Optimising choices with respect to the risk adjustment in IFRS 17

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Abstract

On 18 May 2017, IFRS 17 was released. This is a new accounting standard for insurance contracts. The goal of this standard is making insurance contracts globally more comparable. IFRS 17 is principles-based, which means insurers have to develop many interpretations that will impact the information shared with financial stakeholders about the financial performance of the company. An important element of IFRS 17 is the risk adjustment for non-financial risk (RA). The RA represents a compensation for the uncertainty in non-financial risks. Calculating the RA involves several choices an insurer needs to make, some of which need to be disclosed. The goal of this research is to study suitable and explainable choices a typical Dutch insurance group can make in order to calculate the RA. In order to do this a model was developed that can calculate the RA for term life insurance, immediate annuity, insured pension and disability insurance, taking into account mortality, longevity, lapse and disability risk. This model determines the RA using the VaR, CTE and CoC technique and various confidence levels. This model was used to find suitable and explainable choices for the estimation technique, confidence level, capital rate and diversification method. Furthermore, in case of a lack of data for deriving distributions and standard deviations for the risks and cash-flows and correlations between the risks, one also needs to make choices on these elements. This is discussed as well. With the discussion on these choices, this thesis helps insurers to implement IFRS 17.

Keywords: IFRS 17, Risk adjustment for non-financial risk, Principles-based, Insurer.
Executive summary

On 18 May 2017, IFRS 17 was released. This is a new accounting standard for insurance contracts. IFRS 17 will be mandatory, effective from 1 January 2021 (or later) for all entities reporting on IFRS that have insurance contracts in their portfolio. Reporting on IFRS is mandatory for all stock market listed insurance companies. For other companies it is not mandatory, but it is a way to show others that ones company has a sound performance. IFRS 17 was introduced with the overall goal of providing a more useful and consistent accounting model for insurance contracts globally, so these can be more easily compared between firms and across countries.

IFRS 17 is more principles-based compared to prior accounting standards. Due to these principles, insurers are required to develop many interpretations that will impact the information prepared for, and then shared with, financial stakeholders about the financial performance of insurance contracts and the company’s financial position. Insurers reporting on IFRS are required to justify some of their choices made in disclosures in an auditable fashion. This is useful information for financial stakeholders that allows them to better compare insurers based on reliable information.

An explicit and important element defined in IFRS 17 for which disclosure is mandatory, is the risk adjustment for non-financial risk (RA). The RA represents the required compensation by the insurance company for the uncertainty in non-financial risks in the expected insurance contract cash-flows. Calculating the RA involves several choices an insurer needs to make, which have both financial and operational impacts.

The goal of this research is to study suitable and explainable choices a typical Dutch insurance group can make for addressing the estimation technique, the level of confidence, the method for measuring risk diversification and any other potentially unknown input variables for the calculation of the RA, in order to deduce the optimal choices for determining the RA.

In order to reach this goal nine research questions have been formulated. 1) Why is the RA an important measure? 2) What are the criteria for optimal choices with respect to the RA? 3) What is a relevant Dutch insurance group and insurance contracts to research? 4) What non-financial risks are typically relevant for Dutch insurance groups? 5) What are suitable probability distributions for these non-financial risks? 6) What are suitable estimation techniques for the RA? 7) What are suitable dependency structures between the relevant risks? 8) What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA? 9) What are the various perspectives on the benefits of IFRS 17?

We looked into IFRS 17 and solvency II, a standard for capital requirements that has a component that resembles the RA, for which there is experience from practice on how it is perceived. It is found that the RA is an important measure because it impacts the financial performance of the insurance company and can be used for steering some of the financial performance. Furthermore others e.g. financial stakeholders will use disclosures about (components of) the RA to compare insurance companies on their financial performance.

By looking into IFRS 17 and several Dutch insurers, five criteria for optimal choices with respect to the RA were formulated. The RA should be technically sound, consistent, explainable, calculated for non-financial risks and diversified. Furthermore it is preferable if the computation for the RA is also operationally possible and allows for steering of the financial performance of the company.

Looking into several Dutch insurance groups, a relevant insurance group to research was found. Relevant insurance products that this group should offer are term life insurance, immediate annuity, insured pension and disability insurance.

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1The RA is less significant for short term contracts and contracts where claims are dealt with fairly quickly such as property insurance and health insurance, so these are not considered in this research.
Looking into Solvency II and several Dutch insurance groups it is found that non-financial risks that are typically relevant for these insurance products are mortality risk, longevity risk, lapse risk and disability risk\(^2\). Term life insurance is affected by mortality and lapse risk, immediate annuity is affected by longevity risk, insured pension is affected by longevity and lapse risk and disability insurance is affected by disability risk.

Via literary research it is found that suitable probability distributions for all found risks are the normal and log-normal distribution. Furthermore suitable estimation techniques for the RA are the VaR, CTE and CoC technique. Moreover suitable dependency structures between the relevant risks are correlations.

In order to find the suitable and explainable choices a Dutch insurance group can make in relation to determining the RA, a model was made that can compute the RA for all found insurance products, for all found risks and with all found methods for computing the RA as well as different confidence levels. For building this model, the found distributions for the risks were used. With this model the optimal choices for determining the RA were computed. It is discussed how to make choices on the estimation technique, confidence level, capital rate and diversification method. Furthermore, in case of a lack of data for deriving distributions and standard deviations for the risks and cash-flows and correlations between the risks, one also needs to make choices on how to determine these. This is discussed as well, together with the effect of changes in the interest rate.

Finally, we looked into the various perspectives on the benefits of IFRS 17. Four IFRS 17 stakeholders were interviewed. From the interviews it can be concluded that in general all interviewee agree on the utility, goal and influence of IFRS 17 as well as what influence it has on the various parts of society. They all agree that IFRS 17 had to be written, a complete and functional standard for insurance contracts needs to exist. Writing IFRS 17 was a lot of work and so is implementing it. This is mostly a disadvantage for insurers and an advantage for advisors and investors. For clients the impact is not yet clear. For the Netherlands as a country IFRS 17 has both positive and negative effects. It is positive that insurance contracts become more comparable. However, insurance companies cannot invest the money that is needed to implement IFRS 17 into other projects.

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\(^2\)Lapse risk is not taken into account because of a lack of data and the fact that it would distort other results.
Preface

This thesis was written for the SMI department of the Radboud University. Being a mathematics student I chose a topic that combines mathematics with the social components of the SMI. When I started my internship at EY, I knew next to nothing about insurance companies let alone IFRS 17 or the RA. During this internship I have learned a lot, both about actuaries and about business in general. Therefore I would like to thank the people who made this possible.

First of all I want to thank my supervisors at EY, Maarten and David for all the work they have put into helping me complete this project, for answering all my questions and for believing I could do this despite my lack of foreknowledge.

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I hope you enjoy reading,
Lieke-Rosa Koetsier
# Contents

**Executive summary**  
2

**Preface**  
4

1 **Introduction**  
7  
1.1 Topic and problem  
7  
1.2 Research goal  
8  
1.3 Research questions  
8  
1.4 Host organisation  
8  
1.5 Impact of this research  
8

2 **Theoretical framework**  
10  
2.1 International Financial Reporting Standards (IFRS)  
10  
2.2 IFRS 17 Insurance Contracts  
11  
2.3 The risk adjustment  
13  
2.4 Non-financial risks  
15  
2.5 Summary of theoretical framework  
15

3 **Methodology**  
17  
3.1 Why is the RA an important measure?  
17  
3.2 What are the criteria for optimal choices with respect to the RA?  
17  
3.3 What is a relevant Dutch insurance group and insurance contracts to research?  
17  
3.4 What non-financial risks are typically relevant for Dutch insurance groups?  
17  
3.5 What are suitable probability distributions for these non-financial risks?  
18  
3.6 What are suitable estimation techniques for the RA?  
18  
3.7 What are suitable dependency structures between the relevant risks?  
18  
3.8 What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA?  
18  
3.9 What are the various perspectives on the benefits of IFRS 17?  
18

4 **Analysis**  
20  
4.1 Why is the RA an important measure?  
20  
4.2 What are the criteria for optimal choices with respect to the RA?  
21  
4.3 What is a relevant Dutch insurance group and insurance contracts to research?  
22  
4.4 What non-financial risks are typically relevant for Dutch insurance groups?  
28  
4.5 What are suitable probability distributions for these non-financial risks?  
31  
4.6 What are suitable estimation techniques for the RA?  
32  
4.7 What are suitable dependency structures between the relevant risks?  
39  
4.8 What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA?  
42  
4.9 What are the various perspectives on the benefits of IFRS 17?  
66

5 **Conclusions and recommendations**  
70  
5.1 Conclusions  
70  
5.2 Recommendations  
74

6 **Discussion**  
75  
6.1 Reflection  
75  
6.2 Limitations of this study  
75  
6.3 Suggestions for further research  
76
## References

## Appendix A Model results
- A.1 Lapse 80
- A.2 Base case model 82
- A.3 The duration of the contract 86
- A.4 Derived confidence level 89
- A.5 Sensitivity testing 90

## Bijlage B Interviews (in Dutch)
- B.1 Interview met een EY accounting specialist 96
- B.2 Interview met een oud werknemer van de IASB 98
- B.3 Interview met een werknemer van een verzekeraar 100
- B.4 Interview met een EY tax specialist 103
1 Introduction

1.1 Topic and problem

On 18 May 2017, IFRS 17 was released. This is a new accounting standard for insurance contracts. This standard will replace IFRS 4, which was issued in 2005. IFRS 17 will be mandatory, effective from 1 January 2021 (or later) for all entities reporting on IFRS that have insurance contracts in their portfolio [1, 2]. Reporting on IFRS is mandatory for all stock market listed insurance companies. For other companies it is not mandatory, but it is a way to show others that one company has a sound performance.

IFRS 17 is more principles-based compared to prior accounting standards, which are usually more rule-based. This means that in IFRS 17 there are less strict rules about how to implement the standard. The insurer first has to interpret the standard and then disclose how they have interpreted it. Due to these principles, insurers are required to develop many interpretations that will impact the information prepared for, and then shared with, financial stakeholders about the financial performance of insurance contracts and the company’s financial position. Insurers reporting on IFRS are required to justify some of their choices in disclosures in an auditable fashion [3]. This is useful information for financial stakeholders that allows them to better compare insurers based on reliable information.

An explicit and important element defined in IFRS 17 for which disclosure is mandatory, is the risk adjustment for non-financial risk (from now on RA). This represents the required compensation by the insurance company for the uncertainty in non-financial risks in the expected insurance contract cash-flows [3], see section 2.3 for a more in depth explanation of what the RA is and section 2.4 for the definition of non-financial risk. The RA is an explicit part of the insurance contract liability. The RA will release into the profit and loss by the release of risk over time. This means that the capital that is stored in the RA will be relocated to the profit and loss over time. The determination and use of the RA, as well as the disclosure of the method to determine the RA, is a new element to insurance accounting and one of the more technical topics of IFRS 17. Calculating the RA involves several choices an insurer needs to make, which have both financial and operational impacts.

Choices need to be made about the estimation technique for calculating the RA, about what confidence levels should be applied and about what method for capturing diversification benefits should be used. Furthermore, there are several more input variables for the calculation of the RA that could be unknown such as distributions and standard deviations for the non-financial risks and correlations between the risks. Moreover, these choices should be workable for the insurer, lead to reliable results, and the results from these implemented choices should be explainable to, and understandable for, users of financial information, for both internal and external reporting purposes (for a more in depth description of these choices see section 2.3). Furthermore, the determination of the RA must be compliant with the IFRS 17 technical requirements and disclosure requirements, and suit relevant business criteria such that it provides concise and informative disclosures to users of financial information.

3Such as shareholders and investors.
4The RA is less significant for short term contracts and contracts where claims are dealt with fairly quickly (within one year) such as property insurance and health insurance, so these do not fall within scope of this research. This will be explained in more detail in section 4.3.
1.2 Research goal

The goal of this research is to study suitable and explainable choices a typical Dutch insurance group can make for addressing the estimation technique, the level of confidence, the method for measuring risk diversification and any other potentially unknown input variables\(^5\) for the calculation of the RA, in order to deduce the optimal choices for determining the RA.

1.3 Research questions

In order to reach this goal, the following research questions have been formulated, which need to be answered.

1. Why is the RA an important measure?
2. What are the criteria for optimal choices with respect to the RA?
3. What is a relevant Dutch insurance group and insurance contracts to research?
4. What non-financial risks are typically relevant for Dutch insurance groups?
5. What are suitable probability distributions for these non-financial risks?
6. What are suitable estimation techniques for the RA?
7. What are suitable dependency structures between the relevant risks?
8. What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA?
9. What are the various perspectives on the benefits of IFRS 17?

1.4 Host organisation

EY is a global leading company in assurance, tax, transactions and advisory. This thesis was written at the Actuarial Services department that is situated in Amsterdam [4]. Actuarial Services offers services for insurance, pension and other financial services. They provide support in various areas of risk management and capital optimisation such as asset management, capital and risk, financial accounting, reserving and auditing. They work with other advisory colleagues in providing advice on product development, pricing, development of analytics and model development [5].

1.5 Impact of this research

By answering the research questions, EY will enrich their knowledge of the RA which allows to improve their service to clients in implementing IFRS 17, and allows for more efficient audits on this standard. Furthermore it allows for better comparisons of concepts from other frameworks that are similar to the RA.

In order to determine the RA an insurer has to make many choices. This research will help them with this. It will help them in answering questions like

- what combinations of choices result in a RA that is compliant with IFRS 17;

\(^5\)These will be the capital rate, the distributions for the risks, the standard deviations for the risks, the correlations between risks, the distribution of the cash-flows and the standard deviation of the cash-flows. All will be explained in more detail in chapter 4.
• what combination of choices fits our company the best;
• what choices have a more severe impact on the RA.
2 Theoretical framework

2.1 International Financial Reporting Standards (IFRS)

The International Accounting Standards (IAS) were designed to harmonise accounting principles across the European Union. Between 1973 and 2001 the IAS were issued by the Board of the International Accounting Standards Committee (IASC). Soon after this, the value of harmonisation was recognised around the world since it leads to better comparability. On 1 April 2001, the new International Accounting Standards Board (IASB) took over from the IASC and the IAS were renamed to International Financial Reporting Standards (IFRS) [6].

On 18 May 2017, the IASB released IFRS 17 Insurance contracts6. This standard will replace IFRS 4, which was issued in 2005. IFRS 4 provides guidance for the accounting of insurance contracts, but it was not complete and meant to be replaced by an improved standard in the future [7]. IFRS 17, the new standard for insurance contracts, is exactly this. It will be mandatory, effective from 1 January 2021 (or later) for all insurance companies reporting on IFRS that have insurance contracts in their portfolio [1, 2]. For the transition to this new standard, insurance companies already have to report IFRS 17-based results based on their insurance contracts by the effective date of 1 January 2020.

There are several reasons for the introduction of IFRS 17. There is enormous divergence in current accounting for insurance contracts across the world. There are many different national standards that are often very outdated and of poor quality. For example, many insurers use historical interest rates, which means that the true value and performance of the insurance contracts is grossly understated7, and the old standards allowed this. Also, currently the premiums received are often considered revenue even if a part of that premium will always be paid back. This would be similar to a bank’s saving deposit being recognised as revenue by the bank, which is not providing useful information and actually does not provide a faithful representation of the performance of the bank. As a result, the IFRS results from insurance contracts were not comparable between insurance contracts in an insurance company, nor between countries or between industries. This potentially provides a so called “insurance blackbox discount” on the market value of insurance companies. Via globally consistent principles, IFRS 17 aims to provide more useful and transparent information about the profitability of insurance contracts towards the users of IFRS (such as investors, rating agencies and internal management). Nonetheless, IFRS 17 requires many interpretations of principles and requires extensive disclosures.

IFRS 17 is expected to affect 450+ companies globally, with total assets in the order of 13 trillion USD [9]. It is clear that IFRS 17 will have a great impact on the accounting for the financial performance in the insurance industry, and their required preparations to comply with the standards. The sector has a societal role to play, and value to add, by accepting to transfer and efficiently pool risks and providing services to many policyholders. Time will tell what the consequences of the accounting changes are for the industry sector and all their financial stakeholders.

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6 This standard has nothing to do with stopping a new financial crisis, this is addressed in IFRS 9 Financial instruments.
7 Calculating future cash-flows with, for instance, an interest rate of 4% is not realistic and thus gives misleading information.
2.2 IFRS 17 Insurance Contracts

IFRS 17 was introduced with the overall goal of providing a more useful and consistent accounting model for insurance contracts globally, so these can be more easily compared between firms and across countries. IFRS 17 is a fundamental accounting change for the insurance sector that will change insurers and the way their financial stakeholders, such as investors and rating agencies, look at them, because it will provide more clarity in the financial performance of insurance companies [9]. It impacts insurers, their financial performance, their strategies, their planning, potentially their product offerings, expected dividends and share prices and tax payments [2]. How it will exactly impact them will become clear in the future.

Compared to prior accounting standards, IFRS 17 is more principles-based. Due to these principles, insurers are required to develop interpretations. This provides some freedom in how to implement the standard. The interpretations that are developed will impact the information prepared for, and then shared with, financial stakeholders about the financial performance of insurance contracts and the entity’s financial position. Insurers reporting on IFRS are required to justify some of their choices in disclosures in an auditable fashion [3]. Note that for IFRS 17 there is a tight balance between the goal of harmonisation and comparability and the choice to make the standard principles-based. The freedom that a principles-based standard gives might impede the comparability. The IASB has chosen to make IFRS 17 principals-based because all insurance companies are different and they wanted to give them the option to apply IFRS 17 in a way that fits them.

At the core of IFRS 17 lies information about the measurement of insurance contracts9. First we will explain the technical terms that are used for this measurement and how they relate to each other.

The present value (PV) of an amount of money is the amount of money one needs to have now in order to have the amount one wants to have in the future, taking into account the interest one expects to get for this money. For example, if one needs to pay €100 in one year and one expects to get 2% interest in this year, one now needs to have $\frac{100}{1+0.02} \approx 98.04$, so the present value of €100 in one year is €98.04.

The Fulfilment Cash-Flows (FCF) is an explicit, faithful and probability-weighted estimate of the present value of the future cash outflows less the present value of the future cash inflows that will arise as the entity fulfils insurance contracts, including a risk adjustment for non-financial risk [1]. The Contractual Service Margin (CSM) is the unearned profit that the insurer expects to recognise10 in the future for providing services [11], i.e. the CSM is the amount of profit an insurer expects to make from the contract during the entire coverage duration of the contract.

IFRS 17 defines the value of an insurance contract (V) as the sum of the FCF and the CSM [11], so

$$V = FCF + CSM.$$ (2.1)

This is a new way of determining the value of insurance contracts.

The FCF is measured as the sum of the present value of the expected insurance contract cash-flows (from now on denoted with $\Gamma$) and the RA, so

$$FCF = \Gamma + RA.$$ (2.2)

The RA represents the required compensation by the insurance company for the uncertainty in non-financial risks in the expected insurance contract cash-flows, see section 2.4 for the definition of

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8With entity a part of the company is meant. People do not agree yet on what an entity should be. It is either the party that is issuing the contract or it is the party that is reporting on IFRS [10].

9Measuring the value of the contract.

10The profit that they expect to gain.
non-financial risk. This value should always be positive. The measurement of the RA in particular is a measurement that involves a lot of interpretation and expert judgement.

At the start of the contract the CSM is defined as the sum of the PV of the expected insurance contracts cash-flows and the RA. Note that both the RA and the CSM are liabilities, so they are calculated as negative values. The fact that the CSM is a liability might seem strange, but the CSM is not yet recognisable profit which, once recognised, will go to equity\footnote{The own funds.}, which is also a liability. We have:

\[-\text{CSM} = \Gamma + \text{RA}.\tag{2.3}\]

This way the CSM is designed to make the total insurance contract liability to have a value of zero, and is therefore fully derived from the FCF. Combining equations 2.1, 2.2 and 2.3, we find

\[V = \text{FCF} + \text{CSM} = \Gamma + \text{RA} + \text{CSM} = \Gamma + \text{RA} - \Gamma - \text{RA} = 0.\tag{2.4}\]

So indeed, the value of the insurance contract equals zero at initial recognition.

The intuition is that the more positive the FCF is at the start of the contract (resembling a net asset value of the expected future cash-flows and the RA), the higher the unearned profit, hence the higher the CSM. This follows from the fact that \(V = 0\), so \(\text{FCF} + \text{CSM} = 0\), so \(\text{CSM} = -\text{FCF}\). See figure 1 for an overview of these concepts. Note that the RA could be bigger than the PV of expected insurance contract cash-flows. According to the given formulas this should give a negative CSM, but by definition, the CSM cannot be negative, so in this case the CSM is set at zero, and we say that the contract has a loss component, which is not part of the insurance contract liability but is immediately recognised as a loss in the profit and loss statement. A contract with a loss component is also called an onerous contract.

\textit{Figure 1: Top: the value of an insurance contract with positive CSM; Bottom: the value of an insurance contract with a loss component, adapted after [12].}

A. The value of an insurance contract at initial recognition, with a positive CSM

B. The value of an insurance contract at initial recognition, with a loss component

\footnote{The own funds.}
The expected insurance contract cash-flows represent the expected future cash-flows directly related to the insurance contract in a faithful way (a probability weighted-mean). These cash-flows should reflect the perspective of the insurance company, based on current estimates about future cash-flows, and be estimated separately from the RA.

From figure 1 and formula 2.4, one can see that at the start of the contract the RA (being a part of the FCF) directly impacts the CSM. A higher RA means a lower CSM, and vice versa. At subsequent measurements the RA and CSM are still related, but no longer as direct as at the start of the contract. Also, at subsequent measurements, only the changes in the RA that relate to future service will adjust the CSM. Note that both the RA and CSM will be recalculated each year during the life of the contract.

The statement of comprehensive income is a statement of all income and expenses recognised during a specified period. Each year the difference between the old and new RA will be relocated to the statement of comprehensive income. This is also called the run-off from the RA and this process is called the release of risk.

The RA is a technical measure that has to be explicitly determined based on principles that require multiple interpretations and judgement in order to apply them in practice. IFRS 17 requires several elements of the RA to be disclosed, to facilitate a transparent comparison between insurers. Also, the RA impacts how the total financial performance is accounted for over the lifetime of the contract, either directly through the release of risk or indirectly through adjustments to the CSM. The combination of the technical nature, the impact on the financial performance and the disclosure requirements creates challenges for insurers to balance the financial and operational implications of their interpretations and choices to be made therein also involving expert judgement.

2.3 The risk adjustment

IFRS 17 requires an explicit measurement of the RA [3]. As stated in the IFRS 17 standard: “an entity shall adjust the estimate of the present value of the future cash-flows to reflect the compensation that the entity requires for bearing the uncertainty about the amount and timing of the cash-flows that arises from non-financial risk” [3]. The RA is the compensation an entity requires for the uncertainty in the cash-flows from insurance contracts. For example, when an insurer offers a life insurance contract, there is uncertainty (risk) in the expected future cash-flows, because it is uncertain how long the policyholder will live and thus how often he/she will pay premiums and how long he/she will be receiving benefits for provided coverage. The insurer will have developed a current estimate of the remaining life expectancy of policyholders, but there will always be uncertainty in this estimate from assumptions about the future, generating a risk. The risk here being that the amount and timing of actual cash-flows will deviate from the currently expected amount and timing of cash-flows.

In order to measure this compensation, an insurer has to make several technical choices based on interpretations and expert judgement, a couple of which are provided below.

First, there are several estimation techniques identified to estimate the RA, such as Value at Risk (VaR), Conditional Tail Expectation (CTE) and Cost of Capital (CoC), see section 4.6 for an in-depth explanation of these techniques. In order to use these techniques, one needs to understand how the technique suits the probability distribution for the non-financial risks which influence the expected cash-flows.

Second, one needs to apply or derive a corresponding confidence level, see section 4.6 for a more in-depth description of the confidence level. This confidence level should correspond to the compensation the entity requires for taking on non-financial risks [13]. The confidence level needs to be
disclosed, to allow a transparent comparison of insurers by users of financial reports.

Third, the entity needs to allocate risk diversification benefits. *Diversification* is the act of combining risks, resulting in one risk that is less than the sum of all combined risks [14]. The pooling of more (individual) risks reduces the total risk per individual for the pool, a key reason why insurance companies add value to society and exist. Diversification benefits arise when multiple risks are joined, where the total risk from the joined distribution is lower than the sum of the risks from each underlying (marginal) distribution. This is because it is assumed (as is shown from past experience) that not all risks emerge together, and there can be dependency structures between risks (e.g. “if this happens, that almost never also happens”, or “this event is not correlated with that event”, etc.). To allocate diversification benefits, one needs to develop and apply a method for measuring risk diversification, and a method to allocate the diversification benefits to the RA measure as part of the FCF for the insurance contracts. In case of the previous example about the life insurance contract, if the insurer has multiple life contracts, say one where they have to pay out as long as the client is alive (here people living longer is a risk), and one where they have to pay out when the client dies (here people living shorter is a risk) than the combined risk of these products is less than the sum of the separate risks, because a large group of people generally will not live both longer and shorter. There are multiple methods for measuring the risk diversification such as simple sum, using correlations and using copulas. Because insurers usually deal with multiple risks, it is important to know how to compute the combined risk while meeting the requirements [15], see section 4.2 for a list of requirements.

In making technical choices that fulfil the IFRS 17 requirements, an insurer also has to consider the business impact of these choices, or the business criteria that a choice needs to fulfil. One also needs to consider the impact of choices on the financial performance over time, and the ability to work and communicate about those choices and techniques/methods etc.

