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INTERSHIP REPORT

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Determining Discount Rates and Sensitivity Analysis on Pension plans in Netherlands

PAULA BARUGA ATUHAIRE

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Report Supervisors

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ABSTRACT.

Discount Rate is one of the main assumptions to be used when determining the future liabilities of any pension plan. After the financial crisis in 2008, different sectors of the economy had to adapt to the changes in the financial situations, to do this the pension sector had to revisit its measures on how to maintain a sustainable funding ratio for the future pension payments of future and current pensioners.

In this report, the different ways in which the discount rates were determined in the Dutch pension plans after the crisis by using different methodologies are discussed. The essay goes a step further to investigate how an effective discount rate is determined during the internship process using the Mercer Yield Curve (MYC) in conjunction with the durations of the different pension plans. After the discount rate has been determined, we then analyse how sensitive the plan liabilities are to changes in the discount rate. The analysis involves estimating the plan liabilities with the sensitivity run discount rates and analyzing the impact on the liabilities for plans with both actives and inactives members. We consider inactive members to be the deferred participants and the pension plan current pensioners.

We made use of the "Tool Uitkeringstromen", Retirement Studio (Mercer) software and the Mercer Yield Curve (MYC) reports for our analysis, and the graphics were produced using Excel.

Keywords: Discount Rates, Sensitivity Analysis, Netherlands.

RESUMO.

A taxa de juro é um dos principais pressupostos na determinação das obrigações futuras de qualquer plano de pensões.

Após a crise financeira de 2008, diferentes setores da economia viram-se obrigados a adaptar-se às mudanças na situação financeira global. Não sendo exceção, a indústria de fundos de pensões teve que rever as suas políticas para manter um nivel de financiamento sustentável das responsabilidades inerentes aos futuros pagamentos de pensões.

Neste relatório, são descritas as várias formas de determinação da taxa de juro nos planos de pensões Holandeses após a crise, através de diversas metodologias.

Adicionalmente, no processo de estudo da determinação da taxa de juros, é usada a curva de rendimento da Mercer (MYC) em conjunto com as durações dos diferentes planos de pensões.

Após a determinação da taxa de juros, analisamos a sensibilidade dos passivos do plano às variações na taxa de juro.

Esta análise consiste em estimar as responsabilidades do plano a partir da variação da taxa de juro e analisar o impacto sobre as responsabilidades dos planos de membros ativos e inativos. Consideramos inativos os ex-activos com direitos adquiridos mas que ainda não se encontram a receber pensão e os beneficiários que já se encontram a receber pensão.

Na nossa análise, utilizámos uma ferramenta especifica da Mercer de Holanda "Tool Uitkeringstromen", o programa Retirement Studio (Mercer) e a Mercer Yield Curve (MYC). Todos os gráficos obtidos foram produzidos no Microsoft Excel.

Palavras-chave: taxa de juro, análise de sensibilidade, planos de pensões, Holanda.

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LIST OF ABBREVIATIONS

Abbreviations	Meaning
AOW	Algemene Ouderdomswet
DB	Defined Benefit
DC	Defined Contribution
DNB	De Nederlandsche Bank
DR	Discount Rate
EA	Entry Age
FTK	Financieel Toetsingskader
FV	Full Valuation
IFRS	International Financial Reporting Standards
MMC	Marsh & McLennan Companies
MYC	Mercer Yield Curve
NRA	Normal Retirement Age
PAYG	Pay-as-you-go
PPI	Pension Policy Institute
PVB	Present Value of Benefits
RF	Roll Forward
S&P	Standard & Poor's
UFR	Ultimate Forward Rate
UK	United Kingdom
USA	United States of America
USGAAP	Generally Accepted Accounting Principles (United States)
VA	Valuation Age
WAS	Wealth Analytical Services

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1.INTRODUCTION

1.1 Motivation

Discount Rates are at the heart of most actuarial calculations, and discount rates may implicitly reflect some of the underlying risk. In the year 2012, the dawn of the European crisis, Dutch pension funds faced a dual challenge of disappointing asset returns and low interest rates, resulting in a decline of their funding ratios. The Dutch pension system differs from many other systems in that a greater part of an individual final pension is funded from the occupational pension funds operating in the private sector. The significant pension savings accumulated over the years of service help to overcome the burden placed upon the statutory pension plan or non-funded pension systems. However, this also means that these plans are highly susceptible to the negative effects of risks of a financial crisis. The emergence of this crisis brought about the most contentious debate on the choice of the appropriate rate to discount future pension benefits. (Beetsma et al, 2015)

The Dutch Central Bank, **De Nederlandsche Bank, (DNB**) regulated the pension plans using its Financial Assessment Framework, **Financieel Toetsingskader**, (FTK), with its market-based valuation of liabilities, was introduced in January 2007. (Beetsma et al, 2015). The aim of the FTK was to ensure that pension plans were fully funded, and the required funding levels it sets were demanding by international regulatory standards. The framework was tabled and published in 2010 and it exposed the structural problems in the design of occupational pension plans especially with the standard sustainability of the fund and the consequences of the newly realized longevity risk. The new framework was discussed extensively both internally and externally with the general public until a consensus was reached, a framework to induce greater stability in the underlying economic policies to be followed by the pension fund, to avoid major shifts in the value of the pension contract between generations and to enhance the system's sustainability with regards to rising longevity.

During the reform process to get the "perfect" interest rate to be applied to discount the pension liabilities, the discussions have been intense. The importance of the discount rate lies in the fact that it is an important determinant for the distribution payments values of fund assets across the participating cohorts. Since the crisis, there have been adequate measures taken to stabilize the discount rate such that it does not go too low, increasing the liabilities and unwelcome pressure on the fund assets and surplus available.

Setting the suitable discount rate is imperative to present an adequate pension plan with the appropriate/sustainable funding valuation (ratio). This discount rate is then used to calculate the present value of expected benefit payments. More importantly it's important when projecting values as contributions for a Defined Contributions (DC), used as the expected rate of return on assets in some instances, implicit in the asset allocation and in settlement of new investment strategies.

1.2 Research Objective

Given the value of the funds' assets, an increase in the discount rate shifts value from younger to older cohorts and vice versa. This discussion has been fueled by the extremely low interest rates dropping to unprecedented levels; as a result there has been a sharp increase in the value of liabilities while the value of assets has not kept up. Even with increased contributions from pension plan sponsors, funding ratios have declined to levels that had caused concern to the stakeholders involved. With the different endeavors that have been undertaken by the Dutch regulators and sponsors, in the project, our objectives are:

i. To study the different ways to determine the Discounts Rate required in funding Defined Benefit (DB) plans.
ii. The impact of the discount rate sensitivity in pension plan liabilities, go a step further to determine the influence of the set discount rate on other set assumptions in a pension plan.

1.3 Internship Process

This work is a result of an internship carried out at Mercer Services (Portugal), Lisbon Wealth Analytical Services (WAS), which operates under the Marsh & McLennan Companies (MMC) umbrella. This curricular internship lasted a period of five months which was adequate enough to formulate this analysis for the Internship Report, as such due to the new EU privacy restrictions, the plans schemes or names will expressed as XYZ. The Lisbon WAS is the hub for most European Mercer valuations extended from other countries to Portugal, valuations for countries like Netherlands, UK, Germany, Spain, Ireland, USA, Portugal to mention but a few, all these sum up to 13 countries. This internship work was mainly focused on Netherlands valuations.

During the internship, internal software and calculation formats, templates and VBA (Macros) Excel tools were used. The process of valuation did not alter much from one plan scheme to another, the noticeable difference that determined the change of the valuation process was either if the calculation was a Roll Forward (RF) or a Full Valuation (FV). The major distinction between the two valuations is that;

1.3.1 Roll Forward Valuation

When performing a Roll Forward, there is no update of participant data in its entirety except for special events like a Plan Amendment. The liabilities and benefit cost are determined by a change in valuation assumptions. Roll forward period differs identically to each plan, depending on the valuation date of the last full valuation, could be months or years. A company/consultant would go in for a RF if it doesn't except a significant change in census data or participant number, with this method, the actuary is able to determine the present value of liabilities taking into account the discount rate.

Projected Benefit Obligations (PBO): The actuarial present value of benefits, vested and non-vested, attributed to the pension formula to employee past services, based on employees' future salary levels.

More formally when the roll forward period is known, then the PBO is estimated by:

$$PBO_t = PBO_{t-1} * (1 + i * RF_t) + NC_t + IC_t - (EBP_t * RF_t) \tag{1.1}$$

Where

- PBO_t is the Projected Benefit Obligation for the current year end valuation.
- PBO_{t-1} is the Projected Benefit Obligation for last year end valuation.
- i is Interest (discount) rate used to discount liabilities.
- RF_t is the Roll Forward period measured in years.
- NC_t is the calculated Normal cost for the current year of service.

- IC_t is the Interest Cost for the current year end valuation.
- EBP_t is the Expected Benefit payment for that financial year.

Therefore the Roll Forward PBO is then considered as the expected liability to the employers or plan sponsors for the end of the year. These terminologies will be discussed further in greater detail through the course of the report

1.3.2 Full Valuation

In this case, we have new census data for the new valuation. Its entails a complete understanding of the benefits and new accrual methods if any, all this analysis is done during the Data treatment process for the new data. After the data treatment is complete, the liabilities and benefit cost are also defined using the suggested assumptions from the consultant. With a FV, the actuary is able to determine the individual impact on the liabilities of each member extensively.

2. PENSION SYSTEM IN THE NETHERLANDS

In this chapter the pension system of the Netherlands will be discussed, it introduces the basic notion of pension schemes which will be required throughout the text.

2.1 Current Pension System

The government obligates most working people to participate in the pension system, in this way the lower income earners will have a guaranteed pension after retirement at the retirement age. The risk sharing in the pension fund is on the most part based on solidarity for all. In the Netherlands, a pension benefit in retirement consists of three main pension pillars:

1. State sponsored pension
2. Occupation pension accrued by the employer and employee
3. Private pension

2.1.1 First pillar: State pension

The first pillar of the Dutch pension system is the state pension. Also called the “Algemene Ouderdomswet” (AOW) was started in 1957. (Beetsma et al, 2015)

Through the AOW the Dutch government provides all inhabitants older than the legal pensionable age with a basic pension income. The benefit is flat, hence independent of an individual’s wage history. All residents older than 15 and living in the Netherlands are insured till the age of 67 and 1 month. Each year you live in the Netherlands between age 15 and 67 counts for 2% of the total benefit. The value of the benefit differs for single and married people. For a single person the payment is approximately 70% of the minimum wage, while married or co-habiting persons receive 50% of the minimum wage. Since the AOW pension is on a Pay-as-you-go (PAYG) basis scheme, the contributions are paid by the working population are immediately used to finance the benefits for the current beneficiaries. With the population getting older and living longer, more people retire every year and the working population is decreasing, the PAYG becomes more expensive each year. Therefore there is a lot of discussion about the cost of the state pension. This has led to the recent raise of the Normal Retirement Age (NRA) to 68 as at beginning of 2018.

