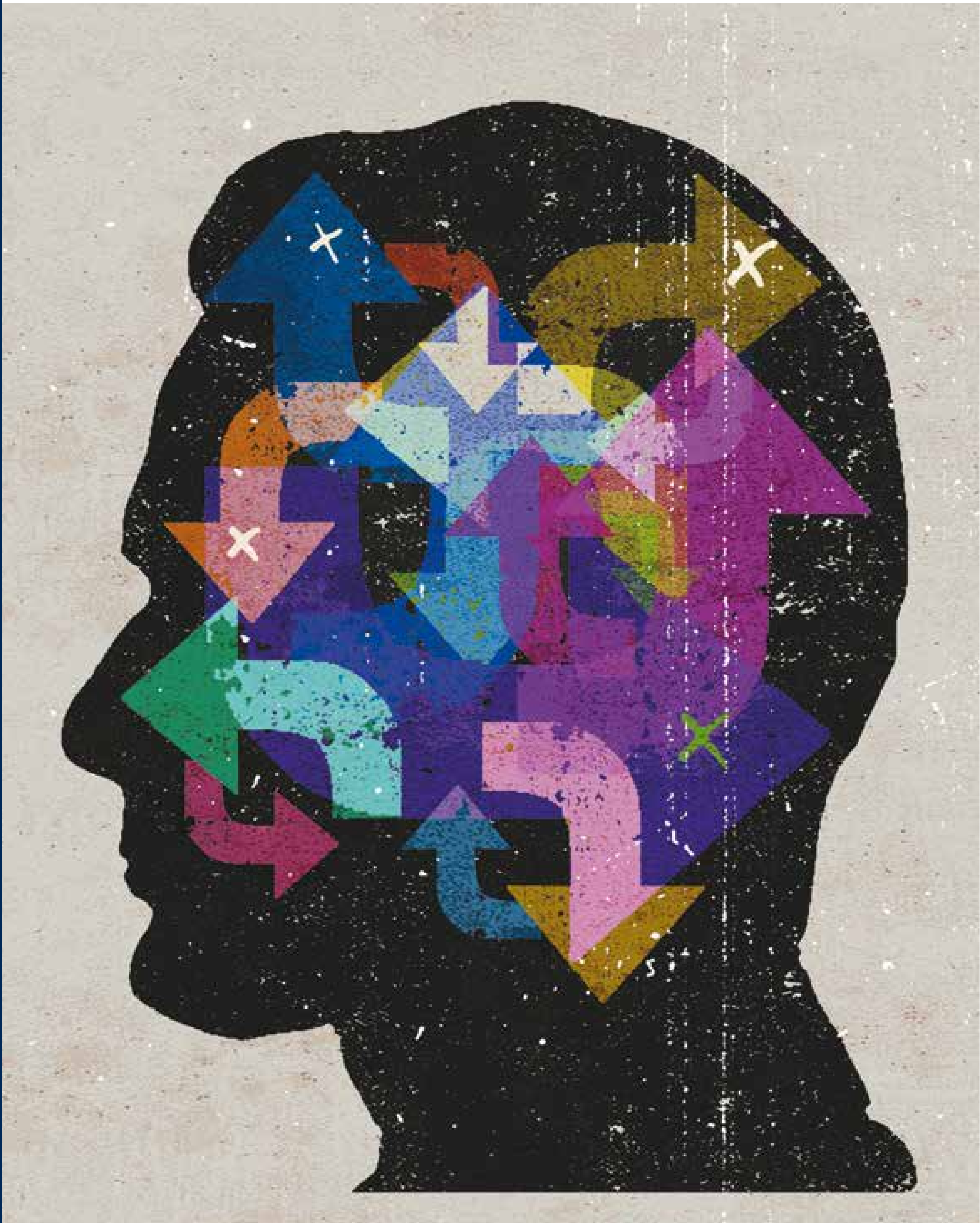
GOSSE A.G. ALSERDA

Choices in Pension Management



Choices in Pension Management

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Keuzes in pensioenbeheer

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Acknowledgements

About five years ago, as most young people, I'd never seriously thought about my pension until, with some coincidence, I ended up in the seminar 'Pension Markets: Governance and Institutions', which led me to writing a master thesis about pensions and finally to starting this PhD project in pensions. However, I can't say I wasn't warned, as the first thing I was told in the seminar was: 'Pensions are addictive'.

Until I was asked for the project, I'd never seriously considered pursuing a PhD, but I took up the glove, and enjoyed (almost) all of it. However, this work wouldn't have been possible without the help and support of some wonderful people that have accompanied me during the journey of this PhD project.

First of all I want to thank Fieke van der Lecq, who addicted me to pensions. I can't thank you enough for the endless amount of feedback that you've provided me over the years, and for the always interesting meetings we had. In short: *'t kon minder.*

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Now it's time to start accumulating some serious pension benefits.

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Chapter 1

Introduction

Choices in pension plan management have large effects on both households and the economy as a whole. However, the choices that are made in pensions tend to differ greatly across the globe, resulting in significantly different outcomes.

During working life a part of income is normally redirected to act as income during retirement so that individuals can still pay for themselves even if they are no longer able or willing to work. The way that this is organised, the organization of pensions, differs greatly across, and within, countries. Pensions can take the form of funded pensions, where saved capital (during working life) is extracted during retirement. However, pensions can also be pay-as-you go. In this case the working population pays the retirement benefits of the retired population. However, within funded and pay-as-you go pensions there is great diversity as well. Pensions can be accumulated individually or in a collective; they can be accumulated in a pension fund, pension insurance firm or via a deposit fund. The contribution can be constant, or increasing with age and the asset allocation can be the same for everybody, or adjusted to suit individual preferences and/or according to age (lifecycles). While some countries have pension capital that exceeds their Gross Domestic Product (GDP), other countries have virtually no pension capital at all. This raises the question as to how pensions can be arranged best, taking into account individual and national characteristics.

Pensions represent a great part of household wealth. The net pension wealth[1] expressed as a multiple of individual annual gross earnings averages 8.8 for OECD countries (OECD, 2015c). This suggest that individuals spend on average almost 9 years of their lives working to build their retirement income (including tax benefits and social security). In return, individuals in OECD countries have on average a net replacement rate[2] of 63% (OECD, 2015c), implying that after tax retirement income is equal to 63% of pre-retirement income. However, these values differ strongly between OECD countries where net pension wealth ranges from 3.8 (Mexico) to 15.5 times (Luxembourg) individual annual gross earnings, while the net replacement rates ranges from 28.4% (Mexico) to 104.8% (Turkey) (OECD, 2015c). The great many choices in pensions produce very different pension outcomes, and as the numbers show, these have a major impact on household financials.

Pensions are not exclusively relevant for individuals or households, but also for the economy as a whole. In 2013, the assets of pension funds were equal to on average 83% of GDP in OECD countries (OECD, 2015c). This means that 34 OECD countries together had USD 24.8 trillion worth of assets in pension funds (OECD, 2015c). Not surprisingly, there is a great variety in the relative size of pension fund assets across countries. The value of pension funds assets equalled 0.1% of GDP in Greece compared to 148.7% of GDP in The Netherlands in 2013 (OECD, 2015c). The properties of the pension system influence economic growth. The presence or absence of large amounts of pension fund assets will influence capital markets, and properties of the pension system will influence the effect of ageing on the economy (Bloom et al., 2010). These effects run via changes in saving rates, government spending and labour-force participation.

A particular feature of the pension sector is the large number of stakeholders involved. Foremost are the pension plan members. However, pension plan members themselves do not always take one position, and even within this group interests may not always align. Pension plan members differ in terms of age, gender, education, income and risk preferences (Van Rooij et al., 2007), which affect their preferred options among the great many choices available. For example, older members benefit from higher contributions, while younger members benefit from greater risk taking (Viceira, 2001). Members with a higher income are less affected by changes in a base

[1] Definition: "The present value of the flow of pension benefits, taking account of the taxes and social security contributions that retirees have to pay on their pensions" (OECD, 2015c, p.150)

[2] Definition: "The individual net pension entitlement divided by net pre-retirement earnings, taking account of personal income taxes and social security contributions paid by workers and pensioners" (OECD, 2015c, p.145)

pension or franchise, and women and better educated individuals tend to live longer (Crimmins and Saito, 2001) and therefore benefit more from higher pension benefits.

Other stakeholders are employers (plan sponsors), providers of pension related services, supervisors and the government. Employers often pay a substantial part of the contributions and can be liable for financial deficits and higher contributions when the cost of pensions goes up. Depending on the exact situation, employers may even be forced to take a provision in their own account for any deficits of the company pension fund. Providers of pension services are also stakeholder, these include pension funds, insurance companies, administration companies, asset managers, etc. Choices in the pension sector can influence these institutions' operations, affecting profitability and/or trust. Financial supervisors monitor the pension providers, and are mandated to ensure pension provider performance and prevent risks. Finally, the government represents the taxpayers, mostly also pension plan members, and influences the pension sector with its regulations. Choices concerning regulations in the pension sector will have specific effects for different groups, who might be represented by different political parties, *e.g.*, younger members benefit from increases in the retirement age, while older members benefits from increases in the discount rate for pension liabilities.

Given the large number of stakeholders, the misalignment of interests, and the great importance of pensions for individuals and the economy alike, it is paramount to have a detailed analyses of the impact of different choices in the pension sector on individual well-being and on the position of pension funds in the economy. Only when all the information is available can the consequences of different stakeholders be weighed and choices be made that improve the pension system.

1.1 Motivation

The 2007-2008 financial crisis revealed the vulnerability of many of the world's pension systems. Pension funds, like that of the city Detroit, became insolvent and pension benefits were lowered (Davey and Walsh, 2013). As a result, many countries reconsidered their choices made in pension design. However, these choices are very complicated, and they affect a large number of stakeholders, whose interests are often not aligned. In order to make the choices that improve the pension system, more information about the consequences is necessary.

This thesis analyses some of these choices. Empirical data and a case study are used to draw conclusions about the consequences of choices in real life. When applicable the empirical data is combined with stylized simulation models, to take into account situations that have not (yet) materialized but can be relevant for the pension system, while avoiding unnecessary complexities, keeping the dynamics of the choices visible.

In particular, three issues are analysed that have not been analysed before. First, previous research has shown that there is heterogeneity in risk preferences between individuals (Harrison et al., 2007; Holt and Laury, 2002), and that different risk preferences lead to different optimal asset allocations (Campbell et al., 2003; Viceira, 2001). However it is unclear how heterogeneity in risk preferences should be incorporated in pension plan asset allocation, and how pension plans can elicit the true risk preferences of pension plan members. Chapters 2 and 3 discuss these problems.

Second, large differences are observed in the costs of pension fund administration and investment. These differences can result from differences in size, complexity or efficiency of the pension fund, but it is unclear to what extent these factors influence costs. Chapter 4 separates scale effects from efficiency and analyse the relation between pension fund properties and cost levels.

Finally, the presence of discontinuity risk decreases the value of collective pension plans. Collective plans benefit (among others) from intergenerational risk sharing, but this is no longer true in the case of a discontinuity event. Although the occurence of discontinuity events is recently analysed in a number of papers (amongst others Beetsma and Bovenberg (2009); Bovenberg et al. (2007) and Bovenberg and Mehlkopf (2014)), the impact of discontinuity events, and the continuation options after closure of the fund have not been analysed in detail so far. Chapter 5 discusses this topic.

The issues that these chapters discuss are relevant for the design of the pension systems. It deals with the question how members should be allocated to different pension funds. A single pension fund can optimally benefit from cost advantages when there are economies of scale, but it might face higher costs when there are diseconomies of scale. In addition, larger funds may be more robust to discontinuity risk due to diversification of members and due to a lesser sensitivity to scale effects in costs. However, a lack of competitive pressure might reduce the efficiency of the pension fund. Although most pension funds do not compete in the traditional sense, a lack of a benchmark to the pension fund, and the absence of alternatives for the members will reduce the incentive of the pension fund to optimize their operations.

This will lower X-efficiency, lead to higher costs, and therefore to lower benefits. This suggests that there may be an inverse u-shape in average costs in relation to pension fund size. Small pension funds do not benefit from economies of scale, while large pension funds lack competitive pressure.

In addition to costs, the customization of pensions may be relevant for pension plan members. When pensions are customized to personal preferences, they will provide higher welfare to the members, which may make up for higher costs associated to the customization. A particularly relevant preference of members are their risk preferences. Members may differ in the extent to which they are willing to accept risks in their pension in return for higher expected benefits. Smaller pension plans may be better equipped to customize their plan to personal preferences. Alternatively, if multiple pension plans exist, pension fund members may be divided over these funds in line with their preferences, which is not possible in the case of a single pension plan.

Furthermore, there can be differences in the possibilities for risk sharing in the pension fund. Risk sharing, both intra- and intergenerational, can add value to pension fund members, as it reduces the risk exposure, without reducing expected return. Large pension funds, with little customization, can optimally benefit from risk sharing. As the population becomes larger, the impact of idiosyncratic risks falls. However, a smaller and more similar population may increase the willingness to share risks. This implies that larger pension funds will face fewer financial deviations, while smaller (more similar) pension funds may fewer societal deviations, both of which can trigger the end of the pension fund (discontinuity event) and therefore of risk sharing.

The combination of these factors influences the optimal division of pension fund members over different pension funds. In a situation with low economies of scale, and large heterogeneity combined with little customization options, more pension funds may be optimal. In a situation with substantial economies of scale, and with a relatively homogeneous population or many customization options, a single pension fund might be preferable. The optimal division will be somewhere in this spectrum, and might ask for a division in line with member characteristics or preferences. This will depend on the size of the market (country) and possibilities available for customization. In countries with fewer members, economies of scale might be more relevant, while in larger countries the heterogeneity might be dominant. In addition, the availability of customization options (*e.g.*, dependent on local regulations and on whether financial literacy of members is high enough to make informed choices) will make economies of scale more relevant, as the welfare loss of combining more heterogeneous members in larger funds is neutralized. In the chapters of this dissertation we will discuss these issues, and finally (Section 6) we will put everything together and analyse pension design in a world with scale effects, risk sharing and heterogeneity.

1.2 Contributions

This section presents an overview of the research discussed in this thesis.

Individual pension risk preference elicitation and collective asset allocation, Gosse A.G. Alserda, Benedict G.C. Dellaert, Laurens Swinkels, and Fieke (S.G.) van der Lecq.
In chapter 2 the risk preferences of pension fund members of five pension plans are elicited that participated in a specially designed online survey. Multiple elicitation methods are applied and the information of these methods is combined to give more robust results. We analyse to what extent risk preferences can be explained by socio-demographic information, like age, income and gender. When the explanatory power of these variables is high enough, elicitation might not be necessary as risk preferences can be predicted with these variables accurately enough. By applying a pension income simulation model the chapter will show to what extent heterogeneity in risk preferences lead to heterogeneous optimal asset allocation. The results to these two aspects, risk preference heterogeneity and optimal asset allocation, will show whether it is worthwhile for pension funds to elicit their members risk preferences, or that they can either accurately predict risk preferences of their members or use a single (one-size-fits-all) asset allocation for all members.

Measuring Latent Risk Preferences – Minimizing Measurement Biases, Gosse A.G Alserda.
Chapter 3 focuses on the measurement of latent (real) risk preferences. I use an improved online survey (incorporating the feedback from Chapter 2) to elicit pension plan members risk preferences using multiple methods. Factor analysis is applied to measure the accuracy and relevance of the different elicitation methods, and to determine the methods' sensitivity to certain biases. The relevant methods are combined into a single composite score making use of item response theory, which should reduce measurement noise and the influence of symmetrical biases. In addition, two

types of manipulations of the elicitation methods are analysed to measure specific framing effects on elicited risk preferences.

X-efficiency and economies of scale in pension fund administration and investment. Gosse A.G. Alserda, Jaap A. Bikker and Fieke (S.G.) van der Lecq.
Chapter 4 discusses pension fund administration and investment costs. These costs are highly relevant, as pension fund costs reduce members' final benefits. Increasing costs with 1% (of AUM) can reduce pension benefits by 27% (Bikker and De Dreu, 2009). In particular we analyse economies of scale and X-efficiency. We apply data envelopment analysis, order-α, linear regression, and stochastic cost functions to estimate scale effects and efficiency, and for the latter two we apply a number of different cost functions. The method that gives the best estimation of scale effects and efficiency of pension funds is selected for both administrative and investment costs, and the results of the two selected models are analysed. This analysis will indicate to what extent administrative, investment and total (combination of these two) costs depend on the size of pension funds expressed in the number of members and the value of assets under management. In addition the analysis will indicate to what extent pension funds are X-efficient and how various properties of pension plans influence efficiency in costs.