This is needed as the insurer needs to have the understanding and some level of control over his financial performance (as the RA impacts the financial performance), where surprises in the financial performance (in either direction) are very often not appreciated internally nor externally. Furthermore, these considerations are needed as insurers are required to disclose various measurements and choices related to the measurement of the RA, to allow users of financial information to compare insurers. If an insurance company can provide a higher level of transparency in their financial performance and choices made better than another insurance company, this in itself can increase the trust and willingness to invest. This allows for a better relation and level of communication between the entity and their financial stakeholders, which can increase the trust in the entity and willingness to invest in that company compared to another.

These business impacts and related criteria can lead to different choices than just considering technical requirements. If an estimation technique or diversification method is theoretically exact, but is too complicated for preparers\(^{12}\) to understand and work with, or is too difficult to explain to financial stakeholders, then this technique should maybe not be chosen. So there is a balance between transparency and accuracy.

As such, fulfilling technical requirements (involving choices following interpretation and expert judgement) within business criteria creates a balancing act for insurers, a balancing act in their specific context. This creates an optimisation problem, to fulfil the requirements within the business criteria given various underlying choices to be made. Each insurer has to solve this optimisation problem in their business context separately. In this optimisation problem the business criteria can somewhat vary between insurers, but the IFRS 17 technical requirements and required disclosures will be the same.

\(^{12}\)The people who prepare financial information.
For example, an insurer who only wants to be compliant can make less complicated choices that are easy to explain, but in doing so provides less manageable and/or higher RAs (with lower expected CSM). On the other hand, the “sophisticated insurer” can develop a sophisticated estimation technique and risk diversification method, that would allow them to identify and steer financial results to a high degree, however its methodology may be perceived as a black box by the internal users, as it requires more model assumptions that need to be explained and monitored, and is not understood by external stakeholders.

One business criterion that will likely be relevant in practice, but will not be taken into consideration for this paper’s optimisation problem, are the operational impacts for the model development (having to design, implement and test), model use and maintenance. These operational impacts can in reality determine choices (developing a new system, adjust existing systems, etc.) and depend to a large extent on the specific context and ambition of the insurance company (e.g. current financial reporting architecture, presence and level of resources and ability to develop resources). As this criterion cannot be properly assessed, and can be very specific for each insurer, it is not a criterion that will be considered further in this study.

2.4 Non-financial risks

The RA should only be calculated for non-financial risks [3]. Here risk is in the entity’s perspective, about the uncertainty in the amount and timing of cash-flows around an expected amount and timing. Risk is seen as the uncertainty in \( \text{probability of something happening} \times \text{impact if it happens} \). IFRS 17 only defines financial risk, not non-financial risk: “financial risk is defined as the risk of a possible future change in one or more of a specified interest rate, financial instrument price, commodity price, currency exchange rate, index of prices or rates, credit rating or credit index or other variable” [3]. Non-financial risks are all risks not specified as financial by the definition above. Therefore a non-financial risk is a risk that is not a possible future change in interest rates, financial instrument prices, commodity prices, currency exchange rates, indexes of prices or rates, credit ratings or credit indexes. For example the risk that the insured dies earlier than expected (also called mortality risk) is a non-financial risk, because it is not specified as one of the mentioned financial risks.

2.5 Summary of theoretical framework

IFRS 17 is a new accounting standard for insurance contracts. It will be mandatory, effective from 1 January 2021 (or later), for all insurance companies reporting on IFRS that have insurance contracts in their portfolio. IFRS 17 was introduced with the overall goal of providing a more useful and consistent accounting model for insurance contracts globally, so these can be more easily compared between firms and across countries. Compared to prior accounting standards IFRS 17 is more principles-based. Due to these principles, insurers are required to develop interpretations, which provides some freedom in how to implement the standard.

The CSM is the amount of profit an insurer expects to make from the contract during the entire coverage duration of the contract. We denote the sum of the PV of the expected insurance contract cash-flows with \( \Gamma \). The RA represents the required compensation by the insurance company for the uncertainty in non-financial risks in the expected insurance contract cash-flows. Both the CSM and the RA are liabilities. IFRS 17 defines these concepts in such a way that at the start of the contract it holds that \( \text{CSM} + \Gamma + \text{RA} = 0 \). At the start of the contract, the CSM is calculated from \( \Gamma \) and the RA using this formula. The CSM cannot be negative. In case the CSM should be negative, it is set at 0 and the contract is called onerous. This should be reported separately.
The RA is a technical measure that has to be explicitly determined based on principles that require multiple interpretations and judgement in order to apply them in practice. IFRS 17 requires several elements of the RA to be disclosed, to facilitate a transparent comparison between insurers. Examples of these elements are the used estimation technique, confidence level and method for risk diversification. An insurer has to choose these elements in such a way that they can explain to their stakeholders how the choices are made while also being compliant with IFRS 17. Note that the RA should only be calculated for non-financial risks.
3 Methodology

In order to answer the research questions stated in the previous section, this study will take the approach as defined below for each research question.

3.1 Why is the RA an important measure?

First it needs to be researched why exactly it is important to research the RA. This will be done by literature research into IFRS 17 itself and into the “risk margin”, a somewhat similar concept as the RA that is defined in Solvency II. Solvency II is a standard for capital requirements that has been effective since 2012 [16], so there is experience from practice about the risk margin and how it is perceived, which is not the case for the RA at this point in time. Also, there are many reports on Solvency II that can be used for this research. For the RA only the IFRS 17 requirements are known, and that these should be complied with in making choices about the RA.

3.2 What are the criteria for optimal choices with respect to the RA?

In order to determine optimal choices with respect to the RA, it needs to be determined on what dimensions it would be determined what optimal is. Furthermore, the criteria should be made explicit in order to easily test if an estimation technique suffices.

The RA needs to always meet the requirements mentioned in the standard itself. These criteria can be found by literary research into the standard. In addition the estimation technique needs to be workable for the insurer. In order to determine these extra criteria, literature research into Dutch insurance companies will be done.

3.3 What is a relevant Dutch insurance group and insurance contracts to research?

Optimal choices for determining the RA will be determined for a typical Dutch insurance group. In order to do so, it needs to be researched what a typical insurance group is. As little assumptions as possible will be made about the insurance company, but some choices need to be made about the portfolios they offer. Later, this will determine the risks they face.

In order to make these choices, Dutch insurance companies will be researched to determine what mix of portfolios is mostly used in the Netherlands. We will focus on the insurance companies that are listed on the Dutch stock market, as they are required to annually report financial statements according to IFRS standards. From this research a typical insurance company will be determined including its entities and the products these entities offer. These entities all need to make their own IFRS report [3].

3.4 What non-financial risks are typically relevant for Dutch insurance groups?

In order to compute the RA, it needs to be known what non-financial risks Dutch insurance companies are facing and in particular what the company found answering the previous question is facing. This question will be answered by literature research into insurance companies in the Netherlands
and into Solvency II, which defines a list of risks that insurance companies have to take into account [17].

3.5 What are suitable probability distributions for these non-financial risks?

Probability distributions will be determined for all risks found by answering the previous question. First, literature research will be done to find if these distributions are already known. Furthermore, we will look into getting data from the CBS\textsuperscript{13} in order to derive these distributions ourselves, if possible.

3.6 What are suitable estimation techniques for the RA?

In section 2.3 the three most common methods for measuring the RA are mentioned, but there are other methods, and the standard does not state what method should be used. Therefore it needs to be researched what methods are suitable, i.e. can be used to calculate a RA in a way that suits the criteria found in section 4.2. This will be done through literature research.

3.7 What are suitable dependency structures between the relevant risks?

In order to determine the risk diversification, dependency structures between the relevant risks need to be found. First, literature research will be done to find relevant dependency structures. Second, some of these dependency structures will depend on correlations. Literature research will be done to find if these correlations are already known. Furthermore, some of these correlations may be derivable from data from the CBS.

3.8 What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA?

In order to determine the best choices for computing the RA, a model will be made that can compute the RA for the insurance company found in section 4.3, for the risks found in section 4.4. This model needs to be able to handle all methods for computing the RA found in section 4.6 and all methods for computing risk diversification found in section 4.7, as well as different confidence levels. This model needs to meet the criteria set in section 4.2. For building this model, the distributions found in section 4.5 will be used. With this model, the optimal choices for the RA can be computed.

3.9 What are the various perspectives on the benefits of IFRS 17?

In order to see how IFRS 17 is relevant in society, several people who are related to the standard will be interviewed. During these interviews, questions about their views on IFRS 17 will be asked. Potential interviewees are:

- A representative of an insurance company who has to implement IFRS 17;
- An advisor who helps insurance companies with the implementation of IFRS 17;

\textsuperscript{13}Centraal Bureau voor de Statistiek.
• An accountant who has to check that IFRS 17 has been implemented correctly;
• A representative of the IASB who helped writing IRFS 17.
4 Analysis

In this section we will describe the execution of the approach as described in the previous chapter, per research question.

4.1 Why is the RA an important measure?

In order to determine why the RA is an important measure, we first look at the Risk Margin (RM) as defined in Solvency II. The RA, as designed under IFRS 17, serves a similar purpose as the RM under Solvency II. The difference between the RA and the RM is the way they are calculated and the way they impact the performance of a contract. The difference between IFRS 17 and Solvency II is that IFRS 17 is dealing with the annual financial performance of insurance contracts over the lifetime of those contracts, while Solvency II is dealing with the available and required capital of an insurance company.

Since Solvency II has been effective since 2012, there is experience from practice about the RM and how it is perceived, which is not so literally the case for the RA [16]. The RA has more freedom (from principles) in how to calculate it, and the RM has a more rules based calculation.

The RA is designed to represent the amount an insurance company would require to take on the obligations of a given insurance company. It effectively means that if an insurer were, as a result of a shock, to use up all its free surplus and capital, then it would still have sufficient assets to safely wind-up and transfer its obligations to a third party [18]. Therefore, the RA is an amount of capital held for dealing with uncertainty in the cash-flows. In case the RA is set too low, the insurance company might not have enough capital to pay its creditors in case of a shock. In case the RA is set too high, less capital is available to perform investments.

The technical provisions are the expected value of the liabilities of the insurer, and the own funds are the excess of assets over liabilities. Under Solvency II, the RM adds to the technical provisions, and thus reduces the own funds [19, 20]. IFRS 17 is a standard for the performance of insurance contracts globally, while Solvency II is a regime that focuses primarily on the capital to be held to protect the policyholder. This, combined with the fact that the RA is calculated in a different manner, means that the RA impacts the own funds in a different way. However, the RA is also storage of capital for uncertainty.

Note that a higher RA\textsuperscript{14} at the start of the contract does not imply that more capital is stored. It is only stored in a different place (in the RA or in the CSM). This follows from the relation between the RA and the CSM as described in section 2.2.

An important difference between the RA and the RM is that the determination of the RM is more prescribed under Solvency II than the determination of the RA under IFRS 17. Solvency II states that the RM needs to be calculated using the CoC technique, using a confidence level of 99.5\% and a capital rate\textsuperscript{15} of 6\%, see section 4.6 for the definition of CoC. However, IFRS 17 is more principles-based and thus less restrictive on the techniques that could be applied [3]. Insurers have to choose a suitable technique for calculating the RA, which gives them more flexibility, but they need to explain the choices made to the users of financial statements. Under Solvency II, insurers only are to report the RM in their annual report, and most of them also do not elaborate on this, given the prescribed calculation method of the RM [21, 22]. Therefore the introduction of IFRS 17

\textsuperscript{14}Compared to another one.

\textsuperscript{15}The capital rate can be seen as the percentage of profit that could be made from an amount of capital by investing it.
will have large implications on how insurance companies calculate and report the compensation for risk, because now they do have to give a more in-depth disclosure of how they derive this value.

Furthermore, others, like financial stakeholders, will use these disclosures to compare insurance companies on their financial performance. This means that it is important to calculate the RA in a transparent way. If, for example an insurance company chooses an extreme low confidence level, which results in a relative low RA compared to the technical provisions, then a potential stakeholder might find it too risky to invest in this company.

The RA also impacts the financial performance of the company. Over time the RA will change as the insurer fulfils the contract or because of a change in assumptions, or because the insurer gets more information about things that have now already happened. That is, the RA should decrease over time as the uncertainty in the amount and timing of future expected cash-flows decreases. As mentioned in section 2.2, the difference between the old and new RA will be relocated to the statement of comprehensive income. This means that the RA impacts the financial performance, which amongst others is reported in the statement of comprehensive income.

As shown in section 2.2, the RA has great influence on the starting value of the CSM. Later in time there is still a relation between the two, but this relation is weaker. The CSM too has a run-off to the statement of comprehensive income over time and thus also influences the financial performance.

The RA requires expert judgement and can thus be used for steering part of the financial performance of the company. This also implies that it is important to understand the RA and the way it is measured, for both the insurance company and its financial stakeholders such as investors.

4.2 What are the criteria for optimal choices with respect to the RA?

There are several criteria that should be met in order for the choices with respect to the RA to be optimal. First of all, the standard itself states several requirements that need to be met in order to be compliant [3]. The RA should be:

1. Technically sound: The RA needs to meet the following five requirements [3], section B91:
   a. Risks with low frequency and high severity will result in higher RA than risks with high frequency and low severity;
   b. For similar risks, contracts with a longer duration will result in higher RA than contracts with shorter duration;
   c. Risks with a wider probability distribution will result in higher RA than risks with a narrower distribution;
   d. The less that is known about the current estimate and its trend, the higher will be the RA;
   e. To the extent that emerging experience reduces uncertainty about the amount and timing of cash-flows, the RA will decrease and vice versa.

Examples of what these requirements imply are the following.

a. In the Netherlands the RA for damage by a hurricane is expected to be higher than the RA for damage by rain.

b. The RA for a disability insurance with a duration of 30 years is expected to be higher than the RA for a disability insurance with a duration of 10 years.
c. If the risk of getting disabled for insured people in the Netherlands resembles a normal distribution, and for insured people in the UK this risk resembles a student-t distribution\textsuperscript{16}, the RA for disability risk in the UK is expected to be higher than the RA for the same risk in the Netherlands.

d. If an insurance company has less data about when their Dutch clients become disabled than when their clients from the UK become disabled, the RA for disability risk in the Netherlands is expected to be higher than the RA for disability risk in the UK.

e. If an insurer has more data than before about when people become disabled, the RA for disability risk will decrease.

2. Consistent: The RA should be consistent with the observed market prices and other market variables that it depends on, and it shall reflect the entity’s current estimates of how the actual behaviour of the policyholders may differ from the expected behaviour \cite{3}, section B53.

3. Explainable: The confidence level, estimation technique and related financial results need to be explainable, understood both by internal and external stakeholders of the company. Furthermore the confidence level should appropriately fit the underlying risk distributions and if a technique other than VaR is used, the confidence level should be derived from the results of the used technique (in this case the applied confidence level is not the same as the derived confidence level which should be disclosed\textsuperscript{17}) \cite{3}, sections 117, 119 and B92. This means that the computation should be understandable by all stakeholders. Therefore, choosing a known method for computing the RA which is in line with existing regulation, such as Solvency II, might initially be preferable above a new, self-invented method, even if this new method gives better results.

4. Calculated for non-financial risks: The RA should only be calculated for non-financial risks \cite{3}, section B86.

5. Diversified: Risk diversification should be taken into account \cite{3}, section B88.

Viewing the RA from the perspective of the insurer, it is preferable that the following criteria are met as well, however this is not mandatory to comply with IFRS 17. The calculation for the RA should be

6. Operationally possible: The computation needs to be operationally possible, meaning that it needs to be possible to compute the RA with the data that an insurer has available.

7. Allow for steering: As described in section 4.1, the RA can be used for steering of the financial performance of the company. This means that the RA should preferably be computed in a way that allows for some level of steering, mitigating the risk from creating onerous contracts that are not really onerous and the consequences from performance volatility over time (getting unexplainable).

### 4.3 What is a relevant Dutch insurance group and insurance contracts to research?

By looking into the annual reports and websites of Dutch stock market listed insurance groups, we found most of them have entities for asset management, individual life, group life, non-life, health and reinsurance \cite{21, 22, 23, 24, 25}, see figure 2.

\textsuperscript{16}Which is wider than the normal distribution.

\textsuperscript{17}This will be explained in further detail in section 4.6.5.
The most common individual life insurance products are term life insurance, immediate annuity and unit linked, and the most common group life insurance is insured pension.

The portfolios for non-life, e.g. property and travel insurance, are mostly short term contracts for which a RA is only included in the liability for incurred claims. Since these incurred claims are settled in a short period of time (less than one year), the uncertainty in the amount and timing of the cash-flows that arises from non-financial risks is limited and thereby the RA is expected to be less relevant for short term non-life contracts. As defined in IFRS 17, contracts where claims are settled in less than a year, and contracts that hold for less than a year, fall under the *Premium Allocation Approach* (PAA), which is a simplified way of implementing IFRS 17 [3]. There are two kinds of non-life insurance products that may not be eligible for the PAA and thus do count more significantly toward the RA. These are disability insurance and liability insurance.

Health insurance products are yearly contracts so they also fall under the PAA. Furthermore, there are only two insurance groups that have a health entity and report on IFRS, namely Achmea and ASR [21, 24]. Since health entities are allowed to apply a simplified approach of IFRS 17, health insurance products are not in scope of this research.

Another relevant insurance is the funeral insurance. However, for most big Dutch insurers who implement IFRS 17, such as Achmea, Aegon Group, ASR, NN Group and Vivat, either funeral insurance is relatively small, or they do not offer this insurance at all [21, 22, 26, 24, 25].

See figure 3 for an overview of the entities and products that are considered to be relevant for this study. All found insurance products are explained below.
**Term life insurance** ("overlijdensrisicoverzekering")

A term life insurance is a type of life insurance. The client periodically pays a premium. In case of a temporary term life insurance the contractually set death benefit will be paid to the beneficiary if the insured dies before a set end of coverage date. In case of a lifetime term life insurance the contractually set death benefit will be paid to the beneficiary if the insured dies, no matter when this happens.

One reason for someone to buy this type of insurance is to leave ones relatives with some money if one dies. Another reason is that banks often oblige one to buy a term life insurance when one get a housing loan, so in case one dies the death benefit can pay off (part of) the loan [27].

*Figure 4: Overview of the cash-flows of a term life insurance contract.*
Immediate annuity ("direct ingaande lijfrente")

The client pays a single premium\(^{18}\). Every year, the client receives a set amount of money if he/she is alive. This yearly payment stops after a contractually set date or when the client dies. In some cases, a percentage of the original pay-out will be paid to the spouse of the insured, in case the insured has died and his/her spouse has not.

If one has a large amount of money, for example money that became available from another annuity insurance, it can be beneficial to buy an immediate annuity with this money. This way, one is guaranteed a steady income and since the money is not in one’s own possession anymore, it can be used to avoid paying taxes \([28, 29]\).

*Figure 5: Overview of the cash-flows of an immediate annuity contract.*

Unit linked ("beleggingsverzekering")

The client periodically pays premium. Part of this goes to the accumulated reserve, and the other part is invested by the insurer. If the client is still alive at the contractually set end date, he/she receives the current value of the investment. If he/she dies before the end date, he/she receives a contractually set sum from the insurer. Each year a percentage of the investment is subtracted as income for the insurer \([30]\).

Unit linked is in fact a combination of an investment and a term life insurance. For this insurance, most risks are in the investment and these are all financial risks. Since the RA is only meant for non-financial risks, this insurance is considered not relevant for this research.

\(^{18}\)Also called *lump sum.*
Insured pension ("verzekerd pensioen")

Insured pension is a form of deferred annuity. An employer can use it to insure his employee’s pension. The employer pays the insurer a predetermined percentage of his employee’s salary. After the employee has reached his/her retirement age, the insurer pays the pension monthly to the employee.

The advantage of this product is that, in return for the insurance premium, the employee is insured to receive his/her pension, which may not be the case for a pension fund.

*Figure 6: Overview of the cash-flows of an insured pension contract.*
Disability insurance ("arbeidsongeschiktheidsverzekering")

The client periodically pays a premium. If the client becomes disabled and because of this cannot work (partially) anymore, the insurer will pay a monthly set sum to the insured. This insurance ends at a set end date, which is usually set at the moment the insured reaches the retirement age.

One can buy this insurance to supplement one’s WIA benefit in case one becomes disabled. In the Netherlands a WIA benefit is a benefit for people who are disabled for more than two years to replace (part of) their income.

This insurance provides some financial compensation as a protection to the loss of income due to having become (partially) disabled. In the Netherlands disability insurance products are usually arranged by the employer, but freelancers have to buy this insurance themselves. This is the group that we will look at in this research. Furthermore we will only look at the case were the insured cannot work at all anymore.

Figure 7: Overview of the cash-flows of a disability insurance contract.
Liability insurance (“aansprakelijkheidsverzekering”)

The client periodically pays a premium. The liability insurance protects the insured in the event he/she creates a loss to a third party by his/her actions or inactions, potentially creating a valid claim for financial compensation. In this case, the insurer pays the compensation for the loss of the third party.

One can purchase this insurance to make sure that one does not have to pay a big amount of money if one damages someone else’s property, health, income potential etc.

Reinsurance (“herverzekering”)

Reinsurance is a method to contractually transfer insurance risks from an insurance company to a reinsurance company. These risks are from the insurance products the insurance company has issued. For reinsurance contracts, IFRS 17 requires that these contracts are measured with assumptions that are consistent with those of the underlying insurance contracts, and that the RA reflects the amount of risk that is being transferred. As such it is expected that when the RA for relevant insurance contracts is considered, that this implicitly and sufficiently covers the RA (transfer) for reinsurance contracts. Therefore reinsurance contracts are not further considered in this research.

4.4 What non-financial risks are typically relevant for Dutch insurance groups?

Because of the similarities between the RM under Solvency II and the RA under IFRS 17, and because there are no IFRS 17 reports yet prepared and published, we have assessed what types of risks are included in the RM calculation under Solvency II. Furthermore, we looked into the annual reports of the biggest insurance groups from the Netherlands namely Achema, Aegon group, ASR, NN Group and Vivat [21, 22, 26, 24, 25]. Using the definition of non-financial risk as given in section 4.4 we found the following risks to which they report to be exposed to. The risks are divided into risks more relevant to life insurance products and risks more relevant to non-life insurance products.

4.4.1 Life risks

The non-financial life risks that were found are the following.

Mortality risk

*Mortality risk* is the risk that people die earlier than expected resulting in the insurer having to pay out more or sooner than expected [31].

Longevity risk
Longevity risk is the risk that people die later than expected, resulting in the insurer having to pay out more or longer than expected [31].

Disability risk

Disability risk is the risk that more policyholders than expected become disabled, or that policyholders become more severely disabled than expected, resulting in the insurer having to pay more or longer than expected [22]. Considering the insurance products found in section 4.3, we see that disability risk only plays a role in disability insurance, which is a non-life product, so in this research disability risk is seen as a non-life risk.

Expense risk

Expense risk is the risk that the expenses, either by amount or timing, will be higher than expected [32]. It refers to expenses for the insurer that are related to fulfilling an insurance contract, such as administration costs and claim handling costs. For example if a contract was terminated earlier than expected, these costs would be lower.

Expense levels can vary a lot across insurers, which makes it difficult to make a general model for this risk. Furthermore, insurers have a high degree of influence on cost levels, since they control their own expenses. There is a natural impulse to decrease this risk for an insurer, which is not possible for any other risk that this research takes into account. Given these two facts, this research will not take expense risk into further consideration.

Revision risk

Revision risk is the risk of loss, or of adverse change in the value of insurance liabilities resulting from fluctuations in the level, trend, or volatility of the revision rates applied to annuities, due to changes in the legal environment or in the state of health of the person insured [33]. In the annual reports that were researched, it was found that insurers usually do not take this risk into account and therefore it is outside of the scope of this research.

Lapse risk

Lapse risk is the risk associated with the consequences of cancellation by the policyholder before the envisioned end date or expected lapse date, resulting in that the insurer may have to pay out more than expected or may receive less premium (e.g. to compensate for expenses) than expected [22].

Life catastrophe risk

Life catastrophe risk is the risk that a life catastrophe such as a medical epidemic occurs, impacting many people at the same time. It is mostly relevant in group insurance. Participants in a group contract often work at the same location or undertake joint activities, which brings about a concentration of risk [22]. However, this risk is seen as not very important by most insurers so it is outside the scope of this study [24].

4.4.2 Non-life risks

The non-life risks that were found are the following.

Premium and reserve risk

Premium risk is the risk that premiums pertaining to future exposure are insufficient to meet all corresponding claims and costs or that the accrued claims reserves are insufficient to settle all claims already incurred [22]. The RA is meant to take care of this risk, so this risk is not relevant in this research.
Non-life catastrophe risk

*Non-life catastrophe risk* is the risk of losses due to extreme or exceptional events. This includes both natural disasters and events caused by human actions [22]. This risk is mostly relevant in the parts of non-life insurance that are not relevant for the RA such as insurance of property. Therefore, we do not take this risk into account.

Expense risk

This is the same as expense risk for life [32].

Lapse risk

This is the same as lapse risk for life [22].

Summarising our findings, we find that the most relevant life risks are mortality risk, longevity risk and lapse risk and the most relevant non-life risks are disability risk and lapse risk. Note that according to the definition of non-financial risk given in section 2.4, these risks are all non-financial.

Now we determine what risks are relevant for what types of insurance. Our findings are summarised in table 1.

For term life insurance, the insurer will incur more expenditure if people die earlier, because then they receive less premium and have to pay out earlier. Furthermore the insured can lapse. Therefore, for term life insurance there is considered to be mortality risk and lapse risk.

For immediate annuity, the insurer will incur more expenditure if people die later, because then they have to pay out more often. For immediate annuity, the insured cannot lapse. Therefore, for immediate annuity there is considered to be longevity risk.