2.1.2 Second pillar: Occupational pension

The second pillar, the occupational pension, is organized at the level of the employer and is part of the terms of employment agreed upon by the social partners (representatives of employer and employee organizations). Over 90 percent employees in the Netherlands participate in an occupational pension scheme. (PPI, 2014)

Pension schemes can be administered by a pension fund or by an insurer. There are three types of pension funds:

- Industry-wide pension funds (bpf): All companies in the industry are obliged to participate in the offered pension scheme. The government decides whether an industry gets an industry-wide pension fund. The only exception is that when a company offers its employees a better or equal pension scheme than the industry-wide pension fund does, then in that case, the company can offer its superior pension scheme.
- Professional pension funds: some professions have their own pension plan; in that case the pension contract for that profession is mandatory.
- Company pension funds (opf): if a company isn't obliged to join an industry-wide or professional pension scheme, it can start its own pension fund, it doesn't have to however.

The accrual of pension is exempt from taxes; taxes are paid whenever a pension benefit is in payment. The pension funds can provide different types of pensions. The pension Act describes three different types of pension schemes:

- A defined benefit argument (DB): This is a guaranteed pension benefit where the contribution varies. The final pay plan and the average pay plan are the two types of DB schemes. The final pay plan guarantees a pension entitlement based in the career end salary whereas the average pay plan guarantees a pension entitlement based on the salary earned on average in a career. In a DB scheme, the employer bears all the risk (except the default risk) and makes contributions which cover the statutory funding ratio and these contributions are expected to be sufficient to cover the benefits. The FTK, however, may require a higher level of contribution from the sponsors, to reflect the actual scheme experience or to cover any existing scheme deficit.

- A defined contribution agreement (DC): In this case, the benefit is not guaranteed, but the contribution is fixed. The pension benefit accrued at retirement, when received as a pension, will depend on the interest rate used to discount payments, change of mortality rates and changing value of investments. This type of pension involves more risk for participant with the transference of the major risks from the company (sponsor of the pension fund) to the employee (individual member). In recent years more and more companies have changed their DB agreements to DC agreements to reduce their risk.
- An agreement to payment of a capital sum: Each year a part of the guaranteed capital is accrued, sometimes raised with profit sharing. The capital at retirement should be used to purchase a pension benefit at the pensionable age. During the accrual period, the investment risk is for the pension provider. The interest rate risk in this scheme is fully borne by the participant. This type of pension is not common in the Netherlands.

An important part of the Pension Act is that a pension fund and the sponsoring company should be strictly separated. This is done to prevent that when the company goes bankrupt the pension fund will go bankrupt as well. Otherwise the employees will not only lose their jobs but their pension entitlements too.

2.1.3 Third pillar: Private pension.

The third pillar is there to facilitate the opportunity to accrue private pension with the advantage of tax benefits as long as you stay within the fiscal boundaries. This makes it possible to accrue extra pension benefits for people who want a higher pension on top of their additional pension or people without a pension agreement or an employer who wants to pay for an extra pension. As long as the participant stays within the fiscal boundaries, this pension is handled with the same tax benefits as in the second pillar.

It is made on a voluntary, individual basis. This type of pension provision consists of life insurances, individual annuities or specifically labelled savings. Banks and insurance companies are the typical providers of these types of pension products.

In the remainder of this paper, we will focus our attention on the second pillar; we will mainly discuss the methodology of determining the discount rate for the liabilities and their sensitivity to the change in Discount Rates.

2.2 Developments of the Discount Rate in Dutch Pension systems

Due to the financial crisis and the ageing population, the sustainability of the current pension system is at risk. In recent years many suggestions have been done and plans have been made to change the current pension system. In this section an overview of the suggested changes is given.

2.2.1 The new prudential Financieel Toetsingskader (FTK)

The FTK for pension funds, supervised by the DNB, requires annual valuations to determine funding ratios against plans “minimum regulatory own funds”. The funding ratio is the total assets as a percentage of total liabilities for benefits accrued, with the liabilities excluding any allowances for future increases, and calculated with a discount rate that is broadly risk free. The FTK with its market-based valuation of liabilities was introduced in January 2007. (Marossy & Gilfedder, 2012)

As result of the Global Financial crisis that hit late 2007, the average funding ratio of the Dutch occupational pensions fell from over 150% in 2007 to just 92% in 2009. This led to the fall of equity prices which reduced assets and low interest rates which then reduced the discount rates and increased the present value of liabilities. After a modest recovery in 2010, the funding levels then fell back down to 94%-99%in late 2011 and early 2012.

The global crisis came as a shock to the rather healthy well-funded Dutch pension system and so did the sudden funding gaps especially for the funds that had not yet hedged their interest rate exposure as they experience large fall in funding levels.

In response to the emerging funding shortfalls, an immediate step was taken to soften the blow to plans: the DNB announced that recovery plan periods would lengthen form three to five years to enable pension plans get recovery plans to restore them to over 105% funding levels. And it was also agreed that any recovery plans that include the reduction in pension rights would not begin until April 2012 at the earliest, although a majority of the plans were still unable to reach the 105% bench mark. The additional suggestions were to increase contributions, capital injections from sponsoring employers or as a last resort, a reduction in both pensioners' benefits and the accrued entitlements of members of the working age.

2.2.2 September Pension Package

In September 2012 (Beetsma et al, 2015), the government formed the September package in consultation with the DNB and the Pension federation. The September Package formulated as a "future proof" pension system because the new FTK was delayed and hence it focuses mainly on the year 2013 and included the following suggestions:

- The introduction of the Ultimate Forward Rate (UFR) in the calculation of pension liabilities, which is also the rate used within the Solvency II framework for insurers who were also supervised by DNB. The 3-month average yield curve is manipulated in the long end more stable and less sensitive to short term fluctuations in the financial markets by using an UFR of 4.2% in 2012.
- **Ultimate Forward Rate (UFR)** is the interest rate for very long durations (over 20 years), which was set at 4.2% for the year 2017, at 4.05% for the year 2018 and at 3.90% for the year 2019 for the Euro Area. This is ultimately the upper bound of the interest rate term structure.
- As a result, the pension plans funding positions improved to an average of 102% because the UFR of 4.2% was significantly higher than the prevailing discount rate at the time. Its introduction was not without controversy, as there were associated concerns around intergenerational fairness and transfers from younger generations to the old.
- There was also an option to spread the possible benefit cuts which allowed maximizing a benefit cut of 75% immediate and the rest would be realized later. There was a suggestion to increase the pensionable age 65 to 67 as at 1st January

2013 instead of 1st January 2014, a type of adjustment mechanism where the indexation would become conditional to an increasing life expectancy and only granted if the funding ratio was 110% or higher.

2.2.3 Latest Developments

The discount rate that funds apply to calculate their liabilities has been changed several times; 2007 saw a switch from a fixed rate to discounting based on the risk free term structure in the market; then came December 2011 where the discount rate was changed to the moving average over the past three months of the market term structure of risk-free interest rates. As mentioned above, the UFR was then introduced in the discount curve which was beneficial for the funding ratios as well the three-month moving average of the term structure for discounting for some periods, depending on the trend in interest rates of the prior three months. (PPI, 2014; Keijzer, 2014)

After many negotiations, the Dutch cabinet finally approved proposed changes to the FTK. The changes were mainly focused on tightening up the existing nominal contracts and include a range of measures which, as a package, clarify the new processes for funding valuations, recovery plans and remedial action when a pension fund is underfunded. The suggested measures below will be allowed provided that:

- Discount rates will be based on the new UFR approach from 2015 onwards so as to lower discount rates compared to the current approach.
- Higher solvency buffers will be required in order to secure the legally required degree of actuarial certainty.
- As an alternative to the solvency buffer, the use of a smoothed discount rate over (maximum) 10 year period to determine the required contributions (additional) will be allowed. Also possibly the use of the expected return on assets as the discount rate for determining the required contributions under certain conditions.
- A 12-month-moving-avergae funding ratio to replace the current point estimate funding ratio.
- An extended recovery period, a rolling 10 year recovery plan to get the funding ratios up to around 130%.

- Benefit reductions amounting to one tenths of the deficit will be required if the full funding ratio is not expected in 10 years.
- Further reductions in benefits are required if funding level are below 105% for six consecutive annual measurement dates.
- The increase in contributions requirement has been dropped since it only affects active members, otherwise its accepted.
- Schemes are required to outline they intend to deal with funding deficiencies in the future ahead of time.

Finally, in January 2015, the three-month-moving-averaging effect in the discount curve was abolished.

2.3 Valuation process of Defined Benefit in the Netherlands.

Financial institutions like DB pension plans, with liabilities contingent on survival, need to set aside reserves or funds to meet their payment obligations. Indeed, the scheme funding requirements of the Pension Act 2004 (Van der Wal, 2014) focus on the value to be paced on a scheme's liabilities. The amount necessary is dependent on when and for how long the benefits are to be paid for in the case of demographic assumptions and the amount of the benefit to be paid in the case of economic assumptions.

An actuarial valuation is an assessment which requires an actuary to advise the company sponsoring the fund on the choice of prudent actuarial assumptions to assess the financial health of the pension scheme as it is a requirement stated by the DNB, that the pension funds are financially healthy and can be expected to fulfil their obligations in the future.

2.3.1 Actuarial assumptions

There are two main types of actuarial assumptions

1) **Economic assumptions**; Assumptions relating to future economic factors which will affect the funding position

a) Discount Rate or Interest Rate: This is the rate used to discount future benefits, thus determining the plan liabilities, and should be a rational expectation of the future rate of return on the plan assets.

   It is usual to have two separate assumptions for the discount rate: one for preretirement, and the other for post-retirement. The difference lies in the duration of the liabilities for pensioners and non-pensioners. The lower the discount rate, the more conservative the valuation of liabilities will be, and vice versa.

b) Inflation: Benefits are often linked to price inflation (both pre and post-retirement), so projected benefits will depend on the level of inflation assumed for the future. The actuary must determine the evolution of the consumer price index (CPI) and the retail price index (RPI), and the inflation forecasts, when setting the inflation assumption.

c) Salary scale: In case the benefit is dependent on the final salary on retirement (or on exit from the scheme, or on death), a salary scale assumption should be set to calculate the projected benefits. This assumption reflects expected inflation, productivity growth, merit scale, and other factors that affect wages.

d) Pension Increase: This can be considered as an increase rate in the after retirement "salary", it would depend on factors like the age, past service and productivity of the plan participant. This rate can be set by considering a specific plan sponsor with similar characteristics and using its historic and current data as well as the current market conditions like inflation.

2) **Demographic assumptions**: These are assumptions required to project how long the benefits are expected to be payable; and hence how much money a pension scheme needs to meet its liability. We explore some components of demographic assumptions in more details below.

   a) Mortality tables: Analogous to a discount rate which accounts for the time value of money, the plan must assume mortality rates, both pre-retirement and post-retirement. A mortality rate is an assumed probability of dying within a year, whereas longevity refers to the future expected lifetime derived from any set of mortality rates. High mortality rates will either increase or decrease the total benefits to be paid, depending on how the value of the death benefits compares with the benefits payable should the member have survived. Since mortality is mostly uncertain, the actuary must check the consistency of the mortality tables used in the valuation to the actual death experienced, and update the tables to reflect the plan's mortality experience. An assumption that reflects the scheme's experience ensures more certainty in the expected liabilities.

b) Withdrawal rates: Assumptions which reflect the termination that can be expected to occur each year at each age. Schemes hope to profit from members leaving service, as the deferred benefit is only subject to price inflation and not to a salary increase. Thus, higher withdrawal rates reduce the amount of total expected liability. In case of vested rights, the Dutch law requires the transfer values to be at least equal to the cash equivalent of the deferred pension benefits accrued.

c) Disability rates: In case of allowance for a disability benefit, an assumption is needed to assess the amount to be paid. Depending on the benefit rules set on disability, lower assumed disability rates might decrease the amount of expected liability. Disability rates can be calculated partly through some analysis of national disability rates. However, the nature of the industry and the terms of schemes vary significantly; thus a study of credible data from the scheme experience should be considered (when available) in developing the decrement table.

