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The Holistic Balance Sheet as the new framework for European Pension Supervision

Evaluation from a Dutch Perspective*

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Working paper: comments welcome**

Abstract

The European Commission (EC) plans to revise the IORP Directive in order to introduce a harmonized framework of quantitative requirements for European pension funds. The so-called 'holistic balance sheet approach' is advised by EIOPA, which enables regulators to compare various pension systems across Europe in one framework. A holistic balance sheet is an extension of the traditional balance sheet, as next to the usual assets and liabilities, conditional assets and liabilities are stated. These conditional assets and liabilities are the economic value of the various policy instruments, which can be valued as embedded options with the help of derivative pricing techniques.

The impact of the holistic balance sheet approach is compared to a traditional balance sheet and alternative holistic balance sheet methods are put forward. The holistic balance sheet is intellectually tempting, however it could be further improved. This paper comes up with three concrete proposals in order to improve the proposed holistic balance sheet: an open fund framework instead of a closed one, a dynamic solvency measure instead of a static one, and specific supervision regarding the risk model to be used in the valuation of the holistic balance sheet.

Keywords: Holistic Balance Sheet, European pension supervision, value-based ALM, embedded pension options

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1 Introduction and Summary

1.1 Towards a harmonized supervision for European pension funds

In 2003 the Institution for Occupational Retirement Provision (IORP) Directive was introduced. The objective of the IORP Directive has been to provide a regulatory framework for occupational pension funds across Europe. The current IORP Directive provides national Member States a lot of freedom of determining the national quantitative and qualitative requirements for pension funds. In the Netherlands, the requirements of the IORP Directive are embedded in the Dutch Pension Law. Part of the Dutch Pension Law is the FTK regulation (Financial Assessment Framework), which prescribes the quantitative requirements for IORPs.
The European Commission is willing to harmonize the quantitative requirements for pension funds across Europe, just like the earlier harmonized supervision on banks (Basel III) and insurance companies (Solvency II).

In February 2012, the European Insurance and Occupational Pensions Authority (EIOPA) gave the European Commission an extensive advice on the revision of the IORP Directive, both on qualitative and quantitative requirements. The quantitative requirements proposed by EIOPA are often based on the already existing Solvency II framework (European insurance legislation). However, it should be noted that pension funds are other kind of institutions than insurance companies from a governance perspective; pension funds have the ability to use risk-mitigating instruments such as steering mechanisms (e.g. higher contributions, additional sponsor support) and adjustment mechanisms (e.g. conditional indexation, cutting benefits) for adjusting the financial position of the fund. According to EIOPA all these unique characteristics of pension funds should be incorporated in the revised IORP Directive.

The harmonization of quantitative requirements is a complex issue as occupational pension plans differ considerably across Europe because of country-specific first pillar pension schemes and labor legislation. An important issue regarding the quantitative requirements for pension funds is to safeguard the pension promise, which currently varies across Europe due to the different steering and adjustment mechanisms pension funds are able to use in the different Member States. For example, German pension plans could rely on a strong employer guarantee, participants of UK pension plans are able to fall back on the pension protection fund in case of a pension fund default, whereas Dutch pension plans might make use of recovery contributions and benefit cuts to restore the solvency position.

As pension systems and their steering and adjustment instruments vary significantly across Europe, it is hard to compare different pension funds of different member states of IORP. In order to obtain more harmonization across Europe, EIOPA proposes a harmonization of all the valuation rules across Europe and a so-called holistic balance sheet, in order to be able to take into account all the different policy instruments of pension funds across Europe. In addition, this holistic balance sheet provides the opportunity to have a prudential framework which is based on Solvency II, but which is tailor-made for IORP pension funds. Such a balance sheet is an extension of a traditional balance sheet, as next to the usual assets and liabilities also immaterial and conditional assets and liabilities are stated. The values of these conditional assets and liabilities are contingent on the regulation of the pension system and will therefore result in different values across countries in Europe. Hence, the holistic balance sheet aims to deliver a more complete picture of the financial position of a pension fund than the traditional balance sheet. For instance, consider two different pension funds with the same traditional balance sheet at one moment in time, and thus the same funding ratio. Suppose pension fund 1 has a policy in which the participants get conditional indexation, while pension fund 2 has the additional right to cut the benefits of the participants if the funding ratio becomes extremely low. As can be concluded from this example, the actual financial position of pension fund 2 is much better than that of pension fund 1. The funding ratio of the holistic balance sheet takes these policy instruments explicitly into account and gives thus a better representation of the financial position of the pension fund.

In its advice to the European Commission, EIOPA said that its advice is conditional on the outcomes of a Quantitative Impact Study (QIS). This QIS will be performed in Q4 2012. European pension organizations are concerned that this new way of supervision is very complex and could lead to additional funding requirements which might hamper the pension benefits of European retirees[1]. However, it is still quite diffuse what the actual impact of a revised IORP Directive will be. In the draft specification of the QIS, there is a broad range of different parameters which will be tested. For example, crucial elements like the confidence level of the pension promise, the discount rate for the valuation of the liabilities and the length of recovery periods. The question if the proposal for a revised IORP Directive will lead to higher capital requirements, is very dependent on these parameters, and can therefore not be answered. Therefore, the current FTK parameters are used in this study in order to show the difference between a traditional and a holistic balance sheet. This study only focuses on pension funds from a Dutch perspective and the applicability of the concept of the holistic balance sheet.

1.2 Our proposals

The holistic balance sheet is intellectually tempting and could provide useful information for a pension fund, however it needs improvements. This paper comes up with two concrete proposals in order to improve the proposed holistic balance sheet: a dynamic solvency measure instead of a static one and an open fund framework instead of a closed one. Furthermore we advise that the supervisors should assess the risk models which are used for the holistic balance sheet calculation, since the outcome of the holistic balance sheet is very dependent on the used risk model.

1. Dynamic Solvency measure:

[1] EFRP response - EC Call for Advice to EIOPA on the Review of the IORP Directive - Consultation 2

EIOPA proposes to value the options on the holistic balance sheet as if the fund is fictitiously closed at time zero. Additionally, EIOPA proposes a solvency measure which takes into account the embedded options stated on the holistic balance sheet. However, EIOPA does not properly clarify the required level the pension fund should have in order to be solvent, where this required level turns out to be too high. EIOPA does not yet take into account the closed fund aspect. We introduce a new solvency measure called the dynamic measure, which does take into account the closed fund aspect, since the required level decreases over time, as a consequence of the decreasing duration of the liabilities.

2. Open Framework:
   EIOPA only proposes to value the holistic balance sheet in ABO terms (Accrued Benefit Obligations), where it is assumed that the pension fund is fictitiously closed at the time the holistic balance sheet is set up. A reason for this approach could be that in this way fewer possibilities for differences in subjective interpretations are possible. However, it is more fruitful to consider a PBO framework (Projected Benefit Obligations), where the pension fund remains open for new participants during the horizon considered, new benefits are accrued, and contributions are paid, since such an approach is more in line with reality.

3. Risk model:
   The holistic balance sheet results are significantly dependent on the risk model used, i.e. on the economic scenario generator used. Therefore it is important that in case the holistic balance sheet will be implemented within the European pension supervision, there is a supervision on the risk models used by the different pension funds. It is important that the risk model can be justified, in order to reduce the influence the trustees of a pension fund have on the option values and their (holistic) solvency position.

1.3 Structure paper

First related literature is described in Section 2. The concept the holistic balance sheet is explained in Section 3. In Section 4 the characteristics of the pension fund considered in this paper are described. The type of embedded options that are valued on the holistic balance sheet are introduced in Section 5. For eight different policies the holistic balance sheet is set up in Section 6. In Section 7 the holistic balance sheet is implemented in the closed fund framework and in Section 8 implementations of the holistic balance sheet in the open fund framework are presented. A sensitivity analysis is done in Section 9, after which a conclusion follows in Section 10.

2 Literature

The holistic balance sheet approach is connected to the literature on framing pension funds in terms of embedded options. Since the classic paper of Sharpe (1976), there has been a large number of applications of contingent claim analysis to real-life problems in the fields of pensions and insurance (Blake 1998; Chapman, Gordon and Speed 2001; Guillén, Jørgensen, and Nielsen 2006; Kortleve and Ponds 2006; Kocken 2006, Hoevenaars and Ponds 2008, Lekniute 2011, Lever, Mehlkopf and van Ewijk 2012). It should be emphasized that an analysis with the help of embedded options, also called value-based ALM, is complementary to classical ALM analysis.

Asset Liability Management (ALM) is being used in the pension industry to come to optimal pension deals. Board members of pension plans have to decide what the optimal funding strategy, indexation policy, and investment strategy is for the fund, as well as how risks can be shared best over the various stakeholders like members and sponsors. Value-based ALM adds an extra, new dimension by showing the present value - also called economic value - of all decisions about the funding strategy, indexation policy, and investment strategy. Using the techniques of pricing options and other derivatives, one can calculate the present value of contributions (conditional), benefits (including indexation) and shortfalls/surpluses for the fund collectively and also for the various stakeholders. Value-based ALM essentially uses the same output from scenario analysis as classical ALM, but the future outcomes are either discounted back to the present with an appropriate discount factor, also called deflators, or are valued by making use of risk neutral valuation as is done in this paper.

3 Holistic Balance Sheet

A pension fund has a balance sheet on which the assets and liabilities of the fund are stated, which we call the traditional balance sheet in this paper. A traditional balance sheet gives the financial position of a firm at one moment in time and is given in Table 1. However, as a pension fund has steering and adjustment instruments, the actual financial position of a pension fund is not displayed in the traditional balance sheet. Recall the two different pension funds with the same traditional balance sheet introduced in Section 1.1, where fund 1 gives conditional indexation and fund 2 has the additional right to cut benefits. The actual financial position of fund 2 is much better comparing it with the financial position of fund 1. Therefore, the traditional balance sheet does not provide the actual financial position of a pension fund.

Traditional Balance Sheet

Assets	A_0	Liabilities	L_0
		Residue	R_0
	A_0		A_0

Table 1: The traditional balance sheet

The holistic balance sheet approach does include the steering and adjustment instruments of a pension fund and values them as embedded options on the holistic balance sheet. The steering option that is valued on the holistic balance sheet is named the 'sponsor support' and the adjustment option that is valued on the holistic balance sheet is named the 'adjustment mechanism'.

In Table 2 the holistic balance sheet in a closed fund framework is given, i.e. no new

Holistic Balance Sheet			
Assets	A_0	Liabilities	L_0
Sponsor support	V_0^{SPS}	Adjustment mechanism	V_0^{AM}
		Residue option	V_0^{RO}
	A^{HBS}		A^{HBS}

Table 2: The holistic balance sheet in the closed fund framework

participants are entering the fund after time zero, no contributions are paid, and no new benefits are accrued. In order to obtain a balanced holistic balance sheet, the residue option is added on the liability side, which can be either positive or negative.

In an open fund framework, the holistic balance sheet looks slightly different, as two additional aspects are added on the balance sheet, namely the contributions paid and the new benefits accrued during the horizon considered. In Table 3 the holistic balance

Holistic Balance Sheet			
Assets	A_0	Liabilities	L_0
Contributions	CON	New accrued benefits	NAB
Sponsor support	V_0^{SPS}	Adjustment mechanism	V_0^{AM}
		Residue option	V_0^{RO}
	A^{HBS}		A^{HBS}

Table 3: The holistic balance sheet in the open fund framework

sheet in the open fund framework is displayed, where again the residue option is added on the liability side such that the holistic balance sheet is balanced.

The total assets on the holistic balance sheet are given by A^{HBS}, where it holds that

$$A^{HBS} = A_0 + CON + V_0^{SPS}.$$

The total liabilities on the holistic balance sheet are given by L^{HBS}, where it holds that

$$L^{HBS} = L_0 + NAB + V_0^{AM}.$$

Note that CON and NAB are equal to zero in case of the closed fund framework. Finally, the holistic funding ratio FR^{HBS} is given by

$$FR^{HBS} = \frac{A^{HBS}}{L^{HBS}}.$$

Note that in the case the holistic funding ratio will be larger than 100%, the residue option is positive.