For insured pension the insurer will receive less income if people die earlier before they retire, because then less premium will be paid. However, the probability that someone dies before he/she reaches his/her retirement age is relatively small, which makes this risk negligible [34]. Furthermore the insurer will incur more expenditure if people die later after they retire, because then the insurer has to pay out more often. This means that insured pension is affected by longevity risk. Furthermore, the insured can lapse before he/she reaches the retirement age. This means that for insured pension there is considered to be longevity risk and lapse risk.

For disability insurance, mortality risk is usually not taken into account because the risk of people dying before reaching their retirement age is negligible. Therefore, for disability insurance there is considered to be only disability risk.

 Liability insurance is not subject to any of the risks that are taken into account in this research. Consequently, this research will not further look at the liability insurance.

**Table 1: Overview of what non-financial risks are relevant for what insurance products.**

<table>
<thead>
<tr>
<th></th>
<th>Term life insurance</th>
<th>Immediate annuity</th>
<th>Insured pension</th>
<th>Disability insurance</th>
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<tbody>
<tr>
<td>Mortality</td>
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<td>Longevity</td>
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<td>Lapse</td>
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<tr>
<td>Disability</td>
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<td>*</td>
</tr>
</tbody>
</table>
4.5 What are suitable probability distributions for these non-financial risks?

In section 4.4 we have found that the most relevant risks for this research are mortality risk, longevity risk, lapse risk and disability risk. Here we will look into suitable probability distributions for these risks. When doing this it is important to understand that we are looking for the distributions of the factors that generate the uncertainty in the cash-flows of an insurer, which are usually probabilities of something happening (or not happening), such as the probability that a person dies, stays alive, or becomes disabled. The uncertainty in the amount and timing of expected future cash-flows is more driven by the uncertainty in these probabilities than in the uncertainty in the amounts to be paid given that something happened.

This generates a problem for us because there is not much research done on the distributions of these probabilities. For example, there are many sources on the distribution of the amount of people that die in a certain period of time, yet there are not many sources on the distribution of the probability of someone dying. For most risks there are some sources that state what distribution they have assumed for their probabilities, but nothing that is more theoretically substantiated.

Using experience data one could derive these distributions oneself, but for this study there is little data available. The CBS was contacted. They have not stored old predictions for survival- and mortality rates, which would be needed to find the distributions for mortality- and longevity risk.

We first state what is said in the found sources after which we determine what this implies for this research.

4.5.1 Mortality risk

For mortality risk, the factor that generates uncertainty in the cash-flows is the mortality rate, which is the probability that someone dies at a certain age. This should not be confused with the number of people that die at a certain age.

The European Insurance and Occupational Pensions Authority (EIOPA), which has developed the Solvency II regulations, suggests using either the normal distribution or the binomial distribution, which is a discrete version of the normal distribution [35, 36]. However, they also state that the distribution is skewed, which would suggest a log-normal distribution. The department of the host organisation of this research also uses the log-normal distribution for mortality risk.

4.5.2 Longevity risk

For longevity risk, the factor that generates uncertainty in the cash-flows is the survival rate, which is the probability that someone is still alive. The binomial distribution is suggested for this variable [37]. At the department of the host organisation of this research the log-normal distribution is used for longevity risk.

4.5.3 Lapse risk

For lapse risk the factor that generates uncertainty in the cash-flows is the lapse rate, which is the probability that someone lapses. For lapse rates EIOPA suggests both the normal and log-normal distribution [35, 36].
4.5.4 Disability risk

For disability risk the factors that generate uncertainty in the cash-flows are the disability rate, and the recovery rate. The disability rate is the probability that a healthy person becomes disabled and the recovery rate is the probability that a disabled person recovers. At the department of the host organisation of this research the log-normal distribution is used for these rates.

It can be concluded that for all these risks, there are no sources that suggest there is one distribution that is best suited. Keeping in mind that the distribution that is chosen should not be too complicated, as mentioned in section 2.3, we chose to use both the normal and log-normal distribution for all risks. These seem the most suitable and explainable. Probabilities cannot be negative, which would suggest that the log-normal distribution would fit better, however, probabilities also cannot be bigger than one, which would suggest that the normal distribution would fit better because the log-normal distribution has a much longer right hand tail.

There is no reason to assume that either the normal or the log-normal distribution will fit better, so both distributions will be explored to understand the impact on the RA to the choice of these risk distributions.

Note that the fact that we have to make the choice for the distribution in this way does generate some uncertainty in this research. However, many insurers will have to do the same thing, since in many cases they also do not have data or better sources that can help to make this choice.

It is worth noting that if an insurer wants to be able to better derive the probability distributions for the risks they face, they should store data in order to be able to do this, which is something they typically do not do at the moment.

4.6 What are suitable estimation techniques for the RA?

There are three by IFRS 17 provided potential estimation techniques for calculating the RA, namely Value at Risk (VaR), Conditional Tail Expectation (CTE) and Cost of Capital (CoC). One can also use other techniques, as long as they meet the criteria given in section 4.2. In this research we will only look at the three given techniques, since the use of these is much better explainable than other self-invented techniques.

We will describe these techniques separately in sections 4.6.1, 4.6.2 and 4.6.3. First a mathematical definition will be given for each technique after which they will be explained in less technical terms.

As mentioned in section 2.2, we define $\Gamma$ to be the PV of expected insurance contract cash-flows. We define $p$ to be the variable that gives uncertainty to the cash-flows\(^{19}\), so $\Gamma$ depends on $p$. This means that we can see $\Gamma$ as a function\(^{20}\), $\Gamma(p) : [0, 1] \rightarrow \mathbb{R}$. We denote the set of functions $f : [0, 1] \rightarrow \mathbb{R}$ as $\mathbb{R}^{[0,1]}$. Furthermore let $X \in \mathbb{R}$ be a randomly distributed variable for the distribution of $p$. Let $F : \mathbb{R} \rightarrow [0, 1]$ with $F(x) := P(X \leq x)$ be the corresponding cumulative distribution function and let $f : \mathbb{R} \rightarrow [0, 1]$ with $f(x) := \frac{d}{dx}F(x)$ be the corresponding probability density function. Moreover let $\mu \in \mathbb{R}$ be the mean of the liability cash-flows, not to be confused with the median. Note that

$$\mu = \int_{-\infty}^{\infty} f(x) \cdot x \, dx.$$
This formula basically states that the mean is the average of all values.

Note that the following follows from the definition of \( f(x) \):

\[
\frac{d}{du} F(u) = f(u)
\]

\[
\int_{-\infty}^{x} \frac{d}{du} F(u) \, du = \int_{-\infty}^{x} f(u) \, du
\]

\[
F(x) - F(-\infty) = \int_{-\infty}^{x} f(u) \, du
\]

\[
F(x) - P(X \leq -\infty) = \int_{-\infty}^{x} f(u) \, du
\]

\[
F(x) - 0 = \int_{-\infty}^{x} f(u) \, du
\]

\[
F(x) = \int_{-\infty}^{x} f(u) \, du.
\]

(4.1)

Furthermore we define \( \Gamma_t \) to be the PV of the expected insurance contract cash-flows at time \( t \). Thus, \( \Gamma_0 \) is the PV at time 0 of all future cash-flows that are expected at time 0, and \( \Gamma_1 \) is the PV after 1 year of all future cash-flows that are expected after 1 year. We use the convention \( \Gamma = \Gamma_0 \).

Lastly we define \( P_{s,t}(x) \) with \( s \leq t \) to be the PV at time \( s \) of an capital that has a value of \( x \) at time \( t \). This means that if one wants to have \( x \) money at time \( t \), one should have \( P_{s,t}(x) \) money at time \( s \). In example 1 one can see how to calculate these values. In section 4.6.5 the difference between these two will be explained in more detail.

**Example 1**

Assume one has a contract with a duration of two years. In year one we expect an income of €100 and in year two we expect an expense of €50. Assume that the interest rate for one year is 1% and the interest rate for two years is 2% per year. We find \( P_{0,1}(100) = \frac{100}{1+0.01} \approx 99.01 \) and \( P_{0,2}(-50) = \frac{-50}{(1+0.02)^2} \approx -48.06 \). This means that the PV of all future cash-flows at time zero is \( \Gamma = P_{0,1}(100) + P_{0,2}(-50) \approx 50.95 \).

**4.6.1 VaR**

The RA calculated using the Value at Risk technique (VaR) is defined as follows. Let \( C \in [0, 1] \) be the confidence level, then we define the VaR of \( C \) to be \( \text{VaR}(C) : [0, 1] \rightarrow \mathbb{R} \), with \( \text{VaR}(C) = F^{-1}(C) \) where \( F \) is the cumulative distribution function corresponding to the used distribution. This gives \( F(\text{VaR}(C)) = C \). From equation (4.1) it follows that \( \text{VaR}(C) \) can be calculated using

\[
\int_{-\infty}^{\text{VaR}(C)} f(x) \, dx = C.
\]

(4.2)

One can see \( \text{VaR}(C) \) as the value such that \( C\% \) of the distribution of \( p \) lies to the left of \( \text{VaR}(C) \), see figure 9a.
Now we denote the RA calculated using VaR with $\mathcal{R}_A^{VaR}(\Gamma, C) : \mathbb{R}^{[0,1]} \times [0, 1] \to \mathbb{R}$ and we define $\mathcal{R}_A^{VaR}(\Gamma, C)$ to be the difference between $\Gamma(VaR(C))$ and $\Gamma(\mu)$.

$$\mathcal{R}_A^{VaR}(\Gamma, C) = \Gamma(VaR(C)) - \Gamma(\mu).$$

(4.3)

See example 2 for an explanation of how to calculate this value.

One should see $\Gamma(\mu)$ as the PV of all expected future cash-flows and $\Gamma(VaR(C))$ as the PV of all expected future cash-flows in case of a shock. This means that the RA is the difference between the average future cash-flows and the future cash-flows in case of a shock\(^{21}\), so it is the extra amount that would be needed to pay the insurers expenses in case of a shock, see figure 10.

Note that $VaR(0, 5)$ equals the median of the distribution\(^{22}\), see figure 9b. Furthermore $\mathcal{R}_A^{VaR}(\Gamma, C) < 0$ if $\Gamma(VaR(C)) < \Gamma(\mu)$. This means that in general, one should always pick $C$ such that $\Gamma(VaR(C)) \geq \Gamma(\mu)$ when using VaR as the RA may not be smaller than zero. For symmetric distributions the median is the same as the mean, so in that case we find $\Gamma(\mu) = \Gamma(0, 5)$, so we need to have $\Gamma(VaR(C)) \geq \Gamma(0, 5)$, so $C \geq 0, 5$. We can conclude that for symmetric distributions the RA will be positive as long as $C \geq 0, 5$. For non-symmetric distributions we cannot give such a clear boundary for $C$. This depends on the distribution of $p$ and the characteristics of the contract.

Furthermore one should pick $p$ in such a way that $p$ increases if and only if the liability cash-flows increase, otherwise the liability cash-flows in case of a shock will be less than the average cash-flows, which does not make any sense and will result in a negative RA.

\(^{21}\)In case the predicted mean was too low.

\(^{22}\)Because for the median it holds that exactly 50% of all values lie to the left of it.
Example 2

Assume we have a contract for one client with a duration of one year where the insurer has to pay out €100 in case the insured is alive. For this contract all premiums have already been paid. Assume the predicted probability for one year survival of this client is 0.8 and this value is normally distributed with a standard deviation of 0.1. We use a confidence level of 0.7 and an interest rate of 0.2.

The insurance company has to pay out €100 with a probability of 0.8, so the expected pay-out is $0.8 \times 100 = 80$. This gives $\Gamma(\mu) = \frac{80}{1 + 0.02} \approx 78.43$.

We find $\nu a R(0.7) \approx 0.85$ (note that for this calculation one should use $\mu = 0.8$). This can be calculated using formula 4.9. This means that in case of a shock, the insurer expects an expense of $0.85 \times 100 = 85$. This gives $\Gamma(\mu) = \frac{85}{1 + 0.02} \approx 85.33$.

This gives $\mathcal{R}_A(\nu a R, C) = 85.33 - 78.43 = 4.90$.

4.6.2 CTE

The RA calculated using the *Conditional Tail Expectation* technique (CTE) is defined as follows. We define $C \in [0,1]$ to be the confidence level, and we define the *tail* of the liability cash-flows as the set of all values bigger than $\nu a R(C)$, see figure 11a. Now we define $CTE(C) : [0,1] \to \mathbb{R}$ to be the expected value23, of the values in the tail, so

$$CTE(C) = \frac{1}{1-C} \int_{\nu a R(C)}^{\infty} f(x) \cdot x \, dx.$$  \hfill (4.4)

Now we denote the RA calculated using CTE with $\mathcal{R}_A_{CTE}(\Gamma, C) : \mathbb{R}^{[0,1]} \times [0,1] \to \mathbb{R}$ and we define $\mathcal{R}_A_{CTE}(\Gamma, C)$ to be the difference between $\Gamma(CTE(C))$ and $\Gamma(\mu)$, see figure 11b. Thus,

$$\mathcal{R}_A_{CTE}(\Gamma, C) = \Gamma(CTE(C)) - \Gamma(\mu).$$ \hfill (4.5)

See example 3 for an explanation of how to calculate this value.

One should again see $\Gamma(\mu)$ as the PV of all expected future cash-flows and for CTE one should see $\Gamma(CTE(C))$ as the PV of all expected future cash-flows in case of a shock. The reasoning behind this technique is again that the RA is the extra amount that would be needed to pay the insurers expenses in case of a shock.

---

23The average.
Note that $\text{CTE}(0) = \frac{1}{\Gamma_0} \int_{\text{VaR}(0)}^{\infty} f(x) \cdot dx = \int_{-\infty}^{\infty} f(x) \cdot x \cdot dx = \mu$, so $\mathcal{RA}_{\text{CTE}}(\Gamma, C) \geq 0$ for all $\Gamma$ and all $C$.

Figure 11: The CTE technique.

Note that from the definitions of $\mathcal{RA}_{\text{VaR}}$ and $\mathcal{RA}_{\text{CTE}}$ it follows that $\mathcal{RA}_{\text{VaR}}(\Gamma, C) \leq \mathcal{RA}_{\text{CTE}}(\Gamma, C)$ for all $\Gamma \in \mathbb{R}$ and all $C \in [0, 1]$. This can also be seen in figure 11b.

**Example 3**

Looking at the contract in example 2, we will now calculate the RA using CTE.

We find $\text{CTE}(0, 7) \approx 0, 92$. This can be calculated using formula 4.10. This means that in case of a shock the insurer expects an expense of $0, 92 \cdot 100 = 92$. This gives $\Gamma(\mu) = \frac{92}{1+0, 02} \approx 90, 20$.

This gives $\mathcal{RA}_{\text{CTE}}(\Gamma, C) = 90, 20 - 78, 43 = 11, 76$.

4.6.3 CoC

The RA calculated using the Cost of Capital technique (CoC) is defined as follows. Let $C \in [0, 1]$ be the confidence level and $B \in [0, 1]$ the capital rate\(^{24}\), then we denote the RA calculated using CoC with $\mathcal{RA}_{\text{CoC}}(\Gamma, C, B) : \mathbb{R}^{[0, 1]} \times [0, 1] \times [0, 1] \rightarrow \mathbb{R}$ and we define $\mathcal{RA}_{\text{CoC}}(\Gamma, C, B)$ to be the following

$$\mathcal{RA}_{\text{CoC}}(\Gamma, C, B) = B \cdot \sum_{t \geq 0} \mathcal{P}_{t}(\Gamma_t(\text{VaR}(C)) - \Gamma_t(\mu)). \quad (4.6)$$

See example 4 for an explanation of how to calculate this value.

\(^{24}\)The capital rate can be seen as the percentage of profit that could be made from an amount of capital by investing it.
One could see this technique in the following way. For all future years that lie in the cover period of the contract, the RA is calculated using $\text{VaR}^{25}$. The present value of all these values is calculated, these are added together and the result is multiplied with the capital rate. The resulting RA can thus be seen as the capital rate times the sum of, for all future years, the difference between the average future cash-flows and the future cash-flows in case of a shock.

Note that $\mathcal{R}A_{C\text{CoC}}(\Gamma, C, B)$ could be smaller than zero if for too many $t$ it holds that if $\Gamma_t(VaR(C)) < \Gamma_t(\mu)$. One should be careful with this when using CoC.

**Example 4**

Looking at the contract in example 2, we will now calculate the RA using CoC. A capital rate of 0.06 will be used.

The contract has a duration of one year, so we find $\mathcal{R}A_{C\text{CoC}}(\Gamma, C, B) = B \cdot P_{0,0}(\Gamma_0(\text{VaR}(C)) - \Gamma_0(\mu))$. Note that $P_{0,0}(x) = x$, so $\mathcal{R}A_{C\text{CoC}}(\Gamma, C, B) = B \cdot (\Gamma(\text{VaR}(C)) - \Gamma(\mu)) = 0.06 \cdot (85,33 - 78,43) = 0,29$.

An example with multiple years should thus be more realistic, however we first need some more understanding about calculating the present value over multiple years, so this example (example 6) can be found in section 4.8.6.

### 4.6.4 Comparing the techniques

The VaR technique has the easiest calculation which means it is the easiest to use, and it is also the easiest to explain what happens here. A disadvantage with this technique is that it ignores all results higher than the chosen confidence level, which is a problem, especially if the distribution has heavy tails \[15\]. However, because we are talking about the distribution of a probability, which always lies between zero and one, these tails cannot be that heavy. However, when the mean is closer to zero, the right tail could be heavier than when the tail is closer to one. We can conclude that one should especially pay attention to this when working with probabilities with low means.

Note that the VaR technique is not a statistical coherent measure. A *statistical coherent measure* $f(x)$ satisfies all following properties.

1. Monotony: if $x \leq y$, then $f(x) \leq f(y)$;  
2. Sub-additivity: $f(x + y) \leq f(x) + f(y)$;  
3. Homogeneity: $\forall a > 0 : f(ax) \leq a \cdot f(x)$;  
4. Translation invariance: $\forall a$ constant: $f(x + a) = f(x) + a$.

The VaR technique is not sub-additive. Taking $x = y = \frac{1}{2}$ we get $\text{VaR}(x + y) = \text{VaR}(1)$ and $\text{VaR}(x) + \text{VaR}(y) = 2 \cdot \text{VaR}(\frac{1}{2})$. In Figure 12 we see that for the given distribution we have $\text{VaR}(1) > 2 \cdot \text{VaR}(\frac{1}{2})$, so VaR is not sub additive. This means one could have $\text{VaR}(A + B) > \text{VaR}(A) + \text{VaR}(B)$, which implies that a RA calculated for a higher confidence level might be too high.

\[25\]Note that in any of these years, this means that for that moment the PV is calculated for the cash-flows that at that moment lie in the future.
In contrast to the VaR technique, the CTE technique does take into account the extreme values in the tail, because it takes into account the expected value of all outcomes beyond the chosen threshold. This means that CTE better fits distributions with heavier tails. A disadvantage of this technique is that only the right hand tail of the distribution, i.e. the more extreme unfavourable outcomes, are included in the risk measure.

Calculating the RA using CTE might be complicated. Especially with more complicated distributions, the integral in the definition of \( CTE(C) \) is complicated to solve and might not even be solvable.

If an insurer applies the CTE technique on actual data, this is not a problem because then they can derive the CTE directly from the data by calculating the average of the \((1 - C)\)% highest values. This might also not be correct though because higher, more unlikely values are often not part of a random dataset, which could give a distorted result.

CTE is a statistical coherent measure, which is an argument for it being more suitable than VaR.

All in all, CTE is a valuable measure if the right tail of the distribution is known and heavy. However, from a consistency perspective VaR may be more desired as it is not driven by the shape of the tail which could be volatile and unpredictable [15].

The concept of CoC is based around the amount of capital an insurer must hold for bearing a risk with unknown consequences. For each future year the PV of the total needed capital is calculated times a capital rate. This way the RA calculated using CoC represents the amount of return investors require to be compensated for providing capital to the insurer.

For the CoC technique, usually a much higher confidence level is chosen than for the VaR and CTE technique [13]. This means only a very small part of the tail values will be ignored.

A disadvantage of this technique is that it relies on yet another (potentially unknown) variable, the capital rate. However, this does also give the insurance company more freedom [15]. Furthermore the CoC technique is also not a statistical coherent measure, since it is calculated using \( VaR(C) \), which is not statistical coherent.

4.6.5 Deriving a confidence level

As mentioned in section 4.2, if a technique other than VaR is used, IFRS 17 demands that a confidence level should be derived from the results of the used technique. This should be done in such a way that the derived confidence level of the calculated RA will result in the same RA if the
VaR technique were used\textsuperscript{26}.

As mentioned in section 4.6.1 and shown in figure 9a, \( \text{VaR}(C) \) is the value such that \( C\% \) of the distribution of \( p \) lies to the left of \( \text{VaR}(C) \). This is considered to directly translate to the cash-flows, so \( \Gamma(\text{VaR}(C)) \) is the value such that \( C\% \) of the distribution of the future cash-flows lies to the left of \( \Gamma(\text{VaR}(C)) \), see figure 13.

\textit{Figure 13: The distribution of the future cash-flows and the RA calculated using VaR.}

The derived confidence level can be calculated in the following way. Derive or assume a distribution and a standard deviation for the future cash-flows. The mean of this distribution should be \( \Gamma \). We denote the probability density function of this distribution with \( g(x) \). Now the derived confidence level, \( C_d \) is the percentage of the distribution that lies to the left of \( \Gamma + \mathcal{R}A \). This means that \( C_d \) can be calculated using

\[
C_d = \int_{-\infty}^{\Gamma + \mathcal{R}A} g(x) \, dx. \tag{4.7}
\]

The application and results of this theory can be found in section 4.8.14.

4.7 \textbf{What are suitable dependency structures between the relevant risks?}

Here we look at several dependency structures between the risks. The RA will be calculated per insurance type, per risk, after which all resulting RAs have to be merged into one RA for the entire group. From table 1 it follows that the separate RAs that will be calculated will be:

- the RA for mortality risk in term life insurance;
- the RA for lapse risk in term life insurance;
- the RA for longevity risk in immediate annuity;
- the RA for longevity risk in insured pension;
- the RA for lapse risk in insured pension;
- the RA for disability risk in disability insurance.

RAs that are calculated for the same risk, are 100\% correlated, so between these there are no diversification benefits, which implies that these can just be added together. This means adding up the RA for longevity risk in immediate annuity and the RA for longevity risk in insured pension.

\textsuperscript{26}In mathematical terms: if the CTE technique was used to calculate the RA for an insurance contract with PV of all future cash-flows is \( \Gamma \) and using an applied confidence level of \( C \), then the derived confidence level \( C_d \) should chosen in such a way that it holds \( \mathcal{R}A_{CTE}(C) = \mathcal{R}A_{\text{VaR}}(C_d) \).
This gives one RA for longevity risk. Furthermore it means adding up the RA for lapse risk in term life insurance and the RA for lapse risk in insured pension. This gives one RA for lapse risk.

Now there are four RAs, one for each risk. We denote these by $\mathcal{R}A_{\text{mor}}$, $\mathcal{R}A_{\text{long}}$, $\mathcal{R}A_{\text{lap}}$ and $\mathcal{R}A_{\text{dis}}$. Merging these into one RA can be done using the following techniques.

- Simple sum
- Correlations
- Correlations at zero
- Copulas

These will be explained below.

4.7.1 Simple sum

The first an most simple way to combine all RAs is to add them all up, so

$$\mathcal{R}A = \mathcal{R}A_{\text{mor}} + \mathcal{R}A_{\text{long}} + \mathcal{R}A_{\text{lap}} + \mathcal{R}A_{\text{dis}}.$$ 

Note that for this technique, no diversification is taken into account, so it is considered less suitable.

4.7.2 Correlations

We combine the RAs using a correlation matrix. A correlation factor between each two risks $x$ and $y$ is derived. This factor is denoted by $\operatorname{corr}_{x,y}$, so for example we call the correlation factor between mortality an longevity risk $\operatorname{corr}_{\text{mor},\text{long}}$. Note that in general we have $\operatorname{corr}_{x,y} = \operatorname{corr}_{y,x}$. Denoting the correlation matrix with $M$ we find

$$M = \begin{pmatrix}
\operatorname{corr}_{\text{mor},\text{mor}} & \operatorname{corr}_{\text{mor},\text{long}} & \operatorname{corr}_{\text{mor},\text{lap}} & \operatorname{corr}_{\text{mor},\text{dis}} \\
\operatorname{corr}_{\text{long},\text{mor}} & \operatorname{corr}_{\text{long},\text{long}} & \operatorname{corr}_{\text{long},\text{lap}} & \operatorname{corr}_{\text{long},\text{dis}} \\
\operatorname{corr}_{\text{lap},\text{mor}} & \operatorname{corr}_{\text{lap},\text{long}} & \operatorname{corr}_{\text{lap},\text{lap}} & \operatorname{corr}_{\text{lap},\text{dis}} \\
\operatorname{corr}_{\text{dis},\text{mor}} & \operatorname{corr}_{\text{dis},\text{long}} & \operatorname{corr}_{\text{dis},\text{lap}} & \operatorname{corr}_{\text{dis},\text{dis}}
\end{pmatrix}.$$ 

We denote the row vector $(\mathcal{R}A_{\text{mor}}, \mathcal{R}A_{\text{long}}, \mathcal{R}A_{\text{lap}}, \mathcal{R}A_{\text{dis}})$ with $v$. We can now compute the combined RA using

$$\mathcal{R}A = \sqrt{v' M v}.$$ 

In table 2 one can find the correlations that are used in solvency II [17].