2.3.2 Forms of Valuation of Dutch Pension Funds

Dutch pension schemes are required to be valued at least once each financial year, this assessment is necessary to conform to the legal and regulatory guidelines set up by the DNB while also following the Pensions Act 2004. The scheme managers have to inform the regulator about the health of the scheme, as well as for security and financing purposes, as they have to review the funding ratios, investment strategies and study the scheme's solvency position. There are three main types of valuations, and the purpose of a valuation drives the kinds of assumptions to be used. (Schmitz et al, 2015)

a) **Solvency Valuation:** One of the main objectives of Dutch pension funds valuation is to preserve the schemes' solvency, in other words, to ensure the ability of the scheme to meet the long-term financial obligations. The solvency valuation is valued regarding "discontinuance". In practice, the pension regulator, DNB introduced a rule on the minimum solvency requirements for all defined benefit plans. It assumes the scheme discontinues at the valuation date (all active members are evaluated as deferred pensioner) but the deferred members do not start receiving pension with no further support from the company. The solvency calculation shows the cost of "buying out" members' benefits in full with an insurance company if the scheme were to be wound up.

The assumptions used in this valuation are decided not based on the scheme's experience, but on what is believed to be the assumptions used by the insurer. The discount rate set out is usually very low, as it often has reference to government bonds (risk-free), which results in a high present value of the liability, when compared to that from other valuations. This is the reason why a solvency valuation is called the Wind-up Valuation; the solvency valuation assumes maximum prudence.

b) **Funding Valuation**: This kind of valuation is required by the technical actuarial valuation standards and should also be in accordance to the Pension Act 2004. The scheme liabilities are valued for an "ongoing basis". The purpose of this scheme is to ensure that the plan sponsors have control over the cost of the scheme. If the funding ratio of the scheme does not meet the required standard in order to meet the promised benefits, the employer would have to increase funding by increasing contributions to a level that meet the projected liabilities. Alternatively, the employer can also reward the employees with a contribution holiday in case the funding ratio has been exceeded and is higher than necessary. The existing market conditions define the process for the asset-liability value, the assets are taken at market value and the liability assumption should be consistent with market conditions. The assumptions used to value the liabilities are to be determined by the scheme actuary based on scheme-specific experience, where applicable.

The legislation requires employers to adopt assumptions which include a margin of prudence below the best estimate of mortality rates. There is no agreed definition of what prudence means; the employers must decide based on actuarial advice. The employer's agreement with the employees is important and when this agreement is strong, they might be willing to accept a lower level of prudence since the employer can meet any further deficit.

c) **Accounting Valuation**: The major process of this valuation is to value the scheme's assets for year-end financial reporting. The accounting valuation is valued on "ongoing" basis, meaning the scheme is considered to be finally healthy and in full operation. It is required by the employer for preparation of their year-end accounts. The method used to set the assumptions is prescribed by the relevant accounting standards, which depend on where the accounts will be disclosed but should be the nearest value to a "best estimate".

The discount rate for the valuation is set regarding "AA high-quality corporate bonds", and thus is higher compared to the discount rate used in the solvency valuation. The mortality assumptions set are usually the best estimate from the scheme experience. Accounting valuations are essential because the value of the assets on the company's financial statement needs to be reliable. The report from this valuation allows users of the accounts, especially the shareholders, to study the financial position of the company.

We will focus on accounting valuations for our analysis on the chapters that follow.

3.DETERMINING DISCOUNT RATES

Discount rate is typically the most financially material assumption and therefore rates used in setting provisions must be chosen prudently and take into account the yield on assets held by the scheme to fund future benefits and the anticipated future investment returns and the market redemption yields on government or high quality bonds (Cowling et al, 2011).

One of the goals of our analysis is to select the prudent discount rate for pension schemes. A pension can be defined as a series of payments made to retirees usually for their lifetime; it is therefore seen as by employees or the current workforce as a form of savings for future expenditures especially during retirement. An actuary is tasked with estimating these payments that are made to all future participants at retirement. The pension discount rate is used to calculate the present value of employee pensions.

Consider the time value of money formula:

$$PV = FV/(1 + R\%)^\wedge N \tag{3.1}$$

where: PV – Present Value, FV – Future Value, $R\%$ - Interest rate, N – Time period (<1year for pensions)

This goes to show that the discount rate has an inverse effect on the present value of obligations.

Understanding the measurements of pension obligations requires recognizing the purpose and meaning of each and some factors need to be considered when determining the rate.

3.1 Determine the form of valuation to be applied in the scheme valuation:

3.1.1 For **Accounting valuations**

The discount rate must reflect the rate of return on high quality fixed income securities at the valuation data. In this case, the method uses fixed-income yield data because fixed income securities are similar to pension obligation as both make fixed payments in future years.

3.1.2 For **Funding valuations**

The discount rate is used to discount future benefits to determine plan liabilities and therefore should be a reasonable expectation of the future rate of return of pension plan assets are to produce during that time period in which benefits are paid and also based on the assumption that the asset allocation will be maintained in the future.

The two approaches of valuation may produce the same discount rate (DR) if a pension scheme is invested entirely in the same type and same duration of the fixed-income securities. Usually the discount rate determined for funding valuations is higher than that to be used for accounting valuations (Patel & Daykin, 2010).

3.1.3 **Investment Policy and Volatility**

It is paramount to generate the highest possible returns consistent with the liabilities and liquidity needs of the pension plan. This is used to gauge the volatility or risk level for the plan assets being invested to fund the future plan liabilities. It goes hand in hand with the investment strategy of the plan provider or sponsors in for instance a risk averse plan provider will prefer a low rate of return on the plan assets as its associate with a lower risk hence investing in less risky deratives or ventures with a long time horizon.

It is common to have two different discount rates assumptions: one of them for the pre-retirement period and another for the post-retirement. The fundamental distinction between the rate for Active members plan and Inactives (deferred and pensioners) members plan is the duration of the liabilities is different for each group.

3.2 Development of discount rates in Netherlands Valuations.

The method of valuation focused on during the internship process was **Accounting valuations** therefore our main focus will be on determining the discount rate for IFRS/USGAAP accounting standards that are mainly applied in Netherlands valuations. There is no significant difference between the discount rates used for each accounting standard.

Mercer derives monthly information on discount rates for IFRS and US-GAAP valuations to help companies in determining the discount rate for the pension obligations valuations. Further as it is a high valuation season during November and December each year, Mercer reports weekly on the development of discount rates for the year-end accounting purposes (Mercer, 2017).

Accounting standards require the discount rate used when calculating pension benefit obligations to be based on the yields on high quality corporate bonds. The specifics of his methods are not extensively outlined which means that choice of bonds and methodology for determining the rate is the responsibility of company directors, subject to review of their auditor.

To determine the discount rate recommendation, Mercer uses its own tool, the 'Mercer Yield Curve Approach' (MYC). The MYC is a popular tool for determining discount rates; it is being used for setting rates for UK, USA, Canada, Eurozone area and some other countries' valuations. Following this approach, Mercer creates a 'Spot Rate Yield Curve' based on bonds from the Thomson Reuter's Data stream indexes (until 31/05/2015 from Bloomberg indexes) in the Euro area (Mercer, 2018a).

Since the discount rate in accordance with IAS19.78 is defined by the time value for money, which by definition does not incorporate any significant default risk, Mercer therefore mainly uses those bonds that are free from interest rate distorting options, like put or call options that are laced with a risk of default. Furthermore, the bonds with much higher or lower interest rates compared to the other bonds (statistical outliers) are not also considered.

As the discount rate is determined according to the liability maturity based on high quality bonds but in the long term average, these rates were only around 0.5% higher than the rates for AAA (quasi safe) government bonds. Therefore, the auditors, actuaries and standard setters typically used AA rated corporate bonds as a substitute. For example, the iBoxx corporate AA10+ is commonly used as a benchmark index.

Due to the uncertainties in the financial markets, the spread between the yields on the AAA rated government bonds and yields on AA rated corporate bonds had reduced from an earlier 0.5% up to 0.25% in 2008. This results from the fact that markets had yet equipped many AAA rated bonds with a significant risk premium. In the meantime, the spread has returned again nearly to the situation before the crisis of financial markets (Mercer, 2017).

Selecting the right method to determine the discount rate has a very strong impact. The companies therefore have a certain latitude in the choice of the discount rate) although principles of continuity and consistency still must be followed).

In the Eurozone, where the Netherlands operates, it is recommended based on durations of 10, 15 and 20 years. The discount rates for different durations can be determined by interpolating the values from the table below. It should be noted that the current low level of discount rates may results into higher durations than those in the previous years.

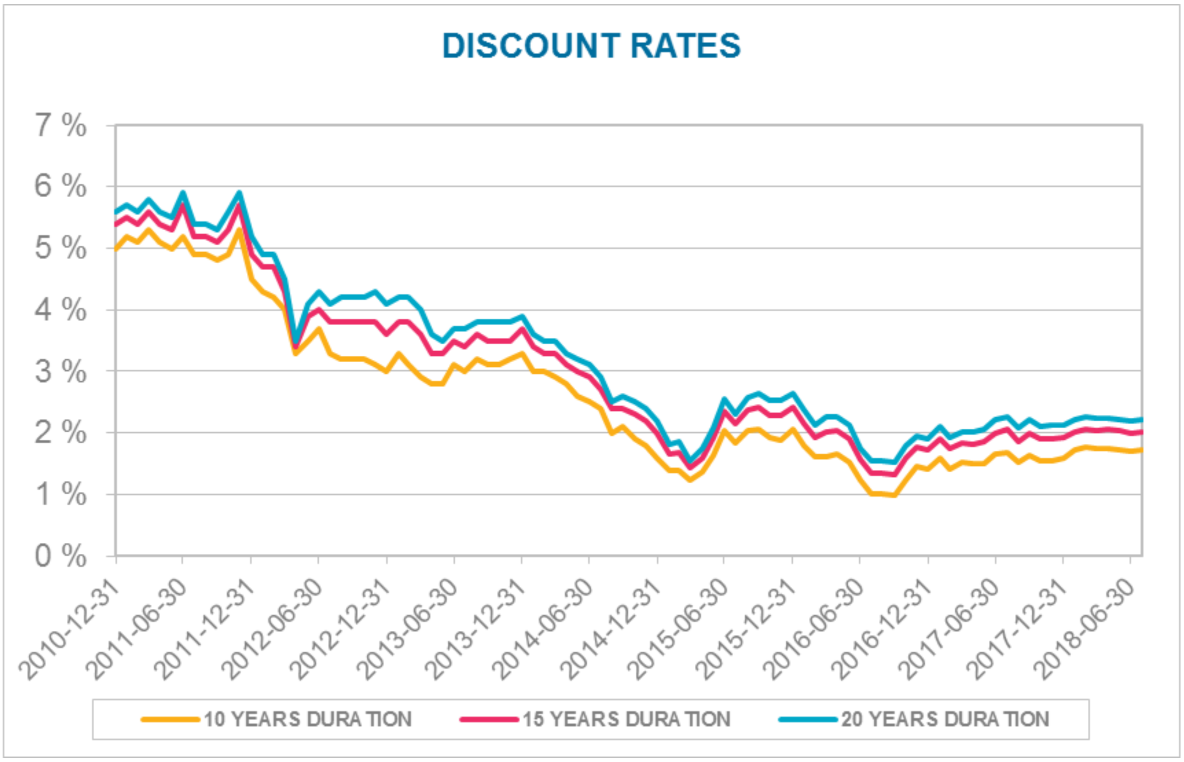

Figure 3.1: The trend movements of Discount Rates determined by the MYC with different durations. Source: Eurozone Mercer Yield Curve (Mercer, 2017)

