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The Holistic Balance Sheet

An Analysis of Benefit Reduction and Conditional Indexation

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The Holistic Balance Sheet:

an analysis of benefit reduction and conditional indexation

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Abstract

In this master thesis the aspects and importance of the options of conditional indexation and benefit reduction in the Holistic Balance Sheet approach are investigated. The value of these embedded options are not determined with the standard value-based Asset Liability Management (ALM) approach, but by taking the difference between a pension fund with and a pension fund without the options. The reason for the use of this new approach is that there is an interaction between the two options as well as a changing premium rate, which influences the actual value of the options. It is found that this results in a value of the benefit reduction option between 1.9 and 7.7 percent of the liabilities and a value of the conditional indexation option between 1.5 and 6.7 percent of the liabilities, which means that these options are important to take into account in the Holistic Balance Sheet. These values are dependent on certain parameters, namely: the length of the simulation horizon, the volatility of the underlying financial market, the current funding ratio and the investment strategy. However, the latter two are not important for the option of conditional indexation, because an increase in volatility only increases the height of the shocks and not the number of times the option will be executed on average. Furthermore, it is found that using the approach presented in this thesis to determine the values of the options leads to lower option values as compared to the standard value-based ALM approach.

Chapter 1

Introduction

Pension funds and insurance companies both face the problem of promising a long-term cash-flow to a participant in the future. These promised cash-flows are subject to certain risks since they are calculated now and will be paid out around forty years later. Up until the last decade of the twentieth century, the stock market was doing fine and the interest rate was stable for several years, resulting in stable prices and a clear expectation of these future cash-flows. However, in the first crisis of the twenty-first century in 2002, this structure started to fall apart. The funding ratios of the pension funds dropped and the first measures to acquire a better insight in the risks of a pension fund and insurance company were presented. After this crisis the market recovered again, but only to fall in the biggest crisis since the 1930's six years later. This 'credit crisis', in the year 2008, changed the market drastically. The interest rates dropped and the stock market collapsed, whereafter many pension funds and insurance companies, especially in the Netherlands, became heavily underfunded. Insurance companies even had to ask the state for support[1] and pension funds had no other way to improve their funding ratio than to cut the benefits of their participants.[2]

These two crises thus had a big impact on the promised future cash-flows of pension funds and insurance companies. In order to make sure that this will not happen again, "the European Commission requested the Committee of European Insurance and Occupational Pension Supervisors (CEIOPS) [in 2006] to advise on the development of a new solvency system (Solvency II) to be applied to European life, non-life and reinsurance undertakings" (CEIOPS, 2006). The new system will be used from the beginning of 2014 in the insurance industry as a way to determine the value of the discounted future cash-flows. In this system, risks will be taken into account by determining the size of the buffer,

[1] http://www.rijksoverheid.nl/onderwerpen/kredietcrisis/aanpak-kredietcrisis-nederland-financiele-sector

[2] http://www.pensioenfederatie.nl/actueel/persberichten/Pages/Pensioenfederatie_publiceert_overzicht_met_80_pensioenfondsen_16.aspx

the Solvency Capital Requirement. Furthermore, the successor of CEIOPS, the European Insurance and Occupational Pensions Authority (EIOPA) is now investigating whether the same way of accounting these risks can be implemented for Institutions for Occupational Retirement Provision (IORPs), which stands for pension funds and all institutions that are related to pension provisions. Although pension funds and insurance companies have many similarities, they differ on certain major parts. For instance, an insurance company guarantees the participant a certain amount of money and fully bears the risks itself, which means that the only risk participants of an insurance company bear is credit risk. Dutch Defined Benefit (DB) pension funds, however, can influence the benefits of their participants by conditional indexation and benefit reduction, which both have an impact on the benefits of the participants. These mechanisms can thus be seen as risks for the participants. Conditional indexation means that a pension fund guarantees a nominal payout in the future and decides once a year if the benefits are compensated for inflation, the indexation. If a pension fund has a healthy funding ratio, the pension fund will apply full indexation. If not, a pension fund will apply partial or no indexation. In some instances, a pension fund can cut the benefits leading to what can be seen as a negative indexation. However, this will only be done under certain restrictions. If for instance the funding ratio is low, a pension fund can cut the benefits of their participants only as a measure of last resort. The above described mechanisms of conditional indexation and benefit reduction can thus influence the benefits of the pension participants and can therefore de- or increase the risk of a low funding ratio. In order to get a better understanding of these risks and to give them an actual value, EIOPA came up with a new approach, called the Holistic Balance Sheet (HBS) approach, which will be explained in more detail in Section 2.3.

This new approach has only recently been investigated and a couple of problems with respect to the differences between the pension system and the insurance system have been identified. One of these problems is the influence of cutting benefits, which is an option that is unavailable for insurance companies while could be important for pension funds. The cutting of benefits, however, was not expected to be used. Therefore, little research in this field has been performed. Nevertheless, pension funds nowadays have such low funding ratios that the cutting of benefits is becoming a serious option. Since only limited research has been done to this aspect of pension funds, one of the goals of this thesis will be to investigate what the value of the option of benefit reduction will be and which parameters will be of influence on its value. Furthermore, the option to take conditional indexation into account is an important new option which is related to the cutting of benefits. Therefore, this option will also be investigated in this thesis. These two options will have a direct impact on the liabilities of a pension fund: the best estimates of the discounted future benefits combined with a risk margin. In order to investigate the different aspects and the value of these options, a model of a pension fund will be constructed with an underlying financial market. With the use of this model a new form of value-based ALM approach will be performed, which gives new insights in the valuation and behaviour of the embedded options. This new approach determines the value of the options by looking at the difference in funding ratio between a pension fund with and a pension fund without that option. The new approach has been developed because the two options possibly have interactions which will then result in lower values as compared to the standard value-based ALM approach as presented in the working paper of Fransen et al. (2012).

The described options are bound to certain rules. A pension fund is not allowed to simply cut the benefits of their participants and is also not allowed to simply compensate the benefits for inflation. The reason for this is that these actions have a large impact on the liabilities and consequently also on the funding ratio. In order to make sure that pension funds use these options only when it does not harm the future potential, the Dutch government made rules presented in the pension law. These rules also consist of a financial framework, or 'Financieel ToetsingsKader' (FTK) in Dutch. These rules could however, not protect the funds against the two crises of the beginning of this millennium, which had a big impact on the funding ratios of the pension funds. In response to these crises the Dutch government introduced changes to the existing rules via a new pension agreement and a corresponding new FTK, called FTK2.[3] As is stated above, EIOPA also introduced a system for all countries in the European Union. One of the differences between those two plans is that EIOPA is solely focused on the way the liabilities are determined while the new pension agreement is primarily focused on the actions allowed by pension funds. Nevertheless, these two systems have a large overlap. In addition to these new systems, the Dutch government is also making new rules which infect the pension funds by, for instance, increasing the retirement age. These new rules are presented in what is called the 'agreement of September 2012'[4] and the coalition agreement of October 2012.[5]

As can be read in Chapter 6, four conclusions can be drawn from the research in this thesis. Firstly, it has been found that both options have a significant influence on the HBS, as can be seen in Table 4.2. This shows that it would be recommending for EIOPA to implement these options in the HBS approach. Secondly, the current state of the pension fund as well as the current investment strategy has an impact on the value of the options, although the latter has not got a significant impact on the option of conditional indexation, as can be seen in Tables 4.6 and 4.7. Thirdly, the length of the horizon for which the scenarios are constructed is not of much influence on the value of the options, as can be seen in Table 4.3 and the volatility of the underlying financial market model is only of influence on the option of benefit reduction and not on the option of conditional indexation, as can be seen in Tables 4.4 and 4.5. Fourthly, the method that has been used in this thesis to determine values for the different options is significantly different from the standard value-based ALM approach, as can be

[3]Kamerstukken I 2011/12, 33 046 nr. H
[4]Kamerstukken II, 2012/13, 32 043 nr. 129
[5]VVD and PVDA, *Bruggen slaan,* Regeerakkoord.

found in Table 4.8. This shows that there are large interaction effects between both options and possibly other mechanisms and it would thus be recommended to use the method presented in this thesis to determine the option values.

The remainder of this thesis is organized as follows. First of all, in Chapter 2 the current Dutch pension system will be explained in detail in order to get a better understanding of the Dutch pension system. Thereafter, the new rules as presented by the Dutch government and EIOPA, respectively, will be discussed, whereafter the options of conditional indexation and benefit reduction will be explained. Second of all, the model of the pension fund, the underlying financial market and the new value-based ALM approach will be explained in Chapter 3. Third of all, the results from the model will be presented in Chapter 4, whereafter the sensitivity of the results will be tested in Chapter 5. Finally, conclusions will be drawn and recommendations for further research will be given in Chapter 6.

Chapter 2

The Dutch pension system

The Dutch pension system is a complex system of many rules, different pension funds and different pension schemes. There exist three different forms of pension schemes, namely the Defined Contribution (DC), the Defined Benefits (DB) and the Hybrid scheme. In a DB scheme, participants pay a variable yearly contribution and receive a fixed benefit at retirement. This means that the risks of this scheme are borne by the pension fund, since the pension fund still has to pay the guaranteed benefits if it performs bad. In a DC scheme, participants pay a fixed contribution each year, but receive a variable benefit at retirement which is dependent on the market returns throughout the years. This means that the risks of this scheme are borne by the participants themselves, since the participants simply get less benefits at retirement if the fund performs bad. Finally, a Hybrid scheme is a combination of the above two described schemes. Of these three pension schemes, the DB scheme is the most common in the Netherlands and also the most interesting one with respect to the new rules of EIOPA. In order to understand what the changes are which the Dutch government and EIOPA are willing to implement for Dutch pension funds, certain parts of the current pension law will be explained first.

2.1 The current system

In addition to investing the assets of the pension fund in an appropriate way, the most important aspect of a pension fund is to determine the value of the liabilities: the present value of the expected future cash-flows. The expected future cash-flows have to be discounted to the present with the use of an interest rate term structure which is presented on a frequent basis by the Dutch central bank, De Nederlandsche Bank (DNB). The cash-flows must be determined on the basis of expected market changes and other possible future changes that could have an impact on these cash-flows, such as the change in life expectancy. In order to finance these cash-flows, a pension fund has to determine a premium level for which a pension fund is allowed to take future expected returns into account. This premium level should be based on a well–substantiated analysis and it is not allowed to fluctuate much over time.