The occurrence and impact of pension fund discontinuity. Gosse A.G. Alserda, Onno W. Steenbeek, and Fieke (S.G.) van der Lecq.
Chapter 5 discusses the occurrence and impact of pension fund discontinuity events. A case study with 6 real-life pension funds is conducted to observe the motivation for pension fund discontinuity, the continuation options and the impact on the different stakeholders. Using the input from the case study we build a simulation model to simultaneously simulate a collective pension plan and an individual pension plan. The results should indicate how probable a discontinuity event is for a pension fund, and what the impact is on pension plan members. In addition, we apply a number of sensitivity analyses to measure to what extent various properties, such as discounting rules, cost structure and unexpected shocks influence the impact of a discontinuity event.

1.3 Authorship

This section provides the contribution of the author of this thesis to the different chapters.

Chapter 1 and 6 were written independently by the author of this thesis.

Chapter 2: prof dr. Benedict G.C. Dellaert, dr. Laurens Swinkels and prof. dr. S.G. (Fieke) van der Lecq were involved in designing the survey, defining the research questions, developing the conceptual frameworks, and providing continuous feedback on the analyses and writing of this chapter. Data provided for this chapter was collected in collaboration with Korn Ferry Hay Group.

Chapter 3 was written independently by the author of this thesis. The survey is based on the survey of Chapter 2. Data provided for this chapter was collected in collaboration with Korn Ferry Hay Group.

Chapter 4: prof. dr. Jaap A. Bikker and prof. dr. S.G. (Fieke) van der Lecq were involved in defining the research questions, developing the conceptual frameworks, and providing continuous feedback on the analyses and writing of this chapter. Data was collected with the assistance of De Nederlandsche Bank.

Chapter 5: prof. dr. Onno W. Steenbeek and prof. dr. S.G. (Fieke) van der Lecq were involved in defining the research questions, developing the conceptual frameworks, and providing feedback on the analyses and writing of this chapter. The simulation model was developed independently by the author of this thesis.

Chapter 2

Individual pension risk preference elicitation and collective asset allocation[1]

Collectively organized pension funds increasingly must demonstrate that the risk preferences of members in their pension plans are adequately reflected in the plan's asset allocations. Yet, it remains unclear whether funds should elicit individual members' risk preferences to achieve this goal, or whether they can rely on other indicators, such as socio-demographics. To address this question, we apply a tailored augmented lottery choice method to elicit individual pension income risk preferences from 7,894 members from five different pension plans. The results show that member risk preferences are strongly heterogeneous and can only partially be predicted from individual and plan characteristics. We find that asset allocations are safer than implied by members' risk preferences across five real-world pension plans. Differences in risk preferences imply different optimal asset allocations. We find large welfare losses for heterogeneous members in a pension plan with a single asset allocation and provide a framework for pension funds to gauge the need to elicit risk preferences in their member population.

[1] An earlier version of this chapter was published as: Alserda, Dellaert, Swinkels, and Van der Lecq (2016). Pension risk preferences. *Netspar Industry Design Paper 62, Rotterdam.*

2.1 Introduction

Pension capital is a major component of savings for many individuals worldwide, and pension funds are some of the largest investors in the world, with considerable impact on stock markets (OECD, 2015c). The investment decisions of pension funds also impact the retirement income of large segments of the population (OECD, 2015a). Optimal pension asset allocation is a rigorous financial optimization process that takes into account the projected retirement age and desired replacement ratio, among others. For individual retirement accounts, the member herself is responsible for processing this information to find the asset allocation that suits her situation best. However, in collectively organized pension plans, where members are forced to share the same asset allocation, the board of trustees is responsible to ensure that the pension plan asset allocation adequately reflects the collective risk attitude of its members. This requirement is challenging, because the risk preferences of members are not directly observable. Moreover the measurement of risk preferences can be noisy (Dave et al., 2010). The challenges in accurately measuring risk preferences may be a reason why, as far as we know, risk preference measurements hardly have been used as input to determine pension plan asset allocation. In the little research that has been done, substantially lower risk aversions have been measured when directly eliciting pension members using surveys, than the risk aversion used when calibrating optimal pension asset allocations (Mankiw and Zeldes, 1991; Barsky et al., 1997). Therefore, currently pension funds lack a clear basis for determining whether they should elicit individual members' risk preferences, or whether they can rely on other indicators such as social demographics. In addition, it is not clear what the welfare loss is when an individual is forced into a collective pension asset allocation that does not match her risk preferences. We aim to fill both gaps in the literature.

Doing so is important because the literature shows that there is substantial heterogeneity in (investment) risk preferences among individuals; see, e.g., Holt and Laury (2002); Harrison et al. (2007); Paravisini et al. (2017). Moreover, the existing pension asset allocation models, for example those by Campbell et al. (2003) and Viceira (2001) show that risk preferences are an important input for optimal asset allocation. Yet, despite this research, Clark and Bennett (2001) and Frijns (2010) find that many pension funds pool investments such that everyone has the same asset allocation, which clearly ignores heterogeneity in risk preferences. This may be optimal in case of pure defined benefit schemes, where all investment risks are borne by the employer(s) and pensions are risk-less to the members in the fund, but is likely to be harmful to members in case of collective defined contribution schemes. However, our results are also important beyond the case of collective pension plans. Individual retirement accounts typically offer a life-cycle asset allocation that is age-dependent. In case the life-cycles are also dependent on pension risk preferences, insights from our elicitation method could be used.

Three factors distinguish the pension domain from other finance domains, which makes a domain-specific analysis on how individual's risk preferences affect optimal asset allocation especially relevant. First, choices in pension plans are mostly made by delegation. Pension plan members need not to have the financial literacy necessary to make adequate choices for retirement savings; see, *e.g.*, Lusardi and Mitchell (2007) and Balloch et al. (2014). Nevertheless, their preferences should be taken into account in pension scheme design. This calls for an instrument that measures member risk preferences, without being too demanding. Second, the presence of state-pensions and income taxes may influence pension asset allocation (Fischer and Jensen, 2015). This calls for a contextual analysis of an individual's risk preferences. Third, in many countries participation in a pension plan is mandatory, for example through collective labour agreements. Since members cannot exit these pension plans, their preferences should be incorporated to keep the pension system sustainable. In addition, risk preferences are domain dependent, meaning that individuals have different risk preferences depending on which domain the choice refers to (Weber et al., 2002; Van Rooij et al., 2007). Pensions are cognitively classified as a separate risk-decision domain by individuals, and financial risk aversion is higher in the pension domain than in other financial domains (Van Rooij et al., 2007). For pension funds, this implies that risk preferences should be elicited within the context of the pension domain to be relevant to their decision-making.

The specific contribution of this paper is two-fold. First, we design a novel questionnaire to measure risk preferences in the pension domain and relate the responses of pension scheme members to their socio-demographic characteristics. Second, we analyse the welfare gains of allowing pension fund members to have an asset allocation that is different from the average of the pension fund. Despite research on the investment consequences of pension plan age heterogeneity (Bikker et al., 2012; Molenaar and Ponds, 2012), it remains unclear to what extent allowing for pension plan member risk preference heterogeneity would affect optimal asset allocation in real-world settings.

These real world settings are changing, since many sponsors are shifting from defined benefit (DB) plans to individual or collective defined contribution plans (CDC). CDC plans are sometimes also called 'defined ambition' (DA), since there is no longer a sponsor available who makes extra contributions in case of funding rate deficit. In CDC/DA plans, the investments are done collectively, and individuals are not allowed to choose their personal asset allocation. However, the collective asset allocation should meet the demands of the fund population, both in terms of age and in terms of risk preferences. By implication, eliciting risk preferences is useful in collective plans as well, as long as the members are exposed to investment risk. This is the very setting in which we conducted our surveys. Although such CDC/DA plans are most widespread in The Netherlands, we note that they are also well known in the United Kingdom, as well as in EU member states that want to enhance their second pillar.[2]

We use unique data from 7,894 members in five Dutch pension plans that completed our novel questionnaire to assess the value of matching asset allocations to individual risk preferences. Our augmented lottery choice method is tailored to individual pension risk preference elicitation. Lottery choice questions (Holt and Laury, 2002) are personalized to each individual's pension income based on current income to accurately reflect risk-return trade-offs. The augmented lottery choice method combines information from lottery choices with observations of two other risk preference elicitation methods (Kapteyn and Teppa, 2011; Van Rooij et al., 2007) to reduce the level of measurement noise in the risk preference measure.

This augmented lottery choice method allows us to determine the pension plan population characteristics and assumed equity premiums for which individual member pension risk preferences should be elicited to ensure an adequate fit between pension plan asset allocation and member preferences. This question is vital both from a pension fund and societal perspective, because substantial retirement welfare losses can arise to pension plan members if there is a mismatch between their risk preferences and the plan's asset allocation. This may imply, for example, that members incur a greater risk of a low pension income than they wish to have, or that they lose out on the equity premium they prefer to have. However, when the impact on asset allocation is small, pension funds can largely ignore differences in preferences

[2]See, for example, the Defined Ambition Research Briefing in the UKs House of Commons Library: http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06902 or Pension & Investments (December 2016) "Germany gearing up for new mandatory DC plan: Proposal borrows much from collective hybrid system of the Netherlands".

among members in setting plan asset allocation, saving on costly, time-consuming risk preference elicitation.

2.2 Eliciting pension plan member risk preferences

During their working lives, pension plan members contribute a substantial proportion of their incomes to pension capital. Pension plan managers invest this pension capital to have it grow over time. At retirement, the pension capital is converted to monthly benefits, either by regular withdrawals or through purchase of a lifetime annuity. Besides member income and contribution rate, final pension benefits and pension benefits' risk depend on the asset allocation (OECD, 2015a). Asset allocations with more equities and less bonds have higher expected returns, but are riskier (Dimson et al., 2003). The optimal asset allocation for an individual depends, among other things, on the individual's risk preferences (Bodie et al., 1992; Campbell et al., 2003; Viceira, 2001). Research shows that individuals differ significantly in terms of how they trade off (expected) returns with risk in financial investments (Holt and Laury, 2002; Weber et al., 2002; Tversky and Kahneman, 1992). Therefore, members are likely to also differ in terms of the extent to which they trade off (expected) pension benefits and the riskiness of those benefits. This implies that the optimal pension asset allocation likely differs among members.

2.2.1 A novel measure of individual pension risk preferences

In this paper we explicitly model normative risk preferences. Normative risk preferences can deviate from revealed risk preferences due to much described measurement irregularities, such as probability weighting, loss aversion and the reflection effect (Tversky and Kahneman, 1992; Bleichrodt et al., 2001; Beshears et al., 2008). The elicitation methods are selected to minimize measurement biases (e.g., by avoiding certainty effects), but we do not (ex post) adjust the results in order to deal with possible behavioural effects, as this would lead to many arbitrary choices. Any remaining behavioural effects are minimized by combining multiple elicitation methods in the composite score, which is the measure of risk preferences that combines the information of the different elicitation methods. Expected utility (EU) is generally accepted as the model to describe normative risk preferences (Quiggin, 2012), we will apply this method for quantifying elicited risk preferences.

To express the risk preferences of members, we construct a pension-specific metric based on individuals' constant[3] relative risk aversion (γ) coefficient, a commonly used financial measure of risk preferences (Chiappori and Paiella, 2011). This metric expresses how risk averse an individual is with respect to pension wealth or retirement income. It captures risk aversion in a single coefficient, which is independent of an individual's wealth and can be easily used to assess distributions of pension outcomes.

Positive values of γ indicate risk aversion, while negative values indicate risk-seeking. A value equal to zero indicates risk neutrality. Individuals who are more risk averse require higher return premiums before they are willing to accept a risky investment. In the EU framework, risk aversion depends on the concavity of the utility function (Arrow, 1965; Pratt, 1964), and can therefore be defined as:

$$\gamma_i = P_i * \frac{-U''(P_i)}{U'(P_1)} \tag{2.1}$$

where γ_i is (constant) relative risk aversion and P_i is pension income for individual i. U' and U'' are the first and second derivatives, respectively, of U, which is the utility function for pension income.

From this expression, it is clear that the value of γ depends on the shape of the utility function. To infer preferences for pension risk from observed risky decisions (e.g., lottery choices), we use the following power utility function (Holt and Laury, 2002; Harrison et al., 2007):

$$U_i(P_i) = \frac{P_i^{1-\gamma_i}}{1-\gamma_i} \tag{2.2}$$

where U_i is utility, P_i is pension income, and γ_i is (constant) relative risk aversion for individual i.

Next, EU can be used for (ordinal) comparison of different asset allocation options for each individual. The EU of an asset allocation is obtained by multiplying the utility of each outcome by the probability of that outcome. The option that has the

[3]Relative risk aversion is ex-ante assumed to be constant with income / wealth, but we do add income in a regression to try to explain risk aversion.

highest EU represents the option that gives the highest utility to an individual on average over the possible outcomes, given the individual's relative risk aversion.

This provides pension plan managers a metric to calculate the fit between the pension plan's asset allocation and members' risk preferences, if these preferences are known. Managers tend to make investment decisions primarily on the basis of performance targets (March and Shapira, 1987). These performance targets may not (perfectly) represent the risk preferences of the members. To prevent this potential mismatch from occurring, supervisors, such as central banks, increasingly demand that pension plan managers ensure that their asset allocation adequately reflects individual pension plan members risk preferences (EIOPA, 2013; Frijns, 2010; Rozinka and Tapia, 2007). Pension plan managers can match asset allocation to the risk preferences of members only if members' risk preferences are known. Nevertheless, it is unclear whether plan managers should elicit individual members' risk preferences as input to this process or whether they may rely on other indicators, such as socio-demographics and industry sector employment to project member risk preferences (Bikker et al., 2012). To disentangle the determinants of pension risk preferences, we develop a measurement instrument for individuals' risk preferences tailored to the pension domain and observe the heterogeneity in members' preferences in five Dutch pension plans, which are connected to different pension funds.

The elicitation of risk preferences in this study expands and tailors the traditional multiple lottery choice (MLC) method (Binswanger, 1980; Holt and Laury, 2002). The MLC method is a well-accepted risk preference elicitation method (Dohmen et al., 2011; Andersen et al., 2006; Harrison et al., 2007; Pennings and Smidts, 2000). It introduces a series of choices between two lotteries. Both lotteries have a good and a bad state with equal probability for realization of both states for each question. The lotteries differ in their dispersion: the "safe" lottery has outcomes that do not deviate much, while there are large differences between the good and bad states for the "risky" lottery. For the first question (see Figure 2.1), the probability of the good state is low, making the safe lottery dominant for all except extremely risk-seeking individuals. In subsequent questions, the probability of the good state increases, making the risky lottery gradually more attractive. The higher an individual's risk aversion, the more questions it will take before an individual switches from the safe to the risky lottery. In order to accept the bad state of the risky lottery, risk-averse individuals demand a higher risk premium, which is defined as the difference between the expected value of the risky lottery and the safe lottery.

Although the MLC method is well accepted and frequently used, it is cognitively demanding for the respondents. There are at least four challenges that we need to deal with. First, the results from this method are often noisy, as members find it difficult to choose their preferred trade-off when utility differences are small, and the results tend to depend on the exact framing of the question. Second, a substantial number of respondents are found to choose a dominated option, (i.e., an option that is lower in both states of the world). Third, the relative risk aversion results of previous studies are limited to ranges rather than to a specific point, which is necessary for use in asset allocation. Finally, previous studies are not linked to the pension domain and not related to respondent income (Dave et al., 2010; Harrison et al., 2007; Holt and Laury, 2002). For pensions, this is a prerequisite, because of the domain dependency of risk preferences. In particular, individuals have different risk preferences depending on to which domain a risky choice refers (Weber et al., 2002; Van Rooij et al., 2007).

Figure 2.1: Example of adjusted MLC question

You have indicated that your after-tax monthly income is between $2,000 and $2,300. The amounts in this question are based on this income level. They represent monthly net income levels, including the state old age pension and after taxes.

The probabilities changes with your choice. Which plan do you prefer?

	Plan A	**Plan B**
Your guaranteed income is:	$1,290	$860
In addition you have a probability of:	**10%**	**10%**
To receive an additional income of:	$220	$1,080
So there is a **10%** probability of a total pension income of:	$1,510	$1,940

Plan A **Plan B**

Notes. Example for a member with a net monthly income of $2,150. This example represents the first choice out of a sequence of 10 in which the probability (bold) systematically increases for the additional pension income. The currency of the Netherlands is EUR, which is used throughout the questionnaire. Here, we convert all amounts to USD.