DISCOUNT RATES OVER THE LAST YEARS				
DATE	10 YEARS DURATION	15 YEARS DURATION	20 YEARS DURATION	IBOXX CORPORATE AA 10+
Dec 31, 2009	5.50%	6.00%	6.20%	
Dec 31, 2010	5.00%	5.40%	5.60%	
Dec 31, 2011	4.50%	4.90%	5.20%	4.60%
Dec 31, 2012	3.00%	3.60%	4.10%	2.69%
Dec 31, 2013	3.30%	3.70%	3.90%	3.17%
Dec 31, 2014	1.60%	2.00%	2.20%	1.49%
Dec 31, 2015	2.06%	2.42%	2.64%	2.03%
Dec 31, 2016	1.41%	1.72%	1.90%	1.31%
Jan 31, 2017	1.59%	1.91%	2.11%	1.49%
Feb 28, 2017	1.42%	1.74%	1.93%	1.29%
Mar 31, 2017	1.52%	1.83%	2.02%	1.39%
Apr 30, 2017	1.49%	1.81%	2.01%	1.35%
May 31, 2017	1.51%	1.86%	2.07%	1.38%
Jun 30, 2017	1.66%	2.00%	2.21%	1.67%
Jul 31, 2017	1.69%	2.05%	2.27%	1.60%
Aug 31, 2017	1.51%	1.87%	2.07%	1.45%
Sep 30, 2017	1.64%	2.00%	2.21%	1.55%
Oct 31, 2017	1.54%	1.90%	2.11%	1.41%
Nov 30, 2017	1.55%	1.91%	2.13%	1.45%
Dec 31, 2017	1.58%	1.93%	2.13%	1.30%
Jan 31, 2018	1.72%	2.02%	2.21%	1.37%
Feb 28, 2018	1.76%	2.06%	2.25%	1.37%
Mar 31, 2018	1.74%	2.05%	2.23%	1.37%
Apr 30, 2018	1.75%	2.05%	2.24%	1.44%
May 31, 2018	1.73%	2.03%	2.21%	1.42%
Jun 30, 2018	1.69%	2.00%	2.19%	1.45%
Jul 31, 2018	**1.72%**	**2.02%**	**2.21%**	**1.44%**

Figure 3.2: The Discount Rates determined by the MYC with different durations of the past months.

3.3 Mercer Yield Curve – Eurozone Cash Flow Discounter

The Mercer cashflow discounter provides a method of calculating an effective rate equivalent to discounting a set of scheme cashflows by spot rates of corporates bond yield curve to calculate an equivalent single discount rate that could be appropriate for valuing pension scheme liabilities and particularly for accounting purposes.

Mercer actuaries use this model to develop an approach that is specific to each scheme and reflect its liability profile. The MYC consists of half-early/zero coupon rates developed from pricing and yield information on high quality bond as such a combination of the bond yield curve and the cashflow discounter is referred to as the Mercer Yield Curve (MYC). The model is used to discount each year's projected benefit cashflow at the associated spot rate back to the measurement date input and calculate the single equivalent rate that, when applied to the same cashflows, results in the same present value. It also calculates the Macaulay duration and the Modified duration.

Macaulay Duration: this is the average time it takes to pay past benefits, weighting each payment by the discounted value of benefit paid at that time. It's defined with the formula;

$$D_{Macaulay} = \sum \frac{tP_t*(1+i)^{-t}}{P_t*(1+i)^{-t}} \qquad (3.2)$$

Where: P_t is the Payment at time t and i is the Interest Rate For the purpose of the report we consider the formula:

$$D_{Macaulay} = \frac{\sum(t-0.5)C_t(1+i)^{-t}}{\sum C_t(1+i)^{-t}} \qquad (3.3)$$

Where: C_t is the annual cashflow in year *t.*

Since the cashflows in pension funds occurred throughout the year in question, for simplicity we consider a single cashflow occurring in the middle of the year.

The modified duration is the Macaulay duration divided by$(1+i)$. It measures the percentage change in the liability in response to a change in interest rates of 1%. The equivalent single discount rate was selected for the calculation of duration. All other assumptions remaining constant, the duration will increase as discount rates decline.

Modified duration ("duration") is an estimate of the percentage change in the present value of a series of cash flows for a one percentage point change in the discount rate. Thus, if a pension plan has duration of 15, a one percentage point decrease in the discount rate (from 6% to 5 %, for example) would be expected to increase the value of the benefit obligation by approximately 15%. In certain situations, duration also corresponds to a weighted-average length of the underlying cash flows – hence its frequent denomination in "years." Comparing the pension plan's duration with that of the plan's fixed-income investments is one tool that can help plan sponsors and fixed income managers assess how well the portfolio responds to changes in the present value of the pension cash flows. Note that duration itself depends on the discount rate and will change somewhat from month to month as the underlying interest rates change.

3.3.1 Constructing the Mercer Yield Curve (Eurozone MYC).

When developing the Mercer yield curve, there are four major areas where choices have to be made (Mercer, 2018a):

- Choosing the appropriate bond universe to use.
- Fit a curve of best fit to the selected bonds.
- Determine the transition point of a par coupon yield curve to a spot rate curve and extrapolate in cases where the data is insufficient.
- Extend the curve beyond the transition point.

The steps above are explained in greater detail as follows;

Step 1. Select the appropriate bonds to use

The MYC is based on euro-denominated corporate bonds rated AA by S&P Global or Moody's Ratings. The bonds used should:

- Have data available from the data provider (Thomas Reuters DataStream)
- Have an outstanding issue value of €50 million.
- Have excepted cash flows (i.e. not callable bonds, or floating coupon rate bonds)

- Have at least 6 months to maturity and, where they have maturity greater than 50 years, they satisfy additional checks to ensure it is reasonable to assume they are actively traded.
- Are not government bonds or government related as these will not be considered as corporate bonds since the government is the majority stakeholder.
- Be non-collateralized bonds. Collaterised bonds are asset backed securities rather than loans taken by companies for business purposes so these aren't valued as corporate bonds.

Before incorporating these bonds in our analysis, their yields get adjusted by a calculated A-AA spread so they can be treated as proxies for AA-rated bonds. We call these bonds synthetic AA bonds. Also zero coupon bonds with a yield (interest) rate equal to coupon rate of a par can be included in the bond selection.

The Eurozone AA rated corporate bonds exists at up to durations of about 15 years, and after this, the number of bonds reduces significantly. Therefore for duration above 15 years, we need to incorporate additional information from A rated bonds with durations higher than 15 years. This allows us to extrapolate the curve for longer durations which adjusts their yields by the A-AA spread.

Using the Eurozone MYC methodology, we are able to create an A rated curve, that is compared against the AA corporate rate curves durations of greater than 7 years. We take the average spread and then exclude outliers.

At the moment, there are not any long-date euro dominated corporate bonds that are AAA-rated and satisfy our criteria.

<u>Step 2: Fit a curve of best fit</u>

Regression analysis is used when constructing the curve of best fit that linked yields to maturity to the maturity time of the selected bond yields. For regression purposes, we choose the fourth degree polynomial based on the logarithm of the time of maturity which minimizes the square differences between itself and data points excluding outliers.

We determine the curve of best fit using the least squares regression, which minimizes the sum of the squares of the differences between the actual data points and regression line.

In order to eliminate the effects of bonds that appear to be outliers, we exclude bonds where the yields to maturity are more than two standard errors from the regressed yield to maturity based on the initial calculation. If the curve has been fitted well, then the differences between the theoretical and actual bond prices should spread evenly around zero. Many positive differences suggest the discount rate is higher that determined by Eurozone MYC; while negative differences of equal proportion suggest the discount rate is lower. The regression analysis is then rerun on the reduced data set to determine the final maturity yield curve.

Step 3: Convert par coupon yield curve into the equivalent zero coupon spot rate curve.

We convert the regressed yield curve into a spot rate curve using the bootstrap method which assumes that the price of coupons bonds for given maturity equals the present value of the underlying bond cash flows using zero coupon rates.

The principle of no arbitrage opportunities holds. During this conversion, we assume that the regressed coupon yield at each maturity date showed a coupon-paying bond at par. The semi-annually compounded yields are converted into effective annual yields.

Additionally we need to determine the transition point; there are a limited number of corporate bonds with maturities higher than 15 years so to enable us extrapolate the curve for higher durations so we need to determine a transition point to extrapolate the MYC. The model is improved to define the transition point as the average term of the five longest bond yields included in the curve excluding the outliers.

Step 4: Extend and extrapolate the curve beyond the transition point.

Having determined a suitable transition point, we need to determine how to extend the curve beyond this point. We choose to extrapolate the curve in line with the yield on government bonds by holding the spread constant between the derived spot rate and the treasury rate, for example, the spot rate at time 1 is used to determine the spot rate at time 0.5.

Although several governments have issued bonds with terms up to around 50 years in the Eurozone, ECB produces its treasury curve that stops at 30 years due to insufficient data. Consequently, spot rates derived are used until the duration equal to the average maturity term for the last five available AA rated corporate yields included in the curve with 30 years maximum, in order to produce a more stable curve. The spot rates from the duration between 30 years to 50 years are determined by holding the spread above treasury rates constant.

In conclusion, the main importance of the MYC is to directly calculate the PV of liabilities. It is however easier to calculate the liabilities using a single equivalent discount rate rather than a yield curve. In order to determine the single discount rate, we need to use scheme specific cash flows. The cash flow discounter mainly assumes that the MYC spot rates remains constants from the time of 50 years onwards therefore the sample cash flow single equivalent rates can be used as a guide to the most appropriate scheme discount rate by comparing the duration of the scheme specific liabilities to that of the sample scheme.

3.4 Discount Rates for sample plans

Cashflows are used to derive the scheme profiles and the categories of liabilities differ from one country to the next, for example the liabilities in the Netherlands are increased with limited price increases or with known increases.

The scheme profiles in the Netherlands are characterized as duration periods corresponding to them as shown in the table **3.1** below;

Scheme Profile	Approximate Duration	Scheme Liabilities	Discount Rate per year
Short Intermediate	15 years	20% older deferreds, 80% pensioners.	2.11%
Intermediate	21 years	25% older actives, 30% deferreds, 45% pensioners.	2.29%
Longer Intermediate	25 years	65% younger actives , 25% deferreds, 10% pensioners	2.36%
Long	30 years	80% young actives, 20% deferreds	2.42%

Table 3.1: The Discount Rates correspondent to the different Scheme profiles with different durations

Note that the status description in reference to the relative duration of the liabilities of the members in that country.