Note that putting all correlation factors at 1 will result in the same computation as simple sum. This is shown in the following equations.
\[ \mathcal{RA} = \sqrt{vMv^t} \]

\[
= \sqrt{(\mathcal{RA}_{\text{mor}}, \mathcal{RA}_{\text{long}}, \mathcal{RA}_{\text{lap}}, \mathcal{RA}_{\text{dis}}) (\begin{bmatrix}
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
1 & 1 & 1 & 1 \\
\end{bmatrix})^t}
\]

\[
= \sqrt{(\mathcal{RA}_{\text{mor}} + \mathcal{RA}_{\text{long}} + \mathcal{RA}_{\text{lap}} + \mathcal{RA}_{\text{dis}}, \mathcal{RA}_{\text{mor}} + \mathcal{RA}_{\text{long}} + \mathcal{RA}_{\text{lap}} + \mathcal{RA}_{\text{dis}})}
\]

\[
= \sqrt{(\mathcal{RA}_{\text{mor}} + \mathcal{RA}_{\text{long}} + \mathcal{RA}_{\text{lap}} + \mathcal{RA}_{\text{dis})}^2}
\]

\[= \mathcal{RA}_{\text{mor}} + \mathcal{RA}_{\text{long}} + \mathcal{RA}_{\text{lap}} + \mathcal{RA}_{\text{dis}}.\]

4.7.3 Correlations at zero

This technique uses the same calculation as the correlation technique, but now we define \( \text{corr}_{x,x} = 1 \) and \( \text{corr}_{x,y} = 0 \) for all \( x \neq y \). This gives

\[
M = \begin{pmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 \\
\end{pmatrix},
\]

which implies

\[ \mathcal{RA} = \sqrt{vMv^t} \]

\[
= \sqrt{(\mathcal{RA}_{\text{mor}}, \mathcal{RA}_{\text{long}}, \mathcal{RA}_{\text{lap}}, \mathcal{RA}_{\text{dis}}) (\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 \\
\end{bmatrix})^t}
\]

\[
= \sqrt{(\mathcal{RA}_{\text{mor}}, \mathcal{RA}_{\text{long}}, \mathcal{RA}_{\text{lap}}, \mathcal{RA}_{\text{dis}}) \cdot (\mathcal{RA}_{\text{mor}}, \mathcal{RA}_{\text{long}}, \mathcal{RA}_{\text{lap}}, \mathcal{RA}_{\text{dis}})}^t
\]

\[= \sqrt{\mathcal{RA}_{\text{mor}}^2 + \mathcal{RA}_{\text{long}}^2 + \mathcal{RA}_{\text{lap}}^2 + \mathcal{RA}_{\text{dis}}^2,\]

Note that for this technique it is assumed that all risks are not correlated, which might give a distorted picture of reality, which means that this technique is considered less suitable.
4.7.4 Gaussian copulas

A copula is a multivariate probability distribution for which the marginal-probability distribution of each variable is uniform. Copulas are used to describe the dependence between random variables [38]. A Gaussian copula is a distribution over the unit cube $[0, 1]^d$. This is considered too complex and not explainable to, and understandable for, users. Therefore it will not be further researched in this study.

There can be many other risk dependency structures, such as various forms of copulas. However, it is considered that these dependency structures will very quickly become too complex to explain to users of financial statements. Therefore they are not further considered for this research.

Insurance companies may develop their own dependency structures and estimate the correlations between risks based on experience data and expert judgement. Since this research does not have such information, we use the Solvency II assumed correlations between risks as given in table 2, since in our case these are most explainable.

4.8 What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA?

We will make a model that can compute the RA for term life insurance, immediate annuity, insured pension and disability insurance. For these insurance products we will compute the RA for the risks as shown in table 1.

4.8.1 Mortality risk

The only insurance that is subject to mortality risk is term life insurance. The cash-flows of this insurance depend on the mortality rate, see section 4.8.8, which is denoted by $q_x(y)$. Here $q_x(y)$ is defined as the probability that a person who has age $x$ in year $y$ will pass away in one year. The mortality rates that were used can be found at the web-page of the “Koninklijk Actuarieel Genootschap” [34]. There are separate mortality rates for men and women. Note that $y$ is in this case the current year, so $y \in \{\text{YearStartContract}, \ldots, \text{YearEndContract}\}$. For example, for the second year of a contract that was closed on in 2018 we have $y = 2019$. This is necessary because mortality rates are dependent on the year.

4.8.2 Longevity risk

Both immediate annuity and insured pension are subject to longevity risk. The cash-flows of these insurance products depend on the $n$ year survival rate, see sections 4.8.9 and 4.8.10, which is denoted with $n p_x(y)$. Here $n p_x(y)$ is defined as the probability that a person who has age $x$ in year $y$ will still be alive $n$ years after year $y$. We can calculate $n p_x(y)$ from $q_x(y)$ using

$$n p_x(y) = \prod_{i=0}^{n-1} (1 - q_{x+i}(y+i)).$$

Longevity risk also changes over time, so from the definition of $n p_x(y)$ it follows that we usually have $y$ is the year in which the contract started.
When calculating the PV of all future cash-flows in case of a shock, we do not directly shock \( nP_x(y) \), but we shock the \( q_x(y) \) and recalculate \( nP_x(y) \) with the shocked \( q_x(y) \). We will now give an example to explain how to do this.

**Example 5**

Assume it is 2018 and we have a contract with a duration of two years where the insurer has to pay out \( \text{€}100 \) each year in case the client is still alive. There is one male client who has an age of 60 years. Assume \( q_{60}(2018) = 0.007 \) and \( q_{61}(2019) = 0.008 \) for males and \( q_x(y) \) is normally distributed with a standard deviation of 0.01. We will calculate the RA using the VaR technique with a confidence level of 0.7. For this example we ignore the time value of money.

We find

\[
1p_{60}(2018) = \prod_{i=0}^{0} (1 - q_{60+i}(2018 + i)) = 1 - q_{60}(2018) = 1 - 0.007 = 0.993
\]

and

\[
2p_{60}(2018) = \prod_{i=0}^{1} (1 - q_{60+i}(2018 + i)) = (1 - q_{60}(2018)) \cdot (1 - q_{61}(2019)) = (1 - 0.007) \cdot (1 - 0.008) = 0.993 \cdot 0.992 \approx 0.985.
\]

This gives \( \Gamma(\mu) = 0.993 \cdot 100 + 0.985 \cdot 100 = 197.8 \).

Note that we should shock the probability that increases if and only if the cash-flows increase, as mentioned in section 4.6.1. If \( q_x(y) \) increases, people will die sooner, so the insurer has to pay out less, so the liability cash-flows will decrease. This means we should shock \( 1 - q_x(y) \), the probability that a person who has age \( x \) in year \( y \) will not pass away in one year. If we increase this value, people will live longer and thus the liability cash-flows will increase. For \( 1 - q_{60}(2018) \) we find \( \text{VaR}(0.7) \approx 0.998 \) and for \( 1 - q_{61}(2019) \) we find \( \text{VaR}(0.7) \approx 0.997 \). We denote the shocked \( nP_x(y) \) with \( nP_x(y) \).

We find

\[
1p_{60}(2018) = 0.998
\]

and

\[
2p_{60}(2018) = 0.998 \cdot 0.997 \approx 0.995.
\]

This gives \( \Gamma(\text{VaR}(0.7)) = 0.998 \cdot 100 + 0.995 \cdot 100 = 199.3 \).

Combining all results we find \( \mathcal{R}_A(\text{VaR}(0.7), C) = 199.3 - 197.8 = 1.5 \).
4.8.3 Lapse risk

Both term life insurance and insured pension are subject to lapse risk. The cash-flows of these insurance products depend on the lapse rate and the “not lapsed rate”, see sections 4.8.8 and 4.8.10, which are respectively denoted with $l(y)$ and $k(y)$. Here $l(y)$ is defined as the probability that a client lapses after precisely $y$ years and $k(y)$ is defined as the probability that a client has not lapsed after $y$ years. Note that $k(y)$ can be calculated from $l(y)$ using

$$k(y) = \prod_{i=1}^{y} (1 - l(i)).$$

Lapse rates depend much on the product and the clients in the portfolio. Therefore their progress over time is hard to predict. For simplicity we have chosen to set all $l(y)$ at the same value.

Lapse rates are not time dependent, so here $y \in \{1, \ldots, \text{DurationContract}\}$. For example for the second year of a contract that was closed on in 2018 we have $y = 2$.

When calculating the PV of all future cash-flows in case of a shock, we also do not directly shock $k(y)$, but we shock the $l(y)$ and recalculate $k(y)$ with the shocked $l(y)$.

It is decided to not include lapse risk when running the model. Many assumptions had to be made about lapse and we were afraid that this would muddle the results. Another reason was that the inclusion of lapse had many effect on the results. When people can lapse, contracts will terminate earlier and the effects of other risks will be reduced. This can be seen in appendix A.1, figures 16 and 17. The cash-flows with lapse are much less extreme than the ones without.

4.8.4 Disability risk

The only insurance that is subject to disability risk is the disability insurance. The cash-flows of these insurance products depend on the possibility that someone is disabled, which is calculated using the disability rate and “cumulative not recovered rate”, see section 4.8.11. These two rates are respectively denoted with $i_x$ and $n_{sx}C$. Here $i_x$ is defined as the probability that a healthy $x$ year old person becomes disabled within the next year and $n_{sx}C$ is defined as the probability that a disabled $x$ year old person has not recovered after $n$ years of being disabled.

In order to calculate $n_{sx}C$ we need two more variables. We define the “not recovered rate”, $n_{sx}$ as the probability that a disabled $x$ year old person does not recover precisely $n$ years after he/she became disabled. Note that $n_{sx}C$ can be calculated from $n_{sx}$ using

$$n_{sx}C = \prod_{i=1}^{n} i_{sx-n+i}.$$ (4.8)

We also define the recovery rate, $r_{sx}$ as the probability that a disabled $x$ year old person has recovered after precisely $n$ years of being disabled. Note that $n_{sx}$ can be calculated from $n_{sx}$ using $n_{sx} = 1 - n_{sx}$. When calculating the PV of all future cash-flows in case of a shock, we also do not directly shock $n_{sx}C(y)$, but we shock the $n_{sx}$ and recalculate $n_{sx}C(y)$ with the shocked $n_{sx}$.

The disability and recovery rates that we have used can be found in the KAZO table published by the “verbond van verzekeraars” (Verbond van verzekeraars, personal communication, April, 2018).

4.8.5 Distributions

The two distributions that are used for all risks are the normal and log-normal distribution. To use the log-normal distribution, the mean and standard deviation need to be converted to log-normal.
variables. This can be done as follows. Let $m$ and $s$ be the normally distributed mean and standard deviation, then the log-normal mean and standard deviation, $\mu$ and $\sigma$ are [39]:

$$\mu = \ln \left( \frac{m}{\sqrt{1 + \left( \frac{s}{m} \right)^2}} \right)$$

$$\sigma = \sqrt{\ln \left( 1 + \left( \frac{s}{m} \right)^2 \right)}.$$

Now we show how to calculate $VaR(C)$ for both distributions. In order to do this we need their respective probability density functions. For the normal distribution this is

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{x-\mu}{\sigma} \right)^2},$$

and for the log-normal distribution it is

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{\ln(x) - \mu}{\sigma} \right)^2}.$$

**Normal distribution**

Equation 4.2 gives the following,

$$\int_{-\infty}^{VaR(C)} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{x-\mu}{\sigma} \right)^2} dx = C;$$

$$\frac{1}{2} \left( 1 + \text{erf} \left( \frac{VaR(C) - \mu}{\sigma\sqrt{2}} \right) \right) = C;$$

$$\text{erf} \left( \frac{VaR(C) - \mu}{\sigma\sqrt{2}} \right) = 2C - 1;$$

$$\frac{VaR(C) - \mu}{\sigma\sqrt{2}} = \text{erf}^{-1}(2C - 1);$$

$$VaR(C) = \sigma\sqrt{2} \cdot \text{erf}^{-1}(2C - 1) + \mu.$$  (4.9)

Here erf is the error function and erf$^{-1}$ is the inverse of the error function. The error function is defined as $\text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_{-x}^{x} e^{-t^2} dt$.

**Log-normal distribution**

Equation 4.2 gives the following,

$$\int_{-\infty}^{VaR(C)} \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{\ln(x) - \mu}{\sigma} \right)^2} dx = C;$$

$$\frac{1}{2} + \frac{1}{2} \cdot \text{erf} \left( \frac{VaR(C) - \mu}{\sigma\sqrt{2}} \right) = C;$$

$$\text{erf} \left( \frac{VaR(C) - \mu}{\sigma\sqrt{2}} \right) = 2(C + \frac{1}{2});$$

$$\frac{VaR(C) - \mu}{\sigma\sqrt{2}} = \text{erf}^{-1}(2C + 1);$$

$$VaR(C) = \sigma\sqrt{2} \cdot \text{erf}^{-1}(2C + 1) + \mu.$$
Now we have found how to calculate $\mathcal{V}aR(C)$ for both distributions.

In order to calculate $\mathcal{R.A}_{CTE}(\Gamma, C)$, we have to calculate $CTE(C)$ which can be done using equation 4.4. We will now calculate $CTE(C)$ for the normal and log-normal distribution.

**Normal distribution**

Equation 4.4 gives the following,

$$CTE(C) = \frac{1}{1-C} \int_{\mathcal{V}aR(C)}^{\infty} \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{(x-\mu)}{\sigma} \right)^2} \cdot x \, dx.$$  

Substituting $y = \frac{x-\mu}{\sigma}$ which gives $x = \sigma y + \mu$, so $\frac{dx}{dy} = \sigma$ which gives $dx = \sigma \cdot dy$, we find

$$CTE(C) = \frac{1}{1-C} \int_{\mathcal{V}aR(C)-\mu}^{\infty} \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{1}{2} y^2} \cdot (\sigma y + \mu) \cdot \sigma \, dy$$

$$= \frac{1}{(1-C)\sqrt{2\pi}} \int_{\mathcal{V}aR(C)-\mu}^{\infty} e^{-\frac{1}{2} y^2} \cdot (\sigma y + \mu) \, dy$$

$$= \frac{1}{(1-C)\sqrt{2\pi}} \left( \int_{\mathcal{V}aR(C)-\mu}^{\infty} e^{-\frac{1}{2} y^2} \cdot \sigma \cdot y \, dy + \int_{\mathcal{V}aR(C)-\mu}^{\infty} e^{-\frac{1}{2} y^2} \cdot \mu \, dy \right)$$

$$= \frac{1}{(1-C)\sqrt{2\pi}} \left( \sigma \int_{\mathcal{V}aR(C)-\mu}^{\infty} e^{-\frac{1}{2} y^2} \cdot y \, dy + \mu \int_{\mathcal{V}aR(C)-\mu}^{\infty} e^{-\frac{1}{2} y^2} \, dy \right)$$

$$= \frac{1}{(1-C)\sqrt{2\pi}} \left( \sigma e^{-\left(\frac{(V\mathcal{a}R(C)-\mu)^2}{2\sigma^2}\right)} + \mu \cdot \sqrt{\pi} \cdot \text{erfc}\left(\frac{V\mathcal{a}R(C)-\mu}{\mu \sqrt{2}}\right) \right)$$

$$= \frac{\sigma}{(1-C)\sqrt{2\pi}} e^{-\left(\frac{(V\mathcal{a}R(C)-\mu)^2}{2\sigma^2}\right)} + \frac{\mu}{2(1-C)} \cdot \text{erfc}\left(\frac{V\mathcal{a}R(C)-\mu}{\mu \sqrt{2}}\right). \tag{4.10}$$

Here erfc is the complementary error function, which is defined as follows $\text{erfc}(x) = 1-\text{erf}(x)$.

**Log-normal distribution**

Equation 4.4 gives the following,

$$CTE(C) = \frac{1}{1-C} \int_{\mathcal{V}aR(C)}^{\infty} \frac{1}{x \sigma \sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{\ln(x)-\mu}{\sigma} \right)^2} \cdot x \, dx.$$  

Substituting $y = \ln(x)$ which gives $x = e^y$, so $\frac{dx}{dy} = e^y$ which gives $dx = e^y \cdot dy$, we find

$$CTE(C) = \frac{1}{1-C} \int_{\ln(V\mathcal{a}R(C))}^{\infty} \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{1}{2} \left( \frac{\ln(x)-\mu}{\sigma} \right)^2} \cdot e^y \, dy$$

$$= \frac{1}{(1-C)\sigma \sqrt{2\pi}} \left[ \frac{\sqrt{\pi}}{\sigma} \cdot \left( -\text{erf}\left( \frac{\mu + \sigma^2 - y}{\sigma \sqrt{2}} \right) \right) \right]_{\ln(V\mathcal{a}R(C))}^{\infty}$$

$$= \frac{-1}{2(1-C)} e^{\mu + \frac{\sigma^2}{2}} \left( -1 - \text{erf}\left( \frac{\mu + \sigma^2 - \ln(V\mathcal{a}R(C))}{\sigma \sqrt{2}} \right) \right)$$

$$= \frac{1}{2(1-C)} e^{\mu + \frac{\sigma^2}{2}} \left( 1 + \text{erf}\left( \frac{\mu + \sigma^2 - \ln(V\mathcal{a}R(C))}{\sigma \sqrt{2}} \right) \right).$$

Now we can also calculate $CTE(C)$ for both distributions.

In sections 4.8.8, 4.8.9, 4.8.10 and 4.8.11 we will use the found calculations for $V\mathcal{a}R(C)$ and $CTE(C)$ to derive how to calculate $\Gamma$ for all insurance products.
### 4.8.6 Discounting

In order to calculate the RA, Γ needs to be calculated. Recall that Γ is the PV of expected insurance contract cash-flows, so after calculating the expected insurance contract cash-flows, their present value has to be calculated. We will now mathematically derive how the present value can be calculated.

For each year \( n \), let \( a_n \) represent the current interest rate for \( n \) year, so \( P_{0,t}(x) = x(1+a_t)^t \). Furthermore we find \( P_{0,r}(x) = P_{0,s}(x) \cdot P_{r-s}(x) \) for all \( s < r \). Therefore \( P_{s,t}(x) = P_{0,s}(x) + t(x) \cdot P_{0,s}(x) \) for all \( s < t \).

Note that \( P_{0,t}(x) = x(1+a_t)^t = x \cdot P_{0,t}(1) \), so we can calculate the PV in year zero of any value in year \( t \) by multiplying it with \( P_{0,t}(1) \). Furthermore we find \( P_{s,t}(x) = x \cdot P_{s,t}(1) \), so we can calculate the PV in year \( s \) of any value in year \( t \) by multiplying \( x \) with \( P_{s,t}(1) \). For easier notation we write \( d_{s,t} = P_{s,t}(1) \).

The interest rates that were used for this research can be found on the web-page of EIOPA [40].

Using this method of calculating \( P_{s,t}(x) \), we will now give an example for calculating the RA using CoC for a contract with a duration of more than one year.

**Example 6**

Assume that there is one client and the contract has a duration of three years. Each year the insurer has to pay out \( e^{100} \) in case the insured is alive. For this contract all premiums have already been paid. Assume the predicted probability of survival for all years is 0.8, so \( n_p(x,y) = 0.8 \) for all \( n,x \) and \( y \). For simplicity we will not calculate the shock via \( q(x,y) \) in this example, but directly using \( n_p(x,y) \). Assume \( n_p(x,y) \) is normally distributed with a standard deviation of 0.1. Furthermore we apply a confidence level of 0.7 and a capital rate of 0.06. Lastly we assume the one year interest rate is 0.01, the two year interest rate is 0.02 per year and the three year interest rate is 0.03 per year.

First we calculate \( d_{0,1} = \frac{1}{(1+0.01)} \approx 0.99 \). In a similar way we calculate \( d_{0,2} \) and \( d_{0,3} \) after which we can calculate \( d_{s,t} \) for all \( 0 < s < t \leq 3 \) using \( d_{s,t} = \frac{d_{0,s}}{d_{0,t}} \). The results are shown in table 3.

<table>
<thead>
<tr>
<th>( s )</th>
<th>( t )</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.99</td>
<td>0.96</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.97</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each year we expect that the insurance company has to pay out \( 0.8 \cdot 100 = 80 \) (note this is not the PV). We find \( VaR(0.7) \approx 0.85 \). This means that in case of a shock, the insurer expects an expense of \( 0.85 \cdot 100 = 85 \) each year (again this is not the PV).

Equation 4.6 gives \( RaCoC(\Gamma, C, B) = B \cdot \sum_{t=0}^{2} P_{0,t}(VaR(C) - \Gamma_t(\mu)) \). We calculate this for each \( t \) separately.
We repeat this calculation for $t=1$ and $t=2$. The results are shown in table 4.

<table>
<thead>
<tr>
<th>$d_{0,t}(\Gamma_t(VaR(C)) - \Gamma_t(\mu))$</th>
<th>t=0</th>
<th>t=1</th>
<th>t=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_{0,0}(\Gamma_0(VaR(C)) - \Gamma_0(\mu))$</td>
<td>$14.35$</td>
<td>$9.3555$</td>
<td>$4.56$</td>
</tr>
</tbody>
</table>

Now we find $\mathcal{R}A_{CoC}(\Gamma, C, B) = B \cdot \sum_{t=0}^{2} P_{0,t}(\Gamma_t(VaR(C)) - \Gamma_t(\mu)) = 0.06 \cdot (14.35 + 9.3555 + 4.56) \approx 1.70$.

Note that the resulting RA is still relatively small, this is because three years is still relatively short. However, one can see from this example that the more years, the higher the RA calculated using CoC.

### 4.8.7 Starting assumptions for the modelling of cash-flows from insurance products

For all insurance products we note the following:

- The RA is a liability and since it is preferable to see the RA as a positive variable, we calculate all liabilities as positive values and all assets as negative values.
- All periodic premiums and pay-outs occur on a yearly basis.
- Immediate annuity is the only insurance were the client pays a one time lump sum. This means that for this insurance the uncertainty in future cash-flows is only in expenses, which means we do not need the lump sum for the calculation of the RA\(^{27}\).
- For all other insurance products we do need the premium in order to calculate the future cash-flows. This premium will be calculated in the following way. First the premium will be calculated in such a way that $[\text{FutureCashOutflow} - \text{FutureCashInflow}]$ equals 0, after which this sum will be multiplied with a profit factor, hereby making it so that the insurer will make profit off the contract.
- The sum that will be paid to the insured in case he/she lapses (from now on lapse sum) is calculated as the total amount of premium that is paid at that moment, times a lapse percentage.
- As described in section 4.5, the factor that gives uncertainty to the cash-flows is usually a probability, so $\mu$ is a probability, which means that $VaR(C)$ and $CTE(C)$ should also be a probabilities. However, with the calculation methods for $VaR(C)$ and $CTE(C)$ that are given in section 4.6 it is not given that $VaR(C)$ nor $CTE(C)$ will not be bigger than one. In this research we have chosen to set $VaR(C)$ and $CTE(C)$ at one in case the calculated value is bigger than one\(^{28}\).

\(^{27}\)The lump sum was already paid, so this is not part of the future cash-flows.

\(^{28}\)It turns out that with the chosen standard deviation, this happens only very rarely.
• For the standard deviation we have assumed that further in the future there is more uncertainty, so all standard deviations increase linearly over time.

• After looking into the annual reports of Dutch insurers [24] and using some expert judgement, we assumed that the relative weight of risk over the insurance products is the following,
  
  - Term life: $\frac{1}{7}$
  - Immediate annuity: $\frac{2}{7}$
  - Insured pension: $\frac{2}{7}$
  - Disability insurance: $\frac{2}{7}$

However, in order to make our model we need to have the number of clients per product, which is not mentioned in the annual reports. Using expert judgement and internal knowledge from EY we assumed the following factors for calculating the amount of clients per product from the amount of risk per product,

- Term life: 2
- Immediate annuity: 2
- Insured pension: 2
- Disability insurance: $\frac{1}{2}$

Multiplying these two results we find the following distribution of clients over the insurance products,

- Term life: $\frac{2}{11}$
- Immediate annuity: $\frac{4}{11}$
- Insured pension: $\frac{4}{11}$
- Disability insurance: $\frac{1}{11}$

From this distribution it follows that a representative amount of clients for the insurance products should be the following (multiplying all factors with $11 \cdot 50 = 550$, we chose 11 and 50 to get round values).

- Term life: 100
- Immediate annuity: 200
- Insured pension: 200
- Disability insurance: 50

This is the number of clients we have generated for the insurance products.

Now we are ready to explain the calculation for $\Gamma$ for all insurance products.

### 4.8.8 Term life insurance

For term life insurance the following policy data was generated.

- The gender of the insured, which is needed to determine $q_x(y)$ and thus $n_p_x(y)$.
- The age of the insured at the start of the contract, which is also needed to determine $q_x(y)$ and thus $n_p_x(y)$.
• The age of the insured at the end of the contract which is needed to determine the duration of the contract. In case of a lifetime term life contract, the end age is set at 122, since the mortality rates that were used, assume that no one gets older than 121 [34].

• The death benefit which is needed to calculate the future cash-flows and the premium.

For this research the policy data that was used was generated in the following way. In general, most people who purchase a term life insurance do this to insure that their surviving relatives can pay off their housing loan. People can also buy this insurance to ensure that their children can study in case they die or to replace alimony [41].

We assumed that 75% of term life insurance products is to pay off a housing loan, 12.5% is to pay for the study of ones children and 12.5% is to pay alimony. Furthermore we made the following assumptions.

• In general one could say that more men than woman would get a term life insurance because usually men pay alimony and because couples usually take out insurance on the life of the man because, statistically speaking, he would die first. We have no data to prove this however, so we chose to set the distribution of male and female insured at fifty-fifty.