4 Specifications

As the Holistic Balance Sheet approach is evaluated from the perspective of the Dutch pension fund sector, this section specifies the characteristics of the Dutch pension fund sector:

- The pension plan is an average wage plan (this is the dominant type in the Netherlands);
- The contribution paid and the pension accrual accrued by the participants, and the indexation given to the participants is uniform across generations and scenarios;
- The benefits received by the pension members are conditional indexed for wage growth;
- The accrual rate ϵ is set equal to two percent of the pensionable wage income (=gross wage minus a franchise income related to the first pillar flat rate public pension);
- An individual in the pension fund is assumed to enter the fund at the age of 25, to pay contributions during his/her working life, to start receiving pension benefits at the age of 65, and to decease at the age of 99 at maximum;
- The investment strategy considered consists of a portfolio invested for 50 percent in stocks and for 50 percent in bonds, where the investment portfolio will be rebalanced each time period.

For the demographics of the fund, a dataset supplied by CBS (Statistics Netherlands) is used. This dataset includes the size of the Dutch population for each cohort and their survival probabilities. Furthermore, it contains projections of both the population size and the survival probabilities for future years. Additionally, the dataset is gender specific, as it is known that males and females have different survival probabilities.
An ALM model uses a risk model, i.e. an economic scenario generator, that produces stochastic simulations of returns on assets, inflation, and other relevant economic data. For this study the APG risk model is used (cf. Van den Goorbergh, Molenaar, Steenbeek, and Vlaar, 2011). The analysis is based on 5000 economic scenarios, both under the real probability measure $\mathbb{P}$ and the risk neutral measure $\mathbb{Q}$. The risk model and ALM model used are further clarified in Appendix A.1 and Appendix A.2 respectively.

5 Embedded options

Within the holistic balance sheet, the value of the conditional assets and liabilities are shown. The economic value of these various policy instruments can be valued as embedded options with the help of derivative pricing techniques. An embedded option is an option or guarantee contained in a financial product. For instance, the indexation given to the participants of a fund can be contingent on the financial position of that

fund. Hence, the indexation payout (when and magnitude) is embedded in the pension contract.
As shown in Table 4, there could be nine types of (embedded) options discerned in total, two as types of the sponsor support displayed on the asset side, five as types of the benefit adjustment mechanism displayed on the liability side and the last two as types of the residue option. These first seven types of options are used by Dutch pension funds. We will describe them all in short:

Holistic Balance Sheet			
Assets	A_0	Liabilities	L_0
Sponsor support	V_0^{SPS}	Adjustment mechanism	V_0^{AM}
1. Employee contribution option		3. Indexation option	
2. Employer guarantee option		4. Catch up indexation option	
		5. Surplus sharing option	
		6. Sustainability cut option	
		7. Recovery plan option	
		Residue option	V_0^{RO}
		8. Surplus option	
		9. Deficit option	
	A^{HBS}		A^{HBS}

Table 4: The holistic balance sheet discerned in nine types of options in the closed fund framework

Sponsor support

1. Employee contribution option: A pension fund may have the option to add to the base contribution rate a surcharge in case of a low funding ratio.[2].

2. Employer guarantee option: The employer may have promised to provide additional funding when the funding ratio falls below some critical level.

Adjustment mechanism

3. Indexation option: The indexation of accrued rights is linked to the funding ratio via a so-called indexation ladder which defines when full indexation, no indexation or partial indexation is granted.

4. Catch up indexation option: When the funding ratio is high, pension funds may consider to redeem missed indexation in the past.

5. Surplus sharing option: When funding has reached high levels and missed indexation and possible cuts are redeemed, the pension fund can opt to share the funding surplus with the participants by granting extra indexation above full indexation.

[2]Additionally it may apply a contribution reduction in case of a high funding ratio, however, this reduction is not implemented in the model used in this paper

6. Sustainability cut option: In case of severe underfunding, a pension fund can reduce the size of the accrued rights such that the funding ratio is at least equal to a certain minimum. Such a cut actually can be seen as negative indexation and can be offset by the instrument of catch-up indexation.

7. Recovery plan option: When the funding ratio falls below some critical level, pension funds need to define a recovery plan in order to restore within a defined number of years above that critical level. If the recovery falls behind the planned recovery, cuts may be applied.

Residue option

8. Surplus option: This option denotes the economic value of the surplus of the pension fund at the end of the evaluation horizon. A change in the size of this option indicates how the future benefits contribute to the steering and solvency position of the pension fund.

9. Deficit option: This option denotes the economic value of the shortage of the pension fund at the end of the evaluation horizon.

The valuation of these options is explained in Appendix B.

6 Effect of different policies on option values in closed fund framework

Policy	Conditional indexation	Recovery premium	Catch up indexation	Sustainability cut	Recovery plan	Surplus sharing	Employer guarantee
1							
2	✓						
3	✓	✓					
4	✓	✓	✓				
5	✓	✓	✓	✓			
6	✓	✓	✓	✓	✓		
7	✓	✓	✓	✓	✓	✓	
8	✓	✓	✓	✓	✓	✓	✓

Table 5: Eight different policies with their types of policy instruments used

We consider eight different pension fund policies, where an overview is given in Table 5. From the table it can be seen that in each policy an additional policy instrument is added compared to the previous policy.

- First of all, in Policy 1 no policy instruments will be used by the pension fund, where full indexation is given to each participant independent of the financial situation of the pension fund.

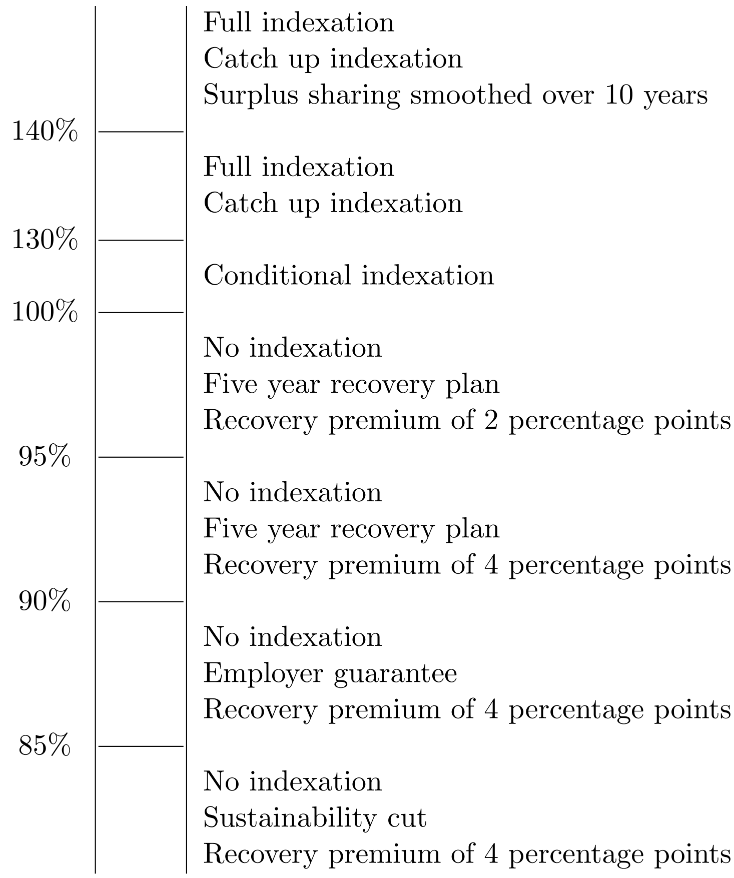

Figure 1: Order of policy instruments the pension fund can use dependent on its funding ratio

- In Policy 2, the adjustment instrument conditional indexation is introduced, where full indexation will not be given in all different scenarios. Full indexation is only given in case the funding ratio is larger than or equal to 130%, no indexation is given in case the funding ratio is smaller than or equal to 100% and conditional indexation is given in between.

- In Policy 3, a recovery premium is added to Policy 2. In case the funding ratio is smaller than or equal to 95% , the recovery premium is equal to 4 percentage points and in case the funding ratio is in between 95% and 100%, the recovery premium is equal to 2 percentage points.

- Catch up indexation is introduced and added to Policy 3 in Policy 4. Catch up indexation will be given to the participants of the fund if the funding ratio is larger than 130%.

- A sustainability cut is added in Policy 5, which occurs if the funding ratio falls below 85%.

- In Policy 6, the five year recovery plan is introduced, in which the funding ratio should be brought back to 100% after five years.
- The participants share in the surplus of the pension fund in case the funding ratio is above 140% in Policy 7, where the surplus is smoothed over 10 years.
- Finally, in Policy 8 the employer guarantee is added to Policy 7, where the employer pays in case the funding ratio is below 90%, i.e. due to a sustainability cut which is used if the funding ratio is below 85%, the employer will pay at most for the difference in the funding ratio between 85% and 90%.

Figure 1 gives an overview of the different policy instruments, in which order they will be used by the pension fund, dependent on its funding ratio.

For each policy considered, it is investigated what the effects will be on the different option values on the holistic balance sheet. To give more insight into the policies and the changes they cause, first some key results from the classical ALM analysis are shown. Here it can be seen how the funding ratio and the pension result will evolve over time dependent on the policy chosen. Furthermore, for each policy instrument the percentage of usage will be shown, which is a percentage across scenarios and time. After the classical ALM analysis, a value-based ALM analysis will be done. Here risk neutral valuation is used to value the different options that are stated on the holistic balance sheet. Note that the policy of the pension fund will still be dependent on the nominal funding ratio and not on the holistic funding ratio, since a policy dependent on the holistic funding ratio will lead to serious nesting problems.

The following assumptions are used in the ALM analysis:

- The pension fund will be closed at time zero;
- The initial funding ratio of the pension fund is equal to the required funding ratio according to the FTK regulation, i.e. $FR_0 = FR^{req} = 1 + S$ (DNB, 2007);
- The pension fund invests for 50 percent in stocks and for 50 percent in bonds, where the portfolio composition is rebalanced each time period;
- The participants within the fund are a projection of the Dutch population;
- The horizon considered is equal to 15 years;
- The interest rate risk is hedged for 50 percent.