3.5 Empirical calculation to determine the Discount Rate using the MYC yield curve.

As the MYC is a cashflow discounter, we need to input the accurate cash flows for the scheme for which we intend to calculate the Discount Rate (Mercer, 2018b).

During the internship process, these input cashflows were determined using the “Tool Uitkeringstromen” which translates to Tool for payment flow in English. As the name suggests, the main purpose of this tool is to estimate the future cashflows for the pension scheme and by doing so we have the expected cashflows for the period we need the Discount rate. While using this tool, we are able to gauge the duration for each of the pension status and therefore the duration of the scheme as a whole. This duration will be used later used as reference in the MYC to achieve the appropriate DR, while assuming the inflation factor to be zero (Mercer, 2018b).

The above mentioned cashflows used are determined by;

$$Uitkering = [RF(Actives) + RF(Deferreds) + RF(Pensioners)] \quad (3.3)$$

The term Uitkering means Payment

Most often, the roll forward period in consideration was one year but this was also dependent of the period of the last full valuation of the pension plan in which case;

$$Rf_t = Current\ valuation\ date - Last\ Full\ Valuation\ date \quad (3.4)$$

For easier illustration, we shall consider a 1 year roll forward;

For Active members;

$$RF_{A1} = [(CF_{A2} * LF_{Act}) + (NC_{A2} * LF_{NC} * Jaar1)] * Jaar1 + (1 - Jaar1) * [(CF_{A1} * LF_{Act}) + (NC_{A1} * LF_{NC} * Jaar1)] \quad (3.5)$$

For Deferred members;

$$RF_{D1} = LF_{Def}[CF_{D2} * Jaar1 + (1 - Jaar1) * CF_{D1}] \quad (3.6)$$

For Pensioners;

$$RF_{R1} = LF_{Ret}[CF_{R2} * Jaar1 + (1 - Jaar1) * CF_{R1}] \quad (3.7)$$

To the final non zero cashflow;

$$RF_{At-2} = [(CF_{At} * LF_{Act}) + (NC_{At} * LF_{NC} * Jaar1)] * Jaar1 + (1 - Jaar1) * [(CF_{At-1} * LF_{Act}) + (NC_{At-1} * LF_{NC} * Jaar1)] \quad (3.8)$$

$$RF_{Dt-2} = LF_{Def}[CF_{Dt} * Jaar1 + (1 - Jaar1) * CF_{Dt-1}] \quad (3.9)$$

$$RF_{Rt-2} = LF_{Ret}[CF_{Rt} * Jaar1 + (1 - Jaar1) * CF_{Rt-1}] \quad (3.10)$$

Where:

$RF_A; RF_D\ ; RF_R$ Is the roll forward cashflow associated with an active, deferred and retired participant respectively. Each of these values is referenced to the time at which they are paid.

$CF_A; CF_D\ ; CF_R$ Is the accrued liability associated with an active, deferred and retired participant respectively. Each of these values is referenced to the time at which they are paid.

NC_A is the normal cost associated with an active participant respectively. Deferred and Retired participants do not have a normal cost value.

$LF_{Status}; LF_{NC}$ is the liability ratio. It is defined as the ratio of the Final studio liabilities to the Estimated Liabilities by the tool.

$$LF_{Status/NC} = \frac{Final\ Studio\ liabilities\ of\ the\ status\ or\ NC}{Estimated\ Liabilities\ of\ the\ status\ or\ NC} \tag{3.11}$$

$Jaar1$ is the yearly factor of the roll forward period, which in this case would be equal to 1.

The liabilities are usually valued for a period of 120 years; therefore the total number of cashflows would not exceed 120 cashflows.

3.6 Converting the cashflows to determine a single effective discount rate

Once the cashflows have been determined using the "Tool Uitkering", we then apply the MYC methodology to determine the appropriate Discount Rate identical to the plan. During the internship process and for majority of the Dutch plan valuations, firstly we need to specify the scheme profile, which in turn determine the appropriate spot rates curve. The "User Defined" scheme profile is selected as the cashflows we are using is specific to the scheme in question and follows that the spot rates allow for the user defined property.

Firstly, the cashflows are adjusted to the measurement year of the curve since the MYC is updated every month's end. The adjusted cashflows are then converted in to weighted cashflows.

$$= Adjusted\ Cashflow * (Year\ Index + 0.5) \quad (3.12)$$

We use the 0.5 as the default timing for the cashflow; we assume that the benefits payments are made at the middle of year. We need to discount the cashflows with the spot rate for the years from the measurement year. These discounted cashflows also be referred to Mercer Discounted Cashflows.

$$Discounted\ Cashflows = Adjusted\ Cashflows * (1 + spot\ rate\%)^{-(Year\ Index+0.5)} \quad (3.13)$$

A preliminary discount rate (DR %) is suggested considering the cashflows and the scheme profile so we use this rate

$$DR\%\ Discounted\ cashflows = Adjusted\ Cashflows * (1 + DR\%)^{-(YearIndex+0.5)} \quad (3.14)$$

The respective discounted cashflows are summed up identically; the totals of these discounted cashflows are then compared. If the Total Discounted cashflows = DR% Discounted Cashflows then we can conclude that;

$$\boldsymbol{Effective\ Discount\ Rate} = Preliminary\ Discount\ Rate \quad (3.15)$$

Alternatively, we calculate the Macaulay Duration of the cashflows that was already calculated by the “Tool Uitkering” and make an estimation of the Effective Discount Rate considering the yield curve duration properties. This is a more robust method compared to the former method that is mainly dependent on the judgement of the analyst.

3.7 Conclusion

After the procedure of determining the discount rate has been finalized, the rate is communicated to the consultant-in-charge and consolidating actuary-in-charge for the professional review. Only after the ultimate sign-off from the consolidating actuary, the Discount Rate is then used for the valuation process.

4. SENSITIVITY ANALYSIS OF DISCOUNT RATES

Having determined an effective discount rate for the valuation, in this chapter we will now consider how the liabilities are sensitive to the changes in discount rate. Sensitivity analysis can be done in many ways and techniques. The basic principle is to change one or several assumptions and see the quantitative impact such change has on the final liabilities.

In financial reporting, for example, sensitivity analysis would generally be based on changes in assumptions regarding discounts, interest or exchange rates, prices, pension obligations, etc. However, if a profit estimate is more sensitive to changes in other economic assumptions, such as development or operating costs, the sensitivity analysis should be based on changes in those assumptions.

A sensitivity analysis is an easy and quick tool that provides useful information for decision-making. It helps to identify those critical assumptions that give rise to volatility of assets, liabilities and consequently financial results. By the means of sensitivity analysis, the attention of management and users of financial statements is brought to the most risky areas. If risks and uncertainties were not considered in financial statements, too much confidence might have been unduly placed on the financial results of an entity which could be misleading information of the entity's financial situation (Ahlgrim et al, 2003).

This analysis may vary from different pension plans with different valuation discount rate. Therefore in order to compare sensitivity information for these plans, the sensitivities must be adjusted to the same discount rate. Sensitivity results are either reported for going concern valuations or solvency valuations, the results are highly consistent between the two forms of valuation.

The sensitivity information is very important in accounting valuations, mostly sensitivity information in relation to assumptions that affect the determination of the obligations. Importantly if the sensitivity on the discount rate is valued as an aggregate with actives and inactives then it is advised to include the sensitivity to a change in the salary increase rate since the salary increase rate interacts directly with the discount rate (Chandler, 2017). However, if the sensitivity to a change in discount rate is valued separately for actives and inactives then there would be no need for the salary increase rate sensitivity as the inactives have no salary.

The sensitivity information can be expressed by performing sensitivity runs on the final liabilities either as a change relative to a 0.25%, 0.50% or 1.00% change in the discount rate, depending on the advice from the consolidating actuary, or it can be approximated by considering the durations of the pension plan liabilities. The small change helps the actuary gauge the change in liabilities caused by a change in the discount rates, and the actuary can then advise the client appropriately on the stability of the pension plan in relation to future change in Discount rate. All this analysis is important for going concern valuations that are prepared on the presumption that the pension plan will continue to operate indefinitely.

In the general view of the fact that liabilities increase with a decrease in the discount rate, the conclusion could be drawn that we could use sensitivity information to make a simple linear adjustment of liabilities. However, this would lead to an understatement of the liabilities because the sensitivity of liabilities payable at a range of dates in the future to a change in the discount rate depends on the Discount rate and the lower the Discount rate and wider the range of payment dates then the greater the sensitivity to a change in the rate. The relationship between the duration liabilities and discount rates is referred to as the Convexity.

Convexity is normally defined as the second derivative of the present value with respect to a change in discount rate and calculated as a second difference of present values. (Lioudis, 2018).

$$Convexity = \frac{1}{PV(i)} * \frac{d^2(PV(i))}{d(i)^2} = \frac{1}{PV*(1+i)^2} \sum_{t=1}^{T} \left[\frac{CF_t}{(1+i)^t} * (t^2 + t) \right] \quad (4.1)$$

Where: PV is the Present Value of liabilities.

- i is the interest rate of the plan.
- CF_t is the cashflow at time t.

Convexity measures the sensitivity of liabilities durations to changes in discount rates. Duration is an imperfect way of measuring the change in liability value as it indicates a linear change in the nature when in fact; liabilities changes exhibit a sloped or "convex" shape. Therefore, for plan liabilities with the same duration and discount rate, a high convexity will mean that the liabilities are more sensitive to change in discount rates compared to liabilities with low convexity.

From earlier research (Chandler, 2017), the convexity factor which could be assumed as the typical second derivative divided by the duration. In contrast, the ratio of convexity to duration varies widely for bonds, depending on the term to maturity.

4.1 Sensitivity Analysis on Sample plans

4.1.1 Inactives Pension Plans members

We will first analyse the discount rate sensitivity on pension plans made up of deferred participants and pensioners. We consider them separately because these plans have an identical and significant response to change in discount rate and interact differently with the selected valuation assumptions. Preliminarily, discount rate is inversely related to the duration that will be our main focus when doing the sensitivity analysis.