• For the age of the insured at the start of the contract we assumed the following.
  – Usually people take out a housing loan when they buy their first house, so for these clients we assumed their age at the start of the contract is between 25 and 35 years old. A random number generator was used to pick a number between 25 and 35.
  – For paying for the study of ones children we assumed that people are between 25 and 40 when they get this insurance, which is around the time people get children plus a few years since one might not get this insurance immediately when their child is born.
  – For paying alimony, we assumed that people are between 35 and 45 when they buy this insurance.

• For the age of the insured at the end of the contract we assumed the following.
  – A housing loan usually has to be repaid after thirty years [42, 43], so for people who have a term life insurance to pay off a housing loan, we set the age at the end of the contract as the age at the start of the contract plus thirty years.
  – Students are on average done with their study around an age of 23 [44]. This insurance is most likely closed on when the child is between zero and ten, so we assume that the age of the insured is between 13 and 23 years older than the start age.
  – Alimony is paid for a maximum of twelve years or until the child is twenty-one years old [45]. We have no data about how old children are when their parents divorce, so we assumed that this contract always has a duration of 12 years.

• For the death benefit we assumed the following.
  – Housing loans are usually between 200,000 and 300,000 euros [46], so we set the death benefit for these clients at a random number between these values.
  – Depending on their income, people usually pay their child between 100 and 500 euros per month for their study. The average amount of children per woman is 1.7 and most studies are four years long [47]. This gives an amount of study costs between 8,160 and 40,800 euros. For most term life insurance products the minimum death benefit is 10,000 [41], so for our model we used random values between 10,000 and 40,000 euros.
Alimony is usually between 200 and 1,000 euros per month [48]. Thus for twelve years this is between 28,800 and 144,000 euros. For this research random values between 30,000 and 150,000 euros were chosen.

During the life of the contract, each year the expected expenses are the following.

- In case the insured has not yet lapsed and dies in the current year, the insurer has to pay out the death benefit.
- In case the insured is still alive and lapses in the current year, the insurer has to pay out the lapse sum as defined in 4.8.7.

This gives that the insurers expenses in year \( i \) of a term life insurance that was closed on in year \( h \) by client \( j \) who had age \( x \) in year \( h \) are the following:

\[
\text{Expense}(i, j) = i p_x(h) \cdot q_{x+i}(i + h) \cdot k(i) \cdot \text{DeathBenefit}(j) + i p_x(h) \cdot k(i - 1) \cdot l(i) \cdot \text{Premium}(j) \cdot i \cdot \text{LapsePercentage}.
\] (4.11)

In this research \( h \) will always be 2018, so for the notation it is chosen to not see \( h \) as a variable that the expense depends on.

During the life of the contract, each year the expected income is the premium, in case the client is still alive and has not lapsed, so the insurers income in year \( i \) of a term life insurance that was closed on in year \( h \) by client \( j \) who had age \( x \) in year \( h \) is the following.

\[
\text{Income}(i, j) = i p_x(h) \cdot k(i) \cdot \text{Premium}(j).
\] (4.12)

Now we can calculate \( \Gamma_t(i, j) \), the PV in year \( t \) of the insurance contract cash-flows in year \( i \) for client \( j \) (it should hold that \( t \leq i \)):

\[
\Gamma_t(i, j) = (\text{Expense}(i, j) - \text{Income}(i, j)) \cdot d_{t,i}.
\] (4.13)

Finally, using \( N = \) number of years and \( M = \) number of clients, we can calculate \( \Gamma_t \), the present value in year \( t \) of the insurance contract cash-flows.

\[
\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} \Gamma_t(i, j).
\] (4.14)

Combining equations 4.11, 4.12, 4.13 and 4.14 we find

\[
\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} (i p_x(h) \cdot q_{x+i}(i + h) \cdot k(i) \cdot \text{DeathBenefit}(j) + i p_x(h) \cdot k(i - 1) \cdot l(i) \cdot \text{Premium}(j) \cdot i \cdot \text{LapsePercentage} - i p_x(h) \cdot k(i) \cdot \text{Premium}(j)) \cdot d_{t,i}.
\] (4.15)
Now we calculate the premium for a given client $j$ as described in section 4.8.7. First we want to calculate the premium such that $[\text{FutureCashOutflow} - \text{FutureCashInflow}] = 0$, so

$$
\sum_{i=1}^{N} (\text{Expense}(i, j) \cdot d_{0,i}) = \sum_{i=1}^{N} (\text{Income}(i, j) \cdot d_{0,i}),
$$

$$
\sum_{i=1}^{N} ((p_x(h) \cdot q_{x+i}(i + h) \cdot k(i) \cdot \text{DeathBenefit}(j)) + i p_x(h) \cdot k(i - 1) \cdot l(i) \cdot \text{Premium}(j) \cdot i \cdot \text{LapsePercentage}) \cdot d_{0,i} = \sum_{i=1}^{N} (p_x(h) \cdot k(i) \cdot \text{Premium}(j) \cdot d_{0,i}),
$$

$$
\sum_{i=1}^{N} (i p_x(h) \cdot q_{x+i}(i + h) \cdot k(i) \cdot \text{DeathBenefit}(j) \cdot d_{0,i}) + \sum_{i=1}^{N} (i p_x(h) \cdot k(i - 1) \cdot l(i) \cdot i \cdot \text{LapsePercentage} \cdot d_{0,i}) \cdot \text{Premium}(j) = \sum_{i=1}^{N} (i p_x(h) \cdot k(i) \cdot \text{Premium}(j) \cdot d_{0,i}),
$$

$$
\text{Premium}(j) = \frac{\sum_{i=1}^{N} (i p_x(h) \cdot q_{x+i}(i + h) \cdot k(i) \cdot \text{DeathBenefit}(j) \cdot d_{0,i})}{\sum_{i=1}^{N} (i p_x(h) \cdot k(i) \cdot \text{Premium}(j) \cdot d_{0,i})},
$$

$$
\text{Premium}(j) = \frac{\sum_{i=1}^{N} (i p_x(h) \cdot q_{x+i}(i + h) \cdot k(i) \cdot \text{DeathBenefit}(j) \cdot d_{0,i})}{\sum_{i=1}^{N} ((k(i) - k(i - 1) \cdot l(i) \cdot i \cdot \text{LapsePercentage}) \cdot i p_x(h) \cdot d_{0,i})}.
$$

Multiplying the found premium with the profit factor, we find the premium the client has to pay.

Using the found premium and equation 4.15, the PV of all future cash-flows can be calculated. Here $\Gamma$ depends on two probabilities, namely $q_x(y)$ and $l(y)$, which is why term life insurance has both mortality and lapse risk.

Using the equations found in section 4.6, the RA can now be calculated for both risks and with all estimation techniques. We now give an example to illustrate how to do this.

**Example 7**

Assume it is 2018 and we have a term life contract with a duration of one year and a death benefit of €100 and a profit factor of 1.1. There is one male client with an age of 60 years. Assume $q_{60}(2018) = 0.007$ and $q_{61}(2019) = 0.008$ for males and $q_x(y)$ is normally distributed with a standard deviation of 0.01. For this example we assume there is no lapse, so $l(y) = 0$ and $k(y) = 1$ for all $y$.

We will calculate the RA using the VaR technique with a confidence level of 0.7. For this example we ignore the time value of money.

First we find

$$
1p_{60}(2018) = \prod_{i=0}^{0} (1 - q_{60+i}(2018 + i))
$$

$$
= 1 - q_{60}(2018)
$$

$$
= 1 - 0.007
$$

$$
= 0.993
$$

52
Now we calculate the premium.

\[
\text{Premium}(1) = \frac{\sum_{i=1}^{\infty} (i p_{60}(2018) \cdot q_{60+i}(i + 2018) \cdot 1 \cdot \text{DeathBenefit}(1))}{\sum_{i=1}^{\infty}((1 - 0) \cdot i p_{60}(2018))}
\]

\[
= \frac{1 p_{60}(2018) \cdot q_{61}(2019) \cdot 100}{1 p_{60}(2018)}
\]

\[
= q_{61}(2019) \cdot 100
\]

\[
= 0,008 \cdot 100
\]

\[
= 0.8
\]

This gives that the premium is \(0.8 \cdot 1,1 = 0.88\).

We calculate the expected future cash-flows.

\[
\Gamma = \sum_{i=1}^{\infty} \sum_{j=1}^{\infty} (i p_{60}(2018) \cdot q_{60+i}(i + 2018) \cdot 1 \cdot \text{DeathBenefit}(j) - i p_{60}(2018) \cdot 1 \cdot \text{Premium}(j))
\]

\[
= 1 p_{60}(2018) \cdot q_{61}(2019) \cdot \text{DeathBenefit}(1) - 1 p_{60}(2018) \cdot \text{Premium}(1)
\]

\[
= 0.993 \cdot 0.008 \cdot 100 - 0.993 \cdot 0.88
\]

\[
\approx -0.079.
\]

Note that since we calculate all liabilities as positive values and all assets as negative values and this is a profitable contract, it is correct that this calculation gives a negative value.

For this contract the liability cash-flows decrease in case people die younger, so one should increase \(q_x(y)\) to calculate the future cash-flows in case of a shock. For \(q_{60}(2018)\) we find \(\text{VaR}(0,7) \approx 0.012\) and for \(q_{61}(2019)\) we find \(\text{VaR}(0,7) \approx 0.013\). Now we have to calculate \(n p_x(y)\) in case of a shock, which will be denoted with \(\overline{n p_x(y)}\).

\[
\overline{1 p_{60}(2018)} = 1 - 0.0012
\]

\[
= 0.998
\]

We calculate the expected future cash-flows in case of a shock.

\[
\Gamma = 0.988 \cdot 0.013 \cdot 100 - 0.988 \cdot 0.88
\]

\[
\approx 0,415.
\]

Combining the results we find \(\text{VAR}(\Gamma, C) = 0,415 - (-0,079) = 0,494\).

**4.8.9 Immediate annuity**

For immediate annuity the following policy data was generated.

- The gender of the insured, which is needed to determine \(n p_x(y)\).
- The age of the insured at the start of the contract, which is also needed to determine \(n p_x(y)\).
- The age of the insured at the end of the contract which is needed to determine the duration of the contract.
- The transfer rate which is needed to calculate the pay-out the spouse receives in case the client has died and his/her spouse is still alive. In case of a contract where the spouse does not receive anything if the client dies, or there is no spouse, this transfer rate is set at zero.
• The age of the spouse at the start of the contract, which is needed to calculate $np_x(y)$ for the spouse.
• The pay-out that the client receives if he/she is alive, which is needed to calculate the future cash-flows.

Note that the gender of the spouse is not generated. For this research we assume that the gender of the spouse is the opposite of the gender of the client.

• We have no data that suggests that the distribution between male and female clients is not fifty-fifty, so we assumed there are equally as many males as females who purchase an immediate annuity.
• Immediate annuity is usually used to buy ones pension, so we assume the start age is 67.
• If one buys an immediate annuity for pension, one wants this insurance for the rest of ones life, so we assume the end date is 122 for all clients.
• We assume that for half of the contracts, 70% of the pay-out will be paid to the spouse of the insured in case the insured has died and his/her spouse has not.
• We assume the age difference between the insured and his/her spouse is between 0 and 5 years.
• In section 4.8.10 we find that $\text{Pension} = (\text{EndSalary} - \text{AOW}) \cdot \text{PercentageOfIncomeForPension}$. In this section we also find that the EndSalary is between 60.000 and 84.000 euros per year, AOW is between 9.000 and 12.000 euros per year and PercentageOfIncomeForPension = 0.7. This gives that a pension between 35.000 and 50.000 is a realistic estimation.

During the life of the contract, each year the expected expenses are the following.

• In case the client is still alive the insurer has to pay out.
• In case the client is not alive and the spouse is, the insurer has to pay out transfer rate times the pay-out.

This gives that the insurers expenses in year $i$ of an immediate annuity that was closed on in year $h$ by client $j$ who had age $x$ in year $h$, and whose spouse had age $z$ in year $h$ are the following.

$$\text{Expense}(i, j) = i \cdot p_x(h) \cdot \text{Payout}(j) + (1 - i \cdot p_x) \cdot i \cdot p_z \cdot \text{Transfer}(j) \cdot \text{Payout}(j). \quad (4.16)$$

Now we can calculate $\Gamma_t(i, j)$, the PV in year $t$ of the insurance contract cash-flows in year $i$ for client $j$ (it should hold that $t \leq i$).

$$\Gamma_t(i, j) = \text{Expense}(i, j) \cdot d_{t,i}. \quad (4.17)$$

Finally, using $N = \text{number of years}$ and $M = \text{number of clients}$, we can calculate $\Gamma_t$, the present value in year $t$ of the insurance contract cash-flows.

$$\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} \Gamma_t(i, j). \quad (4.18)$$

Combining equations 4.16, 4.17 and 4.18 we find

$$\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} (i \cdot p_x(h) \cdot \text{Payout}(j) + (1 - i \cdot p_x) \cdot i \cdot p_z \cdot \text{Transfer}(j) \cdot \text{Payout}(j)) \cdot d_{t,i}. \quad (4.19)$$
Using equation 4.19 the PV of all future cash-flows can be calculated. Here \( \Gamma \) depends on one probability, namely \( n_{p_x}(y) \), which is why term life insurance has only longevity risk.

Using the equations found in section 4.6, the RA can now be calculated with all estimation techniques.

### 4.8.10 Insured pension

For insured pension the following policy data was generated.

- The gender of the insured, which is needed to determine \( n_{p_x}(y) \).
- The age of the insured at the start of the contract, which is also needed to determine \( n_{p_x}(y) \).
- The retirement age of the insured which is needed to determine the future cash-flows.
- The end salary of the insured which is needed to calculate the pension.
- The AOW of the insured which is needed to calculate the pension.

Note that the client can only lapse before he/she reaches the retirement age, so for all \( y \) for which the client has reached the retirement age in year \( y \) we have \( l(y) = 0 \).

For this research the policy data that was used was generated in the following way.

- We have no data that suggests that the distribution between male and female clients is not fifty-fifty, so we assumed there are equally as many males as females who purchase an insured pension.
- People usually start their first full time job around an age of twenty-five, and until an age of fifty it is quite common to switch jobs, so the age at the start of the contract is between twenty-five and fifty.
- We assumed the retirement age is 67 for all clients.
- The end salary can differ a lot, but we chose a portfolio where all clients have about the same end salary. We picked end salaries between 5,000 and 7,000 euros per month, so between 60,000 and 84,000 euros per year.
- AOW for married people is about 9,000 euros per year and for single people it is about 12,000 euros per year [50]. We assumed that 75% of the retired people are married.

The pension is calculated as the end salary minus the AOW times a percentage, “percentage of income for pension”, which is set at 70%. The pension of client \( j \) is

\[
\text{Pension}(j) = (\text{EndSalary}(j) - \text{AOW}(j)) \cdot \text{PercentageOfIncomeForPension}.
\]

During the life of the contract, each year the expected expenses are the following.

- In case the insured has not reached the retirement age, is still alive and lapses in the current year, the insurer has to pay out the lapse sum as defined in section 4.8.7.
- In case the insured has reached the retirement age, is still alive and has not yet lapsed, the insurer has to pay out the pension.
This gives that the insurers expenses in year $i$ of an insured pension that was closed on in year $h$ by client $j$ who had age $x$ in year $h$ are the following:

$$\text{Expense}(i,j) = \begin{cases} 
  i p_x(h) \cdot k(i - 1) \cdot l(i) \cdot \text{Premium}(j) \cdot i \cdot \text{LapsePercentage} & \text{if the client is not retired in year } i; \\
  i p_x(y) \cdot k(i) \cdot \text{Pension}(j) & \text{if the client is retired in year } i. 
\end{cases}$$

(4.20)

During the life of the contract, each year the expected income is the premium in case the client has not reached his retirement age, is still alive and has not lapsed, so the insurers income in year $i$ of an insured pension that was closed on in year $h$ by client $j$ who had age $x$ in year $h$ is the following.

$$\text{Income}(i,j) = \begin{cases} 
  i p_x(h) \cdot k(i) \cdot \text{Premium}(j) & \text{if the client is not retired in year } i; \\
  0 & \text{if the client is retired in year } i. 
\end{cases}$$

(4.21)

Now we can calculate $\Gamma_t(i,j)$, the PV in year $t$ of the insurance contract cash-flows in year $i$ for client $j$ (it should hold that $t \leq i$).

$$\Gamma_t(i,j) = (\text{Expense}(i,j) - \text{Income}(i,j)) \cdot d_{t,i}. \quad \text{(4.22)}$$

Finally, using $N =$ number of years and $M =$ number of clients, we can calculate $\Gamma_t$, the present in year $t$ value of the insurance contract cash-flows.

$$\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} \Gamma_t(i,j). \quad \text{(4.23)}$$

Combining equations 4.20, 4.21, 4.22 and 4.23 and using $R =$ number of years until the client reaches the retirement age we find

$$\Gamma_t = \sum_{j=1}^{M} \left( \sum_{i=1}^{R} (i p_x(h) \cdot k(i - 1) \cdot l(i) \cdot \text{Premium}(j) \cdot i \cdot \text{LapsePercentage} - i p_x(h) \cdot k(i) \cdot \text{Premium}(j)) \right. \cdot d_{t,i} + \left. \sum_{i=R+1}^{N} (i p_x(y) \cdot k(i) \cdot \text{Pension}(j) \cdot d_{t,i}) \right). \quad \text{(4.24)}$$

Now we calculate the premium for a given client $j$ as described in section 4.8.7. First we have to calculate the premium such that $|\text{FutureCashOutflow} - \text{FutureCashInflow}| = 0$, so
\[ \sum_{i=1}^{N} (\text{Expense}(i, j) \cdot d_{0,i}) = \sum_{i=1}^{N} (\text{Income}(i, j) \cdot d_{0,i}), \]
\[ \sum_{i=1}^{R} (p_x(h) \cdot k(i-1) \cdot l(i) \cdot \text{Premium}(j) \cdot i \cdot \text{LapsePercentage} \cdot d_{0,i}) + \sum_{i=R+1}^{N} (p_x(y) \cdot k(i)) \cdot \text{Pension}(j) \cdot d_{0,i} \]
\[ \cdot \text{Premium}(j) = \sum_{i=1}^{R} (p_x(h) \cdot k(i) \cdot \text{Premium}(j) \cdot d_{0,i}), \]
\[ \sum_{i=1}^{R} (p_x(h) \cdot k(i) \cdot d_{0,i}) \cdot \text{Premium}(j) - \sum_{i=1}^{R} (p_x(h) \cdot k(i-1) \cdot l(i) \cdot i \cdot \text{LapsePercentage} \cdot d_{0,i}) \]
\[ \cdot \text{Premium}(j) = \sum_{i=R+1}^{N} (p_x(y) \cdot k(i) \cdot \text{Pension}(j) \cdot d_{0,i}), \]
\[ \sum_{i=1}^{R} (p_x(h) \cdot k(i) \cdot d_{0,i}) - p_x(h) \cdot k(i-1) \cdot l(i) \cdot i \cdot \text{LapsePercentage} \cdot d_{0,i}) \cdot \text{Premium}(j) \]
\[ = \sum_{i=R+1}^{N} (p_x(y) \cdot k(i) \cdot \text{Pension}(j) \cdot d_{0,i}), \]
\[ \text{Premium}(j) = \frac{\sum_{i=R+1}^{N} (p_x(y) \cdot k(i) \cdot \text{Pension}(j) \cdot d_{0,i})}{\sum_{i=1}^{R} (p_x(h) \cdot k(i) \cdot \text{Premium}(j) \cdot d_{0,i})}, \]
\[ \text{Premium}(j) = \frac{\sum_{i=R+1}^{N} (p_x(y) \cdot k(i) \cdot \text{Pension}(j) \cdot d_{0,i})}{\sum_{i=1}^{R} ((k(i) - k(i-1) \cdot l(i) \cdot i \cdot \text{LapsePercentage}) \cdot p_x(h) \cdot d_{0,i})}. \]

Multiplying the found premium with the profit factor, we find the premium the client has to pay. Using the found premium and equation 4.24 the PV of all future cash-flows can be calculated. Here \( \Gamma \) depends on two probabilities, namely \( n_p x (y) \) and \( l(y) \), which is why insured pension has both longevity and lapse risk.

Using the equations found in section 4.6, the RA can now be calculated for both risks and with all estimation techniques.

### 4.8.11 Disability insurance

For disability insurance the following policy data was generated.

- The age of the insured at the start of the contract, which is needed to determine \( i_x \) and \( n_s x C \).
- The age of the insured at the end of the contract which is needed to determine the duration of the contract.
- The pay-out that the client receives if he/she is disabled, which is needed to calculate the future cash-flows.

For this research the policy data that was used was generated in the following way.

- We assumed people usually start their own company at an age of between 35 and 45.
• The disability- and recovery rates that were used still assumed that everyone retires at an age of 65, so we had no disability- and recovery rates for people older than 64. Because of this we set the end of all disability insurance contracts at an age of 64.

• The pay-out for disability insurance is often set at 70% of the salary of the client [51]. The salary of a freelancer is usually below average, which is 37.000 euro per year [52]. We assumed that the salary of a freelancer is between 25.000 and 40.000 euro per year.

First we calculate \( a_x(y) \), the probability that a person who was \( x \) years old at the start of his contract, is disabled in year \( y \) of the contract. This is the sum over all years from 1 to \( y \) of the probability that the client got disabled in that year times the probability that he/she never recovered.

\[
a_x(y) = \sum_{n=x}^{x+y} (i_n \cdot x + y - n \cdot s_{x+y} C). 
\]

Note that \( x + y \) is the current age of the client and \( x + y - n \cdot s_{x+y} C \) is the probability that an \( x + y \) year old person has not recovered after \( x + y - n \) years of being disabled.

During the life of the contract, each year the expected expenses are the pay-out in case the client has been disabled for more than two years. This gives that the insurers expenses in year \( i \) of a disability insurance for client \( j \) who had age \( x \) at the start of the contract are the following.

\[
\text{Expense}(i, j) = a_x(i) \cdot a_x(i - 1) \cdot a_x(i - 2) \cdot \text{Payout}(j). \tag{4.25}
\]

During the life of the contract, each year the expected income is the premium, in case the client is not disabled. The insurers income in year \( i \) of a disability insurance for client \( j \) who had age \( x \) at the start of the contract is the following.

\[
\text{Income}(i, j) = (1 - a_x(i)) \cdot \text{Premium}(j). \tag{4.26}
\]

Now we can calculate \( \Gamma_t(i, j) \), the PV in year \( t \) of the insurance contract cash-flows in year \( i \) for client \( j \) (it should hold that \( t \leq i \)).

\[
\Gamma_t(i, j) = (\text{Expense}(i, j) - \text{Income}(i, j)) \cdot d_{t,i}. \tag{4.27}
\]

Finally, using \( N = \text{number of years} \) and \( M = \text{number of clients} \), we can calculate \( \Gamma_t \), the present value in year \( t \) of the insurance contract cash-flows.

\[
\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} \Gamma_t(i, j). \tag{4.28}
\]

Combining equations 4.25, 4.26, 4.27 and 4.28 we find

\[
\Gamma_t = \sum_{i=1}^{N} \sum_{j=1}^{M} (a_x(i) \cdot a_x(i - 1) \cdot a_x(i - 2) \cdot \text{Payout}(j) - (1 - a_x(i)) \cdot \text{Premium}(j)) \cdot d_{t,i}. \tag{4.29}
\]
Now we calculate the premium for a given client $j$ as described in section 4.8.7. First we want to calculate the premium such that $\text{FutureCashOutflow} - \text{FutureCashInflow} = 0$, so

$$
\sum_{i=1}^{N} (\text{Expense}(i, j) \cdot \text{dt}_i, i) = \sum_{i=1}^{N} (\text{Income}(i, j) \cdot \text{dt}_i, i),
$$

$$
\sum_{i=1}^{N} (a_x(i) \cdot a_x(i-1) \cdot a_x(i-2) \cdot \text{Payout}(j) \cdot \text{dt}_i, i) = \sum_{i=1}^{N} ((1 - a_x(i)) \cdot \text{Premium}(j) \cdot \text{dt}_i, i),
$$

$$
\sum_{i=1}^{N} ((1 - a_x(i)) \cdot \text{dt}_i, i) \cdot \text{Premium}(j) = \sum_{i=1}^{N} (a_x(i) \cdot a_x(i-1) \cdot a_x(i-2) \cdot \text{Payout}(j) \cdot \text{dt}_i, i),
$$

$$
\text{Premium}(j) = \frac{\sum_{i=1}^{N} (a_x(i) \cdot a_x(i-1) \cdot a_x(i-2) \cdot \text{Payout}(j) \cdot \text{dt}_i, i)}{\sum_{i=1}^{N} ((1 - a_x(i)) \cdot \text{dt}_i, i)}. 
$$

Multiplying the found premium with the profit factor, we find the premium the client has to pay. Using the found premium and equation 4.24 the PV of all future cash-flows can be calculated. Here $\Gamma$ depends on one probability, namely $a_x(y)$, which is why disability insurance only has disability risk. Using the equations found in section 4.6, the RA can now be calculated with all estimation techniques.

### 4.8.12 Checking the model

Before using our model, we should first check if it meets the criteria set in section 4.2.

1. Technically sound:
   a. Risks with low frequency and high severity should result in a higher RA than risks with a high frequency and low severity. In the model for this research, nothing was said about either the frequency or the severity of risks, this is considered to be out of scope of this research, so we cannot check our model on this criterion.
   b. Figures 18, 19, 20 and 21 in appendix A.3 show that for all insurance products the RA increases if and only if the duration increases\(^{29}\). Thus, for similar risks contracts with a longer duration will result in a higher RA than contracts with a shorter duration.
   c. Figure 28 and 29 in appendix A.5 show that if the standard deviation increases, so will the RA. This shows that risks with a wider probability distributions will result in a higher RA than risks with a narrower one.
   d. The less that is known about the current estimate and its trend, the higher should be the RA. In this research most input data is based on expert judgement, not on real clients, so we cannot check our model on this criterion.
   e. To the extent that emerging experience reduces uncertainty about the amount and timing of cash-flows, the RA should decrease and vice versa. In this research nothing was said about the amount of experience. This is considered to be out of scope of this research, so we cannot check our model on this criterion.