In Table 6 the classical ALM output is shown and in Table 7 the value based ALM output is shown. In this section below, the results of both ALM studies for the eight policies are discussed:

- Policy 1 is comparable with an insurance contract, as no policy instruments are used by the pension fund and all participants get full indexation. Therefore the

Policy	1	2	3	4	5	6	7	8
Funding ratio								
$FR_{N,15}^{0.025}$	0.51	0.77	0.80	0.79	0.87	0.95	0.94	0.94
$FR_{N,15}^{0.500}$	1.26	1.41	1.42	1.32	1.34	1.36	1.31	1.31
$FR_{N,15}^{0.975}$	2.49	2.56	2.56	2.50	2.50	2.50	1.90	1.92
$\mathbb{P}[FR_{N,15} < 1]$	0.28	0.11	0.10	0.11	0.08	0.07	0.08	0.07
Pension result								
$PR_{15}^{0.025}$	1.00	0.71	0.71	0.72	0.64	0.61	0.61	0.67
$PR_{15}^{0.500}$	1.00	0.86	0.93	1.00	1.00	1.00	1.00	1.01
$PR_{15}^{0.975}$	1.00	1.00	1.00	1.00	1.00	1.00	1.32	1.32
Sponsor support								
recovery premium			0.12	0.12	0.10	0.09	0.10	0.09
employer guarantee								0.04
Adjustment mechanism								
no indexation		0.13	0.12	0.13	0.11	0.10	0.10	0.09
conditional indexation		0.36	0.36	0.38	0.38	0.38	0.40	0.40
full indexation	1.00	0.52	0.52	0.49	0.51	0.52	0.50	0.51
catch up indexation				0.13	0.14	0.15	0.14	0.14
sustainability cut					0.03	0.02	0.02	0.02
recovery plan						0.03	0.03	0.03
surplus sharing							0.29	0.29

Table 6: Classical ALM output of the eight policies introduced in Table 5

Policy	1	2	3	4	5	6	7	8
Total assets	**117.5**	**117.5**	**119.5**	**119.5**	**119.1**	**118.6**	**118.6**	**123.5**
Assets	117.5	117.5	117.5	117.5	117.5	117.5	117.5	117.5
Sponsor support			2.0	2.0	1.6	1.1	1.1	6.0
Employee contribution			2.0	2.0	1.6	1.1	1.1	1.0
Employer guarantee								5.0
Total liabilities	**135.6**	**113.0**	**113.1**	**114.3**	**103.1**	**100.4**	**105.6**	**109.8**
Liabilities	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Adjustment mechanism	35.6	13.0	13.1	14.3	3.1	0.4	5.6	9.8
Indexation	35.6	13.0	13.1	13.0	13.4	14.0	14.3	14.5
Catch up indexation				1.3	1.8	2.4	2.3	2.4
Sustainability cut					-12.1	-6.4	-6.5	-5.7
Recovery plan						-9.6	-9.8	-6.8
Surplus sharing							5.3	5.4
Residue option	-17.7	4.9	6.8	5.6	16.5	18.6	13.4	14.1
Surplus option	14.7	17.5	17.9	16.8	18.2	19.2	14.0	14.7
Deficit option	-32.4	-12.6	-11.1	-11.2	-1.7	-0.6	-0.6	-0.6
Holistic funding ratio	**0.867**	**1.040**	**1.057**	**1.046**	**1.156**	**1.181**	**1.123**	**1.125**

Table 7: The values of the embedded options on the holistic balance sheet for the eight policies introduced in Table 5

funding ratio is extremely volatile over time, where the probability of underfunding is almost 30 percent, as can be seen in Table 6. These effects can be translated into value based terms, where the indexation option gets a value of 35.6. Since a pension fund can be seen as a "zero sum game" between all the different stakeholders, the residue option gets a negative value such that both sides of the holistic balance sheet are balanced. Note that the deficit option is higher in absolute value than the surplus option even though in only 30 percent of the time there is underfunding. Typically underfunding will occur more often in bad states and with risk neutral valuation the cash flows in these states will have a higher economic value in order to obtain a risk neutral world.

- In Policy 2 conditional indexation is given to the participants, such that the funding ratio becomes less volatile and in approximately 10 percent of the time there is underfunding. The consequence is that the participants bear more of the risks, as their pension result becomes more volatile, where in only half of the time full indexation will be given. Hence, the indexation option decreases significantly in value.

- The instrument recovery premium is added in Policy 3, which is used in approximately 12 percent of the time and results in a value of the employee contribution option equal to 2.0. As this instrument is only used in the lower quantiles of the funding ratio, the effect on the 2.5% quantile is the most significant, which increases and therefore decreases the probability of underfunding. This effect makes sure that the deficit option decreases in absolute value with respect to Policy 2.

- In Policy 4 the instrument catch up indexation is added, such that the pension result increases, even though there will be given full indexation in less percent of the time. Therefore the indexation option decreases in value, while the adjustment mechanism increases in value due to a positive value of the catch up indexation option. The consequence of the policy instrument catch up indexation is that the volatility of the funding ratio decreases, since the higher quantiles of the funding ratio decrease significantly, with the consequence that the surplus option decreases in value.

- Due to the sustainability cut in Policy 5, the risks for the participants increase, where the lower quantile of the pension result decreases with respect to Policy 4. The effect that occurs is that the adjustment mechanism decreases significantly, even though the sustainability cut will only be used in approximately 3 percent of the time. Note that this 3 percent is the mean over all scenarios and periods, where the standard deviation over all periods will be positive (Janssen, 2012). The sustainability cut makes sure that the funding ratio becomes less volatile, where the lower quantiles increase, which results in the fact that the deficit option decreases significantly in absolute value. Furthermore, the instrument recovery premium will not be used as much due to cuts, such that the employee contribution option decreases in value.

- In Policy 6 the recovery plan is added, where the same effects are visible as in Policy 5. Due to the recovery plan, the sustainability cut will not be used as much as in Policy 5, which decreases the sustainability cut option in absolute value.
- The participants share in the surplus in Policy 7, such that they not only bear the risks but also share in the upside potential. Hence, the upper quantile of the pension result increases above 1.00. Therefore the adjustment mechanism increases in value again. Due to surplus sharing the funding ratio becomes less volatile, where the upper quantile decreases significantly with respect to Policy 6, which works through on the surplus option as can be seen in Table 5.
- Finally, in Policy 8 the employer guarantee is added, of which the option gets a significant value on the holistic balance sheet. As the employer starts bearing the risks, the participants have to bear less of the risks, which increases their pension result. As can be seen, the most value transfers occur from the sustainability cut option and the recovery plan option to the employer guarantee option.

7 Holistic balance sheet used as solvency measure in closed fund framework

7.1 Introduction

In the framework without the holistic balance sheet the solvency of a pension fund could be assessed by checking whether the funding ratio is larger than a required level, as is the case in the FTK regulation. The traditional funding ratio gives some insights into the solvency and the quality of the fund, as the higher the funding ratio will be, the more able the fund is to pay the accrued benefits to its participants. Therefore, the higher the funding ratio will be, the better the effects are for the participants within the fund, while a lower funding ratio means mostly bad news for its participants. Note that these effects depend on the policy of the fund, where the effects for the participants decrease for lower funding ratios if for instance the fund cuts the benefits of the participants if the funding ratio is low.

The holistic funding ratio only gives insights into the solvency of the fund, but not into the quality of the pension deal for the individual participants. When the holistic funding ratio is above 100 percent, it means that the policy of the fund will be sustainable during the horizon considered, while if the holistic funding ratio is lower than 100 percent the fund has set their policy instruments poorly, i.e. the policy of the pension fund will not be sustainable in the long run. This holistic funding ratio does not provide information on the effects for the different generations. For instance, the holistic funding ratio can be above 100 percent, but if the sustainability cut option is very high in absolute value, the policy used by the fund does not mean good news for its (older) participants, as their benefits are cut extensively.

In the FTK regulation, the required funding ratio is determined such that the probability of underfunding in the next year will be smaller than 2.5 percent, i.e. $FR^{req} = 1 + S$ (DNB, 2007). One might wonder how far the regulator should intervene to decide what is in favor of the participants within the fund. The participants might not be pleased with the buffer S, as all working participants have to pay a cost covering contribution which is increased by S. The role of the regulator should be to check whether the pension fund does not promise pension benefits which are not achievable.

In this section, two different solvency measures are introduced and explained. First of all, EIOPA proposes a solvency measure in which the values of the sponsor support and the adjustment mechanism on the holistic balance sheet are taken into account. This solvency measure is further clarified in Section 7.2.

In Section 7.3 an alternative solvency measure is proposed in which the value of the residue option plays a major role. This solvency measure is called the dynamic approach as the required criteria depends on the horizon considered, where it does take into account the aspect of fictitiously closing the fund at time zero. We think this is a more suitable solvency measure, than the solvency measure proposed by EIOPA. The dynamic measure is developed as if the regulator is right in setting the solvency capital requirement S. This second measure is further explained and illustrated in Section 7.3. The eight policies elaborated on in Section 6 are tested by both solvency measures in Section 7.2 and Section 7.3.

7.2 Solvency measure: EIOPA

First we give an interpretation to the solvency measure proposed by EIOPA in Section 7.2.1. In Section 7.2.2 we give our main critique to this measure and finally in Section 7.2.3 the eight policies introduced earlier will be tested according to the EIOPA solvency measure.

7.2.1 Interpretation and explanation

EIOPA proposes a solvency measure to measure if a pension fund is solvent, in which the options on the holistic balance sheet are taken into account, described as follows:

> "Adjustment and security mechanisms will lower the SCR by absorbing losses incurred by the IORP in a stress situation. In other words, they act as a substitute for financial capital. In a scenario with adverse demographic and capital market developments the value of future benefits - subject to adjustments - will decline and the value of sponsor contributions will rise. These changes in value should be taken into account in the calculation of the capital requirement." (EIOPA, 2012, Technical Specification I.4.9)

The SCR stands for "Solvency Capital Requirement", which means the required buffer for pension funds. We give the following interpretation to this technical specification.

First of all, just as in the FTK regulation in the Netherlands, EIOPA proposes a solvency capital requirement which a pension fund should hold as a surplus, where the Solvency Capital Requirement formula could be based on Solvency II. As the precise parameters in this formula are not yet declared (confidence level, risk categories, discount rate), we will use the FTK parameters for determining the financial position of the fund and the solvency capital requirement. Within the FTK regulation, the prescribed capital buffer should be at such a level that the probability of underfunding in the next period will be smaller than 2.5%, i.e.:

$$\mathbb{P}[FR_{t+1} < 100\%] < 2.5\%,$$

where $\mathbb{P}$ stands for the real probability measure and where $FR_{t+1} = \frac{A_{t+1}}{L_{t+1}}$ is the funding ratio at time $t+1$. Here A_{t+1} and L_{t+1} are the assets and liabilities of the pension fund at time $t+1$ respectively. The standard approach to determine this required buffer S is done with the so called 'square root formula' (DNB, 2007). The result is that a pension fund should hold a required funding ratio equal to $FR^{req} = 1 + S$.

Now, EIOPA proposes that the option values on the holistic balance sheet should be taken into consideration in meeting this solvency capital requirement, where all embedded options are taken into account.
At first, the solvency capital requirement should be determined in the usual way, i.e. with the traditional balance sheet as given in Table 1 where it holds that

$$A_0 = L_0 + R_0.$$

This means that the solvency capital requirement is equal to the percentage of the liabilities a pension fund should hold in addition to its liabilities. In the traditional case this can be translated to the fact that the existing residue should be larger than or equal to the solvency capital requirement, i.e. $R_0 \geq S \cdot L_0$.
However, in the EIOPA measure it is not necessarily the case that if the residue is smaller than the solvency capital requirement, the pension fund is not solvent. Namely, the values of the sponsor support and the adjustment mechanism should be taken into account, where the value of the sponsor support is added to the residue as it is stated on the asset side of the holistic balance sheet, while the value of the adjustment mechanism is subtracted as this is stated on the liability side of the holistic balance sheet. Recall that on the holistic balance sheet assets (A_0) plus the sponsor support (V_0^{SPS}) are stated on one side and liabilities (L_0) plus the adjustment mechanism (V_0^{AM}) plus the residue option (V_0^{RO}) on the other side, such that it holds that

$$A_0 + V_0^{SPS} = L_0 + V_0^{AM} + V_0^{RO},$$

as given in Table 2. Therefore, according to the EIOPA solvency measure, it should hold that

$$R_0 + V_0^{SPS} - V_0^{AM} \geq S \cdot L_0. \tag{1}$$

The reasoning for this solvency measure is that if a pension fund is not solvent taking into account the unconditional assets and liabilities only, and the pension fund is solvent taking into account the option values, the pension fund has the right steering and adjustment instruments to recover to its required funding ratio, such that the pension fund has a hedge for shocks in returns and interest rates that might occur.[3]

7.2.2 Criticism

The solvency constraint given in (1), as interpreted by us, combines two different types of variables, namely variables which reflect one particular moment in time and variables which capture a whole time interval. First, these variables cannot simply be matched, and secondly the solvency requirement will be too severe.
The reason that the solvency requirement is too severe is that each payment made in the future should be covered at least in accordance to the solvency requirement. A pension fund is considered solvent if the residue is larger than the solvency requirement. This solvency requirement is not constant over time, as it depends on several factors such as the duration of the liabilities and the term structure. Since EIOPA proposes to fictitiously close the fund at time zero to value the options on the holistic balance sheet, the fund is shrinking over time. The result is that the duration of the liabilities diminishes, which in turn drives down the solvency requirement.
Therefore, another solvency measure is introduced in Section 7.3, which does take into account the closing fund aspect and does not try to match different types of variables. But first, we will apply the EIOPA solvency measure to the eight policies introduced in Section 6 and illustrate its severity for the typical Dutch pension fund.