Discount Rate	**DR% PBO**	**Sensitivity Runs**	**Sensitivity PBO**	**Impact %**	**Duration (Years)**
2.38%	1,328,713.00	1.38% (-1%)	1,740,795.00	31.01%	26.90
		2.38% (+1%)	1,030,901.00	-22.41%	
1.40%	65,214.00	0.90% (-0.5%)	67,268.00	3.15%	7.86
		1.90% (+0.5%)	63,282.00	-2.96%	
2.30%	199,769.00	2.05% (-0.25%)	204,856.00	2.55%	10.20
		2.55% (+0.25%)	194,869.00	-2.45%	
1.80%	2,571,669.00	1.30% (-0.5%)	2,755,502.00	7.15%	13.80
		2.30% (+0.5%)	2,406,392.00	-6.43%	
1.60%	10,090,460.00	1.10% (-0.5%)	10,763,654.00	6.67%	13.44
		2.10% (+0.5%)	9,681,530.00	-4.05%	
1.90%	7,266,000.00	1.65% (-0.25%)	7,541,000.00	3.78%	15.03
		2.15% (+0.25%)	7,005,000.00	-3.59%	
1.90%	5,578,899.00	1.65% (-0.25%)	5,890,016.00	5.58%	21.89
		2.15% (+0.25%)	5,289,990.00	-5.18%	
2.25%	4,072,995.00	1.75% (-0.5%)	4,571,156.00	12.23%	23.19
		2.75% (+0.5%)	3,643,414.00	-10.55%	
2.00%	16,957,273.00	1.75% (-0.25%)	17,870,678.00	5.39%	21.22
		2.25% (+0.25%)	16,104,809.00	-5.03%	
2.00%	50,472,640.00	1.75% (-0.25%)	53,092,879.00	5.19%	20.42
		2.25% (+0.25%)	48,033,993.00	-4.83%	

Table 4.2: Sensitivity liabilities for plans with inactive participants (Deferreds and Pensioners).

From Table **4.2** above, we have the DR% used for calculating final liabilities (PBO) and sensitivity runs with change in Discount Rate and the percent impact on the liabilities due to the change as well as the duration associated to the final liabilities.

The final plan liabilities are calculated by incorporating the discount rate in the PBO formula along with the other defined assumptions for the plan liabilities calculations. When calculating the final liabilities, the data used, assumptions, plan provisions and valuation method have to be defined. The Projected Unit Method was used for this analysis and the Average Pay plan was used too.

$$Final\ PBO = \sum_{All\ Members} AL = \sum_{All\ members}(PVB_{VA}) \tag{4.2}$$

Where:

PVB_{VA} is the Present Value of Benefits of a participant aged x

For Deferreds: $PVB_{VA} = AccBenefit_{VA} * SurvivalProbability\ till\ NRA * \frac{a_{NRA}}{(1+i)^{NRA-VA}}$

For Pensioner: $PVB_{VA} = AccBenefit_{VA} * a_{NRA}$ (4.3)

AL is the accrued liability at valuation age; i is the discount rate; a_{NRA} is the annuity factor at retirement age; VA is the valuation age.

We then perform the sensitivity runs by holding all plan assumptions constant and adjusting the discount rates by 0.25%, 0.50% and 1.00% depending on the sensitivities suggested by consulting specialist. The duration runs are an additional values to help investigate the relationship how the duration can affect the discount rate sensitivity impact.

As discussed before, the plan liabilities increase with a decrease in the discount rate and decrease with a increase in the discount rate. The decrease in the discount rate has a greater positive impact on the plan liabilities than an increase in the discount rate which would indicate that the plan liabilities are more sensitive to a decrease in the discount rate than to an increase.

It can also be deduced that plans with liabilities that have a low duration are less sensitive to a change to the discount rates as their impact percentages are low when compared to the plans with higher durations. This results directly from the formula that approximates the value of the liabilities taken into consideration its approximation taking its first derative (durations). The higher the duration, the higher the impact of a change in liabilities.

In a further study (Chandler, 2017) to compare the average age of Inactives plan members and the Duration of their liabilities, it was discovered that the Inactive plan liabilities are less sensitive to changes in discount rates and the level of sensitivity reduces with the higher average age of plan participants.

Results tabulated take into account both indexed plans and non-indexed plans. The different variations seen in the liabilities can be explained by;

- The indexation of the inactives pension which can also be referred to as the pension increase or cost of living increase and the indexation will extend the duration of payments and it might or might not be guaranteed on settlement.
- The differential effect caused by use of different mortality tables for the different plan.

4.1.2 Active Pension Plans

Given the nature of pension funds liabilities, the duration of actives tends to decrease with the average age; meaning that pension plans with a higher average age of its participants typically have low durations although other assumptions are at play as well, this was also evidenced when comparing the durations of the pension funds in our study. Although in some situations, this was not the case being the main factor would be the accrual method being used or on the accrual factors used to calculate the accrued benefits.

The Projected Unit Method was used for this analysis and the Average Pay plan was used too.

$$Final\ PBO = \sum_{All\ Members} AL = \sum_{All\ members} (PVB_{VA} * \frac{VA-EA}{NRA-VA}) \tag{4.4}$$

Where: PVB_{VA} is the Present Value of Benefits of a participant aged x and EA is the Entry Age in to the pension plan

The discount rate sensitivity of the liabilities depends on;

- The number of year until the pension is in pay or becomes effective; this could be either the Normal Retirement Age or the early retirement age used to determine the termination benefits.
- The number of years the pension is expected to be paid after commencement, under the assumed form of pension and the rate of early retirement can also affect the sensitivity of active member liabilities
- Variations in annual payments due to form of pension being accrued like the partner pension, indexation offset, special disability pension or maximum salary limits.

4.1.3 Combined Actives and Inactives pension plans.

We shall consider a whole with active and inactive plan members. In the analysis we will investigate the DR sensitivity by increasing and decreasing the DR by 0.25%, 0.50% and 1% to show the range of changes in the liabilities due to these sensitivity runs.

From Table **4.3** below, we have the Discount Rate (DR%) used for calculating final liabilities (PBO) and sensitivity runs with change in Discount Rate and the percent impact on the liabilities due to the change as well as the duration associated to the final liabilities.

As stated before, the final plan liabilities are calculated by incorporating the discount rate in the PBO formula along with the other defined assumptions for the plan liabilities calculations. When calculating the final liabilities, the data used, assumptions, plan provisions and valuation method have to be defined.

We then perform the sensitivity runs by holding all plan assumptions constant and adjusting the discount rates by 0.25%, 0.50% and 1.00% depending on the sensitivities suggested by consulting specialist. The duration runs are an additional values to help investigate the relationship how the duration can affect the discount rate sensitivity impact.

Discount Rate	**DR% PBO**	**Sensitivity Runs**	**Sensitivity PBO**	**Impact %**	**Duration (Years)**
1.30%	8,836,282.00	0.30% (-1%)	10,292,599	16.48%	16.00
		2.30% (+1%)	7,673,527	-13.16%	
2.30%	17,546,677.00	1.80% (-0.5%)	19,847,133	13.11%	24.00
		2.80% (+0.5%)	15,570,619	-11.26%	
2.38%	29,814,966.00	1.38% (-1%)	39,410,607	32.18%	27.55
		3.38% (+1%)	22,988,101	-22.90%	
2.20%	38,796,800.00	1.95% (-0.25%)	41,072,603	5.87%	23.06
		2.45% (+0.25%)	36,621,256	-5.61%	
1.70%	16,653,499.00	0.70% (-1%)	22,379,803	34.38%	30.53
		2.70% (+1%)	12,275,270	-26.29%	
2.00%	3,152,477.00	1.75% (-0.25%)	3,379,210	7.19%	28.13
		2.25% (+0.25%)	2,943,805	-6.62%	
2.20%	3,457,134.00	1.70% (-0.5%)	3,873,005	12.03%	22.72
		2.70% (+0.5%)	3,099,981	-10.33%	
2.10%	5,392,427.00	1.85% (-0.25%)	5,782,851	7.24%	23.00
		2.35% (+0.25%)	5,270,750	-2.26%	
2.00%	12,509,629.00	1.75% (-0.25%)	13,317,103	6.45%	24.00
		2.25% (+0.25%)	11,820,472	-5.51%	
1.75%	334,594,584.00	1.50% (-0.25%)	357,539,455	6.86%	26.73
		2.00% (+0.25%)	313,511,411	-6.30%	

Table 4.3: Sensitivity liabilities for plans with all participants (Actives, Deferreds and Pensioners).

Firstly, as expected, the higher the percentage change in the DR%, the higher the impact % change compared to the other sensitivity runs with the exception of the plans with low liabilities where the impact% is not a perfect illustration of the change. Secondly, it’s noticed that a decrease in the DR% has a greater impact on the final liabilities than the increase in DR%, which indicates that plan liabilities are generally more sensitive to a decrease in DR% than an increase

We note that plan liabilities with high discount rates and high liability durations are more sensitive to changes in the discount rates, on further investigations it was found that these plans where made up of a majority number of actives. For active participants, the impact in the changes to the DR% will be greater, the longer the period of future service

4.1.4 Combined Plans Vs Inactives Plan

It was discovered that pensions in pay tend to be less sensitive to changes in Discount rates when compared with the active plan liabilities. This mainly due to duration of active plan is higher than that of pensions in pay; the range of the durations is bigger therefore more sensitive. But also because at a small proportion, these pensioners that belong to plans that have higher liabilities for pensioners are usually older.

In conclusion, although we were using the average age as the basis for Duration-Sensitivity analysis especially for the active plans, there are other factors to consider, especially the total years until the benefits commence or till the expected retirement, the other actuarial valuations being considered.

Discount rate sensitivity is also influenced by the types of benefit accrual used and other plan provisions that are identical to each pension plan but not as important as the expected number of years till the benefit is in pay.

4.2 Duration Vs Convexity

As earlier stated we can also estimate the change in the final liabilities by using the duration value transformed into a modified duration. In summary, Duration assumes linear relationship between plan liabilities and changes in discount rate. This implies that for a given change in discount rate in either direction, the impact of the change will also be similar.

4.2.1 Duration Analysis of Inactive pension plan members.

Discount Rate	DR% PBO	Change in DR%	Duration (Years)	Modified Duration	Impact %
2.38%	1,328,713.00	-/+ 1.00%	26.90	26.27	(-/+) 26.27%
1.40%	65,214.00	-/+ 0.50%	7.86	7.75	(-/+) 3.88%
2.30%	199,769.00	-/+ 0.25%	10.20	9.97	(-/+) 2.49%
1.80%	2,571,669.00	-/+ 0.25%	13.80	13.56	(-/+) 3.39%
1.60%	10,090,460.00	-/+ 0.50%	13.44	13.23	(-/+) 6.61%
1.90%	7,266,000.00	-/+ 0.25%	15.03	14.75	(-/+) 3.69%
1.90%	5,578,899.00	-/+ 0.25%	21.89	21.48	(-/+) 5.37%
2.25%	4,072,995.00	-/+ 0.50%	23.19	22.68	(-/+) 11.34%
2.00%	16,957,273.00	-/+ 0.25%	21.22	20.80	(-/+) 5.20%
2.00%	50,472,640.00	-/+ 0.25%	20.42	20.02	(-/+) 5.00%

Table 4.4: Sensitivity impact on liabilities using Durations for plan with inactive participants (Deferreds and Pensioners)

Considering **Table 4.4** above, we are investigating the difference in using the duration formula **(4.5)** below on liabilities of inactive plan members and the actual discount rate sensitivity runs in **Table 4.2** above. As expected, we have an increase in the plan liabilities with a decrease in discount rate but different from what we discovered in the earlier analysis is that the impact on liabilities is identical in opposite directions as the discount rate changes.

We realise that the impact change on liabilities determined by the durations is approximately close to the actual impact for small but adequate changes in the discount rate (-/+ 0.25%) but then deviates away from the actual value as the change in discount rate broaden (-/+ 1.00%).

Therefore using the Duration formula to determine the impact on the plan liabilities for inactives plan members would be more applicable for small but adequate changes in the Discount rates (-/+0.25% to -/+ 0.50%). This could be explained mainly by the linear characteristic of the Duration analysis.