As described above, a pension fund thus has to take possible future cash-flows into account, whereafter it assigns a premium level in such a way that these cash-flows can be paid. However, these cash-flows and premiums are subject to risks, which make the values uncertain. A pension fund is obliged to take the risks into account in such a way that these discounted future benefits can be paid with 97.5% certainty in the upcoming year. Therefore, the Dutch government has determined a required and a minimum required capital level. If the capital of the pension fund drops below the minimum required capital level it is under-funded and thus not able to pay the cash-flows. If the capital is above the required capital level, a pension fund is capable of paying all future benefits with a 97.5% certainty. If the capital of a pension fund drops below the required capital level a pension fund is obliged to make a long-term recovery plan which includes the measures a pension fund must take in order to return above the required capital level within a maximum of fifteen years. Furthermore, if the capital of a pension fund drops below the minimum required capital level it is obliged to construct a short-term recovery plan. In this case, it has to return above the minimum required capital level within a maximum of three years. If a pension fund is unable to recover within these three years, it is obliged to cut the benefits of their participants as a measure of last resort. Between the minimum required level and the required level, a pension fund is allowed to compensate the cash-flows for inflation, which is called conditional indexation.

Since the crises in the first decade of this century, the pension system as such is under discussion. The reason for this discussion is that pension funds are not performing well and seem to be subject to more risks than expected before the crises. Therefore, the Dutch government and the European Commission are now investigating different ways to improve the pension system and to make it consistent throughout Europe. In order to do this, the Dutch government ordered the commission Goudswaard and the commission Frijns to investigate the Dutch pension system and the European Commission assigned EIOPA to investigate whether a variant of Solvency II can be implemented for European pension funds.

2.2 The Dutch new FTK

As has been stated above, in the beginning of the twenty-first century the Dutch government assigned the commission Goudswaard and the commission Frijns to investigate the Dutch pension system. From their reports (Goudswaard, 2010 and Frijns, 2010) it followed that pension funds in the Netherlands were suffering from a very low interest rate and an increasing percentage of older people. This leads to lower income for the pension funds due to fewer people who pay premiums and higher liabilities due to a lower rate with which the future cash-flows are discounted. These findings resulted in a new pension agreement, which also consists of a new financial framework, called the second FTK (FTK2).[1] This agreement is scheduled to be implemented in the beginning of 2014 and will change the current system in the following ways:

- A pension fund can decide to fully compensate for inflation and thus use full indexation only if the funding ratio is above the required capital level. In this way a pension fund will not be allowed to use over-indexation which results in an increase in future cash-flows such that a pension fund has a higher probability of underfunding in the future.

- The funding ratio which will be used to make policy decisions such as the premium level or the level of indexation will be the average funding ratio over the past twelve months. In this way, the funding ratio of a pension fund will be less volatile, resulting in more stable decision making. This is important, because if, for instance, interest rates drop just before determining the liabilities, the funding ratio would be much lower than before which again results in lower indexation and/or a higher premium. By using the twelve month average, this problem will be tackled. Nevertheless, a drawback of this approach is that increases and decreases in the funding ratio will only have an impact on decisions several months later.

- The retirement age will be dependent on the future life expectancy, resulting in an increase in retirement age to 67 in the near future and possibly even higher after that. This also means that the future cash-flows will be dependent on the life expectancy and pension funds should thus take this future in- or decrease in life expectancy into account.

- A pension fund is still required to hold capital such that it can pay its future benefits with a certainty of 97.5%. However, due to the other new rules, this will result in the pension funds holding a buffer of twenty-five percent instead of twenty percent of the liabilities.

- A pension fund will be obliged to make an ex-ante instead of an ex-post crisis plan. This will result in a quicker return to the minimal required capital level, because a pension fund can immediately start recovering. The time span in the case that the pension funds capital drops below the minimum required capital level, will remain the same, but if the pension fund drops below the required capital level it will now have a twelve year recovery period instead of fifteen year.

- In the case a pension fund has no other option than to cut the benefits of its participants, it is allowed to spread these cuts over a period of three years maximum. In the first year, a pension fund can cut up to seven percent and if this is not enough it is allowed to cut up to seven percent

[1] Kamerstukken I 2011/12, 33 046 nr. H

again in the next year. If even this amount would not be enough, the remaining part must be cut in the third year.

- Pension funds need to discount their possible future cash-flows using a different term structure. Instead of the forward rate that is normally used, this rate will be corrected in the long run by what is called the 'Ultimate Forward Rate' (UFR). In this way, the forward rates converge to a predetermined level, which will compensate for a possible low level of the forward rates at the moment the liabilities are determined. The reason for this adaption is that the market is supposed to be illiquid for maturities longer than twenty years, because they are not based on the actual market rate but on the forecast of the long term forward rate. This forecast will be done with the use of the present level of the forward rate. This rate thus depends highly on this present level of the forward rate, although it is assumed that the forward rate converges in the long run to a certain value. In order to to tackle this problem, pension funds can now compensate this possible low forward rate by adjusting it to the UFR.

Although this new pension agreement is still under construction and changes are made regularly, the above presented changes in the pension system are expected to have a big impact. Especially now that many pension funds are under-funded and need to cut the benefits of their participants, the government is trying to implement certain changes sooner than expected. In what is called the 'agreement of September 2012', the Dutch government decided that three changes of the current pension agreement should be implemented immediately. The first adaption is that the UFR, which is described above, will be introduced sooner. The second adaption is about the compensation for inflation. Previously a pension fund decides to compensate for inflation if the capital was above the minimum required capital level, often around a funding ratio of 105%. Now, in order to ensure that pension funds recover faster, the funding ratio should be above 110% before a pension fund can decide to compensate for inflation. In the third adaption the accrual rate is lowered from 2.25% to 2.15% in order to compensate for the increase in retirement age.

After the 'agreement of September 2012', the Dutch government presented in the coalition agreement of October 2012 another adaption.[2] This adaption states that the accrual rate will be lowered again, but now with an additional 0.4 percentage point resulting in an accrual rate of 1.75% for an average pay plan. This adaption has been made since the Dutch government believes that everybody should be able to save up to seventy percent of its average income. Additional savings should not be made in a DB system but by the persons themselves. In addition to these changes made by the Dutch government, EIOPA is also making new plans to improve the pension system and to make it more consistent throughout Europe. These new plans are called the Holistic Balance Sheet approach.

[2] VVD and PVDA, *Bruggen slaan*, Regeerakkoord.

2.3 Holistic Balance Sheet

Due to the crises at the beginning of the millennium, people discovered that pension funds were facing more risks than one initially thought. As a result, the performance of most of the pension funds dropped, resulting in low funding rates and possible benefit cuts. This under-performance could be seen throughout Europe even though the pension systems differ substantially. In order to get a better insight in the risks pension funds face and to make sure that there is more consistency in the pension systems throughout Europe, EIOPA started a Quantitative Impact Study (QIS) in October of 2012 (EIOPA, 2012). The goal of this QIS is to find out which risks a pension fund faces and how these risks can be analysed. In order to gain insight in these risks EIOPA came up with a new approach in this QIS, namely the HBS approach. In this HBS, the risks a pension fund face should be measured and they should be presented as adjustment or security mechanisms on the balance sheet. This results in a balance sheet with values that are uncertain, but are determined in such a way that they represent possible future risks discounted to the present. In order to get a better understanding of the HBS approach, a standard balance sheet will be explained first, whereafter the new features of this HBS will be explained in detail.

2.3.1 Standard balance sheet

At the end of each book year a pension fund has to publish an annual report, which, amongst others, consists of a balance sheet. In this balance sheet the present value of the current assets and liabilities are presented. These assets and liabilities are explained in detail in the financial report, which is normally presented right after this balance sheet in the annual report. A standard balance sheet states only the current assets combined with the premiums paid throughout the year on the left hand side and the liabilities combined with the accrued benefits and equity on the right hand side. This equity is simply the difference between the assets and the liabilities and forms the capital of the pension fund. If this equity is positive it thus means that the pension fund has a funding ratio which is above the 100%. A standard basic example of such a balance sheet is presented in Table 2.1.

Standard Balance Sheet

Current assets	Liabilities
Premiums	Newly accrued benefits
	Equity
Assets	Liabilities

Table 2.1: Standard Balance Sheet

The balance sheet above can be seen as the basic balance sheet of a pension fund as it is nowadays. However, as has been stated above, EIOPA is now investigating if it will be possible to implement certain security and adjustment mechanisms to this balance sheet, called embedded options, where EIOPA uses the Solvency II approach of insurance companies as a basis. These options have values that are dependent on future events and are thus not certain at the present. Nevertheless, these options can possibly have a big impact on the valuation of the assets and liabilities. There will be two different types of options that EIOPA would like to introduce, namely: options that have an impact on the asset side of the balance sheet, security mechanisms, and options that have an impact on the liability side of the balance sheet, adjustment mechanisms.

2.3.2 Mechanisms

For Dutch DB pension funds, there are two security mechanisms, namely contingent assets and the possibility of sponsor support, which will both be explained below.

- Contingent assets are assets that have an unsure future payout, which depend on certain events over which the company has no control. An example of a contingent asset will be a lawsuit about a violation of a patent. If a company violates your patent you can start a lawsuit, which can result in certain earnings if it is won. This scenario, however, is still uncertain and can therefore only be given an expected value, which will be the value of the contingent asset on the HBS.

- If a pension fund is heavily under-funded, it can acquire additional support from its sponsor. In the QIS of October 2012 there are four forms of sponsor support stated.

  - The change in contributions, where the sponsor can interfere at a very high or low funding ratio by decreasing or increasing the contribution level.
  - The subsidiary liability of the sponsor, which is the possibility that a sponsor pays the benefits directly to members and beneficiaries.
  - The contingent assets of the sponsor, which are assets that are in possession of the sponsor but are locked for the purpose of flowing to the pension fund under predefined circumstances.
  - The claims on the sponsor, which are values which would be available to the pension fund if the link between the pension fund and the sponsor would be broken.(EIOPA, 2012)

In addition to these security mechanisms, there are thus also adjustment mechanisms. These are mechanisms that can adjust the liabilities in a positive or negative way such that the pension fund remains healthy or the participants benefit. These mechanisms are for instance the possibility of conditional indexation, benefit reduction and catch up indexation which will be explained in Section 2.4.