7.2.3 Application

The eight policies considered in Section 6 are tested on being solvent with the help of the EIOPA solvency measure. In Table 8 the results of the test can be seen. It shows

Policy	1	2	3	4	5	6	7	8
EIOPA measure	-0.181	0.045	0.064	0.052	0.161	0.182	0.130	0.137
Required level	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
	✘	✘	✘	✘	✘	✔	✘	✘

Table 8: EIOPA solvency test for the eight policies introduced in Section 6

that only Policy 6 of the eight policies considered is solvent according to the EIOPA solvency measure in spite of the fact that all pension funds start at time zero with a funding ratio equal to the required level. However, is this really the result the trustees

[3] The quoted technical specification of EIOPA may alternatively also be interpreted that apart from the sponsor support only the negative adjustment mechanism ought to be taken into consideration, where the negative adjustment mechanism options are the sustainability cut option and the recovery plan option. In this case the solvency requirement would be adjusted to $R_0 + V_0^{SPS} - V_0^{AM-} \geq S \cdot L_0$. Note that the negative adjustment mechanism V_0^{AM-} has a negative value. Hence, in order to be able to meet the solvency constraint, the sponsor support should have a large value and/or the negative adjustment mechanism should have a large absolute value. Therefore, not taking into account the positive adjustment mechanism V_0^{AM+}, i.e. the indexation option plus the catch up indexation option plus the surplus sharing option, will create an incentive to implement a riskier policy.

of a pension fund would like to achieve for its participants?

In order to test if a pension policy is desirable from the perspective of the participants, a generational study can be performed. This is important, since it is the main responsibility of a board of trustees to threat the interests of all the different stakeholders in an equal way.
As pointed out by Janssen (2012), Policy 1 up to Policy 4 pass a too large deficit into the future, such that the participants still in the fund in the long run have to deal with these deficits. From the policies remaining, Policy 6 is a policy which creates the largest value transfers to its younger participants, while the older participants will benefit the least from this policy[4]. However, this is the only policy of the eight policies considered that is solvent according to the EIOPA measure, which is not a pension system that would be appreciated by its older participants. Hence, the EIOPA measure is too severe.

7.3 Solvency measure: dynamic approach

First we introduce a new solvency measure, the dynamic solvency measure in Section 7.3.1, whereafter the eight policies will be tested according to this solvency measure in Section 7.3.2. This measure overcomes the time matching problem and makes sure that the severity is in line with the horizon.

7.3.1 Explanation

In this section, we introduce a new solvency measure, the dynamic solvency measure, which does take into account the fact that the fund fictitiously closes at time zero. In the context of the EIOPA set-up, pension funds should on the one hand assume that the fund will be fictitiously closed at time zero, but on the other hand this is not taken into account in the prescribed capital requirement. Furthermore, the required level of this measure is set as if the regulator is right in setting the solvency capital requirement S, where the value of the residue option plays a major role. Note that the values of the other options on the holistic balance sheet are still implicitly taken into account, as a pension fund is a zero sum game.
First of all, recall that the solvency capital requirement S is the surplus a pension fund should have in addition to its liabilities, i.e. S is given as a percentage of the liabilities, where the required funding ratio results in $FR^{req} = 1+S$ (DNB, 2007). Now the dynamic solvency measure is determined in three steps, which are illustrated in Figure 2.

Step 1 At the start of time zero a pension fund should hold a funding ratio equal to at least $FR^{req} = 1 + S$. Therefore, one could reason that the residue option should be equal to at least S, since otherwise a negative value transfer to the younger generations is present. In general terms this can be translated to

$$V_0^{RO} \geq S \cdot L_0,$$

[4] These generational effects are only representative in an open fund framework and not in the fictitiously closed framework proposed by EIOPA (Janssen, 2012)

which is represented by the solid line in Figure 2, i.e. the value of the residue option should be at least above the solid line.

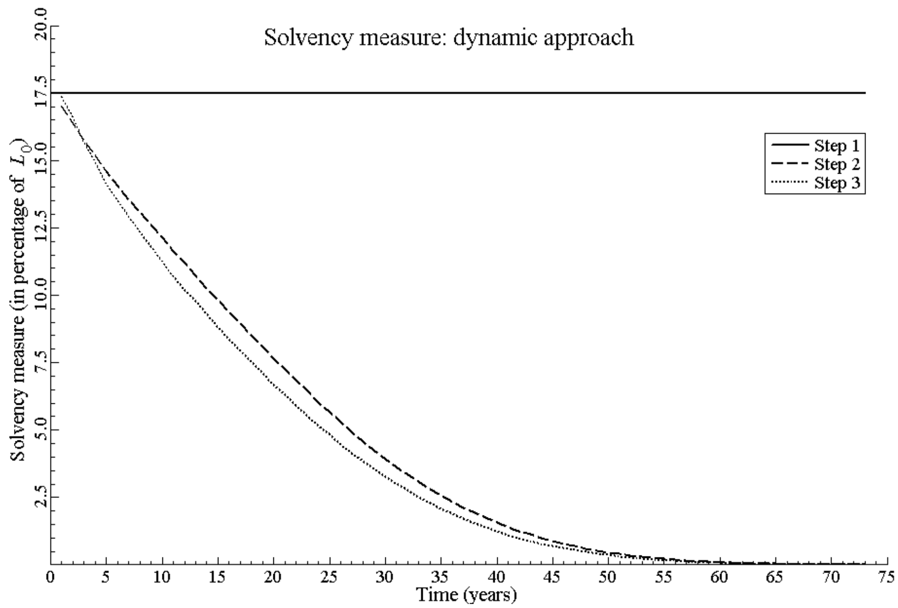

Figure 2: The dynamic solvency measure is presented in three steps, where the third and final step shows the actual dynamic solvency measure; the residue option should be larger than or equal to the dotted line, which is horizon dependent.

Step 2 However, it should be taken into account that as time passes, the liabilities shrink, due to the fact that the fund will be fictitiously closed at time zero. The solvency capital requirement S is set such that the fund will be able to meet its liabilities in case return or interest rate shocks occur. Therefore, as S is a percentage of the liabilities, the pension fund should hold for instance at time 15 the amount $S \cdot L_{15}$, since the fund has no need to withhold the amount $S \cdot L_0$. Therefore, to express the constraint in present value terms, it should hold that the residue option should be larger than or equal to the solvency capital requirement times the present value of the liabilities at the end of the horizon considered, i.e.

$$V_0^{RO} \geq S \cdot PV(L_T),$$

which is illustrated in Figure 2 by the dashed line, i.e. the value of the residue option should be at least above the dashed line. At the end of the horizon the constraint $S \cdot PV(L_T)$ goes to zero, as no liabilities are left. Figure 2 is constructed on the basis of Policy 8, note that due to different policies the present value of the liabilities after time T will be different.

Step 3 One should also take into account that due to fictitiously closing the fund at time zero, the duration of the liabilities decreases, which affects the solvency capital requirement S a pension fund should hold, to be able to be resistant for return and interest rate shocks that might occur. Therefore, the solvency capital requirement is not fixed over time, but will be decreasing over time. In the end the duration of the liabilities will go to zero, such that in case there is invested for 50% in stocks and for 50% in bonds, the solvency capital requirement will go to 12.5% (i.e. only the shocks that might occur in stock returns are taken into account in the end).[5] Therefore, the following restriction should hold instead:

$$V_0^{RO} \geq S(D_L) \cdot PV(L_T), \tag{2}$$

where S does depend on the duration of the liabilities D_L, which is illustrated by the dotted line in Figure 2, i.e. the value of the residue option should be at least above the dotted line.

After three steps, the dynamic solvency measure is presented by (2), which is given in Figure 2 as the dotted line. To be solvent, a pension fund should have a residue option that is larger than or equal to this dotted line, where the measure is dependent on the horizon considered.

7.3.2 Application

In Table 9 the eight different policies presented in Section 6 are tested according to the dynamic solvency measure. To make it more comparable to the EIOPA solvency measure, the required level will not be given in terms of the magnitude of the residue option as in Figure 2, however, it will be given in terms of S. Therefore, the following is checked instead:

$$V_0^{RO} \geq S(D_L) \cdot PV(L_T) \Leftrightarrow \frac{V_0^{RO}}{PV(L_T)} \geq S(D_L).$$

Policy	1	2	3	4	5	6	7	8
Dynamic measure	-0.236	0.083	0.115	0.094	0.321	0.375	0.252	0.251
Required level	0.157	0.157	0.157	0.157	0.157	0.157	0.157	0.157
	✘	✘	✘	✘	✔	✔	✔	✔

Table 9: Dynamic solvency test for the eight policies introduced in Section 6

[5]As the pension fund is fictitiously closed at time zero, the pension fund is aging, where the fund should invest more conservatively as time passes resulting in a solvency capital requirement approaching zero at the end of the horizon.

8 Holistic balance sheet used as continuity analysis and solvency measure in open fund framework

8.1 Introduction

In Section 6 and Section 7 a pension fund is considered where it was fictitiously closed at time zero. In reality, if a pension fund is closing at some time in the future, the policy will be adjusted to this aspect, such that the residue is divided among all participants in the fairest way. However, as the fund will not be closed at time zero, the holistic balance sheet of a fictitiously closed fund gives a financial view of the pension fund which is not in line with reality.
Hence, in this section an alternative use of the holistic balance sheet is introduced, where the fund remains open for new participants after time zero, where contributions will be paid, and where new benefits are accrued by its participants.

The pension fund is sustainable for the horizon considered whenever the holistic funding ratio of an open fund framework holistic balance sheet is at least equal to 100 percent, as in this case the unconditional and conditional liabilities are covered by its unconditional and conditional assets. Therefore, the holistic balance sheet in the open fund framework provides trustees with a more complete picture of the evolution of the fund than the holistic balance sheet in the closed fund framework does.

As the holistic balance sheet in the open fund framework is introduced to provide a more complete picture of the financial position of a pension fund, the holistic balance sheet introduced before will be slightly adjusted and is presented in Table 10. It can be

Holistic Balance Sheet

Assets	A_0	Liabilities	L_0
Contributions	CON	New accrued benefits	NAB
Sponsor support	V_0^{SPS}	Adjustment mechanism	V_0^{AM}
1. Employee contribution option		3. Indexation option	
2. Employer guarantee option		4. Catch up indexation option	
		5. Surplus sharing option	
		6. Sustainability cut option	
		7. Recovery plan option	
		Residue option	V_0^{RO}
		8. Surplus option	
		9. Deficit option	
	$\overline{A^{HBS}}$		$\overline{A^{HBS}}$

Table 10: The holistic balance sheet discerned in nine types of options in the open fund framework

seen that two new additions are stated on the holistic balance sheet, namely the contributions CON, which are the contributions valued at time zero that are paid by the working participants over the horizon considered and the new accrued benefits NAB, which are the new benefits valued at time zero that are accrued by the working participants over the horizon considered. The valuation of these options, along with the valuation of the contributions CON and new accrued benefits NAB, is explained in Appendix B.

In the remainder of this section, four of the eight policies introduced in Section 6 are considered in Section 8.2 for the open fund framework. Here we chose to show the four most relevant policies. We focus on Policy 1, as this is the most extreme policy, furthermore we focus on Policy 3 as such a pension contract was used in the Netherlands for quite some time. Additionally, we focus on Policy 7, as such a pension contract is a typical Dutch pension contract nowadays. Finally, the results of Policy 6 are shown as this is the only policy that is considered solvent by the EIOPA solvency measure.
Furthermore, the solvency measures introduced in Section 7 are slightly adjusted in Section 8.3.

8.2 Effect of different policies on option values in open fund framework

In this section, four of the eight policies introduced in Section 6 are considered for an open fund, i.e. the fund will not be closed at time zero as is the case in Section 6 and Section 7. In Table 11 a summary of these four policies is given, where C stands for closed fund and O for open fund.