2. Consistent: The interest rates that were used in the model are real market values. We have no actual policyholders, so nothing is known about their behaviour. This means we could only partially check this criterion.

\(^{29}\)This is only shown for the normal distribution, but the results for the log-normal distribution were so similar that the difference was hardly visible.
3. Explainable: For this research only known methods for computing the RA were used, which makes the computation more explainable. As mentioned in section 4.6.4, some techniques are easier to explain and understand than others, so this should be taken into account. Confidence levels were derived from official recognised sources such as Solvency II [13, 15, 20], which makes them more explainable. With this it is not meant that the chosen confidence levels in the base case, see section 4.8.13, are the best ones. This is explained in more detail in section 4.8.15. For the CTE and CoC technique a confidence level is derived, which makes the results more comparable to other insurers\(^{30}\).

4. Calculated for non-financial risks: As mentioned in section 4.4, all risks in scope are non-financial.

5. Diversified: Diversification was used in the model, using correlations and the computation described in section 4.7.2.

6. Operationally possible: Under the chosen assumptions, all computations are operationally possible. It is worth noting that a real insurer probably wants to have more data to support these assumptions. This means that for example data about the distribution of risks and cash-flows should be collected and stored.

7. Allow for steering: By making explainable choices for the input variables for determining the RA, the financial performance can be steered, see section 4.1.

4.8.13 Base case

In order to use the model that was created for this research, a base case was set which was used as a basis for all further computations.

**Input**

The standard deviation for all risks\(^{31}\) was set at 0.0002 for the first year and each year this value was multiplied with 1.05 because the further in the future, the more uncertainty there is\(^{31}\), as mentioned in section 4.8.7. These values were chosen in such a way that they give reasonable probabilities.

For CoC the applied confidence level was set at 0.995, which is used in most sources [13, 15]. In Solvency II, it is mandatory to use CoC with a confidence level of 0.995 [20]. For comparability reasons the confidence levels for VaR and CTE were set at 0.995 as well.

The capital rate was set at 0.06, which is the same as in Solvency II [20].

The profit factor\(^{31}\) was set at 1.1, the lapse percentage\(^{31}\) at 0.95 and the lapse rate at zero. This means we assumed no one could lapse in the base case, as mentioned in section 4.8.3.

Lastly the percentage of income for pension was set at 70\%, as mentioned in section 4.8.10.

An overview of all input for the base case can be found in appendix A.2, table 7 and 8.

**Output**

The RAs calculated per insurance for both distributions of all risks and for all techniques can be found in appendix A.2 table 10. The RAs after diversification for all combinations of the distribution of risks can be found in appendix A.2 table 11. There are several things worth noting about these results.

\(^{30}\)In section 4.8.14 more information is given about the implications of how this confidence level is derived.

\(^{31}\)There was no data to base this value on, so expert judgement was used.
The only insurance that is more significantly affected by the choice for the distribution is term life insurance. For all other insurances the difference between using a normal or a log-normal distribution is considered negligible. This can be explained in the following way. For term life insurance the probability that increases if and only if the liability cash-flows increase is the death rate which is in general very small (for example 0.0005). On the other hand for immediate annuity and insured pension the probability that increases if and only if the liability cash-flows increase is one minus the death rate which is in general very big (for example 0.995). Now calculating VaR(C) for C = 0.995 with a standard deviation of 0.0002 gives the values given in table 5.

<table>
<thead>
<tr>
<th></th>
<th>µ = 0.0005</th>
<th>µ = 0.995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.0010152</td>
<td>0.9955152</td>
</tr>
<tr>
<td>Log-normal</td>
<td>0.0012523</td>
<td>0.9955153</td>
</tr>
</tbody>
</table>

One can see that the difference between the normal and log-normal distribution is much bigger for a smaller mean. This can also be seen in figure 14. Here it can be seen that especially for extreme low means (below approximately 0.001), the difference between the normal and log-normal distribution is much bigger than for higher means. In figure 15 it can be seen that this also holds for the CTE technique. Here the difference for extreme low values is even bigger. When looking at the RAs for disability risk it can be seen that these are somewhat more affected by the choice for a distribution. This can be explained by the fact that the disability rates and recovery rates are respectively around 0.01 and 0.7. These values are not very small, which is why disability risk is not affected that much by the choice of the distribution, but it is affected more than immediate annuity and insured pension.

It can be concluded that for risks with lower means it is much more important to choose the correct distribution when choosing between the normal and log-normal distribution. When looking into other distributions it can be useful to make a graph such as in figure 14 and 15, to see what values are more affected by the choice for the distribution.

Figure 14: VaR(0, 995) with σ = 0, 0002 per μ.
The RAs after diversification depend quite little on the chosen distributions. This happens because precisely the insurance products that are almost not affected by the choice for the distribution (immediate annuity and insured pension) have higher RAs, so they count more severely toward the RA after diversification.

The CTE technique always gives a higher RA than the VaR technique, as mentioned in section 4.6. The height of the RA calculated with CoC compared to the other techniques depends much on the durations of the contract. This follows from the time parameter in the calculation of the RA using CoC. The longer the duration, the faster the RA calculated using CoC will increase. We will now explain in more detail why this happens.

For the CoC technique all future cash-flows are calculated for each future year and these are all added together. For the other techniques the future cash-flows are only calculated for the current year. This would result in a much higher RA when using CoC than when using any other technique. However, after all these values are added together, the result is multiplied with the capital rate (which is about 0.06). This will again decrease the RA calculated using CoC. Now one can see that if the contract has a relative short duration the increase that follows from the time parameter in the calculation of $R_A_{CoC}$ is less than the decrease from the multiplication with the capital rate. In this case the CoC technique will give a lower RA than the other techniques. However, if the contract has a relative long duration the increase that follows from the time parameter is more than the decrease from the multiplication with the capital rate. In this case the CoC technique will give a higher RA than the other techniques. This can also be seen from figures 18, 19, 20, 21 and 22 in appendix A.3. We conclude that when choosing between using CoC or another technique, it is important to look at the duration of the contracts.

4.8.14 Derived confidence levels

In section 4.6.5 it is explained how a confidence level can be derived for the CTE and CoC technique. This was done for our results, first of all using a normal distribution for the future cash-flows. The standard deviation was derived in the following way. For VaR it should hold that $C = C_d$, which is 0.995 in our case. Furthermore $\Gamma, R_A_{VaR}$ and the probability density function for the normal
distribution are known. \( \Gamma = 147.612.924 \) which can be found in table 9 in appendix A.2 and for \( R.A_{VaR} \) the RA calculated using the normal distribution for all risks was used. This gives \( R.A_{VaR} = 5.187.431 \) which can be found in table 10 in appendix A.2. Equation 4.7 gives

\[
C_d = \int_{-\infty}^{\Gamma + R.A} \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{1}{2}(\frac{x-\Gamma)}{\sigma})^2} dx.
\]

The calculation in equation 4.9 now gives

\[
\Gamma + R.A = \sigma \sqrt{2} \cdot \text{erf}^{-1}(2C_d - 1) + \mu;
\]

\[
\sigma = \frac{\Gamma + R.A - \mu}{\sqrt{2} \cdot \text{erf}^{-1}(2C_d - 1)}.
\]

Filling in all values this gives \( \sigma = 2.013.888 \). Using this standard deviation, the derived confidence level can be calculated for all techniques. In figure 23 in appendix A.4, the derived confidence levels were plotted against the applied confidence levels. For VaR we find that the derived confidence level equals the applied confidence level, as expected. For both CTE and COC the derived confidence level is bigger than the applied confidence level, which also is to be expected because the RAs for CTE and COC are higher than those for VaR.

In figure 24 in appendix A.4, the RA was plotted against the derived confidence levels for all estimation techniques. This means that for all techniques the RA was calculated and then for the result, the confidence level that will give the same result when using the VaR technique was calculated, which is the derived confidence level. Given this, one would assume that the graphs of the RA against the derived confidence level do not depend on the used estimation technique. This turns out to be correct, all graphs in figure 24 lay on top of each other.

When an insurer uses the CTE or CoC technique, they might not want to calculate the RA using VaR in order to derive the standard deviation of the cash-flows. This means that they might not be able to derive the standard deviation of the cash-flow as precisely as was done in this research. For this reason, the sensitivity of this variable is tested in the next section.

### 4.8.15 Sensitivity testing

We ran the model for various values of all input variables to test their sensitivity. All results can be found in appendix A.5. For most cases only the results for the normal distributions were shown because the results for the log-normal distributions were so similar that the difference cannot be shown in a graph\(^{32}\). The following sensitivities were found.

From the figures in appendix A.5 it can be seen that the RA calculated using CoC is more affected by the change in input variables than the other techniques\(^{33}\). This is because of the following. For the CoC technique all future cash-flows are calculated for each future year and these are all added together. For the other techniques the future cash-flows are only calculated for the current year. Mathematically speaking this means that \( \Gamma_t(VaR(C)) - \Gamma_t(\mu) \) is calculated much more often for CoC\(^{34}\), and for each of these calculations the result adds up to the end result. This means that the CoC technique is more affected by a change in an input variable that affects \( \Gamma_t(VaR(C)) - \Gamma_t(\mu) \), which are all tested input variables except for the standard deviation of the cash-flows and the correlations in the correlation matrix.

\(^{32}\)The graphs literally look exactly the same.

\(^{33}\)The graphs for CoC are steeper than the graphs for VaR and CTE.

\(^{34}\)The difference between the average value and the shocked value is calculated much more often.
Applied confidence level

Mathematically speaking, the confidence level for CTE can be chosen between zero and one, and the confidence level for VaR and CoC can be chosen between a half and one\textsuperscript{35}. This is mentioned in section 4.6 and can also be seen in figure 25 in appendix A.5. However, a confidence level below 0.5 is seen as not explainable\textsuperscript{36}, so also for CTE the confidence level should be chosen above 0.5. This could be seen as a reason to not use CTE, because only the upper half of the available confidence levels can be chosen. In figure 25 it can be seen that for all confidence levels, the CTE technique gives a higher RA than the VaR technique. This is consistent with what was said in section 4.6. This implies that it should make sense to pick a lower applied confidence level for CTE than for VaR. However, this is not always possible with the given lower bound of 0.5. For CTE a confidence level of 0.5 corresponds to a confidence level of around 0.8 for VaR, see figure 25. This implies that confidence levels below 0.8 for the VaR technique cannot be translated to the CTE technique.

Furthermore, the RA calculated using CoC is higher than the RA calculated using VaR for all confidence levels. This follows from the fact that the insurance products in the model have a relatively long duration, as explained in section 4.8.13. This is a remarkable result however, because for VaR and CTE usually a much lower (around 0.8) confidence level is chosen than for CoC (around 0.995), even though the CoC technique would already give a higher RA, even if the same confidence level was used.

The graph has an asymptote at $x = 1$. The value of the RA goes to infinity here. This follows from the fact that both the normal and log-normal distributions have an infinite tale to the right, so the value for which the entire distribution lies to the left of it is infinity. In mathematical terms we say both $\text{VaR}(1) = \infty$ and $\text{CTE}(1) = \infty$, which gives that the RA with a confidence level of 1 is infinite. This means that the RA is sensitive to very high confidence levels (above proximately 0.99).

Finally it should be noted that when using the log-normal distribution, and the VaR or CoC technique the RA cannot be calculated for too low confidence levels, as mentioned in section 4.6. This can be seen in figure 26. For confidence levels under 0.6 the RA for term life insurance does not exist when using the log-normal distribution, so the RA after diversification also does not exist. For even lower confidence levels\textsuperscript{37} the RAs for the other insurance products will also not exist any more. However, this should not be a problem in general, because these low confidence levels are not explainable, so they should not be used anyway.

Capital rate

The capital rate only affects the CoC technique and it affects it in a linear way, as can be seen from figure 27. For this figure, capital rates were chosen between 0.04 and 0.08, since this is a reasonable percentage of profit that could be made by investing. Any value that does not lie between these boundaries is seen as not explainable. Furthermore one can see that the capital rate has quite a significant affect on the RA, so choosing values outside of this boundary will also lead to much too low or too high RAs.

Start value of the standard deviation

First of all we see that if the standard deviation is zero, so is the RA, which is what one would expect because with a standard deviation of 0 the average future cash-flows equal the future cash-flows in case of a shock.

\textsuperscript{35}This only holds for symmetric distributions, for asymmetric distributions a confidence level of a half might be too low.

\textsuperscript{36}Strictly speaking a confidence level of 0.5 is seen as having no RA at all, which is true for the VaR and CTE technique, so the lowest explainable confidence level is around 0.7.

\textsuperscript{37}But still above 0.5.
The graphs for changing the start value of the standard deviation in figure 28 are a little concave, yet they do increase quite fast. This is to be expected since the standard deviation has quite a significant impact on both \( \text{VaR}(C) \) and \( \text{CTE}(C) \). Especially for the CoC technique this graph increases quite fast.

**Increase factor for the standard deviation**

The graphs for changing the increase factor of the standard deviation in figure 29 are convex, which means that the higher this value gets, the more it affects the RA. This is the variable that has the most influence on the RA, which is understandable since each year all standard deviations are multiplied with it, so especially contracts with a longer durations are much affected by this.

**Correlations**

Figure 30 was made by multiplying all correlations \( \text{corr}_{u,v} \) with \( u \neq v \) with a factor. The \( \text{corr}_{u,u} \) were not changed because these should always be one. This means that for \( x = 0 \) the “correlations at zero” case was calculated. The results for simple sum were also calculated. These can be found in table 12 in appendix A.5.

We find that changing the correlations has very little effect on the RA. As the correlations increase, the RA decreases a little. This happens because the negative correlations count more toward the end result. We will now explain this. When looking at the correlations in table 2, we find the following. Lapse was not taken into account in the general model, so these correlations can be ignored. The only other correlations \( \text{corr}_{u,v} \) with \( u \neq v \) are \( \text{corr}_{\text{mor,long}} = -0.25 \) and \( \text{corr}_{\text{mor,dis}} = 0.25 \). In table 10 we find that the RAs for longevity risk are much higher than the RAs for mortality risk and disability risk, which means they count more significantly toward the end result. This means that \( \text{corr}_{\text{mor,long}} \) has more affect on the end result than \( \text{corr}_{\text{mor,dis}} \), and thus we find that the negative correlations count more toward the end result.

As mentioned in section 4.7.2, putting all correlation factors at 1 will result in the same computation as simple sum. This means that there is no negative correlation at all. This explains why the result for simple sum is much higher than for the other diversification methods. This also makes sense because when using simple sum, no diversification is taken into account.

**Standard deviation for the cash-flows**

When making figure 31 a confidence level of 0.995 was used. One can see that the derived confidence level for the VaR technique equals 0.995 for a standard deviation of around 2.000.000, which is consistent with what was said in section 4.8.14.

We find that when the standard deviation of the cash-flows increases, the derived confidence level decreases. This is to be expected because for a higher standard deviation, the distribution will get wider, which means that the percentage of the distribution that lies to the left of the found PV in case of a shock will decrease, and thus the derived confidence level will decrease.

For the CoC technique the RA is so much higher than the RA for VaR, that the derived confidence level is practically one, no matter what standard deviation was used. Note that in case the RAs for VaR and CoC are not that far apart (for example when dealing with contracts with a shorter duration), the RA calculated using CoC would be more sensitive to the chosen standard deviation for the cash-flows.

The same was also done using a log-normal distribution for the cash-flows. The result can be found in figure 32. The shape of the graphics are the same as for the normal case, but the graphs lie further apart. This can be explained by the fact that the log-normal distribution has a heavier tail on the right.
We find from figure 31 and 32 that the derived confidence level is especially sensitive to high standard deviations of the cash-flows. When the standard deviation of the cash-flows is chosen too high, the derived confidence level will be too low. Because the graphs when using the normal distribution are more concave than the graphs for the log-normal distribution, the normal distribution is more sensitive to changes in the standard deviation.

**Interest rate**

Firstly it should be noted that the interest rate is not something the insurer can affect themselves. However, it is interesting to look at the effect of changes in the interest rate on the RA.

Note that an increase in the interest rate gives a decrease in the RA. This happens because if the interest rate increases, the present value of both the average future cash-flows and the future cash-flows in case of a shock will decrease, and so will the difference between them. This implies that the RA will decrease.

It can be seen that especially if the interest rate gets more negative, the RA is more severely affected by it.

**4.9 What are the various perspectives on the benefits of IFRS 17?**

In order to provide the reader a better understanding of IFRS 17 and how it is perceived in the market, four stakeholders with different backgrounds and relation to IFRS 17 were interviewed. The four interviewee were an accounting specialist, an ex-employee of the IASB who helped writing IFRS 17, an IFRS expert who works for an insurer and a tax specialist. The transcripts of the interviews can be found in Dutch in appendix B. We will first give a short introduction per interviewee.

**4.9.1 EY accounting specialist (interviewee 1)**

The interviewee works full-time on IFRS 17. He is project manager for implementing IFRS 17 for several Dutch insurers. He states that IFRS 17 will have a very high commercial priority within the market. International networks and groups will be formed to share experience within EY. EY will gather a lot of information on IFRS 17, which will enable them to contribute by giving advice on IFRS 17 to their clients. For EY these are very fruitful years. They can help many insurers by advising them on implementing IFRS 17, and of course will be paid for that. The only disadvantage of IFRS 17 for EY that the interviewee can think of is that there is too much work. EY has to choose where to employ their personnel, to work on IFRS 17 or on other projects.

**4.9.2 Ex-employee of the IASB (interviewee 2)**

The interviewee worked for the IASB on writing the first exposure draft of IFRS 17. He was a so called “practice fellow”, someone with experience in the field who supported the IASB. Writing IFRS 17 has been a big challenge for the IASB, it is the project with the longest duration that the IASB has ever undertaken. Officially they have already started working on the precursor of IFRS 17 in 1997. The IASB has invested a lot of time and energy into IFRS 17 and one could say that they are glad that it is finally done. It was a very important project and it had to be done properly. Of course they still have some work with it in helping others with implementing IFRS 17. For instance they have put together a “transition resource group”, a group of experts who are looking into practical issues that come up when implementing IFRS 17.
4.9.3 IFRS 17 expert (interviewee 3)

The interviewee works for a Dutch insurance company that from now on will be called “the insurer”. Since November 2017 the interviewee has worked full time on implementing IFRS 17 for the insurer. The implementation of IFRS 17 has a lot of influence on the insurer, all systems and processes have to be changed in order to yield the IFRS 17 results. The insurer also does a lot of checks themselves, to see if everything is correct and these have to be changed too. All of this has to happen quite soon, there is only one and half a year left for transition. Apart from this, knowledge on IFRS 17 has to be dispersed throughout the company, over all 3000 employees. Implementing IFRS 17 is a lot of work and does not yield more income. However, the interviewee also wants to see it as something positive and look at the possibilities. He states that everything has to be changed now anyway, so why not see this as an opportunity to make all systems up to date. Furthermore the implementation of IFRS 17 will give the insurer a lot of insights in which products yield profits for them and which do not.

4.9.4 EY tax specialist (interviewee 4)

The interviewee works as a tax specialist at EY, he helps insurers with their tax return. He has a two sided role. He works both as an advisor and an accountant for assessing the financial position of insurers. The basis for tax return of an insurance company is the statement of comprehensive income, which is quite complex, but IFRS 17 will decrease the complexity in this statement. Therefore the process of tax return should become less complicated with the implementation if IFRS 17\textsuperscript{38}. It could also be that the Dutch tax authority decides to look at the fiscal rules in the Netherlands, to make them more IFRS 17 proof. He predicts that this will happen in one or two years. This could further simplify doing taxes for insurers.

4.9.5 Outcomes of the interviews

All interviewee agree on why IFRS 17 was made. A new stable standard for insurance contracts was needed. IFRS 4 was a temporary solution, and it was clear that it was lacking on certain areas. IFRS 17 needed to be made in order to improve the comparability between insurance contracts and to make all contracts more consistent.

All interviewees agree that the goal of IFRS 17 is better comparability between insurance contracts, giving a more transparent picture on the financial circumstances of insurance companies and stating in a more clear way what is and what is not allowed for insurance companies. The goal of IFRS 17 is to deliver useful financial reporting information on insurance contracts as part of the annual reports of insurance companies.

Implementing IFRS 17 requires large investments, but stock market listed companies are obliged to implement this standard. For other companies this might be a reason to stop reporting on IFRS, because implementing IFRS 17 is so expensive that it is not worth the cost. Insurers have multiple systems in place and all of those have to be adjusted, which is a lot of work. The fact that IFRS 17 is principles-based makes implementing it even harder, the standard first has to be interpreted before it can be implemented. Another problem is that the implementation of IFRS 17 does not yield more income for the insurer. Interviewee 3 says that he thinks that the shareholders are probably going to have to pay for the implementation of IFRS 17.

IFRS 17 will have a lot of impact on insurers. They will have to redesign all of their systems. They also need new input, which means they have to develop processes to get, process and store this data.

\textsuperscript{38}Therefore one could see IFRS 17 as a disadvantage for tax specialists because their work will become cheaper.
Results of IFRS 17 will be shown on the annual report and insurers want to be comfortable with what is on their annual report, this has to be correct and they have to be able to explain it in order to be professional.

Advantages of IFRS 17 for insurers are that they could take this opportunity to renew their financial programs, however this is only possible if there is money and time available to do this. IFRS 17 will give insurers a better insight in their own finances. It could be used to find what products sell better than others and then to terminate the more loss-making products. Insurance companies could also use IFRS 17 to compare themselves more easily with their competitors. The fact that investors can better compare insurers will lead to more fair competition between insurers, that could also be seen as an advantage.

For investors IFRS 17 is something positive. Much more much better comparable information will be produced for them to compare insurers, which means they have to do less work to gather and compare this information themselves. On the other hand, there is also worry that the new system is also too complicated, IFRS 17 is hard to understand.

Interviewee 3 says that hopefully IFRS 17 will not have a direct impact on the clients of the insurer, they are trying to not let the costs of implementing IFRS 17 affect the costs of their products. IFRS 17 could also affect take overs. Many smaller insurance companies will not implement IFRS 17 because they do not report on IFRS. If another company who does report on IFRS now wants to take over this smaller company, IFRS 17 will have to be implemented. Furthermore, before the takeover, the two companies can still not be compared easily because one of them has not implemented IFRS 17.

Eventually IFRS 17 will also have impact on broader society. It will give insurers more insight into what products generate more income. Less income generating insurance products will become more expensive or will be terminated. Furthermore IFRS 17 will make clear to insurers where income and expenses come from and go to. It could be that one insurer is much better in investing than in insuring, this could lead to fusions, which could decrease employment.

On the Netherlands as a country IFRS 17 is seen as a disadvantage by most interviewee. It makes for more comparability, which is good, but insurance companies cannot invest the money that is needed to implement IFRS 17 in other projects. Insurers are also important investors, they invest for example in mortgages and government bonds, they are an important part of society. Solvency II also gives the insurer more security, IFRS 17 does not do this. IFRS 17 is purely meant for accounting, not to provide the clients of an insurer with more certainty.

The fact that IFRS 17 is principles-based is seen as a positive thing by all interviewees. It takes some time to interpret the standard, but it gives the insurer the opportunity to implement the standard in a way that fits their business. On the other hand the fact that IFRS 17 is principles-based does have a negative affect on the comparability because different insurers can interpret IFRS 17 in a different way. All of the interviewee agree that interpreting IFRS 17 is complicated, but they do not think it will lead to serious problems with insurers.

All interviewee were asked the question, if they were an investor looking into what insurance company they would invest into, what would they look at. Interviewee 1 said he would not look at IFRS 17 results, he would look at where profit is made, with investing or with insuring, he would look at what is new business, where is value added. Furthermore he would look at how the insurers fit in bigger topics such as sustainability. He thinks business is much broader than IFRS 17, things like culture and people are also important.

Footnote 39: Furthermore, in case of a rules based-standard, people sometimes try to find the holes in it by doing things that are not strictly forbidden, but were not intended to be possible, like evading taxes. With a principles-based standard this is not possible because one also has to explain what one is doing.
Interviewee 2 would look at the run-off from the CSM and the RA. This gives an indication of the remainder of the amount of possible profitability. Furthermore, he finds it important to look at the statement of comprehensive income and the income mutations in reinsurance reserves. Lastly, he would compare the obligations to the investments. This gives information about the sensitivity of the components.

Interviewee 3 would look at the CSM, both before and after release into the statement of comprehensive income. This gives information on the profitability of the contracts of the insurer. He considers the RA to be less important; it only tells you how much buffer there is.

Interviewee 4 was less informed on the technical components of IFRS 17, but he said he would definitely look at them since they can give very valuable information.
5 Conclusions and recommendations

The goal of this research was to study suitable and explainable choices a typical Dutch insurance group can make for addressing the estimation technique, the level of confidence, the method for measuring risk diversification and any other potentially unknown input variables for the calculation of the RA, in order to deduce the optimal choices for determining the RA. In order to answer this question, nine research questions have been formulated which will be answered here. These questions were: 1) Why is the RA an important measure? 2) What are the criteria for optimal choices with respect to the RA? 3) What is a relevant Dutch insurance group and insurance contracts to research? 4) What non-financial risks are typically relevant for Dutch insurance groups? 5) What are suitable probability distributions for these non-financial risks? 6) What are suitable estimation techniques for the RA? 7) What are suitable dependency structures between the relevant risks? 8) What are suitable and explainable choices Dutch insurance groups can make in relation to determining the RA? 9) What are the various perspectives on the benefits of IFRS 17?