2.3.3 HBS and Solvency II

In addition to these new mechanisms, the capital requirement level is also changed into a Solvency Capital Requirement (SCR) as in Solvency II. The SCR is the amount of capital that a pension fund needs to hold to assure that in the following year the cash-flows can be paid with a certainty of 97.5%. The difference between this SCR and the required capital level, which has previously been described, is that the SCR is derived in a way which includes more uncertainties and more risks.

Additionally, the calculation of some basic values has also been changed in the HBS approach. For instance, the calculation of the discounted future cash-flows, the Best Estimates of the future benefits, now also take into account an additional buffer, the Risk Margin. This is a predetermined percentage of the value of these best estimates of the future benefits. In order to get a better understanding of how such a holistic balance sheet looks like, an example is presented in Table 2.2.

Holistic Balance Sheet

Current assets	Nominal liabilities
Premiums	Newly accrued benefits
Sponsor support	Conditional indexation
Contingent assets	Benefit reduction
	Other adjustment mechanisms
	Equity
Assets	Liabilities

Table 2.2: Holistic Balance Sheet

As has been stated above, EIOPA has used the Solvency II approach for insurance companies as a basis to determine this HBS approach. This means that there are many similarities between these approaches, but also some important differences. One important difference is the fact that insurance companies do not have any sponsors. Therefore, sponsors cannot absorb any shortages, resulting in a higher SCR compared to pension funds. Another difference is that pension funds can change the benefits of their participants by, for instance, conditional indexation, benefit reduction and other means to adjust these benefits while insurance companies cannot. In other words, insurance companies lack the security and adjustment mechanisms that pension funds have. The reason for this is that an insurance company guarantees a certain amount with a 99.5% certainty, where the only risk for a participant is the credit risk, and a pension fund guarantees a certain nominal amount with a 97.5% certainty which can be in- or decreased depending on the future state of the pension fund. One way this value can be increased is by compensating for inflation. Pension funds have the opportunity to decide whether they will compensate for inflation or not once a year, which is called conditional indexation. Although pension funds 'guarantee' nominal benefits, they also have the opportunity to cut the benefits of their participants as a last resort. Because these adjustment mechanisms are important to determine the differences between Solvency II and the HBS and these differences are the main research of this thesis, they will be explained in detail.

2.4 Adjustment mechanisms

The goal of a pension fund is to give a participant as much benefits as possible. These benefits of the participants, the future cash-flows of a pension fund, are subject to certain risks which a pension fund needs to take into account. These risks make the future capital uncertain and this results in a possibility that a pension fund would be unable to pay the future benefits of its participants. There are many types of risks, for example operational risk and financial risk. This thesis focuses on two types of risks which results from the possibility of conditional indexation and from benefit reduction. The reason that these mechanisms are risks is that they can possibly add or subtract a large value of the possible future cash-flows. These two mechanisms will therefore be explained in detail in the next two sections.

2.4.1 Conditional indexation

In order to protect a pension fund against the risk relating to conditional indexation, it is obliged to have a certain amount of capital, which is called the capital requirement level or SCR in the HBS approach. Above this level, a pension fund will decide to fully compensate for inflation, which means that it applies full indexation. Below this level not all pensions can be fully compensated by inflation and a pension fund will be obliged to make a long-term recovery plan which includes a plan to return above this capital requirement level. Instead of fully compensating for inflation, a pension fund will then apply conditional indexation. This means that as long as the capital is below the capital requirement level, the pension fund will only partially compensate for inflation. However, if the capital is below the minimum required capital level, the pension fund is not allowed to compensate for inflation at all. In this thesis, the funding ratio which results from the minimum required capital level is set equal to 105% and the funding ratio which results from the required capital level is set equal to 130%. These values are chosen, because these are the values that are most used in practical discussions. However, due to the changes made in the new pension agreement, a pension fund can only compensate for inflation with a funding ratio higher than 110 %. Therefore, the minimum required level for conditional indexation will be equal to this 110%. Furthermore, the height of the conditional indexation level is determined such that between a funding ratio of 110% and 130% the indexation level is a linear line between no indexation and full indexation. This is shown in Figure 2.1 for an inflation level of 2.1% which is the average inflation level of the past ten years according to the Central Bureau of Statistics Netherlands (CBS).[3]

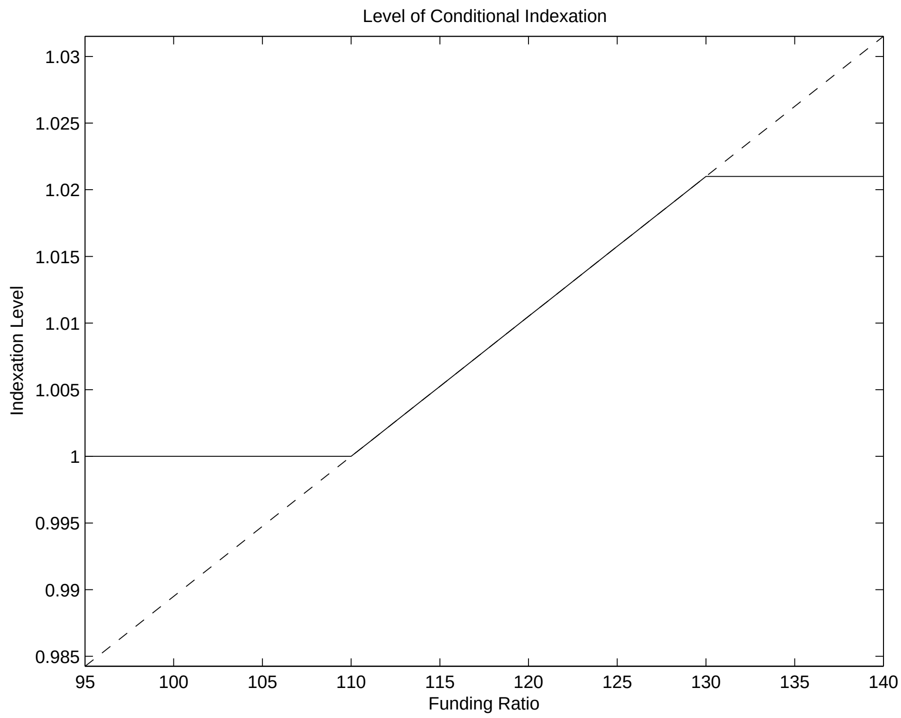

Figure 2.1: Graph of the indexation level

2.4.2 Benefit reduction

In certain scenarios it is possible that the capital of a pension fund drops below the minimum required capital level. If this is the case, the pension fund is obliged to design a short-term recovery plan in order to return above the minimum required capital level within a maximum of three years. Within these three years the capital must increase such that it reaches a level that is higher than the minimum required level. If it looks like the pension fund is not able to reach

[3] http://www.cbs.nl/nl-NL/menu/themas/prijzen/cijfers/default.htm

this level with the current means, it will be obliged to cut the benefits of its participants. This benefit reduction is thus an action that can only be executed as a measure of last resort. Nevertheless, cutting benefits can possibly have a large impact on the pensions of the participants, therefore the boundaries to these cuts are assigned in the 'agreement of September 2012'. The percentage with which the benefits will be reduced must be determined such that the capital reaches the minimum required capital level at the end of the third year after the capital decreased below the minimum required level. However, as has been stated before, a pension fund is only allowed to cut up to seven percent in a certain year to limit the loss for the participants. If this seven percent is not enough, a pension fund is again allowed to cut up to seven percent the next year. After this second year of benefit reductions a pension fund must cut the remaining in a third year if any. Nevertheless, the total amount that has to be cut is determined in the second year after the capital had dropped below the minimum required level. Thus, if the cuts will be spread, the total amount that a pension fund has to cut does not change. Therefore, it could be the case that after the benefit reductions, the pension fund is still underfunded. In order to take this into account, a pension fund will virtually have the minimum required capital at the first cut and if it then again makes losses the procedure will start over.

Both options that are described above result in a benefit loss for participants as compared to real guaranteed benefits. Therefore, some pension funds also apply the option of indexation discounts or catch up premiums. These options make sure that the amount that was lost due to low funding ratios will be paid back when the pension fund has enough capital again. This 'over-indexation' will, however, be neglected in this thesis.

Including both options in the calculation of the liabilities could have a big impact. However, in the QIS of October 2012, EIOPA is not sure whether the option of benefit reduction should be included or not. It is stated in Section 2.4.52 of this QIS that, as a basic case, "IORPS should not incorporate ex post benefit reductions in the valuation of the best estimate of technical provisions."(QIS p. 29, EIOPA, 2012) The next line in the article, however, states that, in addition to this basic case, pension funds have the option to include ex post benefit reduction: "Under this option IORPS should value the best estimate of technical provisions including ex post benefit reductions of the last resort if applicable and allowed for in national law" (QIS p. 29, EIOPA, 2012). This leaves the choice of including benefit reductions to the pension funds themselves. Due to this lack of clarity it is important that this option will be investigated further, which will be done in the next sections of this thesis with the use of a value-based Asset Liability Management (ALM) study.

Chapter 3

Description of the model

The goal of this thesis is to investigate whether cutting benefits and/or conditional indexation has a big impact on the liabilities and to give pension fund managers a better understanding on implementing these embedded options. Before these questions can be answered, a model has to be built under certain assumptions with a steady financial framework and with the proper values assigned to the parameters. These factors will be determined in the next few sections. However, before a model can be chosen the first question is how to actually give a value to these embedded options. In order to do this, a special technique is used, which is called an ALM study, which will be explained first.

3.1 ALM-study

An ALM study is a way to evaluate the future outcomes of a certain pension scheme. This will be done by choosing a corresponding financial market model which for instance makes stochastic simulations of the returns of the assets and the change in interest rate. These scenarios will then be used to determine the future value of the assets and the corresponding liabilities at different horizons. These values can be used to investigate the possible future state of the funding ratio or give insight in the effect of changes in certain parameters. This is what is known as Classical ALM. This approach is not appropriate here because it does not give a certain present value about the embedded options, which is what this thesis is about. Therefore an alternative of the ALM study is used here, which is called value-based ALM. This approach gives a value to these embedded options by using a pricing kernel method or by using risk neutral valuation. Only the latter is used here. Risk neutral valuation means that scenarios are determined under the risk neutral measure, whereafter the corresponding values of the options are discounted to the present by the appropriate risk free rate. In this way a value can be assigned to each option. Nevertheless, this approach only uses the value of executing this option at a certain point in time for a certain scenario. This, however, does not show the true impact of executing such an option. Therefore, an adjustment to this approach will be used, which will be explained further in Section 3.4.2. Now that the basic framework is explained on how to determine the actual value of the embedded options, the next step will be to choose a financial market, which must be based on certain assumptions. EIOPA has made some assumptions about the use of a financial market in their QIS of October 2012. These assumptions are presented and explained in the next section.