In our study, we tailor the MLC method to the pension domain and propose to augment its results with information from additional measures to overcome the previously mentioned concerns (i.e., domain dependency, measurement noise, and cognitive challanges that lead to the selection of dominated options). First, the amounts of both lotteries relate to the pension domain and are denoted in local monetary units, euro, including the state old age pension and after tax. The amounts presented to the respondents are derived from the respondents' incomes and are 60% (bad state) or 70% (good state) of current net income for the safe lottery and 40% (bad state) or 90% (good state) of current net income for the risky lottery. The state old age pension and taxes are included in these amounts to keep as close to the actual situation as possible. An example of the resulting question, converted to U.S. dollars, is presented in Figure 2.1. This representation is the result of various testing rounds, which showed that this visual representation led to the best understanding among respondents. However, this does not rule out that our representation is optimal. We leave improvements on the visual aspects of our questionnaire for future research.

When the respondent chooses Plan B, the MLC is finished. When the respondent chooses Plan A, the next question looks the same as in Figure 2.1, but the 10% probability increases to 20%. Each possible switch-point in the MLC method corresponds with a range of relative risk aversion. This range can be obtained by calculating, for each choice, the value of relative risk aversion that makes an individual indifferent between the two options. Assuming a power utility function (Equation 2.2) and linear probability weighting yields a closed-form solution that can be easily solved (Holt and Laury, 2002). The range of relative risk aversion for a given switch-point is then the range between the point of indifference for the last choice of the safe lottery and the point of indifference for the first choice of the risky lottery. The results of these calculations are presented in Table 2.1 and are irrespective of income, as the options are constant shares of income.

Table 2.1: Adaptation of the Holt and Laury MLC method

Number of Safe Choices	Equal to switch-point with probability of good state	Range of Relative Risk Aversion for $U_i(P_i) = P_i^{1-\gamma_i}/1-\gamma_i$
0	10%	$\gamma < -4.82$
1	20%	$-4.82 < \gamma < -3.00$
2	30%	$-3.00 < \gamma < -1.82$
3	40%	$-1.82 < \gamma < -0.86$
4	50%	$-0.86 < \gamma < 0.00$
5	60%	$0.00 < \gamma < 0.85$
6	70%	$0.85 < \gamma < 1.76$
7	80%	$1.76 < \gamma < 2.85$
8	90%	$2.85 < \gamma < 4.46$
9-10	100%	$4.46 < \gamma$

Notes. Ranges of relative risk aversion scores depending on the number of safe choices / switch-point.

The existence of open γ-ranges instead of specific values presents a challenge to attach values to individual responses. For the first and last switch points, we use a recursive method to determine the ranges. In first instance, they are set equal to the upper and lower bound of their respective range. Since this will underestimate the variance, the open ranges are re-estimated using the mean and standard deviation found in the preceding setting. This procedure to increase the variance is repeated until there is sufficient convergence.[4] This way, the distribution in the tails follows the same approximate normal distribution that is found for the observations in between.

Next, in line with Kapteyn and Teppa (2011), the results from the MLC method are combined with the results from two less time-consuming and cognitively less demanding questions about pension risk preference to form a single composite score (Abdellaoui et al., 2011; Van Praag, 1991).[5] The composite score should reduce noise and therefore provide more stable measures of risk preferences (Ackerman and Cianciolo, 2000). Contrary to the MLC method, these methods do not involve amounts and probabilities, and therefore do not allow for computation of a relative risk aversion coefficient that is needed to determine an optimal asset allocation.

The first question is a self-description task based on Kapteyn and Teppa (2011). The question "Are you willing to take risk with your pension?" should be answered on a seven point Likert scale ("Totally agree" = 1 to "Totally disagree" = 7). The second question is a simplified portfolio choice question on Van Rooij et al. (2007), for which respondents must divide their pension capital between equity (described as risky investments with an expected return of 6% per annum) and bonds (described as savings with a guaranteed return of 2% per annum). We mention the expected returns explicitly to increase the likelihood that the respondents' answers reflect risk aversion and are less influenced by ambiguity aversion with respect to their own (conditional) expected returns on stocks and bonds.

The composite score is formulated as the average of the standardized (z-scores) risk preference of all elicitation methods (Ackerman and Cianciolo, 2000)). Factor analysis and item response theory are used to verify whether all elicitation methods load on one common underlying risk preference factor. If a respondent has failed to respond to one of the elicitation methods, only the observed values are included in the composite score for that person. The composite measure is thus the average of the available standardized elicitation results.

Since the MLC method is the only method that allows us to measure risk preferences in terms of relative risk aversion, the composite score is then fitted on the domain

[4]The stopping criterion is set to the change of re-estimating becomes smaller than 0.00001% of the standard deviation.

[5]We also tested an additional question in the survey based on Kapteyn and Teppa (2011), "My friends describe me as a careful person." but the factor analysis and item response analysis showed that this item was not well correlated with the other three measures. Hence we omitted it from the proposed risk measurement approach.

of relative risk aversion by regressing the relative risk aversion measure of the MLC method (by means of Equation 2.3 and 2.4) on the composite score. We assume measurement noise is independent and identically distributed. The γ from the augmented MLC, which is based on the regression results without the error term, will therefore contain substantially less measurement noise. Hence, we obtain more robust (*i.e.*, less biased and skewed distribution of) relative risk aversion coefficients that can be used to determine the optimal asset allocation for individual pension plan members.

$$MLC_i^{\gamma} = \alpha + \beta StCompScore + \varepsilon_i \tag{2.3}$$

$$\widehat{MLC}_i^{\gamma} = \hat{\alpha} + \hat{\beta} * StCompScore_i \tag{2.4}$$

Where StCompScore represents the Composite Score (γ) and hats represent estimated values.

2.3 Empirical assessment of risk preference heterogeneity in the pension domain

Large-scale data collection was conducted to empirically assess the effect of heterogeneity in risk preference on optimal asset allocation. Data were collected through an online survey with pension plan members of five Dutch company pension funds. The five pension funds have a similar organizational structure, but cover members of strongly varying industries, ranging from blue-collar to white-collar. The survey was administered in collaboration with a consultancy firm and sent to several of its clients, i.e., companies with pension plans administered by different pension funds. Before the survey was sent out, it was first tested using a paper version on a small representative population and then tested online with the consultancy firm's own 172 employees. After minor adjustments, the questionnaire was sent to the active members of five pension plans from five companies from four industries (transportation, manufacturing, automotive, and leisure). All plan members were invited via regular mail and/or e-mail, depending on their channel preferences and the contact possibilities of the companies' pension funds. The surveys were conducted in the first half of 2013. Table 2.2 contains summary data for the aggregate sample and for each pension plan separately.

The response rate is on average 14.1 percent, and varies between 5.5 and 42.4 percent. Differences in response rate may be caused by the method of inviting respondents and in company effort in requesting that members complete the survey. Invitations by regular mail result in markedly lower response rates, and e-mail reminders sent out by the employer increase response rates. Members were not paid or did not receive other forms of compensation for completing the questionnaire. Although the questions were not directly incentivized, pension funds indicated in the invitation that results would be taken into account for future decisions, so participation to the survey was consequential.

Table 2.2: Summary data

Pension plan		**1**	**2**	**3**	**4**	**5**	**Total**
Response	Sample	5,094	1,176	873	437	314	7,894
	Total	29,738	11,093	2,057	8,015	4,211	55,114
Response rate		17.1%	10.6%	42.4%	5.5%	7.5%	13.3%
Gender = man	Sample	86%	90%	80%	25%	66%	82%
	Total	78%	85%	76%	20%	55%	69%
Average age	Sample	50.1	53.8	44.8	52.2	48.5	50.1
	Total	47.4	51.3	45.1	47.6	43.1	47.8
Average income	Sample	$2,537	$2,097	$2,168	$1,813	$2,498	$2,396
	Total	–	–	$1,898	–	$2,648	–
Average education	Sample	3.8	3.0	3.5	4.5	4.1	3.7
Has partner	Sample	86.5%	87.6%	84.1%	80.1%	80.9%	85.8%
Home-owner	Sample	86.3%	76.9%	82.0%	81.2%	84.4%	84.3%

Notes. Number of observations, response rates, % men, average age, average monthly net income, average education (education ranging from 1 (attended primary education) to 6 (attended university)), % with partner, and % that owns a house for total population of the pension plan and the sample of respondents.

Men are more likely to fill out the questionnaire for each of the five pension plan. On average, our sample consists of 82 percent men, while the population has 69 percent men. Note that the first three pension plans have primarily a male workforce, while the fourth pension plan has a female workforce. The respondents are also slightly older than non-responders for four out of five pension plans, with the average age of the responses 50.1 year, while the population was 47.8 years old. For two pension plans, we have the average income of the population. The income of respondents is slightly higher for pension plan three, and slightly lower for pension plan five, compared to their population averages. We have no information on the education level of the population, so we cannot determine whether there is any over- or underrepresentation. Summarizing, our response rate is high, there is substantial variation across pension plans, and the sample of respondents does not contain substantial selection biases.

2.3.1 The pension system in the Netherlands

Our online survey is conducted among five pension funds that operate in the Netherlands. In Appendix 2.6, we describe the essential features of the pension system in the Netherlands and compare this with the pension system in the U.S. where appropriate. This section aims to provide a brief summary of the survey context. The survey is conducted in the second pillar of the pension system, which consist of capital based, collective pension plans. Most of these plans are of a collective defined contribution type, which is to say that the sponsor does not provide any guarantee, but the plan has an ambition in terms of career average salaries. Participation is mandatory for those who are employed with a firm which has a corporate or industry wide pension plan. By implication, most Dutch employees are covered by a second-pillar pension plan. The five pension funds that participated in our online survey offer these second pillar pension plans.

Most pension plans in the Netherlands contain risk-sharing elements between the employer(s) and employees, while the amount of risk borne by the employee is increased considerably. Even though the terminology of career-average pension plan suggests a defined benefit, the risk-sharing arrangements make them closer to defined contribution plans. The strategic pension plan asset allocation is set by the board of trustees, where pension contributions by employer and employees are traded-off against the pension outcomes. Our survey is conducted among members of five second-pillar pension plans. However, the questions that we ask relate to the risk they are willing to take with their pension income after retirement, which is the sum of the three pension pillars. The reason for this not only relates to cognitive capabilities of respondents, but also reflects that it is their total pension income and not the source of the pension income that is relevant for their consumption. By implication, the asset allocation for the second pillar pension plan needs to be calculated after deducting the expected first pillar pension income, which we treat as certain since it is provided for by the government. Our model allows us to calculate differences between outcomes based on the pension asset allocations that are the same for all members in a plan, and pension asset allocations that are tailored to the individual's estimated risk preferences. In this way, we can infer the welfare loss of being forced into an asset allocation that does not match an individual's risk attitude. The caveat remains that these statements are conditional on the simulation model that we use for the assets and the utility framework that we assume the member to have.

2.3.2 Empirical assessment of risk preferences in the pension domain

Respondents' risk preferences were elicited using three different risk elicitation methods; the MLC method, the Likert scale self-description method, and the portfolio choice method. The measures varied in their level of complexity and practical usage. The more complicated MLC method may give noisier results, but is less likely to lead to socially desirable answers. The MLC is also the only one question from which we can back out coefficients of relative risk aversion that can be used as an input parameter for optimal asset allocation.

Table 2.3 contains the results from each of the individual questions and the composite measure that we constructed. In contrast to the other methods, the question with regards to the preferred bond allocation, was not set to be required to fill, which resulted in roughly half of the responses. The group of non-responders to this questions did not show substantial deviations with respect to the other questions compared to the group of responders.

The empirical evidence in the first columns suggests that some of respondents had difficulty with the MLC question, as 2.2 percent of respondents choose the dominated answer of 10 safe choices. This is comparable to other applications (Holt and Laury, 2002). However, it suggests that a few respondents did not fully understand or did not spend enough time on answering the question. This indicates that using information from other, possibly easier to answer questions relating to risk aversion in the pension domain, may increase the reliability of the results.

Table 2.3: Responses to elicitation methods

Multiple Lottery					Stated risk aversion			Bond allocation			Composite measure			
Safe choices	γ		Freq.	%	Likert scale	Freq.	%	Allocation(%)	Freq.	%	γ		Freq.	%
0	$-\infty$	-4.8	1243	15.8	Seeking			0	42	1.3	$-\infty$	-4.8	0	0,0
1	-4.8	-3.0	207	2.6	1	150	1.9	10	25	0.8	-4.8	-3.0	9	0.1
2	-3.0	-1.8	213	2.7	2	508	6.4	20	90	2.8	-3.0	-1.9	153	1.9
3	-1.8	-0.9	428	5.4	3	1,665	21.1	30	175	5.4	-1.9	-0.9	429	5.4
4	-0.9	0.0	712	9.0	4	1,208	15.3	40	271	8.4	-0.9	0.0	688	8.7
5	0.0	0.9	779	9.9	5	1,647	20.9	50	668	20.6	0.0	0.9	1,176	14.9
6	0.9	1.8	1,113	14.1	6	1,686	21.4	60	349	10.8	0.9	1.8	1,211	15.3
7	1.8	2.9	1,157	14.7	7	1,012	12.8	70	456	14.1	1.8	2,9	1,612	20.4
8	2.9	4.5	669	8.5	Averse			80	404	12.5	2.9	4.5	1,704	21.6
9	4.5	∞	1,188	15.1				90	322	9.9	4.5	∞	912	11.6
10			177	2.2				100	435	13.4				
Total			7,886	100	Total	7,876	100	Total	3,327	100	Total		7,894	100

Since only five or safe choices correspond to risk aversion, we see that about 35 percent answered the MLC question as risk seeking, with a peak at the first answer with 15.8 percent. Perhaps part of these most risk seeking respondents have not interpreted the question correctly. The frequency distribution also suggests that perhaps more granularity at the higher risk aversion levels would have been good, as the number of respondents for six to nine safe choices does not seem to decrease.

From the pension asset allocation question it seems that many members are willing to take on risk, as about 35 percent is willing to invest 80 percent or more in equities. The question about stated risk aversion might be least cognitively demanding, but may also lead to socially desirable answers. At least, here we see that most answers are given for answers four to six, suggesting moderate to high risk aversion. Even though all columns are sorted with the most risk seeking answers at the top, the rows do not necessarily correspond to the same risk preferences. For example, the first five choices of the MLC method differentiate between risk seeking individuals, who by their nature should allocate (at least) 100 percent of their financial wealth to equities.

Table 2.4: Item response theory and correlation matrix

Item response theory results				Correlation martrix			
Measure	**Discrimination**	**Difficulty (range)**		**θ IRT**	**MLC**	**Stated aversion**	**Allocation to bonds**
		min	**max**				
MLC	0.724	-2.582	2.362	0.316	1.000		
	(0.026)	(0.093)	(0.089)				
Stated aversion	4.649	-2.227	1.220	0.972	0.255	1.000	
	(0.389)	(0.042)	(0.023)				
Allocation to bonds	1.876	-3.082	1.510	0.744	0.162	0.615	1.000
	(0.073)	(0.115)	(0.048)				

We employed a principal component analysis, which showed that the MLC method, the pension-related self-description question, and the portfolio choice method loaded on a common factor (factor loadings of 0.87, 0.82, and 0.50, respectively, together explaining 57.8% of variation). In addition, Table 2.4 shows the results of an item response theory analysis. The results show that all three methods correlate positively to the latent variable, although to differing degrees. The self-description question has higher discriminative power (are less noisy) and correlate stronger with the estimated latent variable. This is indicative of creating a composite measure that combines simpler (more reliable) and more demanding questions. The results of the principal component analysis and the item response theory analysis suggest that the methods describe a common latent variable, which we feel comfortable defining as risk aversion. Noise present in the measurement of risk preferences is reduced by combining the information from these three questions.[6] This allows us to combine the three elicitation methods into a single composite score, scaled to relative risk aversion (see Section 2.2.1). The resulting values of the rescaled composite score are presented in Table 2.3. Histograms of the composite score per pension plan can be found in Appendix 2.6.