First aspect that can be seen in Table 11 is that in the open fund new benefits are accrued, so that NAB gets a positive value. Furthermore, it can be seen that contributions will be paid by the working participants. Note that CON represents the cost covering contribution that is paid, such that it holds that $CON = (1 + S) \cdot NAB$, where S is defined by DNB (2007).
A second thing that can be seen in Table 11 is that the values of the options increase in absolute magnitude, comparing the open fund framework with the closed fund framework. For instance, concentrating on the positive adjustment mechanism options, as more benefits are accrued by the participants, the absolute value of positive indexation given over these benefits increases. The same reasoning applies for the negative adjustment mechanism options, since the more new accrued benefits, the higher the absolute value of negative indexation given over these benefits will be.
The reason that the sponsor support increases in value due to an open fund is that new participants will enter the fund, which also pay recovery premium.

Another result is that the options react in the same way to policy changes as explained in Section 6. So for instance, if the recovery premium is introduced in Policy 3, the sponsor support gets a positive value, whereby the value of the indexation option increases with respect to Policy 2, and thus the adjustment mechanism increases.
Another example is introducing the instrument surplus sharing, which is the case in Policy 7 as can be seen in Table 11. Due to surplus sharing, the adjustment mechanism

Policy	1_C	1_O	3_C	3_O	6_C	6_O	7_C	7_O
Total assets	**117.5**	**165.8**	**119.5**	**168.2**	**118.6**	**167.1**	**118.6**	**167.2**
Assets	117.5	117.5	117.5	117.5	117.5	117.5	117.5	117.5
Contributions		48.3		48.3		48.3		48.3
Sponsor support			2.0	2.3	1.1	1.3	1.1	1.3
Employee contribution			2.0	2.3	1.1	1.3	1.1	1.3
Employer guarantee								
Total liabilities	**135.6**	**187.0**	**113.1**	**157.7**	**100.4**	**142.2**	**105.6**	**148.0**
Liabilities	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
New accrued benefits		41.2		41.2		41.2		41.2
Adjustment mechanism	35.6	45.8	13.1	16.5	0.4	1.1	5.6	6.8
Indexation	35.6	45.8	13.1	16.5	14.0	17.8	14.3	18.0
Catch up indexation					2.4	3.9	2.3	3.7
Sustainability cut					-6.4	-8.6	-6.5	-8.8
Recovery plan					-9.6	-12.0	-9.8	-12.2
Surplus sharing							5.3	6.1
Residue option	-17.7	-20.0	6.8	11.7	18.6	26.2	13.4	20.4
Surplus option	14.7	19.5	17.9	25.0	19.2	27.4	14.0	21.7
Deficit option	-32.4	-39.5	-11.1	-13.3	-0.6	-1.2	-0.6	-1.3
Holistic funding ratio	**0.867**	**0.887**	**1.057**	**1.067**	**1.181**	**1.175**	**1.123**	**1.130**

Table 11: The values of the embedded options on the holistic balance sheet for the first, third, sixth, and seventh policy introduced in Section 6 for the closed and open fund

increases in value with respect to Policy 6, with the consequence that the residue option decreases in value.

Finally, it can be seen that the value of the residue option increases for every policy by changing from a closed fund framework to an open one. The reason for this effect is that a pension fund could be seen as a zero sum game between all the different stakeholders and due to the fact that the contributions are $S \cdot 100\%$ higher than the value of the new accrued benefits, more money is coming in which can be invested. Hence, in the end, the residue option gets a higher value.
Additionally, the deficit option, which is the negative part of the residue option, increases more in absolute value for an open fund with respect to a closed fund. The reason for this fact is that due to an open fund, the value of the total unconditional assets will get higher through time. The deficit option gets a larger negative value, because of the effects of extremely low returns will be more significant in the open fund framework.
The only exception of the effect that can be seen in the residue option is Policy 1, as in this policy the value of the residue option decreases, where the deficit option increases significantly in absolute value from -32.4 to -39.5, as more bad scenarios occur in Policy 1 with respect to the other policies.

The holistic balance sheet in an open fund framework can be used as an additional tool for a continuity analysis. Where in the usual continuity analysis classical ALM is used, the holistic balance sheet used as continuity analysis is formed with value-based ALM. Both continuity analyses provide similar information, only the information is presented in different value terms.

8.3 Solvency measures: EIOPA and dynamic approach

Due to considering an open pension fund, the solvency measures introduced in Section 7.2 and Section 7.3 have to be slightly adjusted in order to make sense.

First of all, the EIOPA solvency measure should be adjusted such that next to the different options, also the new contributions that will be paid and the new benefits that will be accrued are taken into account. Therefore the restriction formula should be adjusted as follows:

$$R_0 + V_0^{SPS} - V_0^{AM} \geq S \cdot L_0 \Leftrightarrow$$
$$R_0 + CON + V_0^{SPS} - NAB - V_0^{AM} \geq S \cdot L_0. \quad (3)$$

This adjustment is made, as the EIOPA measure takes into account the conditional assets as a positive aspect, while it takes into account the conditional liabilities as a negative aspect. Here the contributions CON are stated on the asset side and should thus be added to the restriction formula, while the new accrued benefits NAB are considered liabilities and should thus be subtracted.

The dynamic solvency measure does not explicitly take into account the different conditional assets and liabilities as the EIOPA solvency measure does; it only uses the value of the residue option V_0^{RO} explicitly. Therefore, the dynamic solvency restriction formula remains exactly the same as before, namely:

$$\frac{V_0^{RO}}{PV(L_T)} \geq S(D_L).$$

However, note that the duration of the liabilities is higher as in Section 7 as the fund is not closed at time zero and will therefore remain approximately constant. Hence, the required percentage that a pension fund should hold as a percentage of the liabilities remains approximately constant, i.e. $S(D_L)$ remains approximately constant over time.

In Table 12 the results of the EIOPA solvency test and the dynamic solvency test

Policy	1_C	1_O	3_C	3_O	6_C	6_O	7_C	7_O
EIOPA measure	-0.181	-0.211	0.064	0.105	0.182	0.249	0.130	0.192
Required level	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
	✘	✘	✘	✘	✔	✔	✘	✔
Dynamic measure	-0.236	-0.163	0.115	0.117	0.375	0.299	0.252	0.223
Required level	0.157	0.170	0.157	0.170	0.157	0.171	0.157	0.170
	✘	✘	✘	✘	✔	✔	✔	✔

Table 12: Solvency tests for the eight policies introduced in Section 6 for the closed and open fund

are displayed for both the closed policies as the open policies, where C stands for closed fund and O stands for open fund. It can be seen that the required level of the EIOPA solvency measure remains the same, as this required level is equal to the solvency capital requirement at time zero S, while the required level of the dynamic measure changes in the open fund framework with respect to the closed fund framework. The reason for this change is that the duration of the liabilities after the horizon of 15 years is higher in the open fund.
Furthermore, it can be seen that where the solvency measures did not give the same result in the closed fund, those measures give the same outcome in the open fund for the policies considered, since Policy 7 is solvent according to both measures.

Here it can be concluded that by adjusting the EIOPA solvency measure to an open fund framework, the problem of not taking into account the fact that the fund fictitiously closes at time zero is more or less solved, as the duration of the liabilities remains approximately constant over time in an open fund framework. While, on the other hand, the duration of the liabilities did not remain constant over time in the closed fund framework, with the result that the required level of the EIOPA solvency test was too high in the closed fund framework.

9 Sensitivity analysis

In this chapter, the impact of different assumptions on the holistic balance sheet is studied. In Section 9.1 this is done for different funding ratio's, Section 9.2 deals with another policy ladder and the impact of another scenario set is shown in Section 9.3.

9.1 Funding ratio

Up to now we have considered an initial funding ratio equal to $1 + S \approx 1.175$. It turns out that additional funding of one percent of the liabilities, will not have a great impact. The reason for this result is that the additional funding will be divided among all different options stated on the holistic balance sheet. Therefore, if a pension fund has more policy instruments it can use, the funding will be divided among more options, and has less effect on the option values and the solvency tests, where the tests do not give a different outcome. Hence, the effect is the largest for Policy 1 and the smallest for Policy 8.

If the funding ratio will be adjusted more extreme, the effects become more significant. If an extremely high initial funding ratio is chosen, the value of the sponsor support decreases significantly, while the positive adjustment mechanism options increase significantly and the negative adjustment mechanism options decrease significantly in absolute value. Even though the funding ratio is extremely high, the effect on the holistic funding ratio will not be that significant, since not only the value of the assets increases, but also the value of the total liabilities increases due to a higher value of the adjustment mechanism. Therefore the holistic funding ratio will be less volatile than the traditional funding ratio.

On the other hand, if an extremely low initial funding ratio is chosen, the opposite effects occur, i.e. the sponsor support increases in value, the positive adjustment mechanism options decrease in value, and the negative adjustment mechanism options increase in absolute value. Here, the effect on the holistic funding ratio is also less significant, since not only the assets decrease in value, but also the total liabilities decrease in value due to a negative adjustment mechanism.

These changes in option values also have an effect on the solvency measures, where the EIOPA solvency requirement will be harder to meet in case of an extremely low funding ratio, since the value of the residue R_0 is low, while the requirement will be met more easily for an initial high funding ratio, since the value of the residue R_0 is high. If the dynamic solvency requirement is met for the initial funding ratio of $1 + S$, the requirement will most likely also be met for the more extreme initial funding ratios. The reason for this fact is that even though the value of the residue option changes, where it increases in value for the high initial funding ratio and decreases in value for the low initial funding ratio with respect to the funding ratio of $1 + S$, the present value of the liabilities will also respectively increase and decrease.

9.2 Policy ladder

Changing the policy ladders will also affect the option values and their resulting solvency tests. For instance, if a policy ladder is chosen in which there will be cut at lower funding ratio levels, in which the recovery premium paid is lower, and in which full indexation and surplus sharing will be given at lower funding ratio levels, this results in a lower value of the sponsor support and a higher value of the adjustment mechanism. If an opposite policy ladder is chosen, in which the benefits will be cut at higher funding ratio levels, the recovery premium is higher, and full indexation and surplus sharing is given at higher funding ratio levels, i.e. a less friendly policy ladder, than the value of the sponsor support increases while the value of the adjustment mechanism decreases.

These results also affect the solvency tests, where the EIOPA solvency requirement will be met more easily in case of the less friendly policy ladder and less easily in case of the more friendly policy ladder. Is this really the effect trustees of a pension fund would like to achieve for its participants? Note that also the order of the policy instruments has an effect on the option values, as the option value of an instrument increases in absolute value in case the instrument will be used earlier than another instrument.

9.3 Scenario set

Furthermore, it turns out that changing the scenario set, while keeping the same risk model has already a great influence on the option values and solvency measures. In Table 13 the results are shown for two different scenario sets, where the first scenario set starts at initial values that are representative for Q4 2011 (the same scenario set used throughout this paper) and the second scenario set start at values representative for Q4 2007. The term structure, which shows the relation between the interest rate and their time to maturity, in the scenario set Q4 2011 is much lower than the term structure for Q4 2007. Hence, the value of the liabilities is much lower for the second scenario set Q4 2007. Note that all values presented in Table 13 are given in terms of the liabilities for each specific scenario set. The value of the liabilities for scenario set Q4 2007 is actually equal to 72.1 in terms of the liabilities of scenario set Q4 2011.

Due to lower liabilities and higher investment returns throughout the horizon considered for scenario set Q4 2007, more positive indexation can be given, which results in a higher value of the positive adjustment mechanism options. As the investment returns are higher for scenario set Q4 2007, the benefits do not have to be cut as much as for scenario set Q4 2011, which results in a lower absolute value of the negative adjustment mechanism options. The steering instrument recovery premium will be used more in case of scenario set Q4 2007, which results in a higher value of the sponsor support.