3.2 Assumptions

In the Sections 2.3.10 up until 2.3.13 of the QIS of October 2012 of EIOPA, assumptions are presented on the underlying market. The first assumption that is presented in the QIS states that a model which will produce future projections of market parameters should have the following requirements:

- It generates asset prices that are consistent with deep, liquid and transparent financial markets;
- It assumes no arbitrage opportunities.

In order to determine when a financial market is deep, liquid and transparent a financial market model should have the following requirements:

- A large number of assets can be transacted without significantly affecting the price of the financial instruments used in the replications (deep),
- assets can be easily bought and sold without causing a significant movement in the price (liquid),
- current trade and price information are normally readily available to the public, in particular to the undertakings (transparent).

It is difficult to find a model that is deep and thus has a large number of assets, since those models are often too advanced for practical usage. However, a large number of assets can also be seen as a portfolio of assets, which has one price and one general volatility. Therefore, a simple model with only one or two assets would be enough. The other assumptions about liquid, transparent and no arbitrage do not need any adjustments or explanations.

In the search to a model which satisfies the three conditions, the model of Black & Scholes, combined with a fluctuating interest rate that follows from the Vasicek model has been chosen. The reason that these combined models have been chosen is that they are frequently used models which are not too advanced. This model will be called the Black-Scholes-Vasicek model.

3.3 Financial Market

As has been stated before, the financial market has to be chosen before the model of a pension fund can be derived. In the previous section, the model that satisfies all conditions and is thus chosen here is the model that is called the Black-Scholes-Vasicek model. This model can be described as follows

$$dS_t = \mu S_t dt + \sigma S_t dZ^{\mathbb{P}}_{1,t}, \tag{3.1a}$$

$$dB_t = r_t B_t dt, \tag{3.1b}$$

$$dr_t = a([b + \frac{\lambda \sigma_r}{a}] - r_t)dt + \sigma_r dZ^{\mathbb{P}}_{2,t} \tag{3.1c}$$

Here, the process $\{S_t\}$ stands for the stock price, the process $\{B_t\}$ for the price of the money market account and the process $\{r_t\}$ for the interest rate. Furthermore, the parameters μ, σ, σ_r, λ, a and b are constants, where the parameter μ stands for the mean stock return with σ its volatility and the parameter σ_r stands for the volatility level of the interest process. Finally, the processes $\{Z_{1,t}\}$ and $\{Z_{2,t}\}$ are two different Brownian Motions where $\mathbb{P}$ stands for the real world measure. In order to give a clear explanation of this model, it will be explained in two parts below. First the Vasicek model and secondly the Black & Scholes model will be explained in detail.

3.3.1 Vasicek model

Now that the basic model has been chosen, the processes have to be changed such that they can actually be used in a model for a pension fund and an insurance company. Therefore, the Vasicek part of the model, the $\{r_t\}$ process, will firstly be investigated. The model presented in (3.1c) is an Ornstein-Uhlenbeck process, which means that it is a mean-reverting process. In such a process, the outcomes of the process $\{r_t\}$ are close to the mean, the parameter $b - \frac{\lambda \sigma_r}{a}$, and become stationary over time. Furthermore, the parameter a stands for the rate by which the shocks, caused by the volatility, expand and the process reverts towards the mean.

This Vasicek model will be used to determine the values of the interest rates in certain points in time. Therefore, this model must be used to derive the term structure model of interest rates. The first step in deriving a formula for this term structure is by determining the price at time t of a bond that pays one unit of currency at time T, $P(t, T)$ (Schumacher, 2011). This formula is shown below

$$P(t, T) = \mathbb{E}^{\mathbb{Q}}\Big[\exp\Big(-\int_t^T r_s ds\Big)\Big],$$

where $\mathbb{E}^{\mathbb{Q}}$ stands for the expectation under the risk neutral measure $\mathbb{Q}$. This process solely depends on the short rate, which is described in (3.1c). In order to determine these prices, the Brownian Motion of this short rate process must also be risk neutral. As can be seen in (3.1c), this is not the case. Therefore, the Girsanov (1960) theorem will be used to change the real world probability measure to the risk-neutral measure:

$$dZ_{2,t}^{\mathbb{Q}} = \lambda_t dt + dZ_{2,t}^{\mathbb{P}}, \qquad Z_{2,0}^{\mathbb{Q}} = 0, \tag{3.2}$$

where $\{Z_{2,t}^{\mathbb{Q}}\}$ is the risk-neutral probability measure, $\{Z_{2,t}^{\mathbb{P}}\}$ is the real world probability and λ stands for the risk premium. Inserting the above formula into (3.1c) results in the following formula for the short rate process

$$\begin{aligned} dr_t &= a([b + \frac{\lambda\sigma_r}{a}] - r_t)dt + \sigma_r dZ_{2,t}^{\mathbb{P}} \\ &= a([b + \frac{\lambda\sigma_r}{a}] - r_t)dt + \sigma_r dZ_{2,t}^{\mathbb{Q}} - \lambda dt, \\ &= a\big(b - r_t\big)dt + \sigma_r dZ_{2,t}^{\mathbb{Q}}. \end{aligned}$$

Now that all aspects are explained, an explicit formula can be derived to determine these prices

$$\begin{aligned} P(t,T) = \exp\Bigg(&- \Big[\Big(b - \frac{\sigma_r^2}{2a^2}\Big)(T-t) + \Big(r_t - b + \frac{\sigma_r^2}{a^2}\Big)\frac{1-e^{-a(T-t)}}{a} \\ &- \frac{\sigma_r^2}{2a^2}\Big[\frac{1-e^{-2a(T-t)}}{2a}\Big]\Big]\Bigg), \end{aligned} \tag{3.3}$$

where the parameters a and b are as they were described above. In order to derive the term structure from these prices, they must be changed into yields. This can be done by the simple formula below

$$R(t,T) = -\frac{1}{T-t}\log\big(P(t,T)\big), \qquad T > 0. \tag{3.4}$$

If the formula of $P(t,T)$ that is previously determined in (3.3) is inserted, the final formula of $R(t,T)$ can be derived. This formula is shown below:

$$\begin{aligned} R(t,T) = \Bigg[&\Big(b - \frac{\sigma_r^2}{2a^2}\Big) + \Big(r_t - b + \frac{\sigma_r^2}{a^2}\Big)\frac{1-e^{-a(T-t)}}{a(T-t)} \\ &- \frac{\sigma_r^2}{2a^2}\Big[\frac{1-e^{-2a(T-t)}}{2a(T-t)}\Big]\Bigg]. \end{aligned} \tag{3.5}$$

With this formula, the term structure can be determined for every time t in the future with horizon T. In the next section, the formulas for the stock and the money market account will be determined.

3.3.2 Black & Scholes model

Now that a formula for the interest rate yield is determined for every time t in the future, the next step will be to determine formulas for the price of a stock and for the money market account. In financial markets, the price of an asset is below its expectation. The reason for this is that investors bear risks and expect a higher payoff because of this risk. Therefore the prices of the financial market should take into account this risk premium. In order to do this, the first theorem of asset pricing states that if these prices are changed to a risk-neutral measure which takes this risk premium into account, these prices will be equivalent with the original prices. The Girsanov(1960) theorem will again be used to change the real world probability measure to the risk-neutral measure, which results in the following formula

$$\begin{aligned} dS_t &= \mu S_t dt + \sigma S_t dZ^{\mathbb{P}}_{1,t}, \\ &= \mu S_t dt + \sigma S_t \big(dZ^{\mathbb{Q}}_{1,t} - \lambda_S dt\big), \\ &= \big(\mu - \lambda_S \sigma\big) S_t dt + \sigma S_t dZ^{\mathbb{Q}}_{1,t}, \end{aligned}$$

Now that this formula is derived, the next step will be to get an expression for the risk premium (λ_S) by taking $\{B_t\}$ as a numéraire over the stock price process $\{S_t\}$. Using the Girsanov theorem again will result in an expression with this risk premium. Finally, the Girsanov theorem states that this function should be a martingale under the risk-neutral probability measure, which means that the part that is dependent on time should be zero. This gives the formula for the risk premium, which will result in the final formula for the stock price, namely:

$$dS_t = r_t S_t dt + \sigma S_t dZ^{\mathbb{Q}}_{1,t}. \tag{3.6}$$

In order to determine the price of the money market account, the above described changes are not necessary, since the process of the money market account only depends on time and not on a Brownian Motion. Therefore, the formula as it was presented in (3.1b) remains the same. Combining now all the above gives the following risk neutral model for the financial market

$$\begin{aligned} dS_t &= r_t S_t dt + \sigma S_t dZ^{\mathbb{Q}}_{1,t}, \\ dB_t &= r_t B_t dt, \\ dr_t &= a\big(b - r_t\big)dt + \sigma_r dZ^{\mathbb{Q}}_{2,t}. \end{aligned}$$

3.4 Dutch Defined Benefit scheme

Now that the financial market is described, the next step will be to determine how a pension fund behaves. As has been stated before, the goal of this thesis is to investigate the impact of the HBS and especially the options of conditional indexation and benefit reduction. In order to do so, a value-based ALM study will be performed as has been stated in Section 3.1. However, before this value-based ALM study can be performed, the derivation of the different values must be explained. Therefore, the asset and then the liability side of the balance sheet will be explained. Nevertheless, both sides are dependent on some basic assumptions of the participants and the pension fund itself, which will be explained first.