4.2.2 Duration Analysis of Active pension plan members.

Discount Rate	**DR% PBO**	**Change in DR%**	**Duration (Years)**	**Modified Duration**	**Impact %**
1.30%	8,836,282.00	-/+ 1.00%	16.00	15.79	(-/+) 15.79%
2.30%	17,546,677.00	-/+ 0.50%	24.00	23.46	(-/+) 11.73%
2.38%	29,814,966.00	-/+ 1.00%	27.55	26.91	(-/+) 26.91%
2.20%	38,796,800.00	-/+ 0.25%	23.06	22.56	(-/+) 5.64%
1.70%	16,653,499.00	-/+ 1.00%	30.53	30.02	(-/+) 30.02%
2.00%	3,152,477.00	-/+ 0.25%	28.13	27.58	(-/+) 6.89%
2.20%	3,457,134.00	-/+ 0.50%	22.72	22.23	(-/+) 11.12%
2.10%	5,392,427.00	-/+ 1.00%	23.00	22.53	(-/+) 22.53%
2.00%	12,509,629.00	-/+ 0.25%	24.00	23.53	(-/+) 5.88%
1.75%	334,594,584.00	-/+ 0.25%	26.73	26.27	(-/+) 6.57%

Table 4.5: Sensitivity impact on liabilities using Durations for plans with all participants (Actives, Deferreds and Pensioners).

Considering **Table 4.5** above, we are investigating the difference in using the duration formula **(4.5)** below on liabilities of active plan members and the actual discount rate sensitivity runs in **Table 4.3** above. As expected, we have an increase in the plan liabilities with a decrease in discount rate but different from what we discovered in the earlier analysis is that the impact on liabilities is identical in opposite directions as the discount rate changes.

We recognise that the impact change on liabilities determined by the durations is approximately close to the actual impact for small but adequate changes in the discount rate (-/+ 0.25%) but then deviates away from the actual value as the change in discount rate broaden (-/+0.50% to -/+ 1.00%). Contrary to what we discovered with the liabilities of the inactives plan members, we know notice that the range of applicability of for the duration formula is smaller than before. This could explain the conclusion that liabilities of inactive plan members are less sensitive to changes in discount rates than liabilities of combined actives and inactive plan member and ultimately less sensitive to discount rate changes than liabilities of active plan members.

However the relationship between changes in liabilities and changes in discount rates is asymmetric in case of large or really small discount rate changes, in this case, the duration is unable to fully capture the discount rate sensitivity of liabilities hence its underestimates the actual value of liabilities for a given change in discount rate.

Duration particularly Modified Duration is related to the first derative of liabilities vs discount rate. The change in liabilities can be estimated by:

$$\Delta PBO \approx (-PBO) * MD * \Delta i_o \tag{4.5}$$

Where: ΔPBO is the change in PBO; PBO is the PBO; MD is the Modified duration and Δi_o is the very small change in discount rate.

In order to counteract this inefficiency of using the duration, we consider the Convexity, which measures the change in duration in response to the change in interest rate (second derative). The convexity captures the change in liabilities for moderately large discount rate increases or decreases. It essentially accounts for the convex curve portion of the graph plotted of discount rates and plan liabilities.

Therefore the convexity of liabilities will give an improved approximation of forecasted impact on pension fund liabilities by applying the formula;

$$\Delta PBO \approx PBO * (-MD * \Delta i_o + \frac{1}{2} * Conv * (\Delta i_o)^2 \tag{4.6}$$

Where; $Conv$ is the Convexity of plan liabilities.

4.3 Additional sensitivity runs on Pension plans assumptions

These are additional sensitivity runs carried out in the valuation process. The purpose of these runs is to estimate the percentage changes in other plan assumptions aside from the discount rates. This analysis help the consolidating actuary understand the future effect of these assumptions on the plan liabilities.

4.3.1 Salary Increase Rate

These sensitivity runs measure the change in the liabilities due to a change in the salary increase rate. This help check the effect on the benefit cost of the pension plan if the salary increase rate were to be changed in future. The salary increase rate interacts directly with the change in discount rate especially with active pension plans in such a way that an increase in salary increase rate will lead to an increase in liabilities and benefit cost and the reverse is true.

4.3.2 Inflation Rate

These sensitivity runs measure the change in liabilities due to a change in the inflation rate. The change in the inflation rate affects the pension liabilities in the same way as the salary increase rates since a margin of the salary increase can be derived from the inflation. The inflation rate is inversely related to the value of the plan liabilities.

4.3.3 Mortality Assumption

Due to the change in the life expectancy, the Dutch mortality tables are updated every 2 years depending on the income class or standard of living. It is therefore imperative we carry out sensitivity checks on the life expectancy of the plan participants. This is done by valuing the projected benefit obligation if the life expectancy is increased and decreased by 1 year. It also follows that an increase in the life expectancy by a year will lead to an increase in the plan liabilities and a decrease in the life expectancy will lead to a decrease in the life expectancy.

5. CONCLUSION

The main objective of this internship report was to discuss the methodology behind determining an effective discount rate to be used for the actuarial valuation of pension plans in the Netherlands. The main form of valuations discussed was the accounting valuations.

After the five-month long internship I decided to focus my research on Discount Rates as it was a fundamental aspect of all the valuations I was involved in and found it to be the benchmark of any valuation and that determining an appropriate discount rate is paramount for any liabilities' valuation. Furthermore, to have an idea for the discount rate for future valuations I thought it is important to analyse the sensitivity of the liabilities to changes in the discount rates.

Determining the discount rates using the MYC helps us exploit the similarity characteristics between final instruments like bonds and pension plan liabilities. Since bonds are more widely documented and with characteristics easier to estimate, we are able to construct a yield curve with spot rates of bonds with the same likeness as the pension liabilities. This proved to be an adequate methodology to determine the discount rates although the inclusion of A-rated bonds to extend the curve for liabilities with higher maturities is still being contested.

With the sensitivity analysis, we were able to confirm that inverse effect that discount rates have on pension plan liabilities and also confirm that the plan liabilities with higher durations will be more sensitive to changes in discount rate than those with lower durations. Although the duration sensitivity analysis assumes a linear connection between the liabilities and discount rates, this doesn't fully exhaust the impact. Further study should be done how to compare to carry out the sensitivity analysis with an additional component of the Convexity.

To conclude this all, in my opinion, the methodology used to determine the discount rate is still one of the most contested topics in the Dutch valuations. There is a lot more that can be done to streamline the process so that it is acceptable to stakeholders involved to a uniform discount rate.

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APPENDIX A

A.1. Estimating Future Cashflows.

As earlier discussed in Chapter 3, to accurately use the Mercer Yield curve to determine the discount rate, we need to input estimated future cashflow for the Fiscal year end in question. In order to estimate these cashflows, we need to apply the "Tool Uitkeringstromen" (Mercer, 2018b)

	Vóór toepassing van de "Opblaasfactoren"				
t	Aktieven	Slapers	Ingeganen	Inkoop jr	Inkoop jr+1
Opblaasfactor :	1.00007	1.00007	1.00007	1.00009	1.00009
Verh. Factor :					1.02100
2016	586	258	116,738	46	
2017	1,183	29,959	109,401	92	47
2018	1,804	34,779	108,860	137	94
2019	2,452	43,748	107,304	183	140
2020	3,131	48,257	106,647	230	187
2021	3,848	49,703	105,916	279	235
2022	4,601	59,157	105,100	329	285
2023	44,593	50,939	97,355	392	336
2024	45,811	52,546	96,481	448	400
2025	52,629	55,149	95,492	2,050	457
2026	53,159	54,988	94,372	2,096	2,093
2027	53,713	54,819	93,096	2,145	2,140
2028	63,193	67,261	91,644	2,205	2,190
2029	71,920	64,290	89,992	2,261	2,252
2030	76,604	69,415	88,111	4,161	2,309
2031	91,616	69,044	85,969	4,896	4,248
2032	92,272	56,270	83,533	4,938	4,998
2033	170,387	63,338	80,764	6,434	5,041
2034	194,472	84,524	77,635	6,474	6,569
2035	203,106	92,778	74,115	8,438	6,610
2036	207,868	93,133	70,183	9,689	8,616
2037	220,651	86,238	65,845	9,709	9,893
2038	225,644	86,169	61,113	9,726	9,913
2039	248,716	80,953	56,018	11,762	9,930
2040	260,293	80,301	50,629	13,517	12,009
2041	283,916	79,171	45,040	14,834	13,801
2042	303,343	77,657	39,356	16,491	15,146
2043	312,075	75,764	33,714	19,126	16,837
2044	324,717	73,650	28,257	22,035	19,528
2045	322,714	71,303	23,120	22,169	22,498
2046	328,187	68,735	18,425	22,684	22,635
2047	325,075	65,967	14,271	22,526	23,160
2048	331,410	63,025	10,719	24,035	22,999
2049	327,238	59,950	7,789	23,820	24,540
2050	328,711	56,793	5,464	25,525	24,320
2051	323,244	53,616	3,695	25,236	26,061
2052	317,134	50,477	2,404	24,910	25,766
2053	310,358	47,427	1,503	24,545	25,433
2054	302,894	44,517	904	24,137	25,060
2055	294,751	41,779	522	23,686	24,644
2056	285,943	39,232	290	23,190	24,184
2057	276,478	36,874	154	22,648	23,677
2058	266,376	34,679	79	22,060	23,124
2059	255,667	32,610	39	21,427	22,524
2060	244,361	30,621	19	20,748	21,877
2061	232,457	28,659	9	20,023	21,183
2062	219,987	26,670	4	19,254	20,444
2063	206,984	24,612	2	18,441	19,659
2064	193,473	22,460	1	17,583	18,828
2065	179,528	20,206	0	16,680	17,952

	Ná toepassing van de "Opblaasfactoren" en inkoop			
t	Aktieven	Slapers	Ingeganen	Inkoop jr
Jaren : 2.25				
2018.25	2,235	37,024	108,478	49
2019.25	2,995	44,879	107,147	96
2020.25	3,791	48,622	106,471	144
2021.25	4,627	52,070	105,719	192
2022.25	15,306	57,106	103,171	241
2023.25	45,735	51,344	97,143	293
2024.25	48,872	53,201	96,240	345
2025.25	55,799	55,112	95,219	411
2026.25	57,736	54,949	94,059	469
2027.25	60,937	57,934	92,739	2,148
2028.25	70,354	66,522	91,237	2,197
2029.25	78,662	65,576	89,528	2,248
2030.25	88,080	69,327	87,581	2,311
2031.25	101,842	65,855	85,366	2,370
2032.25	123,262	58,041	82,846	4,361
2033.25	189,567	68,639	79,987	5,131
2034.25	211,573	86,593	76,760	5,175
2035.25	221,854	92,873	73,137	6,743
2036.25	231,524	91,416	69,103	6,785
2037.25	243,808	86,226	64,666	8,844
2038.25	254,108	84,871	59,844	10,154
2039.25	276,812	80,795	54,675	10,175
2040.25	295,190	80,024	49,235	10,193
2041.25	321,360	78,798	43,622	12,327
2042.25	341,877	77,189	37,948	14,166
2043.25	356,599	75,241	32,352	15,546
2044.25	371,051	73,068	26,975	17,283
2045.25	374,113	70,666	21,947	20,045
2046.25	378,598	68,048	17,387	23,093
2047.25	378,520	65,236	13,384	23,233
2048.25	383,661	62,260	9,987	23,773
2049.25	382,333	59,164	7,208	23,608
2050.25	383,829	56,002	5,022	25,189
2051.25	379,203	52,835	3,373	24,963
2052.25	372,601	49,718	2,179	26,750
2053.25	364,856	46,703	1,354	26,447
2054.25	356,332	43,836	808	26,106
2055.25	347,035	41,145	464	25,723
2056.25	336,973	38,645	256	25,296
2057.25	326,156	36,328	136	24,823
2058.25	314,605	34,164	69	24,303
2059.25	302,345	32,115	34	23,735
2060.25	289,384	30,133	16	23,119
2061.25	275,729	28,164	7	22,455
2062.25	261,413	26,157	3	21,744
2063.25	246,469	24,075	1	20,985
2064.25	230,934	21,898	1	20,178
2065.25	214,895	19,623	0	19,326
2066.25	198,487	17,271	0	18,427
2067.25	181,877	14,889	0	17,480

Figure 6.3: Extract from the "Tool Uitkeringstromen". Source: Mercer calculations

The values highlighted in the figure above are the cashflow from the last full valuation pertaining to Actives (Actieven), Deferred (Slapers) and Pensioners (Ingeganen).