5.1 Conclusions

In answer to question 1, the RA is an important measure because it impacts the financial performance of the insurance company. The RA has great influence on the starting value of the CSM and both the RA and the CSM have a run-off to the statement of comprehensive income. Furthermore others e.g. financial stakeholders will use disclosures about (components of) the RA to compare insurance companies on their financial performance. Lastly, the RA can be used for steering some of the financial performance of the company.

Answering question 2, criteria for optimal choices with respect to the RA are that the RA should be technically sound, consistent, explainable, calculated for non-financial risks and diversified. Furthermore it is preferable if the computation for the RA is also operationally possible and allows for steering of the financial performance of the company.

A relevant Dutch insurance group that was found in answering question 3 is one that has the following structure.

Relevant insurance contracts are thus term life insurance, immediate annuity, insured pension and disability insurance.

In answer to question 4, non-financial risks that are typically relevant for the found insurance group are mortality risk, longevity risk, lapse risk and disability risk. Lapse risk is not taken into account because of a lack of data and the fact that it would distort other results. These risks relate to the found insurance products in the following way.
Answering questions 5, 6 and 7, suitable probability distributions for all found risks are the normal and log-normal distribution. Furthermore suitable estimation techniques for the RA are the VaR, CTE and CoC technique. Moreover suitable dependency structures between the relevant risks are correlations. “Correlations at zero” could also be used, but this is less explainable.

The answer to question 8 is as follows. When making choices for determining the RA, the following should be considered.

- Estimation technique: The results on how to choose an estimation technique are summarised in table 6.

<table>
<thead>
<tr>
<th>Usability and understandability</th>
<th>Information in the right tail</th>
<th>Technique specific characteristics</th>
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<tbody>
<tr>
<td>VaR</td>
<td>The VaR technique is the easiest to use and understand. Furthermore, one does not need to derive a confidence level when using VaR.</td>
<td>The VaR is less fit for distributions with heavy right tails, which could happen for probabilities with a mean closer to zero.</td>
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<tr>
<td>CTE</td>
<td>The calculation method for CTE is the most complex one. When using more complicated distributions the CTE technique might be less suitable because the integral in the definition of ( CTE(C) ) might not be solvable, making the technique not operationally possible.</td>
<td>The CTE technique takes all values in the right tail into account. When the distribution of the probability that increases if and only if the liability cash-flows increase has a heavy right tail, the CTE technique is more suited than the VaR technique. In case the shape of the tail of the distribution is unknown and could be volatile and unpredictable, the CTE technique is less preferable because it takes all values in this tail into account.</td>
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<tr>
<th>Mortality</th>
<th>Immediate annuity</th>
<th>Insured pension</th>
<th>Disability insurance</th>
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<tbody>
<tr>
<td>Term life insurance</td>
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<td>Longevity</td>
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<td><strong>Usability and understandability</strong></td>
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<td>To use CoC, more values have to be calculated, yet these calculations are equally as hard as the calculations for the VaR technique.</td>
<td>For the CoC technique, usually a much higher confidence level is chosen than for the VaR and CTE technique, so only a very small part of the tail values will be ignored. This means that also this technique is preferable above the VaR technique when working with distributions with heavy tails.</td>
<td>The CoC technique is quite sensitive to the duration of the contract. For contracts with short durations it gives quite low RAs and for contracts with long durations it can give very high RAs. One should look out for this, especially because the confidence level is in general chosen higher for the CoC technique than for the other techniques, which also increases the RA calculated using CoC. What the exact values belonging to “short” and “long” are, depends much on the characteristics of the insurance contract and its clients. Furthermore, the CoC technique is more sensitive to changes in the confidence level, capital rate, interest rate and standard deviation of the risks than the other techniques. When one is uncertain about (some of) these values, using the CoC technique might not be preferable. Lastly, the CoC technique depends on yet another variable that has to be chosen, the capital rate, this could be seen as a disadvantage to this technique.</td>
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• Capital rate: This variable only affects the CoC technique and it affects it in a linear way. It affects the RA quite significantly, so this variable should be chosen with care. Since Solvency II demands a capital rate of 0.06, deviating much from this is most likely not very well explainable.

• Distribution of the risks: In case the distribution for the risks cannot be derived from data, one should take the following into account when choosing a distribution. When choosing between the normal and log-normal distribution, risks with lower means are more sensitive to this choice and for risks with higher means the effects of this choice are hardly noticeable. For other distributions it could be advised to look into how and when they affect \( \text{VaR}(C) \) and or \( \text{CTE}(C) \) in order to determine when the choice for a certain technique has more effect.

• Standard deviation for the risks: In case the standard deviation for the risks cannot be derived from data, one should try to be as precisely as possible when choosing the standard deviation, because it has a significant effect on the RA. Especially the increase factor of the standard deviation has great influence on the RA, especially when it is chosen too high.

• Diversification method: The best diversification method is using correlations. When using simple sum, no diversification is taken into account, so the criterion “diversified” is not met. For the “correlations at zero” technique, it is assumed that there are no correlations between the risks at all, which is hard to explain. Furthermore copulas are seen as too complicated and thus not explainable.

• Correlations: When the correlations between the risks cannot be derived from data, it is of course important to choose them reasonably, but they have quite little effect on the RA.

• Distribution of the cash-flows: One only needs to make this choice when the used technique is not VaR. Furthermore, there might be data that could be used to derive this distribution. However, if this is not the case, one should know that the normal distribution is more sensitive to changes in the standard deviation for the cash-flows.

• Standard deviation for the cash-flows: This variable is only necessary when the used technique is not VaR. One could always derive the standard deviation for the cash-flows using the calculation given in 4.8.14. However, one does need to calculate the RA using VaR in order to do this. In case one does not want to do this, it is worth knowing that the derived confidence level is quite sensitive to high standard deviations of the cash-flows. Furthermore it is worth noting that when using CoC, \( \text{VaR}(C) \) and \( \text{VaR}(\mu) \) already need to be calculated, so it is not that hard to calculate the RA using VaR.

• Interest rate: The interest rate is not something an insurer can influence, but it is worth knowing that the RA is not that much affected by it. It is mostly affected when the interest rate becomes very small or below zero.

In order to answer question 9, we looked into the various perspectives on the benefits of IFRS 17. From the interviews it can be concluded that in general all interviewee agree on the utility, goal and influence of IFRS 17 as well as what influence it has on the various parts of society. They also all agree that IFRS 17 had to be written, a complete and functional standard for insurance contracts needs to exist.

For insurers IFRS 17 mostly is a lot of work and requires large investments, yet it can also be seen as an opportunity to update old systems, get more insight in ones own financial performance and to compare ones own performance with the performance of others.

For the IASB IFRS 17 has been a very complicated standard to make. Writing it has taken a lot of effort and very much time.

\[40\text{Note that this also depends on the used standard deviation. For bigger standard deviations, the effect will be more severe.}\]
For advisors and consultants IFRS 17 has mostly positive effects since it gives them the opportunity to contribute to society by advising their clients on IFRS 17 and it generates more work for them. For investors IFRS 17 will have a positive effect since it gives them more information to compare insurers.

For clients the impact is unclear, the high costs for insurers for implementing IFRS 17 might also impact the prices of their products, even though they are trying to not let it affect that. Furthermore the products that generate less income for an insurer might get more expensive or be terminated.

For the Netherlands as a country IFRS 17 has both positive and negative effects. It is positive that insurance contracts become more comparable. However, insurance companies cannot invest the money that is needed to implement IFRS 17 into other projects. Furthermore it could lead to fusions which could decrease employment.

5.2 Recommendations

Apart from this list of matters to consider when making choices on input variables for the calculation of the RA given above, EY is recommended to advise their clients to store data that could help them to make these choices. Many of these choices do not have to be made when there is data that can be used to derive what the correct choice is. In order to do this, the following data needs to be stored.

- For all risks old predictions have to be stored as well as data on what has actually happened. This can be used to find how far off the predictions were, which can be used to find their distribution and standard deviation. This means that old predictions of mortality rates, lapse rates, disability rates and recovery rates should be stored as well as data on what the actual mortality rates, lapse rates, disability rates and recovery rates in the same year were. In order to properly derive the distributions, data is needed about several years, so if one still has to start collecting this data it will take multiple years before the distributions and standard deviations can be derived.

- The data on what the actual mortality rates, lapse rates, disability rates and recovery rates were can also be used to derive the correlations between these risks.

- Data on the predicted cash-flows and the actual cash-flows should be stored in order to derive the distribution and standard deviation of the cash-flows. This should also be done for multiple years.
6 Discussion

6.1 Reflection

The goal of IFRS 17 is better comparability between insurers, yet there are many ways of determining the RA, which can lead to very different conclusions. Elements like the chosen estimation technique and derived confidence level have to be disclosed, which gives some insight in how the RA is calculated, yet comparing insurers might still be complicated. The value of the RA can depend on much insurance specific input such as client specific data about mortality, longevity, lapse and disability rates. These values can have much impact on the RA. On the other hand, the derived confidence level gives quite some information on the amount of risk that an insurance company is taking, since it does not depend in the estimation technique. Comparing insurers will definitely become better doable than before since the concept of the RA did not exist under IFRS 4.

There is no correct value for the RA, which makes it complicated to determine what choices will result in the “best” RA. This is why the results of this study are not in the form “this is the best estimation technique, this the best confidence level and this the best method for risk diversification.” All given techniques are compliant with IFRS 17 (in most common cases), so there is no best technique. One can only say something about the differences between the techniques, and in what situations they are either less or more suited.

6.2 Limitations of this study

In this study, several choices had to be made because of a lack of data. In this section we will discuss the effects of these choices on the research.

Two kinds of risks were not taken into account because there was not enough data on how they would impact this study.

Expense risk was not taken into account because it varies a lot across insurers. This makes it difficult to capture in a research where as little as possible is assumed about the insurer. There is a natural impulse to decrease this risk for an insurer, which makes this risk less relevant to this research. However, a very important difference between this risk and all risks covert in this research is that the uncertainty in the cash-flows arising from this risk is an amount of expenses, not a probability. This means that many of the conclusions in this research about risks might not hold for expense risk.

Lapse risk was not taken into account because of a lack of data and the fear that this would distort other results. If more data had been available, lapse risk could also have been researched. In order to do this, data about lapse rates needs to be acquired as well as data about the amount of money that would be paid to the client in case he/she lapses. If EY could acquire this data, this could be used to further research lapse risk. Lapse risk was already fully built into the model, only the correct input variables have to be given in order to run it.

There was no data on the distribution of risks. Sources were found which assumed normal and log-normal distributions, but none of them had any more theoretical substantiation for why they chose these distributions. Since every choice needs to be explainable and understandable, it makes sense to choose the normal or log-normal distribution, since these are widely understood. However, it could also be worthwhile to look into other, potentially mathematically better suitable distributions. Furthermore, there was no data that could be used to derive the standard deviations of the risks. The used standard deviations were purely derived by looking at what values had a sensible effect.
on the probabilities in case of a shock. This could be done much more precise, which would be recommended because standard deviations have a great impact on the RA, as found in this research.

There was no data that could be used to derive the correlations between the risks. There was data in Solvency II on what correlations they use. These are part of an official standard, so they should be relatively realistic, however they are all in quarters\textsuperscript{41} which implies they cannot have been derived from real data. This research could be improved by deriving the correlations from real data. However, this data will be dependent on the characteristics of the clients of the insurer, so each insurer might have to do this themselves.

There was only very little data about the clients of the insurance products in this research. For immediate annuity there was one data set of real clients from one of the clients of EY, however there was no permission to use this data set for this research, so we could only look at it to see generally what the characteristics of the clients were. Of course an actual insurer would have this data, so for them this would not be a problem. Furthermore all client data has impact on both the expected future cash-flows and the future cash-flows in case of a shock, so most likely it will not have that much impact on the RA. Moreover client portfolios could differ a lot across insurers, so it is in general complicated to generate a general client portfolio. However, if all clients for one type of insurance are for example much older or much younger than we assumed, this could have an impact on the RA, because all mortality and longevity rates will change. It can be concluded that this research could be improved with more research into the clients of the insurance products.

Quite a lot of expert judgement was used to find the number of clients per insurance. These especially matter in relation to each other. The distribution of clients over the different insurance products could have quite a significant effect on the RA after diversification. This research could be improved by researching the distribution of clients over the products using data.

Lastly there was no data that could be used to derive the distribution and standard deviation of the cash-flows. Using data about the cash-flows of real insurance contracts this could be derived, however this most likely depends much on the insurer, so it is complicated to do this for a general model.

### 6.3 Suggestions for further research

In the previous section several cases have been found where this research could be expanded if more data was available. If the correct data would be available, the distributions and standard deviations of the risks and cash-flows could be derived to improve this research as well as correlations between the risks. Furthermore, more research can be done into client data and the distribution of clients over the various insurance products.

More research could be done into other insurance products such as reinsurance. Furthermore, more risks could be added such as expense risk and lapse risk. Other estimation techniques could be researched. As insurance companies implement IFRS 17, more estimation techniques will be invented (most likely) and these could be compared to the currently existing techniques. Lastly, more diversification methods such as copulas could be researched to find how much they impact the RA.

Furthermore it could be further researched where in the group the choices for determining the RA should be made. Is it more effective to make these choices group-wide or to let all entities make these choices themselves?

\textsuperscript{41}They are all -0.25, 0, 0.25 or 0.5.
Finally, each insurer will have to research the operational impacts for model development, model use and maintenance themselves. These can determine choices (developing a new system, adjust existing systems, etc.) and depend to a large extent on the specific context and ambition of the insurance company (e.g. current financial reporting architecture, presence and level of resources and ability to develop resources).
References

[40] EIOPA. Risk-Free Interest Rate Term Structures, 2018.
A Model results

In this appendix the results given by the model are given. For all figures, the case were the risks are log-normally distributed are only given if the difference between the normal and log-normal cases were visible in the figure.

A.1 Lapse

Figure 16: The future cash-flows per year for all yeas in the duration of the contracts for term life insurance.
Figure 17: The future cash-flows per year for all years in the duration of the contracts for insured pension.
## A.2 Base case model

### Table 7: Risk input base case.

<table>
<thead>
<tr>
<th>Mortality risk</th>
<th>Longevity risk</th>
<th>Lapse risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stdev 1 year</td>
<td>Stdev 1 year</td>
<td>Stdev 1 year</td>
</tr>
<tr>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
<tr>
<td>Increase std dev per year</td>
<td>Increase std dev per year</td>
<td>Increase std dev per year</td>
</tr>
<tr>
<td>1.05</td>
<td>1.05</td>
<td>1.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disability risk</th>
<th>Not recovered risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stdev 1 year</td>
<td>Stdev 1 year</td>
</tr>
<tr>
<td>0.0002</td>
<td>0.0002</td>
</tr>
<tr>
<td>Increase std dev per year</td>
<td>Increase std dev per year</td>
</tr>
<tr>
<td>1.05</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Table 8: Insurance input base case.

<table>
<thead>
<tr>
<th>Term life insurance</th>
<th>Immediate annuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality risk</td>
<td>Longevity risk</td>
</tr>
<tr>
<td>Confidence level VaR 0.995</td>
<td>Confidence level VaR 0.995</td>
</tr>
<tr>
<td>Confidence level CTE 0.995</td>
<td>Confidence level CTE 0.995</td>
</tr>
<tr>
<td>Confidence level CoC 0.995</td>
<td>Confidence level CoC 0.995</td>
</tr>
<tr>
<td>Capital rate 6% Capital rate 6%</td>
<td></td>
</tr>
<tr>
<td>Lapse risk</td>
<td></td>
</tr>
<tr>
<td>Confidence level VaR 0.995</td>
<td></td>
</tr>
<tr>
<td>Confidence level CTE 0.995</td>
<td></td>
</tr>
<tr>
<td>Confidence level CoC 0.995</td>
<td></td>
</tr>
<tr>
<td>Capital rate 6%</td>
<td></td>
</tr>
<tr>
<td>Remaining</td>
<td></td>
</tr>
<tr>
<td>Profit factor 1.1</td>
<td></td>
</tr>
<tr>
<td>Lapse percentage 0.95</td>
<td></td>
</tr>
<tr>
<td>Lapse rate 0</td>
<td></td>
</tr>
<tr>
<td>Insured pension</td>
<td>Disability insurance</td>
</tr>
<tr>
<td>Longevity risk</td>
<td>Disability risk</td>
</tr>
<tr>
<td>Confidence level VaR 0.995</td>
<td>Confidence level VaR 0.995</td>
</tr>
<tr>
<td>Confidence level CTE 0.995</td>
<td>Confidence level CTE 0.995</td>
</tr>
<tr>
<td>Confidence level CoC 0.995</td>
<td>Confidence level CoC 0.995</td>
</tr>
<tr>
<td>Capital rate 6% Capital rate 6%</td>
<td></td>
</tr>
<tr>
<td>Lapse risk</td>
<td></td>
</tr>
<tr>
<td>Confidence level VaR 0.995</td>
<td></td>
</tr>
<tr>
<td>Confidence level CTE 0.995</td>
<td></td>
</tr>
<tr>
<td>Confidence level CoC 0.995</td>
<td></td>
</tr>
<tr>
<td>Capital rate 6%</td>
<td></td>
</tr>
<tr>
<td>Remaining</td>
<td></td>
</tr>
<tr>
<td>Profit factor 1.1</td>
<td>Profit factor 1.1</td>
</tr>
<tr>
<td>Lapse percentage 0.95</td>
<td>Lapse percentage 0.95</td>
</tr>
<tr>
<td>Lapse rate 0</td>
<td>Lapse rate 0</td>
</tr>
<tr>
<td>Percentage of income for pension 70%</td>
<td>Percentage of income for pension 70%</td>
</tr>
</tbody>
</table>
Table 9: The PV at time zero of all future cash-flows for all insurance products.

<table>
<thead>
<tr>
<th>Term life insurance</th>
<th>Immediate annuity</th>
<th>Insured pension</th>
<th>Disability insurance</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Γ</td>
<td>-53467</td>
<td>-6994226</td>
<td>-73258</td>
<td>147612924</td>
</tr>
</tbody>
</table>

Table 10: The RA per insurance per technique per distribution.

<table>
<thead>
<tr>
<th>Term life insurance</th>
<th>Mortality risk</th>
<th>Longevity risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal distribution</td>
<td>Log-normal distribution</td>
</tr>
<tr>
<td>VaR</td>
<td>487405</td>
<td>718679</td>
</tr>
<tr>
<td>CTE</td>
<td>546263</td>
<td>900463</td>
</tr>
<tr>
<td>CoC</td>
<td>499457</td>
<td>710957</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Immediate annuity</th>
<th>Longevity risk</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal distribution</td>
<td>Log-normal distribution</td>
</tr>
<tr>
<td>VaR</td>
<td>1229434</td>
<td>1229970</td>
</tr>
<tr>
<td>CTE</td>
<td>1381410</td>
<td>1382119</td>
</tr>
<tr>
<td>CoC</td>
<td>1419833</td>
<td>1420532</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insured pension</th>
<th>Longevity risk</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal distribution</td>
<td>Log-normal distribution</td>
</tr>
<tr>
<td>VaR</td>
<td>4051320</td>
<td>4057556</td>
</tr>
<tr>
<td>CTE</td>
<td>4532751</td>
<td>4540742</td>
</tr>
<tr>
<td>CoC</td>
<td>12200750</td>
<td>12220760</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disability insurance</th>
<th>Disability risk</th>
<th>Not recovered risk</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal distribution</td>
<td>Normal distribution</td>
<td>Log-normal distribution</td>
</tr>
<tr>
<td></td>
<td>Normal distribution</td>
<td>Log-normal distribution</td>
<td>Normal distribution</td>
</tr>
<tr>
<td>VaR</td>
<td>173597</td>
<td>170537</td>
<td>179238</td>
</tr>
<tr>
<td>CTE</td>
<td>192947</td>
<td>192948</td>
<td>200548</td>
</tr>
<tr>
<td>CoC</td>
<td>230671</td>
<td>226521</td>
<td>238423</td>
</tr>
<tr>
<td></td>
<td>Mortality</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>Longevity</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Disability</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Not recovered</td>
<td>Normal</td>
<td>Log-normal</td>
</tr>
<tr>
<td></td>
<td>VaR</td>
<td>5187431</td>
<td>5187257</td>
</tr>
<tr>
<td></td>
<td>CTE</td>
<td>5809500</td>
<td>5809500</td>
</tr>
<tr>
<td></td>
<td>CoC</td>
<td>13508483</td>
<td>13508374</td>
</tr>
</tbody>
</table>

|                      | Mortality | Log-normal | Log-normal | Log-normal | Log-normal | Log-normal | Log-normal | Log-normal |
|                      | Longevity | Normal | Normal | Normal | Normal | Log-normal | Log-normal | Log-normal |
|                      | Disability | Normal | Normal | Log-normal | Log-normal | Normal | Log-normal | Log-normal |
|                      | Not recovered | Normal | Log-normal | Normal | Log-normal | Normal | Log-normal | Log-normal |
|                      | VaR       | 5157305 | 5157096 | 5157695 | 5157481 | 5164003 | 5163795 | 5164179 |
|                      | CTE       | 5766237 | 5766237 | 5766793 | 5766793 | 5774822 | 5775377 | 5775377 |
|                      | CoC       | 13529172 | 13529064 | 13529378 | 13529267 | 13529172 | 13529064 | 13529267 |
A.3 The duration of the contract

*Figure 18:* The RA per duration of the contract for all techniques for term life insurance. For all risks the normal distribution was used.

*Figure 19:* The RA per duration of the contract for all techniques for immediate annuity. For all risks the normal distribution was used.
For insured pension the retirement age and end age of the contract are set. Changing these would not be realistic. Because of this, this contract cannot have very short durations, so these values could not be calculated.
Figure 21: The RA per duration of the contract for all techniques for disability insurance. For all risks the normal distribution was used.

Figure 22: The RA per duration of the contract for all techniques for disability insurance. For all risks the normal distribution was used (zoomed in version).
A.4 Derived confidence level

Figure 23: The RA per derived confidence level for all estimation techniques. For all risks the normal distribution was used.

![Graph showing the RA per derived confidence level](image1)

Figure 24: The applied confidence level per derived confidence level for all estimation techniques of the RA. For all risks the normal distribution was used.

![Graph showing the applied confidence level per derived confidence level](image2)
A.5 Sensitivity testing

Figure 25: The RA per applied confidence level for all techniques. For all risks the normal distribution was used.

Figure 26: The RA per applied confidence level for all techniques. For all risks the log-normal distribution was used.
Figure 27: The RA per capital rate for all techniques. For all risks the normal distribution was used.

Figure 28: The RA per start value of the standard deviation for all techniques. For all risks the normal distribution was used.
Figure 29: The RA per increase factor of the standard deviation for all techniques. For all risks the normal distribution was used.
Figure 30: The RA per factor multiplied with the correlations for all techniques. For all risks the normal distribution was used.

Figure 30 was made by multiplying all correlations $\text{corr}_{u,v}$ with $u \neq v$ with a factor. The $\text{corr}_{u,u}$ were not changed because these should always be one.

Table 12: The RA, calculated using the simple sum method for diversification. For all risks the normal distribution was used.

<table>
<thead>
<tr>
<th></th>
<th>VaR</th>
<th>CTE</th>
<th>CoC</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>5941756</td>
<td>6653371</td>
<td>14174372</td>
</tr>
</tbody>
</table>
Figure 31: The derived confidence level per standard deviation of the cash-flows for all techniques. It was assumed that the cash-flows are normally distributed.

Figure 32: The derived confidence level per standard deviation of the cash-flows for all techniques. It was assumed that the cash-flows are log-normally distributed.
Figure 33: The RA per percent point added to the discount rate for all techniques. For all risks the normal distribution was used.

Figure 33 was made by adding percent points to the used discount rate. For example for $x = -1$, -0.01 was added to all discount rates.
B Interviews (in Dutch)

B.1 Interview met een EY accounting specialist

1. Wat heeft u te maken met IFRS 17?
   IFRS 17 is mijn dagelijkse werk. Ik ben op dit moment project manager voor 3 (binnenkort 4) verzekeraars. Ik werk met een internationaal bedrijf, een marktleider in Nederland, en kleinere partij en ben nu ook bezig met het maken van een offerte voor een vierde verzekeraar.

2. Waarom denkt u dat IFRS 17 is gemaakt?
   IFRS 17 vult een hiat in IFRS. Het geeft een nog uniforme manier van het bekijken van verzekeringscontracten. Er is 13 jaar gezocht naar draagvlakken voor een uniforme manier van het vergelijken van verzekeringscontracten. Er is 13 jaar gezocht naar draagvlakken voor een uniforme manier van het vergelijken van verzekeringscontracten.
   a. Wat is het doel?
      Het doel is betere vergelijkbaarheid tussen verzekeringen, minder afwijkingen tussen lokale manieren van accounting en beter onderscheid maken tussen assates en liabiliteits.
   b. Waarom wordt er zo veel geld uitgegeven om het te implementeren?
      Beurs genoteerde verzekeraars kunnen niet anders. Verzekeraars kunnen met IFRS 17 een meer kosten effectief model maken. Ze kunnen ook proberen een breder doel te bereiken. Voor kleinere partijen is het vaak erg duur, zij proberen soms om eronder uit te komen door onder een andere standaard te gaan rapporteren die makkelijker te implementeren is.