Relative risk aversion has a mean value of 1.926 and a standard deviation of 1.901. This mean value is categorized by Holt and Laury (2002) as highly risk averse. This confirms the findings of Van Rooij et al. (2007), who find that risk preferences are relatively high in the pension domain. However, note that in the optimal asset allocation literature typically higher levels of risk aversion are needed to explain observed asset allocations in practice. For example, Viceira (2001) uses coefficients of relative risk aversion ranging from 1 to 10 for his life-cycle asset allocation model.[7] The standard deviation of 1.901 indicates that individuals are strongly heterogeneous in their risk aversion. We now turn to the question whether this heterogeneity can be explained by socio-demographic characteristics.

[6] In other fields of finance the use of composite scores in order to reduce noise is also quite common. For example: Bekaert et al. (2009) use principal component analysis to reduce country-industry level stock returns to three global and local factors and Baker and Wurgler (2006) use the first principal component of a number of noisy proxies for investor sentiment to create a "sentiment index".

[7] Note that they also uses a risk aversion coefficient of 5,000 to show the limiting case with minimum risk.

2.3.3 Drivers of heterogeneity in pension risk preferences

We analyse to what extent the observed heterogeneity in pension risk preferences is predictable from directly observable member characteristics. If the heterogeneity can be explained, pension scheme trustees may use these easily available characteristics instead of sending out questionnaires like we did. Based on the existing literature, our prior is that it is difficult to accurately predict risk preferences, since a substantial amount is difficult to measure as it is either inherited or acquired (Cesarini et al., 2009).

We use an ordinary least squares regression model with the results of the separate elicitation methods, including the composite score as the dependent variable, when applicable expressed in terms of relative risk aversion, and a set of socio-demographic characteristics. The estimation results are in Table 2.5. We include pension plan dummies as independent variables to represent the current pension system in which the asset allocation differs only across pension plans, not members. The first part for each method shows that risk preferences do seem to vary across pension plans, ranging from an average of 1.83 for the first and numeraire pension plan to 2.41 for the fourth pension plan in the case of the composite score. In addition to differences in the average level of risk preferences also the heterogeneity within the plans seems to differ. Standard deviation of the composite score differs between 1.65 for plan 3 and 2.01 for plan 2. So we observe significant differences between the risk preferences of different pension plan populations.

Adding the available socio-demographic information substantially increases the explanatory power of the model with an increase of the R^2 for the composite measure from 0.007 to 0.056, and reduces the effect of the pension plan dummies. Table 2.5 indicates that relative risk aversion correlates negatively with income and positively with age, in line with Watson and McNaughton (2007). The quadratic terms suggest that both effects decline with higher levels of income and age, respectively. Men and home-owners are, on average, less risk averse, while having a partner is positively correlated with relative risk aversion. Finally, higher levels of education correspond with lower levels of relative risk aversion. Due to the addition of socio-demographic information the coefficients of the pension plan dummies reduce, and only the coefficient of plan 5 remains significant. Differences between pension plans populations therefore mainly originate from difference in socio-demographic compositions of the population, and less from possible risk preferences selection effects.

Table 2.5: Explaining risk preferences with socio-demographics

Variables	(1) MLC γ	(2) MLC γ	(3) Stated aversion	(4) Stated aversion	(5) Allocation to bonds	(6) Allocation to bonds	(7) Composite γ	(8) Composite γ
Constant	1.806***	-0.450	4.554***	5.252***	62.378***	101.633***	1.829***	2.284***
	(0.038)	(0.754)	(0.022)	(0.427)	(0.655)	(9.476)	(0.027)	(0.517)
Plan 2	0.119	0.007	0.163***	-0.045	1.741	-2.030	0.156**	-0.070
	(0.088)	(0.091)	(0.051)	(0.051)	(1.476)	(1.468)	(0.061)	(0.062)
Plan 3	0.595***	0.562***	0.057	-0.104*	2.742***	0.022	0.237***	0.058
	(0.099)	(0.102)	(0.058)	(0.058)	(1.033)	(1.040)	(0.069)	(0.070)
Plan 4	0.781***	0.472***	0.409***	0.035	5.288***	0.814	0.582***	0.125
	(0.135)	(0.153)	(0.078)	(0.087)	(1.305)	(1.519)	(0.094)	(0.105)
Plan 5	-0.168	-0.176	0.439***	0.385***	6.443***	5.728***	0.376***	0.311***
	(0.157)	(0.158)	(0.091)	(0.089)	(1.484)	(1.442)	(0.110)	(0.108)
Income ($1,000)		-0.259***		-0.256***		-3.772***		-0.327***
		(0.077)		(0.044)		(0.988)		(0.053)
Income^2 ($1,000)		0.019***		0.013***		0.206***		0.019***
		(0.006)		(0.003)		(0.079)		(0.004)
Age		0.114***		0.046**		-0.350		0.060***
		(0.032)		(0.018)		(0.402)		(0.022)
Age^2		-0.001***		-0.000***		0.003		-0.001***
		(0.000)		(0.000)		(0.004)		(0.000)
Male		-0.178*		-0.437***		-6.585***		-0.506***
		(0.091)		(0.051)		(1.105)		(0.062)
Has partner		0.114		0.107**		0.187		0.143**
		(0.091)		(0.052)		(1.141)		(0.063)
Owns house		-0.045		-0.214***		-3.648***		-0.202***
		(0.088)		(0.050)		(1.164)		(0.060)
Education 2		0.161		-0.339**		-6.413*		-0.248
		(0.259)		(0.147)		(3.760)		(0.178)
Education 3		0.083		-0.484***		-9.647***		-0.423**
		(0.257)		(0.146)		(3.724)		(0.176)
Education 4		0.314		-0.505***		-9.828**		-0.357*
		(0.270)		(0.153)		(3.874)		(0.185)
Education 5		0.158		-0.676***		-13.736***		-0.583***
		(0.265)		(0.150)		(3.802)		(0.181)
Education 6		-0.100		-1.011***		-21.392***		-1.020***
		(0.278)		(0.158)		(3.972)		(0.191)
Observations	7,894	7,894	7,876	7,876	3,237	3,237	7,894	7,894
R-squared	0.008	0.017	0.007	0.063	0.009	0.091	0.007	0.056

Notes. Results of regression analysis of observable characteristics on relative risk aversion. Standard errors in parentheses, * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

The empirical evidence presented here is consistent with the notion that heterogeneity in risk preferences is mainly present at the individual member level, and to a far lesser extent at the pension plan level. Note that the R^2 increases from 0.008 to 0.017 when adding the socio-demographics to the pension plan dummies for the MLC, while this increases to 0.056 for our composite measure. Although the composite measure reduces noise, there is still an enormous amount of variation left to explain. This unexplained variation is only slightly higher than for the two less cognitively demanding questions. However, our analysis cannot rule out that some remaining noise is responsible for the observed heterogeneity at the individual level.

One of our contributions to the literature is to empirically demonstrate that their is heterogeneity of risk preferences both within pension plans and between the populations of different pension plans. Moreover, we show that only some of this heterogeneity can be predicted using socio-demographic information. A substantial proportion of the heterogeneity at the individual level is unexplained, either because it is unobservable (inherited or acquired) or the result of measurement noise, even though we try to reduce this as much as possible by using a composite measure. Hence, we conclude that pension plan managers cannot predict pension plan members' risk preferences from socio-demographics alone and need to elicit them directly from the members themselves to gain an accurate knowledge of these risk preferences. It remains to be seen what the potential effects of this heterogeneity is for the asset allocation decisions of pension plan members. We evaluate this in Section 2.4.

There are four arguments suggesting that the composite score is a more reliable measure of risk preferences. First, the composite score has a correlation of -0.17 with investment experience that we also asked in the questionnaire, while this is only -0.04 for the MLC question.[8] Second, the variation (standard deviation) of risk aversion is 30 percent lower for the composite score, this is likely to represent reduced measurement noise. Third, the explanatory power (R^2) of socio-demographics is three times higher for the composite score than for the MLC method expressed in relative risk aversion. This is consistent with previous research (e.g., Jianakoplos and Bernasek (1998) and Powell and Ansic (1997)), who find that these variables are relevant for risk preferences. Finally, there are 31% fewer members found to be risk-seeking. As we do not expect many individuals to be risk seeking in the pension domain, this is more in line with expected risk preferences in the pension domain.

[8] Investment experience is not included in the regression with socio-demographics, as it is not directly observable to pension plan managers. It requires individual elicitation to know about investment experience.

2.4 Impact of risk preference heterogeneity on pension asset allocation

Viceira (2001) shows that in his life-cycle model an investor with 20 years to retirement should invest 100 percent of his financial wealth in stocks when her coefficient of relative risk aversion equals 3, while this is 52 percent for an γ of 5, and 28 percent for an γ of 8. Benzoni et al. (2007), who consider human capital and equity markets to be cointegrated, find that the optimal asset allocation is 100 percent stocks for an investor with 20 years to retirement and a risk aversion coefficient of 3, while this is around 60 percent for a risk aversion coefficient of 4, and around 40 percent for a risk aversion coefficient of 5. Although these are only two out of many pension asset allocation models, it is illustrative of the importance of risk preferences. Therefore, if heterogeneity in risk preferences is higher, optimal pension asset allocations are likely to be more diverse, and the benefits of eliciting risk preferences increase.

As we ask respondents about their risk preferences with regards to their total pension income, it is important to also include the social security pension income they expect to receive from the state. In the Netherlands, first-pillar social security pension income is a fixed amount irrespective of working history. Second-pillar occupational pension schemes are typically defined as top-up on social security such that a target pension relative to average salary is reached. Hence, for low-income workers the second-pillar pension is only a small amount of total pension income. If we assume that social security pension is safe and therefore bond-like, the equity allocation of the relatively small occupational pension scheme can be 100% even for risk averse members. Since the first-pillar is a fixed amount, the occupational pension will be more important for members with higher income. Heterogeneity in risk preferences therefore has a larger impact for members with higher income. More generally, in countries with pension systems with no or little social security, information about risk preferences is more important for occupational pension scheme asset allocation.

The need for risk preference elicitation also depends on the expected equity premium. This intuition can be obtained from Merton (1969), who shows that the optimal asset allocation to the risky asset under certain restrictions equals the equity premium divided by the variance of the risky asset and the coefficient of relative risk aversion.[9] A low equity premium makes a portfolio of predominantly fixed income assets optimal

[9] Equation (29) on page 251 of Merton (1969).

for almost all risk preferences, while a high equity premium shifts the allocation towards equities for almost all risk preferences. Pension risk elicitation seems to be the most valuable for cases in between, where neither fixed income nor equities is dominant due to the expected equity premium.

2.4.1 The simulation model

Our aim in this section is to analyse the implications of risk preference heterogeneity on asset allocation. The large number of variables and time periods makes it challenging to solve this optimization problem analytically. Therefore, we solve it numerically using a Monte Carlo simulation model (Dai and Singleton, 2002; Sangvinatsos and Wachter, 2005). This simulation model is built in the context of an individual defined contribution pension scheme with investment during retirement. The reason not to simulate the existing collective defined contribution scheme is that it contains the same asset allocation for each individual, and we want to assess the welfare loss from this feature compared to one in which the asset allocation can be different across individuals.

This choice of a constant asset allocation is motivated by the empirical observations on household portfolio choice in Ameriks and Zeldes (2004), who do not find support for traditional life cycle models with bond-like human capital in which the share of equities declines with age such as Bodie et al. (1992) or models with equity-like human capital as in Benzoni et al. (2007).

The asset return model is taken from Koijen et al. (2010). This model has been estimated for data relevant for the Netherlands by Draper (2012, 2014). The estimated equity risk premium is replaced by the official regulatory equity risk premium in the Netherlands (Langejan et al., 2014). This model is also used by the CPB Netherlands Bureau of Economic Policy Analysis. The model is briefly discussed in Appendix 2.6. A complete description of the model and estimation procedure can be found in Draper (2014).

The simulated asset returns are used to calculate total retirement income (before and after taxes) and occupational pension income (before taxes) separately over 10,000 scenarios for allocations of equity from 0% to 100%, with steps of 1%. This simulation is done for three ages, three (starting) incomes, and three equity premiums. All output is given in annual amounts denominated in USD.

The main features of the members in our simulation model are:

- For simplicity, during the lifetime of an individual, there is no real wage growth, a constant real first-pillar pension[10], and income tax brackets[11] remain constant in real terms. In other words, the growth in these quantities equals the inflation rate.
- During a member's working life, each year, 10% of the pension base (income minus deductible) is contributed as pension premium. The premium accrues annually to pension capital.
- Pension capital is invested in a constant asset allocation over the life-cycle (working life and retirement).
- The allocation to bonds is assumed to be invested in a portfolio of safe government bonds with a duration equal to the remaining investment horizon of the member, capped at 30. If necessary, we use interpolated interest rates in between the 1, 5, 10, and 30 year available rates.
- For given income paths and asset returns, this leads to a second-pillar pension capital w at retirement. At retirement, each year a fraction B of the pension capital w (the second-pillar benefit) is withdrawn as follows[12]:

  $$B = \frac{w * R_t}{1 - (1 + R_t)^{-L}} \tag{2.5}$$

  where R_t is the risk-free rate at time t and L is expected remaining life expectancy in years.
- Total after-tax pension benefits are discounted with cumulative inflation to arrive at a net present value of the benefits.
- Pension plan members retire at the fixed age of 67 and pass away at the age of 85, giving 18 years of pension benefits.
- In order to investigate the effects of the age of pension plan populations, our simulations start at different ages, such that the investment horizon differs. The amount of capital that these older members start with in our simulations is for simplicity the total premiums increased with the risk-free rate from age 25.

[10]First pillar income is equal to $15,752

[11]Progressive tax brackets are equal to < $21,610: 18.35%, $21,610-$36,911: 24,10%, $36,911-$62,184: 42.00% and > $62,184: 54.00%

[12]In the case $R_t = 0$ the equation is $B = w/L$

2.4.2 Pension asset allocation

We calculate the average utility (Equation 2.2) that each asset allocation generates. The asset allocations for which the utility is highest are displayed in Table 2.6. The last part shows the results in absence of social security or state pension. This is in principle the case in countries such as Chile, although for most of these countries there are means-tested or minimum pensions offered by the state in case the private pension is not sufficient. To some extent, the government provides a put option that could potentially lead to excessive risk taking in the pension portfolios. In our analyses, we abstract from these government-sponsored minimum pensions and assume that the private pension portfolio is the only source of income.

Our results in Table 2.6 show that heterogeneity in risk aversion leads to substantially different pension allocations using our model settings. As we do not allow for leverage (*i.e.*, allocations to equity financed with short positions in the risk-free asset) in the pension allocation, for γ coefficients of 1.5 and lower we see that a 100% allocation to equities gives highest utility even in the absence of a state pension. This is the case for 42% of our respondents. With the presence of a state pension – which reduces risk in total pension income – more members should fully invest in equity. In total, our survey suggests that approximately 77% of our respondents should be fully allocated to equity.

The first part in Table 2.6 presents the optimal allocation when a state pension is included (e.g., the Netherlands). The state pension is assumed to be risk-free. The equity allocation is now 100% for γ coefficients below 4 (gross salary equal to \$50,000). Traditionally, research on asset allocation focused exclusively on the risk-bearing part of pensions, normally second-pillar occupational pensions (Viceira, 2001; Campbell et al., 2003). However, many countries have systems that include a risk-free state pension or social security (e.g., France, the Netherlands, the US). The total pension amount relevant for individuals is total retirement income, including both risk-bearing pension and the state pension, all after taxes. This is the amount that individuals can use for consumption and that determines their standard of living, *i.e.*, utility. Other studies may ignore first-pillar pensions, for example because their focus or the relative insensitivity to it. However, our results show that we need to address the issue as it has a major impact on the outcome. We are not aware of other pension asset allocation studies that explicitly take this into account. This is a novel aspect of our paper.

Table 2.6 also shows the differences with respect to income. This is important for our study on the Netherlands, as the state pension is a fixed nominal amount, independent of income. The impact of state pension on the optimal asset allocation therefore depends on the income of the member. For higher incomes, the relative importance of the state pension is reduced. For extremely large incomes, the state pension is so small that the optimal asset allocation is close to the case without state pension. For lower incomes, the coefficient of relative risk aversion is unimportant. For an employee with $30,000, the optimal asset allocation is 100% to equities for the range of relative risk aversions that we cover in Table 2.6 .

