secondly, because also in an IDC variant a fixed contribution is generally assumed and therefore this choice is best to generate results for a double transition to SER variant 4A or 4C.

E Analytic model doorsneesystematiek

The model described in chapter 7 leads to extensive formulas. In this appendix I will bring down the number of age categories, which will lead to much easier equations. This simplified model can be used to prove analytically that the compensation costs for the doorsneesystematiek have a maximum in r^f

Keep the notation used in section 7.2. The new model consists of 3 periods: each individual pays contribution at the beginning of two periods, and receives benefits at the beginning of the third period. A period lasts y years. Using this y in the notation will make the formulas slightly more complicated, but it has as advantage that the interpretation of the parameters as for example wage growth in one year remains valid. Use y_1 to refer to a young worker and y_2 for an old worker. Assume that all people live long enough to receive benefits for one period of time.

The benefits received are no longer an annuity, because people live only one period in retirement. Furthermore it is assumed that there is zero probability to die before receiving the retirement benefit. This simplifies the formula of the price of accrual to:

$$\delta(y_1) = \frac{1}{(1+r^f)^{2y}} \qquad \delta(y_2) = \frac{1}{(1+r^f)^{y}}$$

The formula for the contribution in case of degressive accrual becomes (see equation 7.2.3) :

$$\begin{aligned}
\pi_D &= \alpha_U \frac{w_{pb}(y_1,0) + w_{pb}(y_2,0)\cdot(1+i_w)^y}{w_{pb}(y_1,0)/\delta(y_1) + w_{pb}(y_2,0)\cdot(1+i_w)^y\cdot\delta(y_2)} \\
&= \alpha_U \frac{w_{pb}(y_1,0) + w_{pb}(y_1,0)\cdot(1+m)^y\cdot(1+i_w)^y}{w_{pb}(y_1,0)\cdot(1+r^f)^{2y} + w_{pb}(y_1,0)\cdot(1+m)^y\cdot(1+i_w)^y/(1+r^f)^y} \\
&= \alpha_U \frac{1 + (1+m)^y\cdot(1+i_w)^y}{(1+r^f)^{2y} + (1+m)^y\cdot(1+i_w)^y\cdot(1+r^f)^y}
\end{aligned}$$

The degressive accrual for the young and old workers respectively is:

$$\begin{aligned}
\alpha_D(y_1) &= \frac{\pi_D}{\delta(y_1)} = \alpha_U\cdot(1+r^f)^y \frac{1 + (1+m)^y\cdot(1+i_w)^y}{(1+r^f)^y + (1+m)^y\cdot(1+i_w)^y} \\
\alpha_D(y_2) &= \frac{\pi_D}{\delta(y_2)} = \alpha_U\cdot\frac{1 + (1+m)^y\cdot(1+i_w)^y}{(1+r^f)^y + (1+m)^y\cdot(1+i_w)^y} \\
&= \alpha_U\left(1 - \frac{(1+r^f)^y - 1}{(1+r^f)^y + (1+m)^y\cdot(1+i_w)^y}\right)
\end{aligned}$$

To determine the value of the accrual, assume that the benefits are a nominal guarantee. Using equations 7.3.1 and 7.3.2 it can now be show that the total loss of the young worker would be equal to zero, if the doorsneesystematiek would be abolished *before* his first contribution to the pension fund. This is in line with the expectations, because the 'premievrijval' is not measured in the definition of Λ.

As a consequence, the macro compensation costs (or what the CPB calls the implicit deficit) are in this model equal to the subsidy which the old workers are about to pay. This means that the summation in equation 7.3.3 disappears, and the equation can be simplified to:

$$\begin{aligned}
\mathrm{MCC}_{t_0} &= \Lambda_{t_0}(y_2)\cdot N(y_2,t_0)\cdot M = L_{t_0}(y_2,t_0)\cdot N(y_2,t_0)\cdot M \\
&= (1+r^f)^{-y}(\alpha_U - \alpha_D(y_2))\cdot w_{pb}(y_2,t_0)\cdot N(y_2,t_0)\cdot M = (1+r^f)^{-y}(\alpha_U - \alpha_D(y_2))\cdot C
\end{aligned}$$

Where C is short notation and contains all terms which are independent of the interest rate.

This formula can be used to calculate the macro compensation cost, but it requires careful parametrization. Not only must the accrual in both periods add up to a sufficient pension, it is also necessary to take the total pension base over a period of y years instead of 1 year. However, even when this is carefully done, the approximation will remain crude compared to a calculation which uses time periods with a length of 1 year.

An advantage of this analytic representation is that it can be used to study the impact of different variables. I will use it to show that the macro compensation costs have a maximum in the interest rate.

First rewrite the equation:

$$\begin{aligned}
\text{MCC}_{t_0} &= C \cdot \alpha_U \cdot (1+r^f)^{-y} \frac{(1+r^f)^y - 1}{(1+r^f)^y + (1+m)^y \cdot (1+i_w)^y} \\
&= C \cdot \alpha_U \frac{(1+r^f)^y - 1}{(1+r^f)^{2y} + (1+m)^y \cdot (1+i_w)^y \cdot (1+r^f)^y}
\end{aligned}$$

Now substitute $x = (1+r^f)^y$, which gives:

$$\text{MCC}_{t_0}(x) = C \cdot \alpha_U \frac{x-1}{x^2 + (1+m)^y \cdot (1+i_w)^y \cdot x}$$

Take the derivative to x and put it equal to zero

$$\frac{\partial \text{MCC}_{t_0}(x)}{\partial x} = C \cdot \alpha_U \frac{x^2 + (1+m)^y \cdot (1+i_w)^y \cdot x - (x-1)(2x + (1+m)^y \cdot (1+i_w)^y)}{(x^2 + (1+m)^y \cdot (1+i_w)^y \cdot x)^2}$$

This expression is equal to zero if the numerator of the fraction is equal to zero, i.e.:

$$\begin{aligned}
x^2 + (1+m)^y \cdot (1+i_w)^y \cdot x &= (x-1)(2x + (1+m)^y \cdot (1+i_w)^y) \\
0 &= x^2 - 2x - (1+m)^y \cdot (1+i_w)^y \\
x &= \frac{2 \pm \sqrt{4 + 4(1+m)^y \cdot (1+i_w)^y}}{2}
\end{aligned}$$

Of these two solutions, I am only interested in the solution with $r^f > 0$, so I choose the + of the ± symbol. This gives:

$$(1+r^f)^y = 1 + \sqrt{1 + (1+m)^y \cdot (1+i_w)^y} \Rightarrow r^f = \left(1 + \sqrt{1 + (1+m)^y \cdot (1+i_w)^y}\right)^{1/y} - 1$$

It can be shown that at this location the second derivative of the MCC with respect to x is negative, so that this is indeed a maximum of the MCC and not a saddle point. When I take $m = 1\%, i_w = 2\%, y = 23$, then the location of the maximum is $r^f = 4.5\%$. Furthermore, it can be shown that the location of the maximum is increasing in $(1+m) \cdot (1+i_w)$ and decreasing in y.

Hence, this exercise shows that the macro compensation costs for abolishing the doorsneesystematiek have a maximum in r^f and that this maximum is relevant, given the interest rates which are commonly used in the literature. Furthermore, it can be shown that the second derivative is negative for interest rates between 0 and the location of the maximum, which can explain why the MCC will change more in the interest rate for interest rates close to 0% than if the interest rate is assumed to be close to 4.5%.