3.4.1 The pension fund settings

A participant of a pension scheme gets a certain amount of benefits as he or she retires. This amount is based on the accrual rate and a person's average income during his or her working life. It is assumed that a person starts working at the age of twenty-five, retires at the age of sixty-seven and dies at the age of eighty-five. During the time a person works and thus contributes to the pension fund he or she will receive an annual income based on the following formula

$$Income(x) = \begin{cases} € \ 20,000 \ + \ €2,500 \ * (x-24) & \text{if } 25 \leq x < 67 \\ € \ 0 & \text{if } 67 \leq x \leq 85 \end{cases}, \tag{3.8}$$

where x represents a persons age. Furthermore, these income levels will be increased by the inflation level each year, which will make sure that the income differs between each age, scenario and year. It is assumed that the pension fund remains stationary, which means that the pension fund has sixty participants, one of each age between twenty-five and eighty-five, and each year a participant dies and a new participant joins the pension fund.

The above shows what a person will earn at a certain age. However, this does not show the actual accrued benefits that are collected during its working life. These benefits are the average a person earns during his or hers entire working life multiplied by the accrual rate, which is shown in (3.9) below:

$$Benefits(p) = \text{averageincome} * k\% * 42 \tag{3.9}$$

where the parameter k represents the accrual rate and p stands for the participant. In order to derive from these possible future benefits the actual total benefits of a pension fund, these values will be discounted to the present. For example, if someone is new in the pension fund he will receive these benefits in 42 years from now, which means that these values will be discounted for a period of 42 years. The resulting values for all persons of the pension fund will be summed, which gives the total benefits in a year. Above these benefits, a risk margin will be added, which is equal to 8% of these total benefits. These two values together will form the total value of the liabilities at a certain point in time for a certain scenario.

In order to determine the value of the assets, there are three parts that need to be determined successively, namely the financial asset returns, the contributions and the paid out benefits, where the latter will be subtracted from the other two. Firstly, a pension fund holds financial assets to make sure that the contributions that are now collected or have previously been collected will be invested well, such that the liabilities can be paid. At the end of a year, the financial assets are calculated by multiplying the change in stock price ($S_t - S_{t-1}$) by the fraction of the stocks in the portfolio (ϕ_S) times the total value of the assets at time t. This value is added by the change in bond price ($B_t - B_{t-1}$) multiplied by the fraction of the bonds in the portfolio (ψ_B) times the total value of the assets at that year. These values combined form the total return on the financial assets of the pension fund. The second part of the assets is the value of the contributions. These contributions are derived by multiplying the income of a person in a certain year by a premium level. This premium level is set such that it helps contributing to the recovery of a pension fund. This means that if the pension fund is performing well, the premium will be low and vice versa. The formula for the premium level is shown below:

$$Premium_{t+1} = \begin{cases} 0.30 & \text{if } FR_t \leq 105\% \\ 0.30 - \frac{(FR_t - 105\%)*(0.30-0.15)}{(130\%-105\%)} & \text{if } 105\% < FR_t \leq 130\% \\ 0.15 & \text{if } FR_t > 130\% \end{cases} . \tag{3.10}$$

Now that both positive values of the asset side are determined, the last value that has to be derived is the value of the paid out benefits. This is simply the number of persons in retirement, eighteen, times the value of (3.9). This value will be subtracted from the other two values, which results in the following final formula for the total value of the assets:

$$Assets_t = Assets_{t-1}(\phi_S(S_t - S_{t-1}) + \psi_B(B_t - B_{t-1})) + \text{Contributions} - PP, \tag{3.11}$$

Where PP stands for the pension payments that are paid to the retirees. It can be seen that the derivation of the value of the assets depends on the previous value of the assets. Therefore, the initial value of the assets has to be determined first. This will be done with the use of the total value of the liabilities at time zero and the initial funding ratio level:

$$Assets_0 = FR_0 * Liabilities_0 \tag{3.12}$$

Finally, the funding ratio of the pension fund is simply the assets divided by the liabilities. This funding ratio becomes very important in this thesis because the two options investigated here depend on the funding ratio.

3.4.2 Valuation of the options

The embedded options of a pension fund cannot be valued straight away. In the working paper of de Haan et al. (2012) the value of the options are determined by taking the expectation over the discounted sum of added or subtracted value. This way of determining the value of the option gives the added or subtracted value throughout the possible future years, which is called value-based ALM. However, if a pension fund reduces the benefits in a certain year, this will have more effects than just simply the value with which the liabilities are reduced. This also means that the future liabilities will be lower and the expected future funding ratio will thus be higher than without the cutting of the benefits. This higher funding ratio will result in lower premium incomes and a higher possibility of conditional indexation, which will then result in a higher possibility of benefit reduction. Thus, although the liabilities are reduced by a certain value, this value alone does not show the actual value the option contributes to the pension fund, which means that this approach is not optimal. Therefore, in this thesis a different way of valuing the embedded options has been chosen. In order to derive these values, the height of the residue between a pension fund with and a pension fund without the options will be compared. The difference at a certain future year will be the value of the option at that time. This will result, at a horizon of 20 years, in values over 20 years for 10,000 scenarios. These values will all be discounted with the corresponding risk neutral discount rate whereafter the average will be taken over all these scenarios. This results in twenty values of the option, which should be combined such that there is only one value left on the balance sheet. This value must represent the current value of the option for the next year and not for the whole horizon. Therefore, the average over these discounted values will again be taken. Due to this different approach, the values may be different than the values presented by the working paper of de Haan et al. (2012) and the working paper of Fransen et al. as presented in the Netspar meeting of October 8th 2012.

The value of the option of conditional indexation will be derived by taking the difference in residue between the pension fund with a nominal guarantee contract and a pension fund which also assigns for conditional indexation. Furthermore, the value of the option of benefit reduction will also be derived by taking the difference in residue, but now between a pension fund with nominal guarantees and the option of conditional indexation and a pension fund which also assigns for benefit reduction. If these pension funds have the same financial market and parameter values it gives a clear overview of the total added or subtracted value of the options. Finally, in order to investigate the impact of these options, simply presenting the values of the liabilities, assets and the embedded options only gives a certain financial value that is based on the fictional characteristics of this pension fund and is thus of not much help for a pension fund manager. Therefore, the values will be shown as a percentage of the nominal liabilities. This means that the nominal liabilities are set to 100% and the value of each option will be determined by dividing its value by the value of the nominal liabilities, which results in a certain percentage. In this way the different values can be compared and investigated in such a way that the results can be of help for pension fund managers in order to understand the characteristics of these options.

Chapter 4

Results

This chapter shows the results of the Monte Carlo simulation of the previously described model. Monte Carlo simulation has been performed because the problem is too complicated to solve analytically. This way of simulating means that the model will be ran for a predetermined number of scenarios, of which the average will be taken (Schumacher, 2011). Before these simulations can be executed, values need to be assigned to certain parameters. These values are presented in Table 4.1 below.

Parameter	**Value**
r_0	1.048%
a	0.20
b	0.042
σ_r	0.366%
σ	20%
inflation	2.1%
accrual rate	1.75%

Table 4.1: Parameter assumptions

The first parameter is the initial short rate. In order to determine the value of this parameter, the average of the zero coupon rates between November 2011 and October 2012, which are found on the website of DNB, has been taken[1]. The second parameter, the mean reversion speed, is set equal to 0.2 and the third parameter, the mean reversion level, is chosen equal to the Ultimate Forward Rate (EIOPA, 2012). Furthermore, the volatility of the interest rate is set equal to 0.366 percent which is equal to the standard deviation of the zero coupon rates of DNB over the past twelve months. The volatility of the stock market is set equal to 20%. Finally, the accrual rate is set at the same level the Dutch government had decided it would be in their coalition agreement of

[1] http://www.statistics.dnb.nl/financiele-markten/rentes/index.jsp

October 2012[2]. In addition to these stationary parameters, there are also some parameters that possibly have a large impact on the results if changed. These parameters are the initial funding ratio, the percentage invested in stocks/bonds and the horizon. Because these parameters are important the impact of them will be shown in this chapter. Furthermore, the valuation method as presented in this thesis will also be compared to the value-based ALM approach as has been used in the working paper of Fransen et al.. The impacts of changing the model as a whole and changing the volatilities of the underlying financial market will be presented in the next chapter. For the basic case, the initial funding ratio will be equal to 110 %, the percentage invested in stocks will be 60% and the horizon will be set equal to 20 years.

4.1 Basic results

Now that all parameters are determined, the results can be derived. In Table 4.2 below, the resulting balance sheet for the basic case is presented. Here, it can be seen that the value of the liabilities can be increased by 3.51% when a pension fund takes into account conditional indexation instead of nominal benefits. Furthermore, if a pension fund takes into account the possibility of benefit reduction, the value of the liabilities can be decreased by 3.99%. This shows that inserting conditional indexation and/or benefit reduction on the balance sheet has a significant impact. Nevertheless, these values are dependent on many variables and cannot be taken for granted. Therefore, these values cannot be used in decision making straightaway. It will therefore be interesting to investigate how these values behave under certain circumstances. In order to do this, the HBS will be presented with certain parameter values changed and where the outcomes will be compared to the results of Table 4.2.

Assets		**Liabilities**	
Current Assets	110.00	Nominal Liabilities	100.00
Premiums	1.82	Newly accr. ben.	2.26
		Cond. Indexation	3.51
		Benefit Reduction	-3.99
		Equity	10.04
	111.82		111.82

Table 4.2: Holistic Balance Sheet for the basic horizon T=20

[2]VVD and PVDA, *Bruggen slaan, Regeerakkoord.*

4.2 Sensitivity of the key parameters

The parameters that will be analyzed in this section are the following: The horizon length, the volatility of the underlying financial market, the investment strategy and the initial funding ratio. The first two parameters have been chosen because it may give some insight in the fluctuations of the options itself and how the values need to be determined. The last two parameters have been chosen because they represent different states of a pension fund. The initial funding ratio states how the pension fund is currently performing and whether this parameter has an impact on the value of the embedded options. The investment strategy is different for each pension fund and it may be interesting to analyze what the effects of a different investment strategy are on the valuation of the embedded options.

4.2.1 Sensitivity of the horizon length

The first parameter that will be analyzed is the length of the simulation horizon. In Table 4.3, the HBS for different horizons is presented. Here, a horizon length between ten and forty year has been chosen, because forty years is the average time a person is contributing in a pension fund and a longer horizon does not contribute much. Furthermore, a horizon with a length of less than ten years is not helpful, because some options are only rarely executed in such short horizon, resulting in an option value that is unrealistically low. In Table 4.3 this can clearly be seen by the big difference between a horizon with a length of ten and fifteen years as compared to the difference of a horizon with the length of fifteen and twenty years. The focus in this table is primarily on the values of the two embedded options.