Table 2.6: Optimal allocation of pension plan assets to equity

(1) Income: $30.000				(2) Income: $50.000				(3) Income: $70.000				(4) Without state pension			
γ	25	46	67	γ	25	46	67	γ	25	46	67	γ	25	46	67
0.0	100	100	100	0.0	100	100	100	0.0	100	100	100	0.0	100	100	100
0.5	100	100	100	0.5	100	100	100	0.5	100	100	100	0.5	100	100	100
1.0	100	100	100	1.0	100	100	100	1.0	100	100	100	1.0	100	100	100
1.5	100	100	100	1.5	100	100	100	1.5	100	100	100	1.5	100	100	100
2.0	100	100	100	2.0	100	100	100	2.0	100	100	100	2.0	83	78	78
2.5	100	100	100	2.5	100	100	100	2.5	100	100	100	2.5	69	64	62
3.0	100	100	100	3.0	100	100	100	3.0	99	97	99	3.0	59	55	52
3.5	100	100	100	3.5	100	100	100	3.5	91	89	88	3.5	52	47	44
4.0	100	100	100	4.0	95	95	98	4.0	85	82	78	4.0	46	42	39
4.5	100	100	100	4.5	90	89	90	4.5	79	76	71	4.5	42	38	34
5.0	100	100	100	5.0	86	84	83	5.0	74	71	65	5.0	38	34	31
5.5	100	100	100	5.5	82	79	77	5.5	70	66	59	5.5	35	31	28
6.0	100	100	100	6.0	78	75	72	6.0	67	62	55	6.0	33	29	26

Notes. Allocation to equity (in %) for different levels of (starting) income and in the case of no state pension. Results are given for different starting ages and different levels of relative risk aversion.

2.4.3 How costly is having the 'wrong' pension asset allocation?

In the previous sections, we showed that average pension risk aversion is close to 2 and that this implies an asset allocation of 100 percent to equities for a wide range of income levels when we take state pensions into account. Moreover, we also document that there is large heterogeneity in risk aversion within pension plan populations, and that this heterogeneity is not attributable to socio-demographics. In this section, we investigate what that welfare loss is from having one asset allocation for an entire pension plan population. In order to compute the welfare loss, we compare the pension plan allocation to the allocations in Table 2.6 that yield the highest expected utility. We realize that our concept of 'optimal' only applies within the context of our model assumptions, and therefore our welfare losses are also conditional on the assumption that our model and its parameters are correct. Therefore, this section is meant as an illustration rather than a definite answer to the far bigger question how to determine an optimal pension asset allocation. The optimal allocation to equity, and thereby the value of eliciting risk preferences, is conditional on the equity premium that we assume. In Appendix 2.6 we provide a sensitivity analysis to the equity premium, we display optimal asset allocations for equity premiums that are 2% and 4% lower, which are closer to the estimated parameters by Draper (2014), which are lower than the regulatory parameters on the equity risk premium. Even though our model may not be fully correct, we note that different pension asset allocation models estimated by Viceira (2001) and Benzoni et al. (2007) all show strongly different asset allocations for investors with different risk aversions, where higher risk aversion leads to lower allocations to equity. These are the most important features necessary to obtain results with similar interpretation as ours.

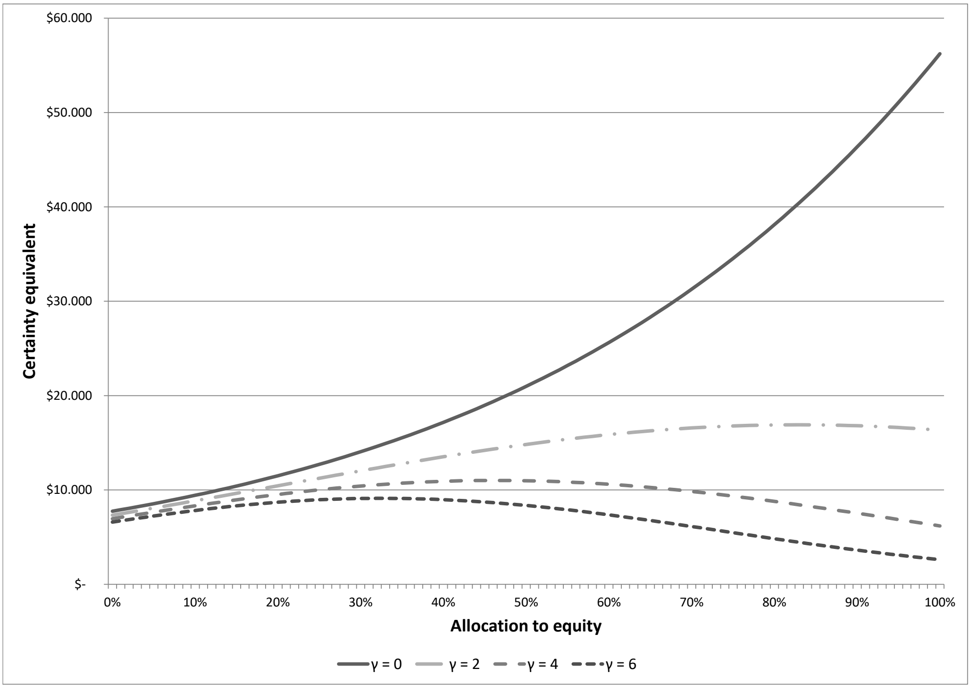
We implement the concept of the certainty equivalent (Arrow and Lind, 2014) to determine, in monetary terms, how much expected utility is lost for an individual who participates in a pension scheme with exogenously determined uniform pension asset allocation. The certainty equivalent transforms a distribution of uncertain outcomes to a single value with probability 1 that has the same utility. This way, we can compare distributions of pension outcomes, where differences represent utility equal to certain reductions in pension income.

$$CE_i = (EU_i(1-\gamma_i))^{\frac{1}{1-\gamma_i}} \tag{2.6}$$

where CE_i is the certainty equivalent of the uncertain total pension income, EU_i is the expected utility of total pension income, and γ_i is the (constant) relative risk aversion for individual i. This framework can be used to assess an individual's pension asset allocation.

Figure 2.2 shows the certainty equivalents for a member who joins the pension plan at age 25 with an (initial) income of \$50,000 for different levels of relative risk aversion, not taking the state pension into account. The graph shows that the expected annual value of pension income greatly depends on the chosen asset allocation. A risk-neutral ($r = 0$) individual will prefer the highest expected value, which is given by a 100% allocation to equity. When the pension plan invests instead 0% in equities, this implies a loss in certainty equivalent of \$56,230 - \$7,750 = \$48,480 each year. For a γ coefficient of 6, the loss in certainty equivalent would be \$6,500 when the pension plan invests 100% in equities, while the model-implied optimal allocation would be 78%.

Figure 2.2: Certainty equivalents



Notes. Annual certainty equivalent plotted against allocation to equity for a member enrolling at age 25 with an income of \$50,000, not taking the state pension and income taxes into account. The certainty equivalent is given for four levels of relative risk aversion. The certainty equivalent is highest (optimal allocation) for an allocation of 100%, 100%, 95% and 78% for relative risk aversion (γ levels 0, 2, 4, and 6, respectively).

Whereas Figure 2.2 shows the certainty equivalents for four different γ coefficients and asset allocations, Table 2.7 shows the loss in certainty equivalent for different asset allocations and risk preferences compared to the optimal asset allocations. This is the loss that a member experiences from being forced into a given pension plan asset allocation that deviates from her personal optimal allocation. If we take γ equal to two from a respondent at face value, the loss in certainty equivalent for a member in a pension plan with an allocation of 40% in equities is \$7,655, or, stated differently, about two monthly salaries! Certainty equivalent losses are typically smaller for higher γ, but typically still exceed one monthly salary for each γ when the member's desired and pension scheme's actual allocation are substantially different. Comparing welfare losses in the situation with (left panel) and without a state pension (right panel) in Table 2.7 shows that including the state pension increases preferences for higher allocations to equity, and thereby larger welfare losses for lower allocations to equity for risk averse individuals.

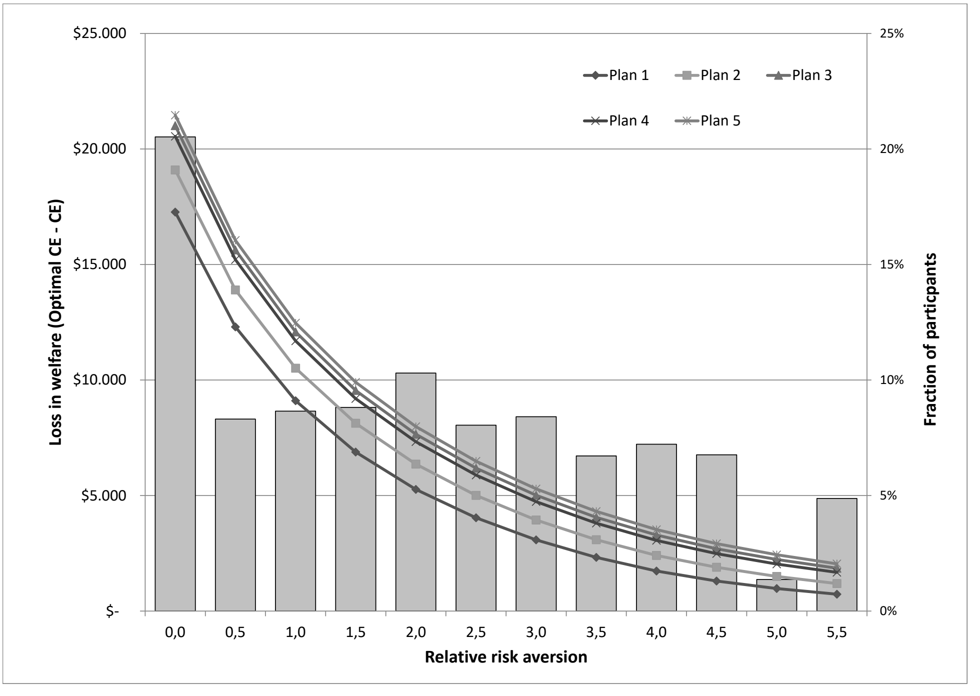
Table 2.7: Loss in certainty equivalent

Allocation	**Including state pension**				**Without state pension**			
to equity	$\gamma = 0$	$\gamma = 2$	$\gamma = 4$	$\gamma = 6$	$\gamma = 0$	$\gamma = 2$	$\gamma = 4$	$\gamma = 6$
0%	27,912	13,520	8,344	5,956	48,484	9,573	4,058	2,525
10%	26,618	12,275	7,145	4,798	46,798	8,052	2,685	1,288
20%	25,046	10,853	5,851	3,615	44,726	6,463	1,488	414
30%	23,166	9,285	4,534	2,502	42,182	4,880	592	17
40%	21,008	7,655	3,291	1,550	39,064	3,389	90	142
50%	18,587	6,044	2,204	818	35,252	2,081	29	753
60%	15,870	4,509	1,321	326	30,604	1,041	404	1,749
70%	12,785	3,100	663	62	24,956	337	1,163	2,984
80%	9,232	1,858	235	3	18,118	18	2,221	4,283
90%	5,054	815	27	116	9,878	100	3,475	5,487
100%	0	0	20	367	0	577	4,822	6,498

Notes. Loss in certainty equivalent (in $) of different asset allocations and risk preferences compared to the optimal asset allocation. Values are given for a member aged 25 with initial income of $50,000. Left panel represents welfare loss in the situation with a state pension and progression income taxes. The right panel represents welfare loss in the situation without a state pension and income taxes.

The analyses above are still somewhat hypothetical cases. Now, we turn to estimating the loss in certainty equivalent for each member given the actual asset allocation in the pension plan she is participating in and taking into account the state pension in the Netherlands. Figure 2.3 shows the loss in certainty equivalents (left axis) for members in the five company pension plans that participated in the survey, dependent on the risk preferences of the members. The certainty equivalents hold for a member that joins the pension plan at age 25 with an initial income of $50,000. The bars (right axis) present the total proportion of members in each of the respective ranges of γ. The results show that every asset allocation in our study is too safe given the preferences of pension plan members. This is due to the safe state pension, that leads even the most risk-averse members favour more risk than is actually taken in the pension plans. This holds especially for the relatively large proportion of members who are risk-neutral or who have relatively little risk aversion. Increasing the allocation to equity moves all the lines downward until eventually turning upward, starting with the most risk-averse individuals (as in Figure 2.2).

Figure 2.3: Loss in certainty equivalent



Notes. Loss in certainty equivalent (in $) for levels of relative risk aversion given asset allocation of the respective company pension plans (lines and left axis). Percentage of respondents with relative risk aversion, truncated at zero (bars and right axis). Certainty equivalents are given for a 25-year-old member, with initial income $50,000 and the state pension of The Netherlands.

Using the same method we can classify the respondents of our survey into different groups, dependent on age, income, pension plan, and risk aversion, and calculate the welfare in certainty equivalence they lose by being forced into their pension plan's asset allocation. Table 2.8, sixth column, shows the average welfare loss for the population of the five pension plans elicited with the current asset allocations. On average the respondents of our survey lose 13.76% of their optimal pension income welfare, about 1.5 - 2 monthly pension incomes, by having a suboptimal asset allocation. These numbers deviate between 12.00% and 18.24% for different pension plans dependent on the average income, age, risk aversion, asset allocation and variation in risk aversion within the pension plan. For the sample as a whole this equates to $47.5 million per year, or $6,019 per respondent per year on average.

Table 2.8: Welfare losses per pension plan

Pension plan	**Current equity allocation**	**Income** (month)	**Age**	**Relative risk aversion**		**Welfare loss average**	
		Average	Average	Average	St. dev.	Current	Optimal allocation
1	55%	$ 2,537	50.1	1.829	1.918	13.25%	0.54%
2	48%	$ 2,097	53.8	1.985	2.009	12.00%	0.36%
3	40%	$ 2,168	44.8	2.066	1.724	18.12%	0.76%
4	42%	$ 1,813	52.2	2.411	1.651	12.47%	0.41%
5	38%	$ 2,498	48.5	2.205	1.861	18.24%	0.47%
Total		$ 2,396	50.1	1.926	1.901	13.76%	0.53%

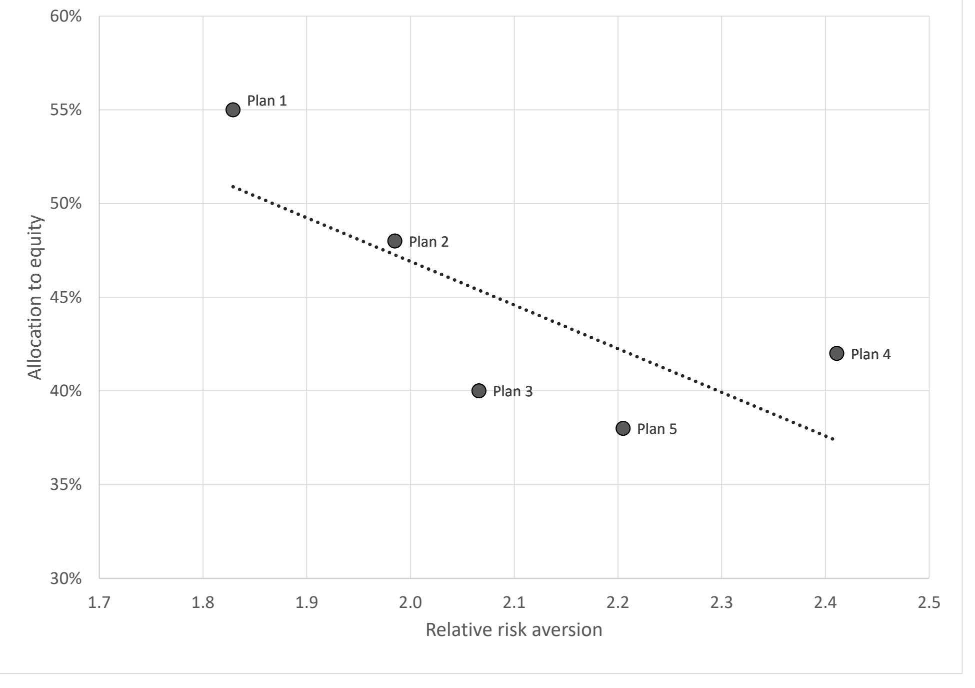
Notes. Welfare losses and socio-demographic information per pension plan with current asset allocations.

However, as we've seen before the asset allocation of the pension plans in our sample are too conservative for their members' risk preferences. By increasing the allocation to equity welfare gains can be made without individualizing the asset allocation. The last column of Table 2.8 shows the welfare losses when the asset allocation is set at the collective optimum of 100% equities. These welfare losses are substantially lower than the current welfare losses, increasing total welfare with $46.3 million per per year, $ 5,865 per respondent per year on average. The value of individualizing asset allocations can improve total welfare with an additional $1.2 million per year, equal to $ 154 per respondent. The value of eliciting risk preferences depends strongly on the assumed equity premium. With the default equity premium there is no value of eliciting risk preferences with a collective asset allocation, as both the optimal allocation for the average respondent (γ = 1.926) and the collective optimum are both an allocation of 100% to equity. In Section 2.5.2 we present the value of eliciting risk preferences for a number of different model assumptions.