The value of the residue option is much lower for the scenario set Q4 2007, since the risk free rate in this set is much higher, where the risk free rate did drop due to the financial crisis.

Table 13 shows that the required level of both solvency measures increases. Due to a higher term structure, the interest rate shocks that might occur are higher, as the reduction factors to calculate the solvency capital requirement remain the same.

It also can be seen that changing the initial values of the scenario set has a significant

Policy	Q4 2011 7_C	Q4 2011 7_O	Q4 2007 7_C	Q4 2007 7_O
Total assets	**118.6**	**167.2**	**118.9**	**156.7**
Assets	117.5	117.5	117.5	117.5
Contributions		48.3		37.6
Sponsor support	1.1	1.3	1.4	1.6
Employee contribution	1.1	1.3	1.4	1.6
Employer guarantee				
Total liabilities	**105.6**	**148.0**	**110.0**	**144.3**
Liabilities	100.0	100.0	100.0	100.0
New accrued benefits		41.2		31.2
Adjustment mechanism	5.6	6.8	10.0	13.2
Indexation	14.3	18.0	20.6	25.7
Catch up indexation	2.3	3.7	2.2	3.3
Surplus sharing	5.3	6.1	2.6	2.9
Sustainability cut	-6.5	-8.8	-7.4	-9.4
Recovery plan	-9.8	-12.2	-7.9	-9.4
Residue option	13.4	20.4	8.9	13.5
Surplus option	14.0	21.7	9.5	14.6
Deficit option	-0.6	-1.3	-0.6	-1.1
Holistic funding ratio	**1.123**	**1.130**	**1.081**	**1.085**
EIOPA measure	0.130	0.192	0.089	0.123
Required level	0.175	0.175	0.205	0.205
	✘	✔	✘	✘
Dynamic measure	0.252	0.223	0.194	0.181
Required level	0.157	0.170	0.182	0.200
	✔	✔	✔	✘

Table 13: Effect of changing the scenario set on the option values on the holistic balance sheet and on the two solvency tests, for Policy 7 in a closed and open fund

impact on the solvency tests, in particular only the dynamic measure for the closed fund framework considers Policy 7 to be solvent for the 2007 scenario set.
However, high interest rates and investment returns are mostly considered as good news for pension funds, since the value of the liabilities decreases while the assets increase in value. As can be seen in Table 13 the opposite effect occurs; the required levels increase, while the solvency measures decrease in value with respect to the scenario set of Q4 2011, with the consequence that fewer solvency constraints are met.
The reason for this consequence is that due to higher asset values and lower liabilities, the pension fund can provide the participants with more indexation, with the result that the conditional liabilities significantly increase in value.

In this sensitivity analysis, only the impact of another term structure is showed on the value of the different (embedded) options. However, pension funds will have to make a lost of different assumptions within the holistic balance sheet approach. Since different initial parameters of the risk model results in different solvency test outcomes, the scenario set that is used has a great influence on the solvency tests. Therefore it is important that in case the holistic balance sheet will be implemented within the European pension supervision, there is a supervision on the risk models used by the different pension funds. It is important that the risk model can be justified, in order to reduce the influence the trustees of a pension fund have on the option values and their (holistic) solvency position.

10 Conclusions and recommendations

EIOPA proposes the holistic balance sheet to make the financial position of different pension systems across Europe more comparable. In this paper we evaluated the holistic balance sheet, where all steering and adjustment mechanisms are valued as embedded options on the balance sheet. The proposed holistic balance sheet approach provides an overview of the existing claims within the pension funds of all the different stakeholders and could be a useful tool for pension funds, however it could be further improved.

First of all, EIOPA does not include the aspect of fictitiously closing the fund in determining the required level. In this paper, an alternative solvency measure is introduced named the dynamic solvency measure. This measure does take into account the aspect of fictitiously closing the fund at time zero and can also easily be used within the open fund framework. It turns out that the dynamic measure does consider policies to be solvent which have the least value transfers between disjoint cohorts, while the EIOPA measure does consider those policies to be insolvent.

Secondly, EIOPA proposes to fictitiously close the pension fund at a certain moment in time ("time zero"). By fictitiously closing the fund, the holistic balance sheet does not provide the different stakeholders of a pension fund the actual financial position of the fund in line with could be expected in reality: in a normal situation ("ongoing concern"), new pensions will be accrued. Instead of closing the fund fictitiously at time zero, the fund should therefore remain open for new participants. In this case, the holistic balance sheet can be used as a continuity analysis, where the holistic funding ratio should be larger than 100 percent in order to have a sustainable pension fund policy over the horizon considered.

The third reason we criticize the approach proposed by EIOPA is that the holistic balance sheet is significantly dependent on the risk model chosen. Therefore it is important that in case the holistic balance sheet will be implemented within the European pension supervision, there is a supervision on the risk models used by the different pension funds. It is important that the risk model can be justified, in order to reduce the influence the trustees of a pension fund have on the option values and their (holistic) solvency position.

Finally, the holistic balance sheet is a good tool to assess within a uniform framework to determine the solvency position of different plans across countries. However, the holistic balance sheet does not give insights into the quality of the pension deal for the participants, but only into the holistic solvency position of a fund. Therefore, next to the holistic balance sheet approach, a generational study could be done in order to provide insight into the generational effects for the participants.

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Appendices

A The model

A.1 Risk model

As explained, an ALM model uses a risk model, i.e. an economic scenario generator, that produces stochastic simulations of returns on assets, inflation, and other relevant economic data.
Risk models widely used by the financial industry regarded events such as the 2008 credit crisis as highly unlikely. These models assumed volatilities and correlations to be constant, while both volatilities and correlations became much more extreme during the financial crisis (Van den Goorbergh, Molenaar, Steenbeek, and Vlaar, 2011).

Therefore, the risk model used in this paper has two additional features, to overcome these drawbacks. First of all, stochastic jumps are introduced, which represent a sudden loss in confidence of the market with the consequence that the stock market drops significantly, risk free interest rates decrease, and credit spreads increase significantly.
Secondly, a time-varying covariance matrix for normally distributed shocks is implemented in the risk model, such that volatilities and correlations can be varied. Here two dominant sources of time-varying risks are assumed, namely monetary uncertainty and real uncertainty. Furthermore, the time-varying second moments generate asymmetry in interest rates, inflation, and credit spreads, with the consequence that negative interest rates exist less likely.
The nominal and real term structure are modeled with an affine term structure model within this risk model. The model can be used under both real world and risk neutral scenarios, in which both arbitrage opportunities are absent.

This risk model with the nominal term structure is introduced by Van den Goorbergh et al. (2011) and is derived from six stochastic and four deterministic state variables. The stochastic variables are modeled with a quarterly vector autoregressive model as follows:

$$x_{t+1} = \begin{bmatrix} \pi_{t+1} \\ y_{t+1}^{(1)} \\ xs_{t+1} \\ dy_{t+1} \\ cs_{t+1} \\ mp_{t+1} \end{bmatrix} = c_t + \Gamma x_t + J_{t+1}\nu + \Sigma S_t^{1/2} \zeta_{t+1},$$

where

$$c_t = (I_6 - \Gamma)(\mu_0 + \mu_{\bar{\pi}} \bar{\pi}_t) - p\nu,$$

$$\zeta_{t+1} \sim N(0, I_6),$$

where π_t is the log of the annual inflation in the Eurozone, $y_t^{(1)}$ is the continuously compounded three-month Euribor, xs_t is the quarterly log excess return on the stock

market, dy_t is the dividend yield in logit form, cs_t is the credit spread between US Baa bonds and treasuries measured in log percentages, and mp_t is an unobservable variable called the maturity preference, which measures time-varying influences on bond prices that are unrelated to the other state variables.
Furthermore, J_{t+1} is the jump indicator which is equal to one with probability p and zero otherwise and the diagonal matrix S_t captures the time-varying volatilities.
The four deterministic state variables are the medium-term price assumption $\bar{\pi}_t$ and three different lagged quarterly inflation π_t^q (i.e. lagged one, two, and three quarters).

The term structure is modeled as an affine model as

$$r_t^{(n)} = exp(A_n + B_n' x_t) - 1, \tag{4}$$

where $r_t^{(n)}$ expresses the rate with maturity n of the term structure at time t. Both a nominal and a real term structure can be derived from this model. Note that also the four deterministic variables are included in x_t, where the last three deterministic variables are equal to zero for the nominal term structure. For the exact specifications see Van den Goorbergh et al. (2011).
The rate $r_t^{(n)}$ is used in this paper to value the liabilities and the adjustment mechanism, in order to make sure that everything is valued in a market consistent way.

As emphasized before, we use real world scenarios and risk neutral scenarios in this paper. Both are derived by the model introduced above. For an extensive explanation of the risk neutral measure used in the risk model, see Lin and Vlaar (2011).

An additional variable that is needed in an ALM model for a pension fund is the average wage growth. As wage growth is not traded in the market, a linear regression is used to generate scenarios for it:

$$w_{t+1} = \alpha + \beta_1 w_t + \beta_2 \pi_{t+1} + \beta_3 y_t^{(1)} + \epsilon_{t+1}, \tag{5}$$

where w is the wage growth, π is the inflation, and $y^{(1)}$ is the short term interest rate. In (5) the wage growth is estimated under the real probability measure $\mathbb{P}$.
In order to generate the wage growth under the risk neutral measure $\mathbb{Q}$, a similar regression is used, where the market related variables π and $y^{(1)}$ are inserted from the risk model introduced above under the risk neutral measure:

$$w_{t+1}^{\mathbb{Q}} = \alpha^{\mathbb{Q}} + \beta_1 w_t^{\mathbb{Q}} + \beta_2 \pi_{t+1}^{\mathbb{Q}} + \beta_3 y_t^{(1)\mathbb{Q}} + \epsilon_{t+1}.$$

Here the β coefficients are the same as in (5), while $\alpha^{\mathbb{Q}}$ is adjusted, such that it is made sure that the wage growth under the risk neutral measure is a martingale.

The total risk model that is used in the ALM model generates 5000 scenarios, both under the real probability measure $\mathbb{P}$ and the risk neutral measure $\mathbb{Q}$.

A.2 ALM model

The risk model introduced in Appendix A.1 is inserted in the ALM model that is explained in this section.
As known, a pension fund has assets A and liabilities L. The funding ratio of a pension fund is the number which represents whether the liabilities can be covered by the assets, and is determined as follows:

$$FR_N = \frac{A}{L_N},$$

where L_N is the value of the nominal liabilities, and FR_N is the nominal funding ratio. In the ALM model, the initial assets of the pension fund are determined by multiplying the initial nominal funding ratio by the initial nominal liabilities, which in turn is calculated as the present value of the total accrued benefit claims at time zero.

In order to calculate the nominal liabilities the amount of participants is needed. The initial Dutch population is used as a starting point, which is adjusted each time step by multiplying the population by their one year conditional survival probabilities:

$$Pop_{x+1,t+1}^{male} = Pop_{x,t}^{male} \cdot p_{x,t}^{male},$$

where $Pop_{x,t}^{male}$ contains the number of males of age x at time t and $p_{x,t}^{male} = 1 - q_{x,t}^{male}$ is the one year survival probability, where $q_{x,t}^{male}$ is the one year death probability, i.e. the probability that a male person of age x will not survive another year at time t.