	Assets						
	T=10	T=15	T=20	T=25	T=30	T=35	T=40
Current assets	110.00	110.00	110.00	110.00	110.00	110.00	110.00
Premiums	1.98	1.91	1.82	1.73	1.64	1.55	1.47
Total assets	111.98	111.91	111.82	111.73	111.64	111.55	111.47
	Liabilities						
	T=10	T=15	T=20	T=25	T=30	T=35	T=40
Nominal liabilities	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Newly accr. ben.	2.62	2.44	2.26	2.08	1.92	1.77	1.64
Cond. Indexation	1.56	2.63	3.51	4.15	4.67	5.08	5.39
Benefit reduction	-1.87	-3.13	-3.99	-4.46	-4.72	-4.82	-4.81
Equity	9.67	9.97	10.04	9.95	9.77	9.52	9.24
Total liabilities	111.98	111.91	111.82	111.73	111.64	111.55	111.47
Holistic FR	109%	110%	110%	110%	110%	109%	109%

Table 4.3: The HBS for different horizons (T)

In Table 4.3 it can be seen that as the horizon increases, the value of the conditional indexation option increases as well. Nevertheless, the slope of the increase in value decreases with the increase in horizon, but remains significant with an increase of around six percent between the horizons with a length of 35 and 40. This thus means that the embedded option of conditional indexation is dependent on the chosen horizon. Therefore, it is important for a pension fund to choose a horizon with which it works best, taking in mind that it does have a large impact on this option. However, it can be seen that, when looking at the value of the benefit reduction option as the horizon increases, the increase in value decreases with an increase in horizon until it reaches a top value at a horizon with a length of 35 years. Thereafter, the value decreases, even with a horizon length of more than 40 years. In Figure 4.1 it can be seen that the value of the option behaves as some sort of parabola. Due to the approach that has been used in this thesis, by averaging over the scenarios and time horizons, the value of the benefit reduction option reaches a maximum, whereafter it decreases again. This means that the horizon should be chosen carefully for both options. In Table 4.3 it can also be seen that applying both options to the balance sheet does not have much impact on the funding ratio of a pension fund, since the holistic funding ratio is equal to the normal funding ratio for almost all horizon lengths, especially with a horizon length between the fifteen and thirty years. Therefore, it can be concluded that the horizon is important for the value of the options, but a change of horizon is not of much impact on the holistic funding ratio and thus not on the HBS as a whole.

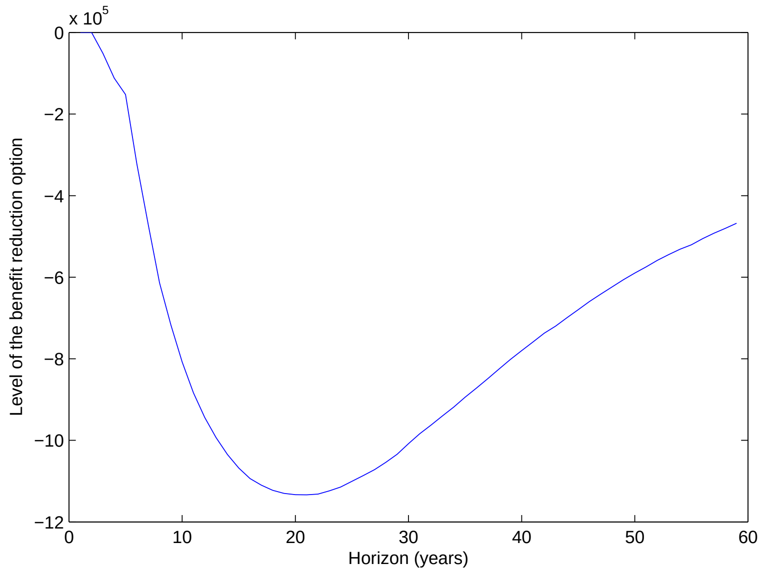

Figure 4.1: Graph of the benefit reduction option for different horizons

4.2.2 Sensitivity of the volatilities of the underlying financial market

In this section, the sensitivity of the model with respect to the underlying financial market and interest rate model will be analyzed by observing the effects of a change in volatility of the interest rate process and a change in the volatility of the stock price.

	Assets				
	$\sigma_r = 0.1\%$	$\sigma_r = 0.366\%$	$\sigma_r = 0.6\%$	$\sigma_r = 1\%$	$\sigma_r = 2\%$
Current assets	110.00	110.00	110.00	110.00	110.00
Premiums	1.81	1.82	1.82	1.84	1.91
Total assets	111.81	111.94	111.82	111.92	111.91
	Liabilities				
	$\sigma_r = 0.1\%$	$\sigma_r = 0.366\%$	$\sigma_r = 0.6\%$	$\sigma_r = 1\%$	$\sigma_r = 2\%$
Nominal liabilities	100.00	100.00	100.00	100.00	100.00
Newly accr. ben.	2.25	2.26	2.26	2.27	2.31
Cond. Indexation	3.51	3.51	3.51	3.63	4.11
Benefit reduction	-3.89	-3.99	-4.02	-4.24	-5.36
Equity	9.93	10.04	10.07	10.18	10.86
Total liabilities	111.81	111.82	111.82	111.84	111.91
Holistic FR	110%	110%	110%	110%	111%

Table 4.4: The HBS for different values of σ_r

In Table 4.4 it can be seen that a change in the volatility level of the interest rate process does not have a large impact on the embedded option of conditional indexation. With the volatility level at 0.1%, the option value is exactly the same as the basic case. Furthermore, if the volatility is increased to a volatility of 2%, the value of the option only increases with 0.6 percentage points. This shows that if the volatility is more than five times higher, the value increases only with eighteen percent. The effects on the other option, the benefit reduction, are more clear, since the value of the option is increased with more than thirty-four percent if the volatility of the discount rate is changed to 2%. Nevertheless, a further decrease in volatility does not have a large impact with only a decrease of 0.1 percentage point. The volatility of the interest rate process thus only has a small impact on the option of conditional indexation and a larger but still not a very significant impact on the option of benefit reduction, because a very large volatility is not realistic. Therefore, a pension fund can choose a logical volatility level of the interest rates process without wondering if this has a large impact on the option value.

Only changing the parameter σ_r of the interest rate process does not give a complete overview of the impact of changing the volatility of the interest rate process. If the parameter a will be in- or decreased, this will also have an impact on the volatility of the interest rates. Nevertheless, it has been found that a change in this parameter does not significantly change the results presented above, even for large changes. Therefore, it can be concluded that the model is robust for changes in the interest rate process.

	Assets			
	$\sigma = 5\%$	$\sigma = 10\%$	$\sigma = 20\%$	$\sigma = 25\%$
Current assets	110.00	110.00	110.00	110.00
Premiums	1.67	1.73	1.82	1.84
Total assets	111.67	111.73	111.82	111.84
	Liabilities			
	$\sigma = 5\%$	$\sigma = 10\%$	$\sigma = 20\%$	$\sigma = 25\%$
Nominal liabilities	100.00	100.00	100.00	100.00
Newly accr. ben.	2.26	2.26	2.26	2.26
Cond. Indexation	2.30	2.87	3.51	3.58
Benefit reduction	-2.08	-2.18	-3.99	-5.11
Equity	9.19	8.78	10.04	11.12
Total liabilities	111.67	111.73	111.82	111.84
Holistic FR	109%	109%	110%	111%

Table 4.5: The HBS for different values of σ

In Table 4.5 it can be seen that a change in the volatility of the stock price process has a significant influence on the values of the two embedded options, although the option of conditional indexation fluctuates less than the option of benefit reduction. A volatility level of 30% is not shown in this table, because a volatility level of that level or above results in very high fluctuations of the asset value, which result in some cases in extreme asset loss. This made the model instable. Therefore, it can be concluded that, although the value of the options are robust with respect to the volatility level of the interest rate model, they are not robust with respect to the volatility level of the stock price process. Thus, this volatility level should be chosen carefully and it might be the case that different underlying models will result in different values for the two options.

4.2.3 Sensitivity of the investment strategy

Now that the effects of a change in horizon length and the volatility of the underlying model are analyzed, the focus will be changed to the current funding ratio and the current investment strategy. Thus to parameters that are primarily dependent on the current pension state and policy. The investment strategy of a pension fund will first be analyzed by changing the percentage of assets invests in stocks. The corresponding results are presented in Table 4.6 for an investment strategy which invests between 40% and 80% of its assets in stocks. These values will be compared to the basic case with an investment strategy which invests 60% of its assets in stocks. When a pension fund has a more risky investment strategy, there will be more and higher downward and upward shocks in the assets and the corresponding funding ratios. As can be seen in the Table 4.6, an increase in the percentage of stocks also increases the value of the embedded options. Nevertheless, it is found that the change in stock allocation does not have a large impact on the option of conditional indexation. A pension fund uses conditional indexation if the funding ratio is between the minimum required funding ratio and the required funding ratio. If a pension fund takes more risks, the height or frequency of the shocks increases, but the average of the shocks and thereby the possibility of a funding rate between the minimum required funding ratio and required funding ratio will remain the same, whereafter the value of the option also remains approximately equal. Nevertheless, the option of benefit reduction is increased by taking more risks, simply due to the fact that an increase in the frequency and height of the shocks increases the probability of a funding ratio which is below the minimum required level of 105%. Therefore, it can be concluded that the investment strategy is only important for the option of benefit reduction and not for the option of conditional indexation.