An ordinary least squares regression with clustered standard errors shows a marginal effect of the measured relative risk aversion of the pension plan population and the current allocation to equity (+1 average γ is associated with -0.23% allocation to equity). Average income appears to be a more important determinant of the asset allocation (10% higher average income is associated with 1.0% higher allocation to equity). The effect of average γ on the asset allocation is larger for the composite score (-0.23%) than for the MLC results (-0,14%). As there are only 5 observations of the asset allocation the statistical power (significance) of the regressions is low.

The relation between the pension plan's average risk aversion and the allocation to equity is illustrated in Figure 2.4. The figure shows that differences across members in pension domain risk preferences do appear to be a relevant determinant for pension plan managers' decisions on setting plan asset allocation for the five pension plans that we study.

Figure 2.4: Scatterplot of pension plans average risk aversion and allocation to equity



Notes. Dotted line represents linear trend line.

The simulations show that most of the welfare losses that we find are the result of an allocation to equity that is too low. The results demonstrate that for the case of the five pension plans that we study, pension plan managers can satisfy most members by increasing the asset allocation. Allocating (close to all) assets to equity (or other higher risk categories) will increase welfare for almost all members. However, while average welfare will increase in this case, many members will still face substantial welfare losses (see Table 2.8) as the collective asset allocation can never accommodate the heterogeneity in optimal asset allocations due to heterogeneous risk preferences.

2.5 Discussion

2.5.1 Implications for academic research

Our research has several implications for the academic research agenda on pension asset allocation. The use of unique data from 7,894 members in five Dutch pension plans allows us to provide real-world empirical insight on the degree of explained as well as unexplained heterogeneity in pension plan members' risk preferences. This confirms earlier findings that a large component of individuals' pension risk preference is idiosyncratic (*e.g.*, due to unobserved individual or environmental factors (Cesarini et al., 2009; Grable et al., 2004)) and only knowable to investment managers after engaging in a dialogue with the individual (*i.e.*, preference elicitation). The levels of relative risk aversion that we find are substantially lower than is often assumed in papers discussing (optimal) asset allocation (*e.g.*, Viceira (2001); Campbell et al. (2003). However, the levels do correspond with most papers eliciting financial risk preferences from individuals (*e.g.* Mankiw and Zeldes (1991); Barsky et al. (1997); Holt and Laury (2002)). This implies that there is a large gap between risk preferences elicited from individuals and those used in setting asset allocations. A fruitful area for further research may be to better explain this gap. Perhaps this increased understanding may lead to questionnaires better suited to elicit pension risk aversion or change the way risk aversion can be incorporated in theoretical pension asset allocation models. Or approach uses the elicited risk preferences directly into existing pension asset allocation models.

This, together with simulation-based evaluations of the impact of risk preference heterogeneity, also provides new theoretical (and real-world) insights into the contingent nature of optimal pension asset allocation. We highlight the importance of pension plan members' characteristics (*i.e.*, time to retirement, income, and risk preference heterogeneity) and pension market conditions (*i.e.*, presence of a state pension) in determining an optimal pension asset allocation strategy. Future research could address other important contingencies and further investigate the interplay between risk preference heterogeneity and the environment in which this heterogeneity occurs in determining optimal asset allocation strategies.

The new augmented lottery choice method tailored to individual pension risk preference elicitation that we develop provides a useful balance between a normative economic basis and individual-level specificity in risk preferences. Because the lottery choice questions were personalized to each individual's pension income based on current income and age (*i.e.*, years to retirement), individuals could also directly take into account their personal situation. Augmentation with two other risk preference elicitation methods reduces the level of measurement error in the risk preference measure and improves robustness. Nevertheless, further research on methods to reduce measurement error in eliciting risk preferences may be warranted.

Traditionally, the research on asset allocation focuses exclusively on the risk-bearing part of pensions, normally second-pillar occupational pensions (Viceira, 2001; Campbell et al., 2003). However, many countries have systems that include a risk-free first-pillar pension (*e.g.*, France, the Netherlands, the US), such as a state pension (*e.g.*, social security). Our findings underline the importance of taking this context into account. They also provide a refinement of Bucciol and Miniaci (2015), in that we find that higher state pensions increase the allocation to equity in optimal asset allocation of the second-pillar pension plans.

2.5.2 Managerial and policy implications

The value of eliciting risk preferences for setting the optimal asset allocation depends on a number of contingency variables, which we summarize in Table 2.9 in a framework for pension plan managers. This table provides a qualitative overview of how the value of eliciting risk preferences depends on pension plan member characteristics and the pension market in which the plan operates.

Pension plans that have an older population, with many retired members, will find that the value of eliciting risk preferences is lower. The investment horizon is short, and therefore the effect of variations in asset allocation is lower. However, the value of eliciting risk preferences for the youngest members is also lower, as these have less heterogeneity in optimal asset allocations. Pension plans that service a population with relatively high incomes compared to their state pensions, or without a state pension (*e.g.*, in countries such as Chile), directly affect a large proportion of individuals' retirement income. Therefore, the impact of asset allocation on members' retirement incomes is larger for these plans. This increases the value of eliciting risk preferences. In other countries with relatively high state pensions (*e.g.*, France), the value of risk preference elicitation is likely to be lower. Market conditions, especially equity premium, also influence the value of elicitation, because they affect the trade-off between equity and fixed income. With high equity premiums, equity becomes dominant, and since all members should (almost) fully invest in equity under these conditions, the value of elicitation is reduced. Finally, for pension plan populations with a larger heterogeneity of risk preferences (such as industry-wide pension plans that combine many different types of plan members), the variation in optimal asset allocations is larger. This also makes eliciting risk preferences more valuable.

Table 2.9: Cost-benefit framework of eliciting risk preferences

	Level of contingency variable	
Contingency variable	**Low**	**High**
Plan population		
Age	A young population should invest in equity anyway, so risk preferences are less relevant. However, due to the longer horizon differences become more pronounced	An old population may differ in terms of optimal asset allocation, however, due to a shorter period, the effect is less pronounced.
Heterogeneity	For a homogeneous population, elicitation may not be worth the while. A sample may suffice. Homogeneous populations may occur in niche industry-wide pension funds, or company pension funds.	Variety in risk preferences can make elicitation worthwhile. In large, widely defined industry-wide pension funds (*e.g.* civil servants), heterogeneity is likely to be large.
Pension market		
Income	State pension is paramount, so asset allocation is less relevant. This holds for low paid workers and/or in Beveridgean pension systems.	State pension is less relevant, so asset allocation, and therefore risk preferences, become more important. This holds for highly paid workers and/or in Bismarckian pension systems.
Equity premium	Large variety of optimal asset allocations, thus preferences are more important	Equity mostly optimal, so risk preferences are not relevant

Table 2.3 shows that all of the pension plans in our sample have asset allocations that are too conservative for the vast majority of their members. This implies that, within our framework, pension plans can improve welfare by increasing the allocation to equity. However, as risk preferences are heterogeneous, a single asset allocation will always lead to welfare losses to some of the members. To illustrate the framework with a numerical example, we assess the impact of risk preference heterogeneity in the case that the asset allocation is matched to the average pension plan member.

Table 2.10 shows the value of a customized individual asset allocation in a number of different situations compared to a strategy of optimizing for the mean level of risk preferences in our sample (*i.e.*, $\gamma = 2$). This would be an alternative, simpler, approach for pension funds compared to setting risk preferences; it matches the plan population average, but accepts welfare losses due to heterogeneity of risk preferences. Hence, these results reflect the value of eliciting risk preferences and customized individual asset allocations.

In this table, we see that the effect of time to retirement (age) is twofold. With longer periods to retirement the heterogeneity in optimal asset allocations is lower, which reduces the value of customized asset allocations. However, with shorter periods to retirement the impact of different asset allocations on pension benefits decreases, which also reduces the value of customized asset allocations.

With larger incomes the relative size of risk-bearing pension increases as the state pension is fixed. This increases the impact of different asset allocations but also increases the heterogeneity in optimal asset allocations. Therefore, higher incomes – or lower state pensions – increase the value of customized asset allocations.

In the absence of intraplan heterogeneity in risk preferences, there is no value in eliciting risk preferences. As risk preferences become more heterogeneous, optimal asset allocations become more heterogeneous, and the value of eliciting risk preferences increases.

Finally, with higher equity premiums the heterogeneity in optimal asset allocations decreases, as more members prefer full equity allocations. Therefore lower equity premiums, with more heterogeneous asset allocations, lead to more valuable risk preferences elicitations and asset allocation customizations. When the equity premium is very low, or absent, most members will prefer no risk taking and the value of eliciting risk preferences becomes lower again. Including ambiguity aversion in our analyses would have similar effects on asset allocation to having a lower equity premium. Therefore, if real-life pension asset allocation is better described by a combination of risk and ambiguity aversion, this would likely lead to similar effects as using a lower equity premium in the current model.

Table 2.10: Value of eliciting risk preferences

Variables	Maximum welfare loss				
Time to retirement (years)	**0**	**10**	**21**	**31**	**42**
	0.38%	0.62%	0.65%	0.40%	0.27%
Income (per year)	**$20,000**	**$30,000**	**$40,000**	**$50,000**	**$60,000**
	0.00%	0.10%	0.42%	0.69%	0.81%
Heterogeneity γ	**2.0 - 2.0**	**1.5 - 3.0**	**1.0 - 4.0**	**0.5 - 5.0**	**0.0 - 6.0**
	0.00%	0.01%	0.08%	0.28%	0.53%
Equity premium	**Default -4%**	**Default -3%**	**Default -2%**	**Default -1%**	**Default**
	2.22%	2.69%	2.11%	0.90%	0.53%

Notes. Average welfare loss as a ratio of total optimal pension income.

2.5.3 Limitations and further research

Several limitations and possibly fruitful extensions of our research are worth noting. Our results are based on cross sectional data. With panel data, more research and management questions could be answered. Future research may shed more light on the time dependency of risk preferences. This is relevant for pension plan management as well, because this influences the frequency of conducting risk preference surveys among plan members. For instance, if the risk preference changes due to large events, such as the 2008 financial crisis, surveys need to be repeated every couple of years. If the risk preference of individuals is stable, then a new survey is warranted only if the plan population changes substantially. Since risk preference surveys are costly to the pension fund, such considerations are material.

Our analysis is set in an individual pension asset allocation setting with constant asset allocations. Although this setting yields the clearest theoretical insights, some adjustment is necessary to allow application of the results to individual pension plans with lifecycling options and to collective pension plans. Also, adding more asset categories and financial derivatives or variable annuities (Mahayni and Schneider, 2012) would yield a more complete insight.

Individual pension plans, such as defined contribution plans, often allow members to invest in line with a lifecycle model. Lifecycle models adapt asset allocation to investor age. Individuals further away from retirement receive a high allocation to equity, and as the time horizon declines, allocation to equity decreases. This mechanism is designed to compensate the stronger effect of equity on the riskiness of final pension income in shorter investment horizons. Or, defined differently, this shift is due to the decline in human capital compared to financial capital (*i.e.*, where human capital acts as a diversification mechanism) (Viceira, 2001). This is in line with our finding that pension members who start later have lower optimal allocations to equity. Since lifecycling can be used to decrease the effect of risk on pension income, equity may be even more desirable when lifecycling is allowed. Adding lifecycling to our model would be an interesting avenue for further research.

In addition, in some countries, members in individual pension plans are obligated to convert (part of their) pension capital to annuities on the retirement date. This reduces the amount of risk that retirees can take and leads to significant welfare losses according to our model (*i.e.*, following from the positive allocation to equity for 67-year-olds). Such a policy influences optimal asset allocation and will presumably transfer risk from the retirement phase to the active phase. Also, such policy adds additional interest rate risk for members, who become highly sensitive to the interest rate on the day of conversion (normally the retirement date). Adding both these mechanisms to the model would increase the practical usability of the model; however, optimizing this model in this way would be computationally demanding given the very large number of possibilities that would result.

Collective pension plans generally provide only a single asset allocation for all their members. As our results show, the heterogeneity in risk preferences and socio-demographic characteristics makes the single asset allocation suboptimal for many members, who will face welfare losses. Another difference in collective pension plans is the possibility of employing intergenerational risk sharing (Chen et al., 2016). Employing intergenerational risk sharing reduces risk through longer time diversification. Further research may reveal whether the benefits of collective schemes, such as intergenerational risk sharing, outweigh the welfare losses that result from the mismatch between a homogeneous asset allocation and heterogeneous risk preferences.

In the case of collective pension plans with a single asset allocation, the question becomes how to use risk preferences in determining the single asset allocation. By definition, a single asset allocation results in welfare losses when there are heterogeneous risk preferences. Choosing the asset allocation that minimizes aggregated welfare losses may be one option to cope with this problem; however, this would weight higher incomes more heavily, which may be considered socially undesirable. Other options include weighting the optimal individual asset allocations with the number of members or accumulated benefits. Each choice weighs specific income and age groups individually; the choice mainly depends on pension plan–specific preferences.

Further, our results show a large discrepancy between optimal asset allocation and current asset allocations of the pension plans studied (Figure 2.3). Several factors may explain this, in addition to previously mentioned points. First, the horizon of pension plan managers and regulators is far shorter than that of most members. Legislation often requires pension plan managers to focus on short term (< 10 years) and nominal – inflation is normally not valued neutrally – performance measures, such as the coverage rate, and pension cuts. Members (in our model) value only actual pension benefits. In this way, more often than not, members are assumed to have a horizon exceeding 20 years. This mismatch may implicitly lead to myopic loss aversion (Benartzi and Thaler, 1995), by reducing year-to-year volatility, long run volatility may be below optimal. Second, interests of other stakeholders, such as the sponsoring company, supervisors, and politicians, may influence asset allocation. However, since pension members are the primary stakeholders of pension plans, integrating their long-term preferences more strongly in the decision process of the (collective) asset allocation may substantially increase their welfare.

We hope that our research can provide a fruitful next step in developing insights into when and how to elicit pension plan member risk preferences to make more informed decisions about how to match members' risk preferences with pension plan investment allocations.

2.6 Conclusion

This study measures risk preferences in the pension domain of 7,894 members in five Dutch pension plans, using an augmented version of the multiple lottery choice method via an online survey. By combining data from multiple risk preferences elicitation methods in a composite score, we assign personal values of relative risk aversion to the members in these pension plans and overcome several difficulties related to individual measures of risk preferences (*i.e.*, dominated choices and measurement noise).

Our results show that there is large heterogeneity in pension income risk preferences. Risk preferences tend to vary both within the population of a pension plan as between the populations of different pension plans, both in the level and in the variation of risk preferences. Variation between pension plan populations is mainly driven due to differences in socio-demographic characteristics, such as age, gender, and income, and to a lesser extent due to possible selection effects of specific industries or employers. Socio-demographic information and pension plan membership only accounts for 5.6% of variation, so modelling risk preferences with observable socio-demographic information cannot replace the measurement of individual risk preferences.

Our simulation quantifies the importance of risk preferences for optimal asset allocation. Allocation to equity in the optimal asset allocation changes by up to 30% in our baseline model. Inclusion of a state old age pension substantially increases allocation to equity, since this increases the security of total retirement income. Other variables that influence optimal asset allocation (given risk preferences) are income (via the relative size of the state old age pension), age, and equity premium.

Further, a suboptimal asset allocation leads to significant welfare losses to pension plan members. Within our model assumptions the respondents of our survey lose on average 13.76% of their pension welfare by being forced into a suboptimal asset allocation given their personal preferences and situation. By increasing the level of the collective asset allocation to the collective optimum welfare can be increased with 13.23%. The remaining 0.53% can only be achieved by allowing members to customize their asset allocation to personal risk preferences.

Finally, the value of eliciting risk preferences and customizable pension asset allocations depend on a number of pension plan characteristics and market expectations. First, higher levels of income, compared to the state pension, increase the effect of asset allocation on total pension income, and therefore increase the value of elicitation. Second, both lower equity premiums and more heterogeneity of risk preferences increase the variance of optimal asset allocations, and increase the value of elicitation. Finally, age influences the value of elicitation through the investment horizon. Shorter periods to retirement cause more variation in optimal asset allocations; however, as the investment period becomes shorter, differences due to asset allocation become less pronounced.