As assumed, participants accrue benefits at a rate of two percent per year. Therefore, since a participant works for maximal 40 years, he/she can collect 80 percent of his/her average wage (plus indexation) at maximum, as after the retirement age the pension payments start. This results in an accrued benefits matrix, in which each row represents a different scenario and each column a different generation. Therefore the accrued benefits matrix at the start of time zero can be shown as follows:

$$B_0 = \begin{bmatrix} 0 & 0.02 & \dots & 0.8 & \dots & 0.8 \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ 0 & 0.02 & \dots & 0.8 & \dots & 0.8 \end{bmatrix},$$

which is updated with the average wage level matrix each time period. The accrued benefits matrix is multiplied by the population, such that is known how much the fund has to pay out in the future. To determine the present value of these accrued benefits, each element in the matrix should be multiplied by an appropriate discount factor, in which also the survival probabilities are contained. The nominal discount factor for a male individual of age x at time t for scenario s is calculated as:

$$D_{x,t}^{s,male} = \sum_{i=max(65-x,0)}^{99-x} {}_{(i-t)}p_{x-(i-t),t}^{male} \left(1 + r_{t,s}^{(i)}\right)^{-i}, \tag{6}$$

where $r_{t,s}^{(i)}$ expresses the rate with maturity i from the nominal term structure at time t in scenario s, which is introduced in (4) in Appendix A.1 and where ${}_{(i-t)}p_{x-(i-t),t}$ is the $(i-t)$ survival probability of an individual aged $x-(i-t)$ at time t. Note that the market consistent term structure is used within the discount factor, such that the liabilities and the adjustment mechanism will be valued as such.
The discount factor is a summation that starts at $max(65-x,0)$ as the accrued benefits of the participants are only paid out when the participant is 65 years or older, where the pension payments start in $65-x$ years if the participant is not yet retired. The summation ends at $99-x$, as the pension payments stop at the moment the participant deceases, where the age of 99 is the maximum age of the participant. This results in a discount matrix for each gender in which again each row represents a scenario and each column represents a cohort. The discount matrix at time zero for the gender male can be shown as follows:

$$D_0^{male} = \begin{bmatrix} D_{25,0}^{1,male} & \dots & D_{99,0}^{1,male} \\ \vdots & \ddots & \vdots \\ D_{25,0}^{5000,male} & \dots & D_{99,0}^{5000,male} \end{bmatrix}.$$

Now, the liability matrix per gender L_t^{gender} is calculated as an elementwise matrix multiplication of the accrued benefits matrix and the discount matrix (multiplied by the number of participants, which is the same for each scenario). Therefore, the structure of the liability matrix is the same as the structure of the accrued benefits matrix and the discount matrix; each row represents a scenario, while each column represents a cohort. The value of the nominal liabilities are calculated per scenario, where it is a summation over all cohorts. For instance, the value of the initial nominal liabilities (at time zero) for scenario s are calculated as follows:

$$L_{N,0}^{s} = \sum_{x=25}^{99} L_0^{s,male} + \sum_{x=25}^{99} L_0^{s,female}.$$

Recall that the initial asset value for each scenario is calculated by multiplying the initial funding ratio by the value of the nominal liabilities for that same scenario.

As the initial values are set, the actual ALM model can start its time loop. Here, a horizon of 15 years into the future is considered, as this is approximately equal to the average duration of the liabilities. There are two main frameworks considered in this paper, namely an open fund is considered in which new participants enter the fund after time zero and in which new benefits are accrued and contributions are paid by the working participants. Besides that, a fund is considered which is fictitiously closed at time zero, in which no new participants can enter after time zero, no new benefits are accrued, and no contributions are paid by the participants already in the fund at time zero.

In the open fund framework, new benefits are accrued by the working participants at the beginning of each time period. Furthermore, the working participants pay their contributions and the pensioned participants receive their benefits at the start of each period. The contributions are added to the assets, while the benefit payments are subtracted from the assets. The resulting asset value is invested in a certain investment portfolio each time period, which will be rebalanced each period:

$$A_{t+1}^s = \Bigg(A_t^s + \sum_{i=25}^{64} c_t^s \cdot \Big(Pop_{i,t}^{male} + Pop_{i,t}^{female} \Big)$$

$$- \sum_{i=65}^{99} b_t^s \cdot \Big(Pop_{i,t}^{male} + Pop_{i,t}^{female} \Big) \Bigg) \cdot (1 + r_t^{inv,s}),$$

where $r_t^{inv,s}$ is the return at time t in scenario s of the portfolio invested in and is obtained from the risk model introduced in Appendix A.1. The level of the contributions c_t^s and the benefits b_t^s for a person aged i at time t in scenario s depend on the average wage level and the policy considered by the pension fund. In what way the contribution level and indexed benefit level will be determined is further explained in Appendix B.1 and Appendix B.2.

In the closed fund framework, no new participants can enter the fund, no contributions are paid, and no new benefits are accrued by the participants in the fund. Therefore, the evolution of the assets is different than in the open fund framework and will evolve as follows:

$$A_{t+1}^s = \Bigg(A_t^s + \sum_{i=25}^{64} c_t^{rec,s} \cdot \Big(Pop_{i,t}^{male} + Pop_{i,t}^{female} \Big)$$

$$- \sum_{i=65}^{99} b_t^s \cdot \Big(Pop_{i,t}^{male} + Pop_{i,t}^{female} \Big) \Bigg) \cdot (1 + r_t^{inv,s}),$$

in which $c_t^{rec,s}$ represents the percentage points of recovery premium at time t in scenario s the participants have to pay in certain policies where the pension fund uses the steering instrument recovery premium. In what way this percentage point of recovery premium is determined is further explained in Appendix B.1.1.

After the investment returns are received by the pension fund at time t, the entitlements of the oldest cohort, the participants aged 99 at the start of time t, are removed, as all those participants are deceased during time period t. Thereafter, the indexation level the participants will receive over their accrued benefits at time $t+1$ is determined. This indexation level depends on the policy of the fund, where different types of indexation are further explained in Appendix B.2.
Due to indexed accrued benefits, the value of the liabilities changes, where the value increases in case positive indexation is given and where the liabilities decrease in value if negative indexation is given. Therefore, these indexed accrued benefits affect the funding ratio of the fund. With this resulting funding ratio, the level of contribution in the open fund framework and the level of recovery premium in the closed fund framework

are determined, which the participants pay at the beginning of time $t+1$.
At the end of the time period, the wage level matrix is adjusted for the new average wage level, with which the accrued benefits are determined, and the new cohorts aged 25 are added in the open fund framework.

With the ALM model the pension result PR can be determined, which shows the purchasing power of wages of the pension the participants receive, i.e. it is a ratio of the cumulative indexation given to the participants to the cumulative wage growth:

$$PR^s = \frac{\prod_t (1+i_t^s)}{\prod_t (1+w_t^s)},$$

where i_t^s is the level of indexation given at time t in scenario s and w_t^s is the wage level at time t in scenario s. The level of indexation i is given in (11) and further explained in Appendix B.2.

B Valuing the embedded options

B.1 Sponsor Support

A pension fund can have some sponsor support, which it can use as steering instrument. The sponsor support can be split up into two parts. First the employee contribution option is explained in Appendix B.1.1, whereafter the employer guarantee option is considered in Appendix B.1.2.
Here the pension protection fund will not be considered, as this type of steering is not used within the Netherlands.

B.1.1 Employee contribution option

In order to be able to determine the value of the employee contribution option V_0^{EC}, first the cost covering contribution rate c_{base} is needed, which the working participants within a fund have to pay. This contribution rate c_{base} is set such that the costs of the pension fund are covered, i.e. the contribution rate is set each year equal to the total new accrued benefits in that year divided by the total working population in that year, which is raised with the percentage of required equity:

$$c_{base,t} = \frac{NAB_t}{\sum_{x=25}^{64} \left(Pop_{x,t}^{male} + Pop_{x,t}^{female} \right)} \cdot (1+S)\,, \tag{7}$$

where S is defined by DNB (2007) and NAB_t is the value of the new accrued benefits at time t which is further explained in (16) in Appendix B.4.2.

A pension fund always receives the cost covering contribution from their participants, therefore this value itself is not an option for the pension fund. However, the recovery premium is, as the pension fund has the option to increase the cost covering contribution c_{base} by a certain percentage point, which depends on the nominal funding ratio as follows:

$$c_t = \begin{cases} c_{base,t} + c^{rec_1} & \text{if } FR_{N,t} \leq floor; \\ c_{base,t} + c^{rec_2} & \text{if } floor < FR_{N,t} < cap; \\ c_{base,t} & \text{if } FR_{N,t} \geq cap, \end{cases}$$

where $c^{rec_1} > c^{rec_2}$.

In order to determine the employee contribution option, one needs to take into account the difference between the actual contribution paid by the participants and the cost covering contribution, i.e. $c - c_{base}$. The contribution rate is a percentage of the wage level, therefore to obtain an absolute value, this difference should be multiplied with the wage level. Furthermore, the total number of working participants should be taken into account, which results in:

$$c^s_{pool,t} = \sum_{x=25}^{64} (c_t - c_{base,t}) \cdot w^s_{x,t} \cdot \left(Pop^{male}_{x,t} + Pop^{female}_{x,t} \right). \tag{8}$$

Now, (8) provides the amount of euros all the working participants pay to the pension fund on top of the cost covering contribution rate, for one particular scenario s and one moment in time t. To value the employee contribution option, all the scenarios and time moments over the horizon considered should be taken into account. To value the options, risk neutral valuation is applied. Therefore, (8) should be discounted back to time zero with the risk free rate. In addition, the expectation with respect to the risk neutral probability measure should be taken, which results in the value of the employee contribution option at time zero:

$$V_0^{EC} = E_0^{\mathbb{Q}} \left(\sum_{t=0}^{T-1} c_{pool,t} \prod_{k=0}^{t} \left(\frac{1}{1 + r_{f,k}} \right) \right), \tag{9}$$

where $r_{f,t}$ is the risk free rate at time t and $E^{\mathbb{Q}}$ is the expectation under the probability measure $\mathbb{Q}$.
Note that the contribution option will be equal to zero in case the contribution rate is set equal to the cost covering contribution rate.

B.1.2 Employer guarantee option

Besides some sponsor support from the working participants of a pension fund, also the employer might provide the fund with some guarantees. In this paper, one type of employer guarantee is considered, namely the type where the employers pay the pension fund an amount of money in case the funding ratio falls below some level $floor_{EG}$. The amount the employers have to pay is equal to the amount such that the funding ratio will be brought back to the level $floor_{EG}$ again as follows:

$$EG_t = \begin{cases} (floor_{EG} - FR_{N,t}) \cdot L_{N,t} & \text{if } FR_{N,t} < floor_{EG}; \\ 0 & \text{if } FR_{N,t} \geq floor_{EG}, \end{cases}$$

The employer guarantee EG_t is added to the assets of the fund A_t, such that the funding ratio $FR_{N,t}$ will be equal to $floor_{EG}$ again.

In order to value the employee guarantee option, again risk neutral valuation is used, where the option value at time zero will be derived as follows:

$$V_0^{EG} = E_0^{\mathbb{Q}}\left(\sum_{t=0}^{T-1} EG_t \prod_{k=0}^{t}\left(\frac{1}{1+r_{f,k}}\right)\right). \tag{10}$$

B.1.3 Valuing the sponsor support

In Appendix B.1.1 and Appendix B.1.2 the employee contribution option and the employer guarantee option are explained respectively. The value of the sponsor support at time zero is simply the sum of both option values:

$$V_0^{SPS} = V_0^{EC} + V_0^{EG},$$

where V_0^{EC} is given in (9) and V_0^{EG} is given in (10).

B.2 Adjustment mechanism

Besides steering options, also adjustment options are stated on the holistic balance sheet. Adjustment options thank their name, as they adjust the accrued benefits of the participants. Such an adjustment can either be positive or negative, i.e. the indexation given can either be positive or negative.
There are three types of positive adjustments that can be given to participants that are considered in this paper, namely indexation, catch up indexation, and surplus sharing. Furthermore, two negative adjustments are considered, namely the sustainability cut and the five year recovery plan, which are both reductions of the accrued benefits.
In Appendix B.2.1-B.2.5 all these adjustment rules are explained separately, whereas the valuation of the adjustment mechanism is explained in Appendix B.2.6.