3. Wat voor invloed heeft IFRS 17 op . . .
   a. EY?
      IFRS 17 gaat de commerciële markt domineren. Netwerken gaan zich ontwikkelen. Groupepen zullen worden opgezet om ervaringen te delen. Er zal meer internationaal gewerkt worden. We moeten kennis gaan ontwikkelen en delen. Over een half jaar heeft EY bij 1/3 van de verzekeraars gezien hoe het werkt, dan weten we veel over hoe IFRS 17 werkt en geïmplementeerd kan worden, misschien wel meer dan de verzekeraar zelf.
   b. Verzekeraars?
      IFRS 17 heeft heel veel invloed op verzekeraars. Ik heb bijvoorbeeld recent naar een kleine verzekeraar gekeken, daar hadden we na 2 dagen al 186 gaps gevonden en je moet heel veel investeren om dat op te lossen. In het algemeen heb je nieuwe data nodig, dus nieuwe input, dus er moet een nieuw proces ontwikkeld worden om die data te verkrijgen en te verwerken. Resultaten van IFRS 17 komen op de jaarrekening en je wil comfortabel zijn met de info die je communiqueert, deze moet correct zijn en je moet hem kunnen uitleggen omdat je niet verrast wil worden en professioneel over wil komen.
   c. Investeersers?
      Investeersers zijn erbij gebaad. Er komt meer informatie die allemaal kan worden gevonden in een centraal punt namelijk op de jaarrekening. Ze hoeven minder informatie zelf te verzamelen.
      Als de standaard voor het eerst wordt geïmplementeerd, en men gaat bepalen hoe ze ermee omgaan, gaan de investeerders zich veelvend opstellen om meer info te krijgen.
   d. Op wie heeft het nog meer invloed?
      Uiteindelijk gaat IFRS 17 invloed hebben op de bredere maatschappij. Het gaat duidelijk maken aan verzekeraars op weke verzekeringsproducten er winst wordt gemaakt, waardoor er druk vanuit verzekeraars en investeersers komt om verliezende producten te
veranderen of ermee te stoppen. Hierdoor zal de prijs van dit soort verzekeringen stijgen of zullen ze niet meer aangeboden worden. 

IFRS 17 gaat duidelijker maken waar inkomsten en uitgaven vandaan komen en naar toe gaan. Het zou bijvoorbeeld kunnen dat een verzekeraar beter is in beleggen dan in het verzekeren zelf, dit kan tot fusies leiden, waardoor de werkgelegenheid kan dalen.

4. Wat vindt u dat de voordelen van IFRS 17 zijn?

a. 

Voor EY?

Voor EY zijn dit gouden jaren, alleen in Nederland al gaat het om 30 tot 40 miljoen euro aan werkgelegenheid. Wereldwijd gaat het waarschijnlijk wel om 600 tot 700 miljoen euro.

b. 

Voor verzekeraars?

IFRS 17 verplicht een verzekeraar om het hele financiële programma om te gooien. Je zou dit als een einmalige kans kunnen zien om alles op te ruimen en eenmalig helemaal goed te doen. Hier moet je echter wel het geld en de mankracht voor hebben. Het kan je ook de kans geven om efficiënter te gaan werken omdat je erachter komt dat bepaalde processen te veel geld kosten voor de hoeveelheid mensen die erop staan. Je kan ook de mogelijkheid aangrijpen om programma’s die niet goed lopen af te schaffen.

In het algemeen kan je wel zeggen dat verzekeraars IFRS 17 erg vervelend vinden door de hoeveelheid werk, tijd en geld die erin geïnvesteerd moet worden.

c. 

Voor Nederland?

IFRS 17 zorgt voor beter inzicht. Betere vergelijkbaarheid is een mooi doel, maar er gaat wel veel geld in zitten dat niet aan iets anders besteed kan worden. Het zou banen kunnen kosten en geeft een druk op het bedrijfsleven. Solvency II geeft de verzekerde ook zekerheid, dat doet IFRS 17 niet.

5. Wat zijn de nadelen?

a. 

Voor EY?

We moeten gaan kiezen waar we mensen op inzetten, op IFRS 17 of op iets anders. We hebben zoveel mensen nodig, daar kan je niet tegenop werven. Dit zijn wel echt luxe problemen.

b. 

Voor verzekeraars?

Zie 4b.

c. 

Voor Nederland?

Zie 4c.

6. IFRS 17 is principles-based, wat vindt u hier van?

a. 

Wat zijn de voordelen?

IFRS 17 is multi-interpretabel, dit kan zowel een voordeel als een nadeel zijn. Een verzekeraar heeft meer vrijheidsgraden om IFRS 17 te implementeren, wat goed is want elke verzekeraar is anders. Aan de andere kant maken deze keuzes het vergelijken van verzekeraars weer lastiger.

b. 

Wat zijn de nadelen?

Zie 6a.

c. 

Gaat het probleem opleveren met interpretatie?

Het duurt even voordat men een meer algemene manier heeft gevonden om IRFS 17 te implementeren, maar daar gaan we uiteindelijk wel naartoe. Na een jaar of wat ontwik-
kelen zich ‘leading practices’. De interpretaties gaan dan dan een bepaalde kant op. De markt beweegt zich ergens naartoe, uiteindelijk.

7. Als u een investeerder zou zijn die mogelijk in een verzekeraar zou willen investeren, in welke delen van de financiële performance zou je in geïnteresseerd zijn? Zou je geïnteresseerd zijn in het vergelijken van verzekeraars op hun
   a. CSM
   b. Inkomsten van de CSM en de RA
   c. Het verloop van de verplichtingen van de CSM en de RA
   d. Iets anders?

Ik zou kijken naar waar de winst wordt gemaakt, met verzekeren of investeren. Binnen het verzekeren zou ik kijken naar wat de ‘new business’ is, waar wordt er waarde toegevoegd aan de Solvency II ratio. Ook zou ik kijken hoe het beleid en strategie van de verzekeraar past in grotere thema’s zoals duurzaamheid. Business is veel breder dan IFRS 17, dingen als cultuur en mensen zijn ook belangrijk.

B.2 Interview met een oud werknemer van de IASB

1. Wat heeft u te maken met IFRS 17?
   Het schrijven van IFRS 17 is 10 jaar geleden begonnen, in de zomer van 2008. Ik ben zelf vanuit EY naar de IASB gegaan en heb daar als project manager gewerkt aan de eerste exposure draft van IFRS 17. Toen heette deze nog IFRS 4 fase 2. Ik kwam zelf terug bij EY in 2010, maar ben de ontwikkelingen wel blijven volgen. Het heeft nog even geduurd voordat de definitieve standaard er was.
   In 2005 was er al een interim standaard, IFRS 4, maar dit was een tijdelijke standaard, omdat er iets moest zijn. In 2007 is het eerste discussie paper gepubliceerd. In 2010 is de eerste exposure draft gepubliceerd, waar ik zelf aan gewerkt heb. In 2013 is de tweede exposure draft gepubliceerd en in 2017 de echte standaard.
   a. Wat is een goede omschrijven van uw rol?
      Toen ik bij de IASB werkte was ik een zo genoemde “practice fellow”, iemand die vanuit de praktijk de IASB ondersteunt.

2. Waarom denkt u dat IFRS 17 is gemaakt?
   Er is een stabiele omvattende standaard nodig voor verzekeringcontracten, als onderdeel van IFRS verslaggeving. IFRS 4 was een eerste nood oplossing, maar die bleek toch echt niet voldoende te zijn. Bijvoorbeeld door lage rente is gebleken dat het erg belangrijk is om goede regelgeving te hebben omtrent verzekeringcontracten.
   a. Wat is het doel?
      Het doel van IFRS 17 is het leveren van bruikbare financiële verslaggevingsinformatie voor verzekeringcontracten, als onderdeel van het bredere jaarverslag van de verzekeraar. Er is een specifieke standaard voor verzekeringcontracten nodig.
   b. Waarom wordt er zo veel geld uitgegeven om het te implementeren?
      Voor verzekeringen is het implementeren van IFRS 17 vrij kostbaar. Het is een grote verandering ten opzichte van huidige verslaggevingsregels. Er was sterke diversiteit, IFRS 17 trekt dit meer uniform. Het implementeren van IFRS 17 heeft heel veel consequenties voor de verslaggevingskant, maar ook vanuit de data en systemen kant, regels leiden ertoe dat je meer data nodig hebt en met andere modellen en systemen moet gaan werken.
3. Wat voor invloed heeft IFRS 17 op . . .

a. De IASB?
Het is een hele uitdaging gebleken om IFRS 17 te schrijven. Het is het project met de langste looptijd van alle projecten van de IASB. Officieel zijn ze in 1997 al aan de voorloper van IFRS 17 begonnen en pas in 2017 is de definitieve standaard beschikbaar gekomen, de IASB heeft erg veel tijd en energie in IFRS 17 moeten stoppen.

b. Verzekeraars?
IFRS 17 is een hele nieuwe manier van IFRS verslaggeving, op basis van volledige actuële veronderstellingen en op basis van verwachtingen en verwachte waarden. Daarnaast brengt het ook een aantal belangrijke wijzigingen mee in hoe de resultaten worden gepresenteerd. Het heeft nog al wat invloed op de “key performance” van de verzekeraars.

c. Investeerders?
Investeerders zijn vaak kritisch geweest over de verslaggeving vanwege diversiteit, compliciteit en gebrek aan consistentie. Het is moeilijk om verzekeringsschulden met elkaar te vergelijken. Het doel van IFRS 17 is de consistentie verhogen, vergelijken makkelijker maken en meer toelichting geven. Aan de andere kant is er nog een zorg dat ook het huidige model vrij complex is. Het is een uitdaging om IFRS 17 goed te kunnen begrijpen.

d. Op wie heeft het nog meer invloed?
In Nederland en de EU in het algemeen valt de invloed van IFRS 17 wel mee. Het Solvency II regime staat los van IFRS 17. Bijvoorbeeld in Canada is IFRS 17 de basis voor toezichthouders en verslaggeving, dus de IASB heeft daar veel meer invloed.

4. Wat vindt u dat de voordelen van IFRS 17 zijn?

a. Voor de IASB?
De IASB is nu eindelijk van het project af. Het was heel belangrijk om dit goed af te ronden, dat moest gebeuren. Nu zijn ze nog niet helemaal van IFRS 17 af, er speelt nog en hoop rondom commentaren en reacties op de standaard, bijvoorbeeld vanuit EU. Verzekeraars in Nederland mogen IFRS 17 alleen gebruiken als het door de EU wordt goedgekeurd. Hier is de IASB ook bij betrokken. De IASB heeft zelf ook een “transition resource group” opgesteld. Dit is een groep van experts die kijkt naar wat de praktische issues zijn die opkomen bij de implementatie van IFRS 17 en hoe deze kunnen die worden opgelost.

b. Voor verzekeraars?
IFRS 17 biedt de mogelijkheid om tot een meer consistent verslaggeving te komen, waarbij verzekeraars ook heel goed moeten kijken naar wat voor producten zij hebben, hoe ze die moeten waarderen en wat voor resultaten eruit komen. IFRS 17 biedt mogelijkheid om diversiteit meer consistent te trekken.

c. Voor Nederland?
Verzekeraars zijn ook belangrijke investeerders. Ze investeren in hypotheken en in staatsobligaties en zijn een belangrijke partij die ook belangrijk is voor de economie. Daarnaast geven ze natuurlijk ook verzekeringsschulden of. Dit is een belangrijke dienst waar Nederland ook van profiteert.

5. Wat zijn de nadelen?

a. Voor de IASB?
Voor de IASB is IFRS 17 geen nadeel meer. Ze hebben de standaard nu uitgegeven. Ze hebben er nu nog wel een hoop werk van, de nazorg, zoals implementatie ondersteuning, maar IFRS 17 heeft niet echt nadelen voor de IASB.
b. **Voor verzekeraars?**

IFRS 17 is een complexe standaard. Het kost veel tijd, moeite en geld om deze te implementeren en het is nog niet duidelijk of de voordelen ook echt merkbaar gaan zijn. Verzekeraars hebben ook te maken met Solvency II en het implementeren daarvan heeft ook veel moeite gekost. Je zou je kunnen afvragen wat dan de toegevoegde waarde van IFRS 17 is.

c. **Voor Nederland?**

De kosten van het implementeren van IFRS 17 zijn een nadeel voor Nederland. Het gaat verzekeraars veel geld kosten en dat kunnen ze niet als dividend uitbetalen of op een andere manier uitgeven.

6. **IFRS 17 is principles-based, wat vindt u hier van?**

a. **Wat zijn de voordelen?**

Ik ben hier positief over. Het past binnen de historie van het verslaggevingsdenken in Nederland. Er is een natuurlijke neiging naar principe-based verslaggeving en een principle-based manier om naar zaken te kijken. Principes-based geeft de verzekeraar de mogelijkheid om zelf keuzes en interpretaties te maken en om zelf invulling te geven aan de standaard.

b. **Wat zijn de nadelen?**

Doordat IFRS 17 principes-based is, is er ruimte voor judgement, je loopt hierdoor wel het risico dat de standaard op verschillende manieren wordt toegepast. Door verschillende interpretaties ontstaan verschillen in toepassing.

c. **Gaat het probleem opleveren met interpretatie?**

Het is een uitdaging. Op de agenda van de IASB staan een hoop issues van dingen waarover men nog niet goed weet hoe het moet worden geïnterpreteerd. Keuzes maken is moeilijk als er nog onzekerheid is over de interpretatie.

7. **Als u een investeerder zou zijn die mogelijk in een verzekeraar zou willen investeren, in welke delen van de financiële performance zou je je geïnteresseerd zijn?**

Zou je geïnteresseerd zijn in het vergelijken van verzekeraars op hun

a. CSM

b. Inkomsten van de CSM en de RA

c. Het verloop van de verplichtingen van de CSM en de RA

d. Iets anders?

Ik zou kijken naar het verloop van de CSM en de RA. Dit geeft een indicatie van hoeveel verwachte winstgevendheid er nog is. De RA geeft een indicatie van de mate van de mogelijke onzekerheid. Daarnaast is het van belang om goed naar de winst en verliesrekening te kijken. Ik zou ook kijken naar de winst en de mutaties in de herwaarderingsreserves. Daarnaast zou ik de verplichtingen naast beleningen leggen. Dit geeft informatie over de gevoeligheid van de componenten.

B.3 **Interview met een werknemer van een verzekeraar**

Deze verzekeraar wordt vanaf nu “de verzekeraar” genoemd.

1. **Wat heeft u te maken met IFRS 17?**

Vanaf afgelopen november ben ik fulltime bezig met IFRS 17 en daarvoor keek ik ook al mee.
met wat het zou betekenen. Je kan het implementeren van IFRS 17 niet naast je baan doen, dus ik werk nu alleen aan IFRS 17.

2. Waarom denkt u dat IFRS 17 is gemaakt?
We wisten 20 jaar al dat er nog iets moest gebeuren. De voorloper van IFRS 17 is begonnen in 2004 met als doel meer conformiteit tussen bedrijven en landen. Het bepalen van verzekeringsverplichtingen was moeilijk. In IFRS 4 stond “doe maar wat je daarvoor al deed”, wat ervoor zorgde dat iedereen dit op een andere manier aanpakte. Dit resulteerde erin dat beleggingen waren gebaseerd op marktwaarden, terwijl verplichtingen waren gebaseerd op boekwaarden, wat ervoor zorgde dat je appels met peren aan het vergelijken bent. Daarnaast is het ook niet logisch en moeilijk te begrijpen. Je kon verzekeringen eigenlijk niet vergelijken en al helemaal niet tussen landen.

De verzekeraar waarvoor ik werk heeft een vestiging in Nederland, de UK en de US. Deze hebben allemaal aparte regels. Volgens het oude systeem telden we de waarden die hieruit kamen gewoon op terwijl ze op totaal andere manieren bepaald waren. Met IFRS 17 mag dit niet meer en wordt alles consistent.

Er zijn 171 landen die IFRS 17 moeten toepassen.

a. Wat is het doel?
Het doel van IFRS 17 is betere verslaggeving voor de prestaties van een verzekeraar. Bijvoorbeeld het feit dat je winst niet meer in één keer mag erkennen, maar dit over de looptijd van het contract moet verspreiden. Dit geeft meer transparantie. Het dwingt je om de informatie op een meer gedetailleerd niveau vast te stellen. Voor de markt is dit ook zeer interessant. Je kan nu zien waar je winst en verlies om maakt. Met IFRS 17 mag je geen verliezen met winsten goed praten, terwijl dat in het verleden wel gedaan werd. Als een contract verlieslijdend is, moet je dat nu melden.

b. Waarom wordt er zo veel geld uitgegeven om het te implementeren?
IFRS 17 implementeren kost heel veel. Omdat IFRS 17 principles-based is, is het niet direct duidelijk hoe je het moet implementeren. Je moest eerst alles interpreteren. Een verzekeraar is opgebouwd uit verschillende systemen en deze moeten allemaal worden aangepast. Dit kost heel veel tijd, werk en geld, terwijl de klant niet een beter product krijgt en ook niet meer wil betalen. Waarschijnlijk moet de aandeelhouder het gaan betalen.

3. Wat voor invloed heeft IFRS 17 op...

a. De verzekeraar?
De systemen en processen moeten worden veranderd zodat de IRFS 17 cijfers kunnen worden opgeleverd. Je hebt nog maar 1,5 jaar voor transitie. De verzekeraar voert zelf ook heel veel checks uit om te zien of alles nog wel goed is. Deze moeten ook worden aangepast. Daarnaast moet de kennis worden uitgesmeerd binnen heel de verzekeraar. Wij hebben 3000 mensen in dienst.

b. Investeerders?
Men weet nog niet echt wat er gaat gebeuren. Bijvoorbeeld, de verzekeraar heeft een jaarrekening waarop staat dat de totale waarde van het bedrijf 25 miljard is. Echter, op de beurs zijn we maar ongeveer de helft daarvan waar. Dit komt doordat de markt het niet vertrouwt. Ze denken dat wij niet genoeg rekening houden met de risico’s die we lopen. Als de transparantie in onze jaarrekening straks beter wordt blijkt misschien wel dat ze te negatief waren en word het bedrijf op de beurs ook meer waar. Aan de andere kant kan het natuurlijk ook zo zijn dat de transparantie ervoor zorgt dat we nog minder waarde zijn dan die 50% die ze eerst rekenden.
c. Op wie heeft het nog meer invloed?
   Op de klanten heeft het waarschijnlijk geen invloed, tenzij de verzekeraar toch besluit een deel van de kosten van de implementatie van IFRS 17 bij de klant te leggen en de premies van verzekeringen te verhogen.
   IFRS 17 zal ook invloed hebben op overnamen. Sommige voornamelijk kleinere verzekeringen passen geen IFRS toe. Zij implementeren IFRS 17 dus ook niet. Als een bedrijf dat wel onder IFRS 17 rapporteert nu een bedrijf dat dat niet doet zou willen overnemen, dan moet IFRS 17 alsnog worden geïmplementeerd. Daarnaast is het vergelijken van de cijfers van de twee bedrijven ook nog steeds lastig.

4. Wat vindt u dat de voordelen van IFRS 17 zijn?
   a. Voor de verzekeraar?
      We moeten IFRS 17 implementeren, we moeten voldoen aan de regels, zo is het nu eenmaal. Ik sla dit echter liever om in iets positiefs en bekijk de mogelijkheden. Je moet nu toch je systeem maanpassen, gebruik dit dan ook om andere producten te gaan verkopen en nieuwe business te ontwikkelen.
   b. Voor Nederland?

5. Wat zijn de nadelen?
   a. Voor de verzekeraar?
      Het kost heel veel geld en je ziet dit niet terug in hogere verkoop.
   b. Voor Nederland?

6. IFRS 17 is principles-based, wat vindt u hier van?
   a. Wat zijn de voordelen?
      Ik zie dit als een voordeel. In Amerika bijvoorbeeld, is alles vastgelegd in een handboek waaraan je moet voldoen, maar dat zorgt er ook voor dat mensen dingen gaan doen die nog net binnen de regels vallen, maar eigenlijk niet de bedoeling zijn. Bij een standaard die principles-based is, is dit moeilijker, omdat je ook alles moet kunnen verklaren.
   b. Wat zijn de nadelen?
      Zeker in het begin kost het heel veel moeite om alles te interpreteren.
   c. Gaat het probleem opleveren met interpretatie?
      Het is aan het begin lastig, maar zal niet echt tot problemen leiden, denk ik.

7. Als u een investeerder zou zijn die mogelijk in een verzekeraar zou willen investeren, in welke delen van de financiële performance zou je je geïnteresseerd zijn?
   Zou je geïnteresseerd zijn in het vergelijken van verzekeraars op hun
   a. CSM
   b. Inkomsten van de CSM en de RA
   c. Het verloop van de verplichtingen van de CSM en de RA
d. Iets anders?

Ik zou geïnteresseerd zijn in de CSM, zowel in de CSM die al is vrijgevallen als de CSM die nog gaat vrijvallen. Als de CSM die nog gaat vrijvallen niet zo hoog is, zegt dat iets over de toekomst. De RA is ook wel interessant, dat is meer bijzaak. Aan de RA kan je zien hoeveel buffer er in het bedrijf zit, maar de CSM is het belangrijkst.

B.4 Interview met een EY tax specialist

1. Wat heeft u te maken met IFRS 17?


Bij verzekeraars kunnen op deze manier hele grote waarderingsverschillen zitten. Daardoor is er een behoorlijke latentie. Er bestaat zowel actieve als passieve latentie. Het voorbeeld dat ik gaf was van passieve latentie. Bij actieve latentie krijg je dus nog belasting terug, maar als je dit op je jaarrekening zet, moet je dat wel goed kunnen uitleggen. In andere landen heeft IFRS 17 ook impact op hoe je aangifte doet, daar heeft het dus veel meer invloed dan hier.

2. Waarom denkt u dat IFRS 17 is gemaakt?

Consistentie, het verbeteren van vergelijkbaarheid qua financiële performance en meer transparantie.

a. Wat is het doel?

Een goed beeld geven van de financiële stand van zaken van het bedrijf.

b. Waarom wordt er zo veel geld uitgegeven om het te implementeren?

De administratie is heel complex. Huidige administratie is er niet op ingericht. Het implementeren is een groot project dat veel geld kost.

3. Wat voor invloed heeft IFRS 17 op . . .

a. EY?

Wij verzorgen de belasting aangifte van verzekeraars. De basis hiervoor is de jaarrekening. Nu is die soms lastig te doorgrenzen. Het is soms onduidelijk hoe bepaalde waardes gewaardeerd worden. Het aangifte proces zou hiermee makkelijker worden. Een nadeel hiervan zou kunnen zijn dat ons werk goedkoper wordt.

b. Verzekeraars?

Solvency II was een hele belangrijke ontwikkeling. IFRS 17 wijkt op bepaalde punten hiervan af. Veel verzekeraars vinden het misschien belangrijker wat rating agencies en de DNB van hen vindt. SII blijft meer leidend. Verzekeraars zouden IFRS 17 ook kunnen gebruiken om zichzelf beter te kunnen vergelijken met anderen en het geeft beter inzicht op product niveau.

c. Investeerders?

Zij kunnen met IFRS 17 verzekeraars beter vergelijken.
d. **Op wie heeft het nog meer invloed?**
   Aandeelhouders, beleggers en rating agencies. Ook zij kunnen met IFRS 17 verzekeraars beter vergelijken.

4. **Wat vindt u dat de voordelen van IFRS 17 zijn?**
   a. **Voor EY?**
      Aangiften doen wordt makkelijker.
      In de toekomst kan de belastingdienst besluiten om de fiscale regels eens tegen het licht houden en ze meer IFRS 17 proof te maken. Dit zal vast een discussie worden over 1 of 2 jaar. Dit zou het doen van aangiften voor verzekeraars nog makkelijker maken.

   b. **Voor verzekeraars?**
      Beleggers en aandeelhouders kunnen verzekeraars beter vergelijken, wat leidt tot eerlijkere concurrentie om kapitaal van de beleggers.
      Soms hebben ze ook nog hele oude IT systemen. Dit is misschien een goed moment om dit over te zetten.
      Het geeft in ieder geval geen direct belasting voordeel.

   c. **Voor Nederland?**
      In Nederland heb je ook verzekeringen die nog rapporteerden volgens IFRS 4. Dit wordt verbeterd.

5. **Wat zijn de nadelen?**
   a. **Voor EY?**
      Het levert werk op.

   b. **Voor verzekeraars?**
      Voor verzekeraars levert het veel hoge kosten op. Ze kunnen het niet zelf implementeren en moeten daarom mensen inhuren om dat voor ze te doen. Dit weegt waarschijnlijk niet op tegen de voordelen. Ze willen het geld en de tijd misschien wel aan andere dingen besteden, maar dat kan niet.

   c. **Voor Nederland?**
      Hetzelfde. (Over de rekeningen die die adviseurs sturen moet btw worden betaald, dit levert meer geld op voor Nederland.)

6. **IFRS 17 is principles-based, wat vindt u hier van?**
   a. **Wat zijn de voordelen?**
      Het past wel in de Europese traditie dat je een standaard kan toepassen op eigen bedrijfsvoering. Als er hele strak gedefinieerde regels zijn gaan mensen er vaak net even omheen zodat ze buiten de regels vallen. Net als belasting ontduiken zeg maar. Het biedt verzekeraars wel de mogelijkheid IFRS 17 op verschillende manieren te implementeren, waardoor ze weer minder vergelijkbaar worden.

   b. **Wat zijn de nadelen?**
      Zie 6a.

   c. **Gaat het probleem opleveren met interpretatie?**
      Ik denk het niet.
Als u een investeerder zou zijn die mogelijk in een verzekeraar zou willen investeren, in welke delen van de financiële performance zou je in geïnteresseerd zijn?
Ik zou zeker naar de IFRS 17 data kijken, ik denk dat die data meer waardevol is dan nu het geval is. De IFRS 17 data is meer objectief.