Appendix 2.1: The pension system in the Netherlands

Our online survey is conducted by five pension funds that operate in the Netherlands. In this section, we describe the essential features of the pension system in the Netherlands and compare it with the pension system in the U.S. where appropriate.[13] This should clarify context of the members in our survey, and indicate how our empirical results can be used by pension funds, regulators, and other stakeholders.

The three pillars of the pension system are organized as follows. The first pillar consists of social security pensions organized by the government and are primarily pay-as-you-go financed. The pension is different for one- or two-person households, but otherwise a fixed amount that each inhabitant receives irrespective of working history. This amount should cover essential expenses and should prevent extreme poverty among the elderly. The second pillar is work-related, voluntarily organized by company or industry, and by law required to be capital financed. It is semi-mandatory to participate if you are employed for a company or industry with a pension plan. This means that most Dutch employees are covered by a second-pillar pension plan. The five pension funds that participated in our online survey offer these second pillar pension plans. In the third pillar, an individual may set-up an individual pension savings- or investment-account with a bank or insurance company. In this U.S., this is often referred to as an Individual Retirement Account. The average replacement rate in 2012 was estimated to be 39 percent from the first pillar and 30 percent from the second pillar by Statistics Netherlands (CBS).

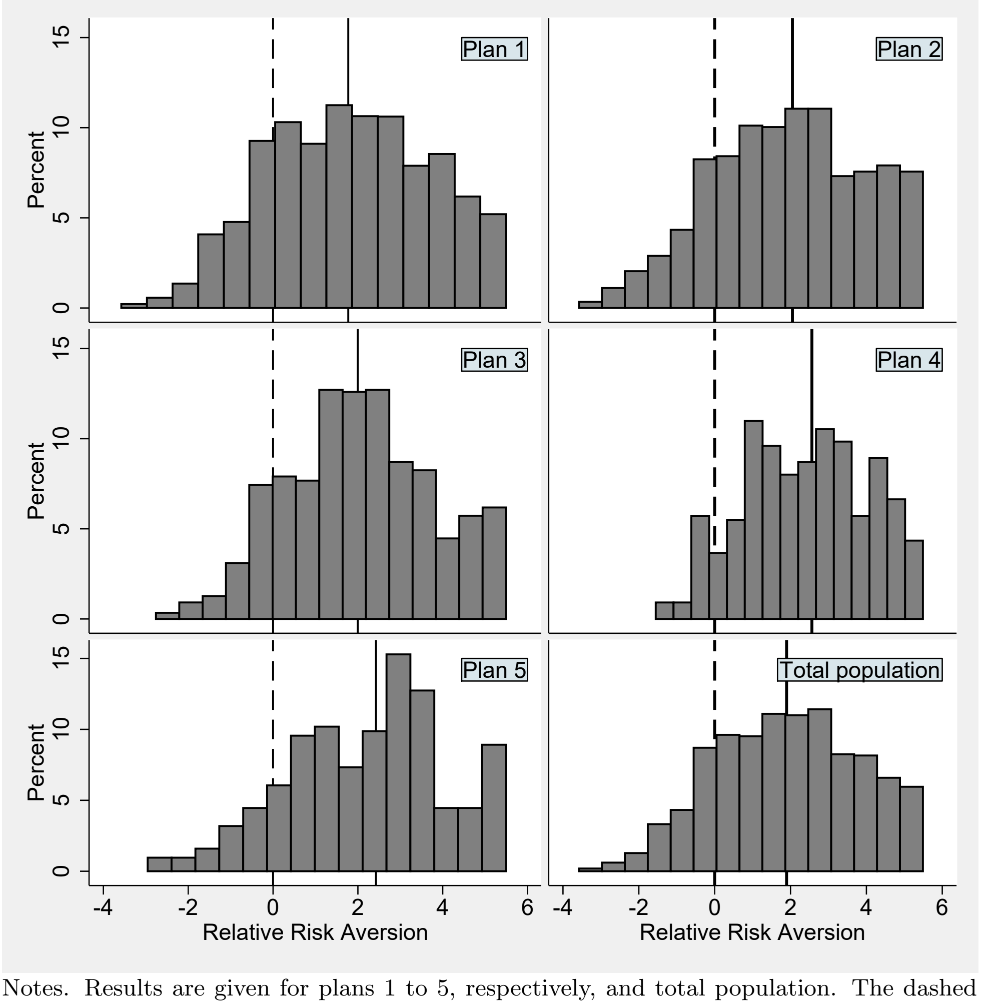
The second pillar pension plan is part of the negotiations between the employer and employees. This means that it can range from a traditional defined-benefit scheme in which the employer bears all the risks related to the final- or average-wage pension that is promised, to a defined contribution scheme with investment choices and/or contribution rates delegated to the individual. In the U.S., many civil servants seem to be part of a defined-benefits pension plan, whereas corporate plans these days are mostly defined contribution plans, of which the 401(k) plans have become popular. However, as Ponds and Van Riel (2009) indicate, most pension plans in the Netherlands contain risk-sharing elements between the employer(s) and employees, which is uncommon to see in the U.S. Moreover, over the past decades, the

[13] For more detailed information, see the report by the Dutch Association of Industry-wide Pension Funds entitled "The Dutch Pension System: An Overview of the Key Aspects."

amount of risk borne by the employee is increased considerably. These risk-sharing agreements may consist of several elements. First, most pension plans make cost-of-living adjustments to accrued payments (inflation compensation), unless the pension plan is not sufficiently funded. Second, when underfunding is severe and exists for a prolonged period, nominal pension benefits may also be reduced. This effectively means that the contributions from the employer(s) to the pension plan are capped, which makes corporate pension expenses more predictable and less pro-cyclical. In case corporate pension plan contributions are fixed for a period of at least five years, they may be considered as defined contribution plans according to International Financial Reporting Standards (IFRS). Industry-wide pension plans are considered to be defined contribution plans, unless the deficits in the pension plan can be easily attributed to an employer. This means that, even though the terminology of career-average pension plan suggests a defined benefit, the risk-sharing arrangements make them closer to defined contribution plans. Note that excess funding is typically kept as a financial reserve for future generations to reduce volatility in pension outcome between generations. Pension funds are governed by a board of trustees that should make sure that the pension plan is fair for all stakeholders. To ensure this, at most half of the board of trustees can be appointed by the employer(s), while the others are appointed by the employees or retirees. The strategic pension plan asset allocation is set by the board of trustees, where pension contributions by employer and employees are traded-off against the pension outcomes. This trade-off takes both the level and variations around this level into account. For the pension outcome, the possibility of cost-of-living adjustments are considered, as well as possible nominal pension reductions. Note that in case the second pillar would offer classic defined benefit pension plans, i.e., a plan in which all investment and longevity risk is borne by an employer that cannot default on its pension promise, our analysis on individual risk preferences in the pension domain would not be necessary. In such case, only the risk preferences of the employer would matter, as the retirement income for the member would be risk-free.

Appendix 2.2: Individual method responses

Figure 2.5: Histograms of relative risk aversion



Notes. Results are given for plans 1 to 5, respectively, and total population. The dashed line represents risk neutrality and the solid line represents the population's median relative risk aversion score.

Appendix 2.3: The asset return model

Here, we highlight only the main features of the model. There are four assets in this model: the stock market, long-term nominal bonds, inflation-linked bonds, and a money market account. The model uses four sources of risk: stock returns, instantaneous expected inflation, unexpected inflation, and the instantaneous real interest rate. the real interest rate r_t and expected inflation π_t at time t depend on two state variables, $X_{1,t}$ and $X_{2,t}$, and six parameters δ:

$$r_t = \delta_{0,r} + \delta_{1,r} X_{1,t} + \delta_{2,r} X_{2,t} \tag{2.7}$$

$$\pi_t = \delta_{0,\pi} + \delta_{1,\pi} X_{1,t} + \delta_{2,\pi} X_{2,t} \tag{2.8}$$

The use of state variables allows the model to capture correlation between the real interest rate and expected inflation. The consumer price index π_t instantaneously increases with expected inflation and an unexpected shock. The return on the stock market index S_t is the short-term interest rate, the equity equity premium, and an unexpected shock.

An affine term structure model for nominal and real interest rates is chosen. This choice implies that once the two factors, which are sometimes interpreted as interest rate level and term spread, are known, it is possible to value fixed income securities for all maturities. Thus, the price of a nominal bond with maturity τ at time t depends on the state variables X_t and model parameters A^N and B^N. Both these parameters are functions of maturity τ. The price for the inflation-linked bond can be expressed in a similar way, but depends on two different model parameters A^R and B^R, as follows:

$$P^N(X_t, t, t+\tau) = exp[A^N(\tau) + B^N(\tau)X_t] \tag{2.9}$$

$$P^R(X_t, t, t+\tau) = exp[A^R(\tau) + B^R(\tau)X_t] \tag{2.10}$$

These stochastic processes must be transformed to discrete time processes for the simulation. The model can be written as a multivariate Ornstein-Uhlenbeck process:

$$dY_t = (\theta_0 + \theta_1 Y_t)dt + \sigma_y Z_t \tag{2.11}$$

where $(\theta_0 + \theta_1 Y_t)$ contains the drift parameters and $\sigma_Y Z_t$ the shocks. In discretized form, this appears as:

$$Y_{t+h} = \mu^{(h)} + \Gamma^{(h)} Y_t + \epsilon_{t+h} \tag{2.12}$$

$$\epsilon_{t+h} \sim N(0, \Sigma^{(h)}) \tag{2.13}$$

The parameters of this model are estimated using maximum likelihood on quarterly data from interest rates and inflation from the Netherlands to match the context of our empirical data, and a global stock market index (MSCI), over the period 1973 to 2013. The estimated parameters imply a equity premium of 6.7%. In Appendix 2.6, the analysis is repeated using a equity premium that is 2% and 4% lower respectively, to show the sensitivity of this parameter. As expected, we find that a lower equity premium increases the impact of risk preference heterogeneity.

Appendix 2.4: Effect of equity premium on optimal asset allocation

Equity premium determines to a large extent the benefits of holding equity. Higher equity premiums make equity more attractive and normally lead to higher (optimal) allocations to equity. Tables 2.11 and 2.12 shows the optimal asset allocation for different levels of the equity premium. Table 2.11 shows the allocation with a 2% reduction in the equity premium that follows from historical data. In this case the benefits of measuring risk preferences become higher, as the allocation to equity decline and therefore heterogeneity in optimal asset allocations increases. In this case, measuring risk preferences can substantially decrease allocation mismatches and the welfare losses resulting from these mismatches. Finally, Table 2.12 presents the optimal allocation in case of a pessimistic equity premium of minus 4% compared to the default equity premium. The heterogeneity in optimal asset allocations is the highest in this case.

Table 2.11: Allocation to equity with equity premium: default - 2%

(1) Income: $30.000				(2) Income: $50.000				(3) Income: $70.000				(4) Without state pension			
γ	25	46	67	γ	25	46	67	γ	25	46	67	γ	25	46	67
0.0	100	100	100	0.0	100	100	100	0.0	100	100	100	0.0	100	100	100
0.5	100	100	100	0.5	100	100	100	0.5	100	100	100	0.5	100	100	100
1.0	100	100	100	1.0	100	100	100	1.0	100	100	100	1.0	98	97	100
1.5	100	100	100	1.5	100	100	100	1.5	100	100	100	1.5	72	69	70
2.0	100	100	100	2.0	100	100	100	2.0	91	91	94	2.0	57	54	52
2.5	100	100	100	2.5	92	92	99	2.5	81	80	79	2.5	48	44	42
3.0	100	100	100	3.0	82	84	87	3.0	74	71	68	3.0	41	37	35
3.5	100	100	100	3.5	79	77	78	3.5	68	64	60	3.5	36	32	30
4.0	100	100	100	4.0	74	71	70	4.0	62	59	53	4.0	32	29	26
4.5	100	100	100	4.5	69	67	64	4.5	58	54	48	4.5	29	26	23
5.0	98	100	100	5.0	65	62	59	5.0	54	51	44	5.0	26	23	21
5.5	95	96	100	5.5	62	59	54	5.5	51	47	40	5.5	24	22	19
6.0	92	93	100	6.0	59	56	50	6.0	48	44	37	6.0	23	20	17

Notes. Allocation to equity (in %) for different levels of (starting) income and in the case of no state pension. Results are given for different starting ages and different levels of relative risk aversion.

Table 2.12: Allocation to equity with equity premium: default - 4%

(1) Income: \$30.000				(2) Income: \$50.000				(3) Income: \$70.000				(4) Without state pension			
γ	25	46	67	γ	25	46	67	γ	25	46	67	γ	25	46	67
0.0	100	100	100	0.0	100	100	100	0.0	100	100	100	0.0	100	100	100
0.5	100	100	100	0.5	100	100	100	0.5	100	100	100	0.5	89	93	100
1.0	100	100	100	1.0	87	91	100	1.0	77	78	86	1.0	55	53	57
1.5	100	100	100	1.5	75	76	85	1.5	64	63	65	1.5	40	38	38
2.0	96	100	100	2.0	66	66	70	2.0	56	54	52	2.0	32	29	28
2.5	89	93	100	2.5	59	58	60	2.5	49	47	43	2.5	26	24	22
3.0	84	86	100	3.0	54	52	52	3.0	44	42	37	3.0	23	20	19
3.5	79	81	94	3.5	50	47	46	3.5	40	38	33	3.5	20	18	16
4.0	95	76	86	4.0	46	43	41	4.0	37	34	29	4.0	18	16	14
4.5	72	72	80	4.5	43	40	37	4.5	34	32	26	4.5	16	14	12
5.0	69	69	74	5.0	40	37	34	5.0	32	29	24	5.0	15	13	11
5.5	66	65	69	5.5	38	35	31	5.5	30	27	22	5.5	14	12	10
6.0	63	62	65	6.0	35	33	28	6.0	28	26	20	6.0	13	11	9

Notes. Allocation to equity (in %) for different levels of (starting) income and in the case of no state pension. Results are given for different starting ages and different levels of relative risk aversion.

Appendix 2.5: Effect of state pension and taxes on optimal asset allocation

Two variables that influence retirement income are the presence of a state pension and taxes in a pension system. A state pension, such as social security, creates a risk-free minimum, which reduces the riskiness of total pension income. Therefore, given total pension risk preferences, members want to increase the riskiness (*i.e.*, allocation to equity) of the risk-bearing pension in the presence of a state pension. Taxes reduce the amount of total pension income. Depending on the kind of system, taxation may result in divergent pension amount outcomes. Progressive systems will (on average) tax higher pensions more than lower pensions. This, in theory, influences the costs and benefits of risk, and therefore asset allocation.

Table 2.13, column 1, presents the optimal asset allocation in the case without a state pension and income taxes. Column 2 presents the optimal asset allocation with a state pension (Dutch old age state pension) and without income taxes, and finally column 3 presents the optimal asset allocation with a state pension (idem) and income taxes (Dutch progressive taxes). Results show that the presence of a state pension substantially increases the allocation to equity. The allocation of equity increases by up to 56%. Income taxes, on the other hand, have only minimal effects. In the presence of income taxes, the allocation to equity increases by a maximum of

5%. Progressive income taxes thus have a (limited) risk-reducing effect.

Table 2.13: Optimal allocation of pension assets to equity, effect state pension and taxes

(1) Pension without state pension before taxes				(2) Pension with state pension before taxes				(3) Pension with state pension after taxes			
γ	25	46	67	γ	25	46	67	γ	25	46	67
0.0	100	100	100	0.0	100	100	100	0.0	100	100	100
0.5	100	100	100	0.5	100	100	100	0.5	100	100	100
1.0	100	100	100	1.0	100	100	100	1.0	100	100	100
1.5	100	100	100	1.5	100	100	100	1.5	100	100	100
2.0	83	78	78	2.0	100	100	100	2.0	100	100	100
2.5	69	64	62	2.5	100	100	100	2.5	100	100	100
3.0	59	55	52	3.0	100	100	100	3.0	100	100	100
3.5	52	47	44	3.5	98	98	100	3.5	100	100	100
4.0	46	42	39	4.0	92	91	94	4.0	95	95	98
4.5	42	38	34	4.5	87	85	85	4.5	90	89	90
5.0	38	34	31	5.0	82	80	78	5.0	86	84	83
5.5	35	31	28	5.5	78	76	72	5.5	82	79	77
6.0	33	29	26	6.0	75	72	67	6.0	78	75	72

Notes. Optimal allocation to equity (in %) in the case of no state pension and income taxes, in the case of a state pension and no income taxes, and in the case of a state pension and income taxes. Results are given for different starting ages and levels of relative risk aversion. Starting income fixed at $50,000.