	Assets				
	$\phi = 40\%$	$\phi = 50\%$	$\phi = 60\%$	$\phi = 70\%$	$\phi = 80\%$
Current assets	110.00	110.00	110.00	110.00	110.00
Premiums	1.76	1.79	1.82	1.83	1.85
Total assets	111.76	111.79	111.82	111.83	111.85
	Liabilities				
	$\phi = 40\%$	$\phi = 50\%$	$\phi = 60\%$	$\phi = 70\%$	$\phi = 80\%$
Nominal liabilities	100.00	100.00	100.00	100.00	100.00
Newly accr. ben.	2.26	2.26	2.26	2.26	2.26
Cond. Indexation	3.23	3.38	3.51	3.55	3.63
Benefit reduction	-2.61	-3.27	-3.99	-4.72	-5.52
Equity	8.87	9.41	10.04	10.74	11.48
Total liabilities	111.76	111.79	111.82	111.83	111.85
Holistic FR	109%	109%	110%	111%	111%

Table 4.6: The HBS for different percentages invested in stocks, ϕ

4.2.4 Sensitivity of the initial funding ratio

The final parameter that will be analyzed is the initial funding ratio. The question with regard to the initial funding ratio is whether the values of the options change when a pension fund has a low or high funding ratio. In Table 4.7 these results are presented for an initial funding ratio between 90 and 130 percent. Here, it can be seen that the funding ratio is important for the value of the two options, as could be expected. If a pension fund currently performs bad, the possibility that this pension fund will cut the benefits of their participants in the future is high, which results in a higher value for the option of benefit reduction. Furthermore, the possibility of conditional indexation is low, which in turn results in a low value for this option. The opposite also holds; when a pension fund currently has a high funding ratio, this corresponds to a low value for the option of benefit reduction and a high value for the option of conditional indexation. Thus, if a pension fund has a high funding ratio, the possibility of benefit reduction does not add much value, but the option of conditional indexation does. The funding ratio of the HBS even improves as compared to the standard funding ratio with a low initial funding ratio. Thus when the current funding ratio is low, taking account for these options improves the funding ratio. Nevertheless, for high funding ratio the exact opposite holds. This thus shows that a bad performing pension fund has less risks to take into account then a good performing pension fund. The risks for participants are the complete opposite, with higher risks if a pension fund performs bad compared to a good performing pension fund.

	Assets					
	$FR_0 = 90\%$	$FR_0 = 100\%$	$FR_0 = 105\%$	$FR_0 = 110\%$	$FR_0 = 120\%$	$FR_0 = 130\%$
Current assets	90.00	100.00	105.00	110.00	120.00	130.00
Premiums	2.08	1.96	1.89	1.82	1.67	1.55
Total assets	92.08	101.96	106.89	111.82	121.67	131.55
	Liabilities					
	$FR_0 = 90\%$	$FR_0 = 100\%$	$FR_0 = 105\%$	$FR_0 = 110\%$	$FR_0 = 120\%$	$FR_0 = 130\%$
Nominal liabilities	100.00	100.00	100.00	100.00	100.00	100.00
Newly accr. ben.	2.26	2.25	2.26	2.25	2.25	2.25
Cond. Indexation	1.53	2.40	3.02	3.51	5.09	6.67
Benefit reduction	-7.74	-5.50	-4.32	-3.99	-3.51	-3.28
Equity	-3.97	2.80	5.93	10.04	17.83	25.90
Total liabilities	92.08	101.96	106.89	111.82	121.67	131.55
Holistic FR	96%	103%	106%	110%	117%	125%

Table 4.7: The HBS for different initial funding ratios

Now that the influence of the initial funding ratio as well as the other important parameters is determined, the question remains what these results say about the two options on the HBS and the balance sheet as a whole. EIOPA is planning to insert the HBS as a way to give insight in the risks a pension fund bears. The above results show that the funding ratio of a pension fund changes if the HBS is used. However, the impact depends on the current state of the pension fund. Using the HBS can be positive for a pension fund if the funding ratio is low and can be negative for a pension fund if the funding ratio is high. It can be seen that the option of benefit reduction is important and has a value that is, as long as the funding ratio is below 110%, even higher than the value of the option of conditional indexation. This is an interesting result, because this option has never been used before and especially foreign policy makers had not even taken this possibility into account until recent years. Seeing that this option thus has a large impact is remarkable. In addition to this option, it can also be observed that the option of conditional indexation is lower than the option of benefit reduction for most scenarios. An explanation could be the new approach that has been used to derive the results in this thesis. By taking account of the full impact of an option, the option of benefit reduction may be higher than just the value of the combined reductions and the option of conditional indexation may be lower than the value of the combined indexation amounts.

Another remarkable finding is that for the option of conditional indexation the investment strategy is not very important. This is remarkable since the goal of the HBS is to give a better understanding of the risks a pension fund bears. Investing a higher percentage of the assets in stocks was thought to have a positive correlation with the risk of conditional indexation. This increase in risk should give a higher possibility of future upwards shocks and thus a higher value to the option of conditional indexation. However, this is not the case. In fact, taking more risks results in only a small increase in value of the option of conditional indexation and a large increase in the value of the option of benefit reduction. Thus, a pension fund is better off by taking less financial risk.

The above results show that the holistic funding ratio changes significantly depending on certain parameters. However, the holistic funding ratio only shows the state of a pension fund with respect to the future if the presented mechanisms are used as they were constructed. Therefore, the holistic funding ratio should not be used for decision making, since it shows the funding ratio based on future expectations and not the current state of a pension fund. For instance, if a pension fund takes into account the possibility of benefit reduction this will result in an increase in the holistic funding ratio, but if this means that due to this holistic funding ratio a pension fund should now not be obliged to cut their benefits or with a much lower percentage, the option should lose value and would therefore not be representative anymore. Therefore, this holistic funding ratio should only be used as a way to get more insight in the risk a pension fund bears.

4.3 Change in valuation method

Now that the importance of the different parameters has been analyzed in detail in the previous section, the valuation method as presented in this thesis will be analysed. As has been stated previously, a new way of deriving the values of the options has been used in this thesis. This new way focuses on the whole impact of the options and not just on the value that is added at each point in time at each scenario. In order to see the difference between this way and the standard value-based ALM, the standard value-based ALM results are presented in Table 4.8 below.

	Assets						
	T=10	T=15	T=20	T=25	T=30	T=35	T=40
Current assets	110,00	110,00	110,00	110,00	110,00	110,00	110,00
Premiums	1,97	1,90	1,81	1,72	1,63	1,54	1,46
Total assets	111,97	111,90	111,81	111,72	111,63	111,54	111,46
	Liabilities						
	T=10	T=15	T=20	T=25	T=30	T=35	T=40
Nominal liabilities	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Newly accr. ben.	2,62	2,44	2,25	2,08	1,92	1,77	1,64
Cond. Indexation	5,49	7,74	9,54	11,03	12,35	13,56	14,68
Benefit reduction	-5,82	-8,03	-9,71	-10,93	-11,81	-12,48	-13,00
Equity	9,68	9,74	9,73	9,54	9,18	8,69	8,13
Total liabilities	111,97	111,90	111,81	111,72	111,63	111,54	111,46
Holistic FR	109%	110%	110%	109%	109%	108%	108%

Table 4.8: The HBS for different horizon under the standard value-based ALM approach

Firstly, in this table it can be seen that, as is the case in the presentation of the working paper of Fransen et al., both options do not converge to a certain value and keep increasing as the horizon increases. Secondly, the most stunning result in this table is the high values of both options. Where the value of the conditional indexation option first was between 1.56 and 5.39 percent of the liabilities, it is now between 5.49 and 14.68 percent of the liabilities. This increase is remarkable, but is more conform the findings of the working papers of Fransen et al. (2012) and de Haan et al. (2012). The standard value-based ALM approach and the new approach presented in this thesis are thus significantly different. The difference, however, can be explained by the increase in liabilities. By executing the conditional indexation option, the funding ratio is lowered, which result in a higher premium rate. This higher premium rate will make sure that the value of the assets increases which will counter the increase in liabilities. This results in a more positive future perspective than just primarily taking into account the value of the indexation, which can be found in the basic results as presented previously. Furthermore, the increase in liabilities also increases the possibility of future benefit cuts and this interaction between the options can also cause the value of the conditional indexation option to decrease. The same explanation can be followed for the option of benefit reduction, where a decrease in liabilities results in a higher funding ratio. This will then result in a higher possibility of conditional indexation and a lower premium level, which will have a negative effect on the funding ratio and would therefore lower the value of the option. It has been found that taking account of the total effects of the options on the balance sheet results in lower values of the options as compared to the standard value-based ALM method. This shows that the actual impact or value of an option is less than previously thought. Therefore, it would be better for pension fund managers to use the approach of this thesis in order to take the actual risk of conditional indexation and benefit reduction into account.

Another important difference between the approach used in this thesis and the approach as it is used above is that the values of the different options are not dependent on the existence of other options. In the working paper of de Haan et al. of October 2012, it is shown that by adding extra options to a model, the previous option values change as well. This is because the values of the options are determined only by the value an option contributes at a certain time. These values can be changed if other options are added, because an extra option can for instance result in a smaller possibility of executing the previous option which lowers its value. This can lead to an option that does not contribute anything to the future perspectives, but due to a transfer of value between options still gets a significant value. Therefore, the impact of the previous options should not be changed by adding a new option and the value of this new option should be the true impact on the future perspectives, with respect to the other options, and should not cause these other options to change value as well. In the approach that is used in this thesis, this is exactly the case. If the options are constructed by the difference in a pension fund with that option and a pension fund without that option ceteris paribus, the value will not change by adding an extra option. The reason for this is that the value of this new option will be determined by the difference of a pension fund with all previous options and a pension fund which also includes this new option. This results in a value that shows the impact of that particular option, ceteris paribus.

Chapter 5

Sensitivity Analysis

In the previous chapter the results of the model are presented. As has already been stated, the interesting part of this study is to see what drives these options, such that pension fund managers can use this information to derive their own value of the different options based on the current status of their pension fund. Where in the previous sections the sensitivity to certain parameters are investigated, in this chapter the model itself will be changed such that the benefits will be cut sooner by making the conditions softer. Firstly, a pension fund will be able to cut the benefits of their participants when the funding ratio of the previous year is below 105% with a maximum of 7% reduction each year. Secondly, a pension fund will be able to cut the benefits of their participants immediately after the funding ratio drops below the level of 105% with no further restrictions.

A pension fund is only allowed to cut the benefits of their participants as a measure of last resort. This means that only if, after two consecutive years, the funding ratio of a pension fund is still below the minimum required level, even with the higher premium level and no indexation, a pension fund is obliged to cut the benefits. An interesting question in this respect is what the effect will be on the value of the option of benefit reduction if these conditions are made softer. If this does not have much impact, the determination of the values of the options can be simplified, which would be a big help for pension fund managers.