B.2.1 Indexation

A pension fund can choose a pension system in which a choice can be made between three types of indexation that can be given, namely:

- No indexation:
  In this case, in each year no indexation is given ($ind_1 = 0$).
- Full indexation:
  In this case, no matter what happens, full indexation is given each year ($ind_1 = w$).
- Conditional indexation:
  Indexation depends on the nominal funding ratio as follows:

$$ind_{1,t} = \begin{cases} 0 & \text{if } FR_{N,t} \leq floor; \\ \frac{FR_{N,t} - floor}{cap - floor} w_t & \text{if } floor < FR_{N,t} < cap; \\ w_t & \text{if } FR_{N,t} \geq cap. \end{cases}$$

If $w_t < 0$, then no indexation is given instead of w_t.

B.2.2 Catch up indexation

In the Netherlands, a well known type of positive adjustment is the catch up indexation in which participants receive their missed indexation back, as due to conditional indexation, the sustainability cut, and the five year recovery plan members do not receive full indexation in each scenario in this paper.
Catch up indexation gives missed indexation back to the members in case the funding ratio is above a certain level FR_N^{cap}.

$$ind_{2,t} = \begin{cases} indmissedcum_t & \text{if } FR_{N,t} > FR_N^{cap}, \frac{FR_{N,t}}{FR_N^{cap}} > 1 + indmissedcum_t; \\ \frac{FR_{N,t}}{FR_N^{cap}} - 1 & \text{if } FR_{N,t} > FR_N^{cap}, \frac{FR_{N,t}}{FR_N^{cap}} \leq 1 + indmissedcum_t; \\ 0 & \text{otherwise,} \end{cases}$$

where *indmissedcum* is the cumulative missed indexation, which is determined as

$$indmissedcum_t = \frac{1 + w_t}{1 + i_t} - 1,$$

where i is the actual indexation given, i.e. positive and negative indexation are taken into account, which is defined by

$$i_t = \sum_{k=1}^{5} (1 + ind_{k,t}) - 1, \tag{11}$$

where $ind_{3,t}, ind_{4,t}$, and $ind_{5,t}$ are defined in Appendix B.2.3, Appendix B.2.4, and Appendix B.2.5 respectively.
Note that catch up indexation will be given until the funding ratio reaches the level FR_N^{cap} again. Besides this, additional conditions are needed. The first additional condition is that catch up indexation is given subject to a maximum, such that not all catch up indexation will be received in one period, but is smoothed over time:

$$ind_{4,t} \leq catchup^{max}.$$

The second additional condition is that the cumulative indexation that the participants missed *indmissedcum* should be larger then zero, otherwise the participants get a negative adjustment instead:

$$indmissedcum_t > 0.$$

B.2.3 Surplus sharing

The last positive adjustment considered is surplus sharing, in which participants share in the surplus of the fund. This positive adjustment instrument is only used in case the funding ratio reaches high levels. These high levels will mostly be reached due to high investment returns. Whereas a pension fund is a zero sum game and is not introduced

to make profits, a pension fund can choose to let their participants share in the surplus, which is a policy instrument that also is used within the Netherlands.
The amount of surplus sharing is determined conditional on the level of the funding ratio, whereas the members share in the surplus if the funding ratio is above a certain level FR_N^{prof}. In this case, the positive indexation level is equal to:

$$ind_{3,t} = \begin{cases} 0 & \text{if } FR_{N,t} \leq FR_N^{prof}; \\ \frac{1}{\gamma}\left(\frac{FR_{N,t}}{FR_N^{prof}} - 1\right) & \text{if } FR_{N,t} > FR_N^{prof}, \end{cases}$$

where γ is the number of years over which the profit sharing is smoothed. Again note that the participants only share in the surplus as long as the funding ratio is still above FR_N^{prof}.

B.2.4 Sustainability cut

The first type of a negative adjustment is the sustainability cut, which actually can be seen as a type of negative indexation or a reduction. The sustainability cut is introduced in case the funding ratio is low.
The accrued benefits will be cut in case the funding ratio falls below a certain level FR_N^{min}. Here they are cut such that the funding ratio will be brought back to FR_N^{min} immediately. The negative adjustment is determined as follows:

$$ind_{4,t} = \begin{cases} \frac{FR_{N,t}}{FR_N^{min}} - 1 & \text{if } FR_{N,t} < FR_N^{min}; \\ 0 & \text{if } FR_{N,t} \geq FR_N^{min}. \end{cases}$$

B.2.5 Recovery plan

The last negative adjustment instrument is the recovery plan. In the Netherlands it is stated in the FTK regulation that a pension fund should have a funding ratio that is equal to at least some fixed value. However, if the funding ratio will get below this value, due to for instance low investment returns, a fund has to start a short recovery plan. In this paper, a five year recovery plan will be considered.
A five year recovery plan starts if the funding ratio falls below a certain level $floor$. In this case the funding ratio should be at a required level each next year, if this required level is not met next year, the benefits of the participants are cut.
The funding ratio which falls below $floor$ for the first time is denoted by FR_N^*. Such that the funding ratio FR_N^* will be at least equal to $floor$ again in five years, the level with which the funding ratio should be increased each year is equal to

$$\frac{floor - FR_N^*}{5}.$$

Therefore the funding ratio that should at least be reached next year is equal to

$$FR_N^{rec} = FR_N^* + \frac{floor - FR_N^*}{5}.$$

Next year the benefits are cut by a factor such that the funding ratio will be equal to at least FR_N^{rec} immediately:

$$ind_{5,t} = \begin{cases} \frac{FR_{N,t}}{FR_N^{rec}} - 1 & \text{if } FR_{N,t} < FR_N^{rec}; \\ 0 & \text{if } FR_{N,t} \geq FR_N^{rec}, \end{cases}$$

After this, the required funding ratio for the next year is increased by the same factor $\frac{floor - FR_N^*}{5}$:

$$FR_{N,t}^{rec} = FR_{N,t-1}^{rec} + \frac{floor - FR_N^*}{5}.$$

After five years the level $floor$ is reached for sure, in which case the recovery plan is finished. In the worst case, the benefits are cut each year, which is the case if the funding ratio does not meet the required level FR_N^{rec}. However, it can also be the case that the benefits will not be cut at all, which is the case if the funding ratio meets the required level FR_N^{rec} by itself, due to for instance investment returns.

B.2.6 Valuing the adjustment mechanism

Now all the adjustment instruments are explained, the value of the adjustment mechanism can be determined. Here the adjustment mechanism is separated into five parts, namely:

- The indexation option;
- The catch up indexation option;
- The surplus sharing option;
- The sustainability cut option;
- The recovery plan option.

Each of these five options can be determined separately. In each time step ind_i ($i = 1, \ldots, 5$) is determined according to the policy ladders explained in Appendix B.2.1-B.2.5. The fraction ind_i is multiplied with the accrued benefits matrix, note that the indexation given at time zero is equal to zero:

$$B_{t+1}^{ind_i,s} = ind_{i,t+1}^s \cdot B_t^s,$$

which in turn is multiplied pointwise by the amount of participants and the discount matrix (and summed over all cohorts):

$$B_{pool,t+1}^{ind_i,s} = \sum_{x=25}^{99} B_{x,t+1}^{ind_i,s} \cdot \left(D_{x,t}^{s,male} \cdot Pop_{x,t}^{male} + D_{x,t}^{s,female} \cdot Pop_{x,t}^{female} \right), \qquad (12)$$

where the oldest cohort is not included in Pop^{male} and Pop^{female}, and where the discount factor $D_{x,t}$ includes the term structure at the end of time t.

Here (12) gives the amount of indexation given per type of indexation, which can either be positive or negative, to all the participants in the fund for one particular scenario s and one moment in time t.

To value one particular option, risk neutral valuation is used, where all the values should be discounted to time zero with the risk free rate:

$$V_0^{ind_i} = E_0^{\mathbb{Q}} \left(\sum_{t=1}^{T} B_{pool,t}^{ind_i} \prod_{k=0}^{t} \left(\frac{1}{1 + r_{f,k}} \right) \right). \tag{13}$$

The approach explained in (13) can be executed for each type of indexation, which results in five different option values, namely the indexation option value $V_0^{ind_1}$, the catch up indexation option value $V_0^{ind_2}$, the surplus sharing option value $V_0^{ind_3}$, the sustainability cut option value $V_0^{ind_4}$, and the recovery plan option value $V_0^{ind_5}$.
To determine the value at time zero of the total adjustment mechanism, one can simply add the five separate option values, or repeat the approach with i instead of ind, where i is given in (11). Therefore the value of the adjustment mechanism can be determined as follows:

$$V_0^{AM} = \sum_{k=1}^{5} V_0^{ind_k} = E_0^{\mathbb{Q}} \left(\sum_{t=1}^{T} B_{pool,t}^{i} \prod_{k=0}^{t} \left(\frac{1}{1 + r_{f,k}} \right) \right), \tag{14}$$

where

$$B_{pool,t+1}^{i,s} = \sum_{x=25}^{99} i_{t+1}^{s} \cdot B_{t+1}^{s} \cdot \left(D_{x,t}^{s,male} \cdot Pop_{x,t}^{male} + D_{x,t}^{s,female} \cdot Pop_{x,t}^{female} \right).$$

Note that in case no adjustment is done, i.e. $ind_i = 0$, $V_0^{ind_i}$ will not have any value.

B.3 Residue option

In order to keep the holistic balance sheet balanced, a residue option can be determined, which is the present value of the residue after a horizon of T years. To determine the value of this option, risk neutral valuation is used, where the residue at time T should be discounted back to time zero with the risk free rate as follows:

$$V_0^{RO} = E_0^{\mathbb{Q}} \left((A_T - L_T) \prod_{k=0}^{T} \left(\frac{1}{1 + r_{f,k}} \right) \right).$$

B.4 Additional aspects in open fund framework

Next to the unconditional assets, the unconditional liabilities, the sponsor support, the adjustment mechanism, and the residue option, two additional aspects are stated on the holistic balance sheet in the open fund framework with respect to the closed fund framework. The first aspect is the value of the contributions, where the valuation is discussed in Appendix B.4.1. The second aspect is the value of the new accrued benefits, where the valuation is discussed in Appendix B.4.2.

B.4.1 Contributions

The contributions CON are valued in a similar way as the employee contribution option. The employee contribution option consists of the contributions the employers pay on top of the cost covering contribution. Therefore, in order to obtain a balanced holistic balance sheet, the contributions CON are exactly the cost covering contribution. First of all, the contributions paid by all the working participants at time t can be valued for each scenario s as the cost covering contribution multiplied by the working participants multiplied by the wage level, i.e.:

$$con^s_{pool,t} = \sum_{x=25}^{64} c_{base} \cdot w^s_{x,t} \cdot \left(Pop^{male}_{x,t} + Pop^{female}_{x,t} \right). \tag{15}$$

Secondly, the contributions should be valued at the total horizon considered and valued back to time zero with the help of risk neutral valuation. Hence, the value of the contributions at time zero is equal to

$$CON = E^{\mathbb{Q}}_0 \left(\sum_{t=0}^{T-1} con_{pool,t} \prod_{k=0}^{t} \left(\frac{1}{1 + r_{f,k}} \right) \right),$$

where $con_{pool,t}$ is given in (15).

B.4.2 New accrued benefits

The new accrued benefits NAB are valued in a similar way as the adjustment mechanism. Where the adjustment mechanism consists of the indexation given over the accrued benefits, the value of the new accrued benefits reflects the nominal value of the new accrued benefits.

First of all, the new accrued benefits at time t are valued as the sum of the accrual rate ϵ multiplied by the wage level for the working participants:

$$NAB^s_t = \sum_{x=25}^{64} \epsilon \cdot w^s_{x,t} \cdot \left(D^{s,male}_{x,t} \cdot Pop^{male}_{x,t} + D^{s,female}_{x,t} \cdot Pop^{female}_{x,t} \right). \tag{16}$$

Secondly, the new accrued benefits should be valued at the total horizon considered and valued back to time zero as follows:

$$NAB = E^{\mathbb{Q}}_0 \left(\sum_{t=0}^{T-1} NAB_t \prod_{k=0}^{t} \left(\frac{1}{1 + r_{f,k}} \right) \right),$$

where NAB_t is given in (16).