The liability factor is represented by the "Opblaasfactor" and the "Inkoop Jr" represents the normal cost. For this illustration, the last full valuation was 2.25 years back and the values to the far right are the values roll forward for 2.25 years.

	RTS1	RTS2
Soort	Vast	Vast
Rente	2.10%	2.10%
Forward duur rente	0	0
Inflatiefactor	0.0%	0.0%
Forward duur inflatie	0	0
Rentecurve	Nominaal	Nominaal
Uitkeringen	Reëel	Reëel
Aktieven		
- Mac. duration		
- Mod. duration		
- Interne rente		
- TV (DBO)	6,475,463	6,475,463
Slapers		
- Mac. duration		
- Mod. duration		
- Interne rente		
- TV (DBO)	1,812,438	1,812,438
Ingeganen		
- Mac. duration		
- Mod. duration		
- Interne rente		
- TV (DBO)	1,736,555	1,736,555
Totaal		
- Mac. duration	24.78	24.78
- Mod. duration	24.27	24.27
- Interne rente	2.10%	2.10%
- TV (DBO)	10,024,455	10,024,455
- Vermogen	0	0
- Dekkingsgraad	0.0%	0.0%
Inkoop 1 jaar		
- Mac. duration	35.30	35.30
- Mod. duration	34.57	34.57
- Interne rente	2.10%	2.10%
- Premie (Service Cost)	378,117	378,117
Verhouding		
- TV (DBO) actieven	100.00%	
- TV (DBO) slapers	100.00%	
- TV (DBO) ingeganen	100.00%	
- TV (DBO) totaal	**100.00%**	
- Premie (Service Cost)	100.00%	

Jaar	Uitkeringen1	Rentecurve1	Rentecurve2
		x1	
1	147,737	2.100%	2.100%
2	155,021	2.100%	2.100%
3	158,884	2.100%	2.100%
4	162,416	2.100%	2.100%
5	175,583	2.100%	2.100%
6	194,222	2.100%	2.100%
7	198,313	2.100%	2.100%
8	206,130	2.100%	2.100%
9	206,744	2.100%	2.100%
10	211,610	2.100%	2.100%
11	228,113	2.100%	2.100%
12	233,765	2.100%	2.100%
13	244,988	2.100%	2.100%
14	253,063	2.100%	2.100%
15	264,149	2.100%	2.100%
16	338,194	2.100%	2.100%
17	374,927	2.100%	2.100%
18	387,863	2.100%	2.100%
19	392,043	2.100%	2.100%
20	394,701	2.100%	2.100%
21	398,822	2.100%	2.100%
22	412,281	2.100%	2.100%
23	424,448	2.100%	2.100%
24	443,780	2.100%	2.100%
25	457,014	2.100%	2.100%
26	464,191	2.100%	2.100%
27	471,094	2.100%	2.100%
28	466,726	2.100%	2.100%
29	464,033	2.100%	2.100%
30	457,139	2.100%	2.100%
31	455,909	2.100%	2.100%
32	448,705	2.100%	2.100%
33	444,854	2.100%	2.100%
34	435,411	2.100%	2.100%
35	424,497	2.100%	2.100%
36	412,913	2.100%	2.100%
37	400,976	2.100%	2.100%
38	388,644	2.100%	2.100%
39	375,874	2.100%	2.100%
40	362,620	2.100%	2.100%
41	348,839	2.100%	2.100%
42	334,494	2.100%	2.100%
43	319,533	2.100%	2.100%
44	303,900	2.100%	2.100%
45	287,574	2.100%	2.100%
46	270,546	2.100%	2.100%
47	252,833	2.100%	2.100%
48	234,518	2.100%	2.100%

Figure 6.4: Figure of the final Roll forward cashflows.

Source; Mercer calculations (Mercer, 2018b)

The discount rate used for last year valuation was 2.10%. And the values highlighted on the right will be the Roll forward final cashflows.

A.2 Determining the Discount Rate.

Continuing with the discussion from Chapter 3, we will now consider how the Mercer Yield curve operates by considering the formulas (3.12) to (3.15).

Once the cashflows have been adjusted to match the valuation year, they are inserted in the tab "Custom Cash Flow and Spot Rates" in the Eurozone Cashflow Discounter (Mercer, 2018a), and then the macros are run by using the button indicated as "Calculate Discount Rate". This tool uses the yield curve determine by Mercer using high quality AA-rated bonds

Eurozone Cash Flow Discounter (including Mercer Yield Curve)
(Currency = Euro)

Calculate Discount Rate

Inputs

Plan Name	XYZ
Measurement Date	28/02/2018
Valuation Date *	28/02/2018
* Must be on or before Measurement Date	
Scheme profile **	User Defined
** See How to choose the appropriate Scheme Profile on the User Notes worksheet	
Spot rates	Corporate bond curve extended to 50 years

Results

Spot rates for:	Corporate bond curve extended to 50 years
Present Value of Discounted Cash Flows	9,416,235
Equivalent single discount / inflation rate	2.36%
Macaulay duration of Cash Flows	24.3
Modified duration of Cash Flows	23.8

You can input custom cashflows and/or custom spot rates in the 'Custom Cash Flows and Spot Rates' tab

		Cash Flow Adjustments				Calculations		
idx	Valuation Year	PBO/APBO Cash Flow	Cash Flows Adjusted to Measurement Year	Weighted Cash Flows	Years from measurement year	Spot rates - Corporate bond curve extended to 50 years	Mercer Discounted Cash Flows	Single Rate Discounted Cash Flows
0	28/02/2018	147,737	147,737	73,869	0.5	-0.1684%	147,862	146,024
1	28/02/2019	155,021	155,021	232,531	1.5	-0.1321%	155,329	149,690
2	28/02/2020	158,884	158,884	397,210	2.5	0.0447%	158,707	149,882
3	28/02/2021	162,416	162,416	568,455	3.5	0.2571%	160,963	149,681
4	28/02/2022	175,583	175,583	790,124	4.5	0.4670%	171,940	158,084
5	28/02/2023	194,222	194,222	1,068,223	5.5	0.6643%	187,277	170,834
6	28/02/2024	198,313	198,313	1,289,033	6.5	0.8468%	187,736	170,409
7	28/02/2025	206,130	206,130	1,545,971	7.5	1.0149%	191,096	173,042
8	28/02/2026	206,744	206,744	1,757,324	8.5	1.1695%	187,289	169,555
9	28/02/2027	211,610	211,610	2,010,294	9.5	1.3120%	186,965	169,544
10	28/02/2028	228,113	228,113	2,395,188	10.5	1.4434%	196,246	178,552
11	28/02/2029	233,765	233,765	2,688,299	11.5	1.5649%	195,537	178,757
12	28/02/2030	244,988	244,988	3,062,349	12.5	1.6773%	198,995	183,019
13	28/02/2031	253,063	253,063	3,416,346	13.5	1.7816%	199,384	184,691
14	28/02/2032	264,149	264,149	3,830,162	14.5	1.8785%	201,676	188,337
15	28/02/2033	338,194	338,194	5,242,000	15.5	1.9685%	250,003	235,570
16	28/02/2034	374,927	374,927	6,186,292	16.5	2.0521%	268,152	255,134
17	28/02/2035	387,863	387,863	6,787,607	17.5	2.1300%	268,222	257,851
18	28/02/2036	392,043	392,043	7,252,790	18.5	2.2025%	261,998	254,620
19	28/02/2037	394,701	394,701	7,696,664	19.5	2.2699%	254,794	250,435
20	28/02/2038	398,822	398,822	8,175,858	20.5	2.3325%	248,599	247,215

User Notes | Calculation | Custom Cash Flow and Spot Rates | Discount Curves chart | Cash Flows | Cash Flows chart | Discount Curves

Figure 6.5: Extract from the Eurozone Mercer Yield curve (Mercer, 2018a).

The effective discount rate calculated will be **2.36%**

A.3 Discount Rate Sensitivity Analysis.

It is important to perform sensitivity analysis on the effective discount rate determined. This is performed by increasing and decreasing the DR by 0.25%, 0.50% and 1% to show the range of changes in the liabilities due to these sensitivity runs.

Check update Benefit Obligation

Sensitivities	2.30%	2.55%	2.05%		
	DR_B	DR_{S1}	DR_{S2}	Duration B vs S1	Duration B vs S2
PBO Actives	6,281,223	5,842,211	6,760,148	29.68	30.03
PBO Deferreds	1,581,661	1,507,629	1,661,038	19.64	20.01
PBO In Payment	1,663,431	1,620,443	1,708,231	10.73	10.86
PBO	**9,526,315**	**8,970,284**	**10,129,417**	**24.64**	**25.09**
NC_Split rate	353,384	325,922	383,561	33.14	33.49

DR update	2.50%
PBO Actives	5,927,404
PBO Deferreds	1,522,139
PBO In Payment	1,628,943
PBO	9,078,485
NC_Split rate	331,233

Figure 6.6: Discount Rate Sensitivity on PBO template.

Source: Mercer calculations

In the figure above, we perform discount rate sensitivity runs of (+ / -) 0.25% on the effective rate of 2.30% to see the impact change on the PBO and the duration in the example is calculated by:

$$Duration\ B\ vs\ S(t) = In\left(\frac{PBO\ at\ DR_s}{PBO\ at\ DR_{S(t)}}\right)/In\left(\frac{1+DR_{S(t)}}{1+DR_s}\right) \quad \text{(A.3.1)}$$

Where:

- $PBO\ at\ DR_s$ is the final liability value (PBO) at the effective rate.
- $PBO\ at\ DR_{S(t)}$ is the liability value (PBO) at different discount rate sensitivity runs.
- DR_s is the effective discount rate.
- $DR_{S(t)}$ is the discount rate change for the sensitivity runs.

This figure is extracted from a sheet used to check/calculate the benefit obligation per status for an updated discount rate. The results are calculated using the base scenario and one of the sensitivities. To check/calculate the updated benefit obligations input the update of the discount rate in the yellow field.