Cond. Index	T=10	T=15	T=20	T=25	T=30	T=35	T=40
Basic model	-1.87	-3.13	-3.99	-4.46	-4.72	-4.82	-4.81
Soft model	-2.43	-3.77	-4.60	-5.06	-5.28	-5.34	-5.30
Immediate model	-3.92	-5.33	-6.09	-6.47	-6.61	-6.59	-6.47

Table 5.1: Values of the option of benefit reduction for the different softer models over different horizons

In Table 5.1 the results are presented for the different horizons, where the soft model stands for the pension fund that will cut the benefits of their participants if the funding ratio is below 105%, with a maximum cut of 7% each year and the immediate model stands for a pension fund that will cut the benefits of their participants with no restrictions if the funding ratio is below 105%. In this table it can clearly be seen that the values of the different models differ significantly, especially for a short horizon. If the horizon increases, softer models will reach their peak value sooner. It is clear that the values of the softer models are higher, but it is remarkable that they reach their top sooner. This can be explained by the fact that with softer conditions, the possible future states of the funding ratio are better, such that the possibility of benefit reduction decreases. Therefore, the value of the option decreases over time until it is close to zero and since the average will be taken over all values this implies a lower value of the option. Thus, the softer the model, the higher the value of the option, but the less important the horizon length becomes.

	$\phi = 40\%$	$\phi = 50\%$	$\phi = 60\%$	$\phi = 70\%$	$\phi = 80\%$
Basic model	-2.61	-3.27	-3.99	-4.72	-5.52
Soft model	-2.92	-3.71	-4.60	-5.52	-6.37
Immediate model	-3.59	-4.78	-6.09	-7.67	-9.13

Table 5.2: Values of the option of benefit reduction for the different softer models for different values of ϕ

In Table 5.2 the influence of a change in the percentage invested in stocks is shown. Here it can again be seen that the values of the soft and immediate model are higher than the basic model. In addition, it can also be seen that the softer models are more sensitive to an in- or decrease in the percentage invested in stocks. The value of the option is decreased by 34% in the basic model and by 41% in the immediate model if the percentage invested in stocks is decreased from 60% to 40%. Furthermore, if the percentage invested in stocks is increased from 60% to 80%, the value of the option increases by 39% in the basic model and by 50% in the immediate model. This shows that the immediate model is more sensitive to changes and is therefore more volatile for a change in the percentage invested in stocks.

	$FR_0 = 90\%$	$FR_0 = 100\%$	$FR_0 = 105\%$	$FR_0 = 110\%$	$FR_0 = 120\%$	$FR_0 = 130\%$
Basic model	-96%	-39%	-9%	0%	11%	17%
Soft model	-77%	-28%	-10%	0%	12%	20%
Immediate model	-79%	-29%	-13%	0%	13%	22%

Table 5.3: Percentage in- or decrease of the option of benefit reduction for the different softer models for different values of the initial funding ratio with as basic funding ratio set at 110%

In Table 5.3 the in- and decreases in value of the benefit reduction option are shown in percentage of the value of the option with the basic funding ratio set at 110%. This shows that making the model softer reduces the influence of a decrease in initial funding ratio. However, it increases the influence of a higher initial funding ratio, although only slightly. This is remarkable, but can be explained by the fact that if the model is softer, the option of benefit reduction is executed right after the funding ratio reaches a level below 105% in a certain year. If the initial funding ratio is low, these conditions result in an increase in the value of the option, but it should not increase the amounts this option is used by much. However, the option in the basic model is only executed if the funding ratio is below the level of 105% for two consecutive years. Therefore, the probability that this option will be executed increases with a low initial funding ratio and decreases more than the other models with a high initial funding ratio. This, combined with the higher expected value, will result in more variability across the funding ratios.

Combining the above comparisons between the different models shows that the value of the option increases by making the conditions for the option of benefit reduction softer. Furthermore, some parameters become less or more important in comparison with the basic conditions. The horizon and the initial funding ratio become less important and the riskiness of the investment portfolio becomes more important. Therefore, it can be concluded that making the conditions softer will change the outcomes of the option of benefit reduction significantly. Thus, in order to give a best representation of the positive 'risk' of benefit reduction, the basic model should be used to value the option instead of a softer version.

Chapter 6

Conclusions and recommendations

This final chapter states the conclusions that can be made based upon the above presented results and the recommendations for further research in this field.

6.1 Conclusions

In the introduction of this thesis it has been stated that the goal of this thesis is to investigate the influence of the HBS for pension funds and especially to investigate the influence the options of conditional indexation and benefit reduction have on the balance sheet. This new way of presenting the balance sheet and the corresponding holistic funding ratio is still under much discussion and will probably only be implemented as a way for pension fund managers to get more insight in the risks and not as an actual method to present in the annual reports. Nevertheless, the concept of this new approach is interesting and pension funds throughout Europe should value their risks in a consistent way in order to be able to compare them. Furthermore, the holistic funding ratio should not be used for decision making, since it shows the funding ratio based on future expectations and not the current state of a pension fund. These insights were gained in this thesis by constructing a pension fund with an underlying theoretical financial market. Through scenario analysis and a new way of value-based ALM values were constructed for the different embedded options.

The results as they are presented in Chapter 4 show some remarkable findings and aspects of these options. It has been found that the option of benefit reduction is really important for a pension fund to take into account. Although this option will not be executed much, it has a large impact on the value of the liabilities. Taking the possibility of future benefit reduction into account can lower the liabilities between 1.87 and 7.74 percent, which is a significant decrease. Furthermore, taking into account the possibility of future conditional indexation can increase the liabilities between 1.53 and 6.67 percent. Nevertheless, the value of these options differ significantly, which means that the option value is not very robust. The reason for this large variation is that the option strongly depends on certain important parameters, namely the chosen horizon, the investment strategy, the current funding ratio and the volatility of the underlying interest rate and financial market model.

The length of the horizon for which the values are determined is only important up till a certain point. Due to the approach that has been used, the value of the benefit reduction option reaches a peak after a certain horizon, whereafter it decreases. This means that as the horizon increases the option becomes less important as compared to the option of conditional indexation that does not have this characteristic. However, the change in horizon has only a very slight impact on the holistic funding ratio, because the value of both options cancel each other out, with only small differences in value. Therefore, it can be concluded that the horizon length is not of much interest for the HBS, which is an opposite conclusion of the working paper of Fransen et al. (2012). Furthermore, it has been found that the investment strategy has a remarkable impact on the values of the options. The value of the option of benefit reduction increases as the riskiness of the investment strategy increases. However, the value of the option of conditional indexation changes only slightly with an increase in the riskiness of the investment strategy. The same phenomenon can be found by in- or decreasing the volatility of the underlying interest rate or financial market model. The reason for this is that conditional indexation will be executed between a minimum and a maximum value of the funding ratio and an increase in volatility only increases the height of the shocks and not the average, the volatility does not have much influence on the value of the conditional indexation option. Since the conditional indexation option is not affected much, the pension fund will be better off by taking little investment risk.

By investigating how the different options behave for different funding ratios, a clear overview of the future perspectives of a pension fund with a certain funding ratio is provided. If a pension fund is under-funded, which means that it has a funding ratio of less than 105%, the HBS shows that, due to the high probability of cutting the benefits and a low probability of indexation, the holistic funding ratio is higher than the actual funding ratio. The reason is that the expectations are better due to possible future decreases in liabilities. Furthermore, if the current funding ratio is high the possibility of conditional or full indexation is also high. This will then result in a large possibility of an extra increase in liabilities. This will result in a large value of this embedded option and therefore in a holistic funding ratio which is lower than the actual funding ratio. Using the HBS does therefore not mean that the funding ratio is improved, but it does give a better insight in the actual state of a pension fund if it should execute each option.

An important contribution of this thesis is the new way of determining the value of the options. In the working paper of Fransen et al. as it was presented in the Netspar meeting of October 2012 a value-based ALM approach was used where the value of the options were equal to the added, or lost, value of executing the options, discounted to the present. In this thesis, the value of the options is determined by looking at the difference between a pension fund which includes the option and a pension fund which does not include the option, ceteris paribus. This new way of valuing the options shows the true impact of these options and not just simply the added value at the moment in time, which results in lower values for both options. Furthermore, this way of determining the value of the options also makes sure that the values of the options do not change by adding a new option. In the working paper of de Haan et al. of October 2012 it is shown that adding different options to the model changes the previous options, which occurs because the values in that paper are determined by the values an option contributes at a certain point in time and this changes if other options are taken into account. Using the approach in this thesis, the previous option values thus remain the same, which gives a better understanding of the option values themselves without wondering about other options.

The two embedded options that are investigated in this thesis show that they are risks that must be taken into account. Although the values depend on many different aspects, they remain significant and change the true future perspective or health of a pension fund. Therefore, it would be recommended that EIOPA changes the 'option' to include the option of benefit reduction into an obligation. However, it should not be forgotten that this holistic funding ratio is only true if the options are executed as they are constructed. It can be concluded that the HBS is definitely an improvement of the traditional balance sheet and it gives clear insight in the different risks of a pension fund as long as it will only be used as a way to acquire extra insights in the risks of a pension fund and not for decision making.

6.2 Recommendations

Every research has its limitations and this thesis is not any different. There are still many questions that can be researched and some questions have arisen due to this thesis. Therefore, recommendations for further research will be presented in this final section.

First of all, the model for the financial market that has been used in this thesis is too simplistic to apply in the determination of these values for actual pension funds. In the QIS of October 2012 as presented by EIOPA, it is also not clear which financial market model should be used. Changing the underlying financial market will have an impact on the values presented in this thesis as can be seen in Section 4.2.2. Therefore, it will be interested to analyze the value of the options with the model which will be presented by EIOPA as the 'actual' financial market model.

Second of all, in this thesis only two possible options which might be included in the HBS have been analysed. However, Dutch pension funds have more options to their disposal, which makes it interesting to apply the same method as described in this thesis to analyze the value of these other embedded options. In this way the total impact of the HBS can be analyzed and a clear insight can be given in the risks a pension fund bears and the true future perspective or health of a pension fund.

Third of all, it would be interesting to see what the effects of the embedded options will be on the SCR itself, as it is presented in the QIS of EIOPA. By investigating the impact of these options on the SCR, especially under the valuation method presented in this thesis, will give a total insight in these risks.

Finally, it would be interesting to run the model presented in this thesis with actual pension fund data. In this thesis only fictitious data has been used, which result in fictitious results. Although the data is constructed to represent a pension fund as close as possible, it does not represent a real pension fund completely. Therefore, using actual pension fund data will be an addition to this research.

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