Chapter 3

Measuring latent risk preferences, minimizing measurement biases[1]

The results of eliciting risk preferences depend on the elicitation method. Different methods of measuring the same latent variable tend to produce different results. This raises the question whether latent risk preferences can be elicited at all. Using two types of manipulations, I assess the measurement accuracy of risk preference elicitation methods. Following Item Response Theory, the results of the multiple lottery choice method are combined with two qualitative methods into a composite score. The responses of 9,235 pension plan members to a dedicated survey indicate that this composite score approximates the latent variable risk preferences better than individual method responses do, thereby substantially reducing measurement noise and method-specific biases. Analysis of the manipulations shows that both the accuracy of the risk preference elicitation methods depend on the specific amounts, order, and endowment chosen. Combining simpler methods with more advanced methods framed closely to the relevant situation yields more accurate and more robust elicited risk references.

[1]This chapter is based on the paper: Alserda (2017) Measuring normative risk preferences. *ERIM report series research in management Erasmus Research Institute of Management No. ERS-2017-003-F&A.*

3.1 Introduction

Risk preferences are relevant to a large number of decisions, including financial decisions, which often involve trading off risk and return. Research has shown that risk preferences tend to differ between individuals (Harrison et al., 2007; Holt and Laury, 2002; Weber et al., 2002) and that differences in risk preferences affect optimal choices (Campbell et al., 2003; Viceira, 2001). Risk preferences can vary between persons for a number of reasons, including parents' risk taking (Levin and Hart, 2003), genetic variation (Zyphur et al., 2009), nationality (Hsee and Weber, 1999), age (Yao et al., 2011), and gender (Jianakoplos and Bernasek, 1998).

Individuals often make choices without explicitly knowing (the quantitative value of) their risk preferences. However, in the case of delegated decisions, risk preferences need to have explicit value for the delegated decision makers to make decisions that maximize value for the relevant person(s). Since most individuals are unaware of their risk preferences, these must be elicited indirectly. Many risk preference elicitation methods are cited in the literature, including the Multiple Lottery Choice (MLC) method (Holt and Laury, 2002), the betting game choice method (Gneezy and Potters, 1997), and the willingness-to-pay (Becker et al., 1964) and self-description methods (e.g. Kapteyn and Teppa (2011)). However, different risk preference elicitation methods tend to yield distinct results for the same latent variable and within the same domain (Alserda et al., 2016). Even the same method can provide different results due to framing (Harrison et al., 2007; Lévy-Garboua et al., 2012), the domain of the question (Weber et al., 2002), or noisy behaviour (Dave et al., 2010).

This raises the question whether it is possible to measure latent risk preferences and, if so, how. Latent preferences are described as preferences that represent an economic agent's true interests (Beshears et al., 2008, p. 3), as opposed to revealed preferences, which are 'preferences that rationalize an economic agent's observed actions' (p. 2). In the case of measurement noise or biases in the elicitation of risk preferences, revealed preferences can differ from the latent preferences. The extent to which revealed risk preferences correspond to latent risk preferences indicates the method's measurement accuracy. However, as latent risk preferences cannot be measured by definition; latent risk preferences always need to be approximated using revealed risk preferences.

Delegated decision makers are increasingly expected to ensure that decisions reflect individual preferences (EIOPA, 2013; Frijns, 2010; Rozinka and Tapia, 2007). Delegated decision makers should thus become familiar with risk preferences. The use of revealed risk preferences that are not in line with latent preferences will lead to suboptimal decisions, which will lower individuals' welfare (Viceira, 2001).

A fundamental trade-off within risk preference elicitation methods is that of simplicity versus practical usefulness. More complicated methods involving monetary amounts and probabilities have better predictive accuracy (Dave et al., 2010) and can be easily translated to relative risk aversion, a quantitative measure of risk aversion. Preferences can thus be easily applied in practical situations, as in setting an asset allocation (Viceira, 2001). However, more complicated methods can also induce noisier behaviour, especially for subjects with lower numeracy skills, who may not fully understand their options (Dave et al., 2010). The accuracy of more complicated methods may therefore be lower.

The simplest methods include self-description questions. In these methods, respondents are asked to describe themselves, normally in comparison to others. The respondents do not need to be financially literate to understand such questions; however, the expectations of others may not be constant and true risk preferences may not be known. The results are thus hard to quantify and therefore difficult to apply to real-life situations, as in asset allocation (Alserda et al., 2016).

Van Rooij et al. (2011) find that large proportions of the population have only a basic understanding of financial topics. Lusardi and Mitchell (2007) confirm this finding and show that only half of older Americans can correctly answer questions about compounding, inflation, and risk diversification. Financial literacy influences financial decision making (Van Rooij et al., 2011) and financially illiterate individuals have difficulty making adequate retirement plans (Lusardi and Mitchell, 2007). Intuitively, respondents who have difficulty understanding basic financial topics cannot be expected to perfectly understand complicated risk elicitation questions. Therefore, one should be careful interpreting the results of more complicated risk elicitation methods.

Beshears et al. (2008) confirm this intuition and show that complexity increases the effect of biases in the elicitation of risk preferences. If the number of investment options increases, experimental subjects are shown to be more likely to choose simple, risk-free investment options compared to complex, risky investment options (Iyengar and Kamenica, 2006). Greater complexity in the form of more options also tends to reduce pension plan participation (Beshears et al., 2013; Iyengar et al., 2004).

In this paper, I elicit risk preferences with three different methods, with two variations of the last method: an augmented version of the MLC method, an investment choice question, and two self-description questions. Using item response theory (IRT), the results of the three methods are combined into a single composite risk aversion score. This composite score is the closest available approximation to the latent variable risk preferences (Menkhoff and Sakha, 2016) and can benefit from both the simplicity of the self-description method and the quantitative value of the MLC method.

Two kinds of manipulation are added to the risk preference elicitation methods. First, the MLC method is manipulated in terms of order, amounts, and starting probability. The composite score is used as a reference point to compare the normative value of the four manipulations of the MLC method. Second, the subjects are split into a group where the (risk-free) base pension is included in the question and a group where it is excluded. Both manipulations indicate the extent to which framing effects influence the normative value of elicitation methods.

Risk preferences are elicited in the pension domain. The pension domain involves a prominent case of delegated decision making, with an investment manager allocating the assets of pension plan members (e.g. pension capital). The optimal mix of assets depends strongly on risk preferences, which must therefore be known to optimize the asset mix (Campbell et al., 2003; Viceira, 2001).

Elicitation of the risk preferences of 9,235 pension plan members confirms that different elicitation methods result in different elicited risk preferences. Combining multiple risk preference elicitation methods reduces measurement noise and method-specific biases. The composite score of risk preferences therefore provides a more reliable estimation of latent risk preferences. Of the individual methods, the augmented MLC method, especially with a manipulated starting point, provides the most useful quantitative information in the domain of pension income. The absence of a strong effect of the inclusion or exclusion of the base pension shows that it is important to elicit risk preferences in a situation (*i.e.*, endowment) as closely as possible to the observed reality for members, since individuals have difficulty processing these kinds of effects. Risk preferences are dependent on sociodemographic information, such as income, age, and education level; however, predictive power is too low to use sociodemographic information to predict latent risk preferences.

3.2 Method

Risk preferences are elicited[2] with three different methods and a number of variations on these methods. The methods include the MLC method (Hardy, 2001), the self-description method (Kapteyn and Teppa, 2011), and the investment choice method (Van Rooij et al., 2007). The choice of methods and description of the questions was the result of several testing phases, which showed that the current configuration yields the best understanding among the respondents.

3.2.1 MLC

In line with previous research (Anderson and Mellor, 2009; Croson and Gneezy, 2009; Dohmen et al., 2011), the MLC method of Holt and Laury (2002) is used as the primary method for eliciting risk preferences in the pension domain. The MLC method presents respondents a series of choices between two lotteries. The first lottery is safe and has a smaller difference between the good state and the bad state. The second lottery is riskier and has a larger difference between both states. At the start, the probability of the good state is low and the safe lottery is dominant for all but extremely risk-seeking individuals. In subsequent choices, the probability of the good state increases and the risky lottery becomes increasingly attractive. At a certain point, the respondents will switch from the safe lottery to the risky lottery, the switching point thereby revealing their risk preferences.

However, I implement a number of improvements to cope with much observed irregularities. First, in line with Weber et al. (2002), the questions are adjusted to the relevant domain (i.e. pensions). Second, the range of possible relative risk aversion values is increased to deal with the higher risk aversion expected in the pension domain (Van Rooij et al., 2007). To keep the maximum number of questions constant and to reduce the predictability of the subsequent questions, the presented possibilities of the good state are changed compared to those of Holt and Laury (2002),see Table 3.1. To prevent respondents from changing between the safe and risky lottery more than once, the online survey is programmed so that when respondents change from the safe lottery to the risky lottery, they must confirm their choice. After confirmation, their switching point is recorded and they proceed to the next survey

[2] A translation of the original survey can be found in Appendix 3.1.

question. Respondents can return to a question and change their choice until they have confirmed it. An example of such a question is presented in Figure 3.1.

In addition, prior to the effective question, respondents must answer an introductory MLC question. This question introduces the respondents to the concept of this method and allows them to make three choices between two lotteries concerning holiday trips. The results of this question are not used but should increase understanding of the question and reduce previously observed biases. (Holt and Laury, 2002; Harrison et al., 2007).

Figure 3.1: Example of an adjusted MLC question

You have indicated that your after-tax monthly income is between $2,000 and $2,300. The amounts in this question are based on this income level. They represent monthly net income levels, including the state old age pension and after taxes.

The probabilities changes with your choice. Which plan do you prefer?

	Plan A	**Plan B**
Your guaranteed income is:	$1,290	$860
In addition you have a probability of:	**10%**	**10%**
To receive an additional income of:	$220	$1,080
So there is a **10%** probability of a total pension income of:	$1,510	$1,940

Plan A **Plan B**

Notes: Example for a member with a net monthly income of $2,150. This example represents the first choice out of a sequence of 10 in which the probability (bold) systematically increases for the additional pension income. All amounts are converted to US dollars.

3.2.2 Manipulations

To assess the effect of theoretically neutral variations in the presentation of the MLC questions, two kinds of manipulation are added. First, 70% of the population are presented the baseline question, using the numbers discussed above, but 10% are instead presented a version with improved amounts for the risky lottery. The risky lottery now has probabilities of 50% and 100% in the bad and good states, respectively, increasing both the minimum and maximum discernible relative risk aversion. Another 10% are presented the same amounts as in the baseline scenario, but with the opposite presentation direction, that is, these respondents start with a dominant risky lottery choice and can reveal their risk preferences by switching towards the safe lottery. The last 10% of respondents are presented the baseline scenario with a different probability for the first question. The first question in this manipulation has a 50%/50% probability for the good and bad states.

Manipulation 1: Baseline question. The safe lottery provides 60% or 70% of one's income and the risky lottery 40% or 90%. It starts with a 10% probability for the good state and this probability increases with each subsequent question.

Manipulation 2: The risky lottery is changed to a 50% probability in the bad state and 100% in the good state, so the range of measurable relative risk aversion values increases upwards.

Manipulation 3: The series follows the opposite direction, respondents start with a dominant risky lottery (i.e. 100% probability for the good state), and the probability for the good state decreases with subsequent questions.

Manipulation 4: The lottery starts with a 50% probability for the good state, which increases again with subsequent questions.

In addition to manipulations of the values and probabilities of the MLC method, the survey also included a manipulation in the endowment. This manipulation concerns the inclusion of the state's base pension. Half of the respondents are presented the questions with the amounts representing full pensions (occupational pensions and base pension). The other half is presented the same amounts, but for occupational pensions only. Since the base pension is between $862 and $1,696 a month, this would, rationally, lead to substantial differences in the revealed risk preferences.

Relative risk aversion

The points at which respondents switch between the risky and the safe lotteries can be translated into a range of relative risk aversion (γ) levels. This range is obtained by calculating the relative risk aversion that makes the respondent indifferent to the trade-off switching point (first choice for the risky lottery) and the relative risk aversion that makes the respondent indifferent to the question before that (last choice for the safe lottery) (Holt and Laury, 2002). This approach yields the relative risk aversion ranges presented in Table 3.1, which depend on the manipulation. To obtain the distribution of relative risk aversion, a uniform distribution is used for the closed range switching points. For the open ranges, without an upper or lower limit, a normal distribution is assumed and observations are distributed in the tail.

Table 3.1: Risk aversion scores based on lottery choices

Switching	**Relative risk aversion range for $U(X) = x^{1-\gamma}/(1-\gamma)$**			
point	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**
(p =)	*Standard*	*Alternate values*	*Opposite direction*	*Different starting value*
10%	$\gamma < -4.82$	$\gamma < -2.49$	$\gamma < -4.82$	
30%	$-4.82 < \gamma < -1.82$	$-2.49 < \gamma < 1.00$	$-4.82 < \gamma < -1.82$	
50%	$-1.82 < \gamma < 0.00$	$1.00 < \gamma < 2.61$	$-1.82 < \gamma < 0.00$	$\gamma < 0.00$
65%	$0.00 < \gamma < 1.00$	$2.61 < \gamma < 4.13$	$0.00 < \gamma < 1.00$	$0.00 < \gamma < 1.00$
80%	$1.00 < \gamma < 2.85$	$4.13 < \gamma < 6.09$	$1.00 < \gamma < 2.85$	$1.00 < \gamma < 2.85$
90%	$2.85 < \gamma < 4.46$	$6.09 < \gamma < 8.22$	$2.85 < \gamma < 4.46$	$2.85 < \gamma < 4.46$
95%	$4.46 < \gamma < 5.91$	$8.22 < \gamma < 10.22$	$4.46 < \gamma < 5.91$	$4.46 < \gamma < 5.91$
99%	$5.91 < \gamma < 9.03$	$10.22 < \gamma < 14.88$	$5.91 < \gamma < 9.03$	$5.91 < \gamma < 9.03$
100%	$9.03 < \gamma$	$14.88 < \gamma$	$9.03 < \gamma$	$9.03 < \gamma$

Notes: The relative risk aversion ranges for different switching points in the MLC question, given one of four samples.

3.2.3 Self-description questions

Two self-description questions are added to the survey, in line with and based on the work of Kapteyn and Teppa (2011). The first question, resulting in the variable *Careful*, is 'Does the following statement apply to you? My friends describe me as careful'. The answer is on a seven-point Likert scale ranging from totally disagree (1) to totally agree (7). The second question is framed in the pension domain and asks, 'Are you willing to take a risk with your pension contributions?' Answers to this question range from totally agree (1) to totally disagree (7) and results in the variable *Stated aversion*.

Careful (0–7)

My friends describe me as a careful person.

Stated aversion (0–7)

Are you willing to take a risk with your pension?

3.2.4 Investment choice question

For this question, respondents are required to make a simplified allocation of their fictitious pension capital. For this method, the respondents can allocate their pension allocation over fixed income, described as a fixed return of 2%, and equity, described as risky, with an expected return of 6%. The minimum incremental step is 10%. Although many respondents will find it hard to allocate their assets in line with their normative risk preferences, the question does show how individuals respond to the risk and return trade-off (Lusardi and Mitchell, 2007). Therefore, this measure is expected to add information about latent risk preferences (Van Rooij et al., 2007).

Allocation to bonds (0–100%)

How would you invest your pension contributions?

3.2.5 Latent risk preferences

Revealed preferences do not necessarily represent latent preferences. Latent preferences are preferences that reflect true interests, whereas revealed preferences rationalize observed behaviour (Beshears et al., 2008). Revealed preferences can differ from latent preferences for several reasons, including individuals having large areas of perceived indifference (Anderson and Mellor, 2009), choices depending on (unstable) emotions Soane and Chmiel (2005), lack of attention (March and Shapira, 1992), or framing effects (LeBoeuf and Shafir, 2003). Different elicitation methods therefore tend to produce different results. Even the same method can produce different risk preference results if applied multiple times (Fellner and Maciejovsky, 2007). This makes the measurement of latent risk preferences far from straightforward.

I use two criteria to assess the accuracy of different risk preference elicitation methods and manipulations in describing latent risk preferences and combine information from these methods to create a single measure of risk preference. Latent risk preferences can deviate from revealed risk preferences due to (measurement) noise and biases.

Noise represents symmetric deviations, that have no clear direction, while biases have a direction. The first criteria is mainly related to noise, while the second criteria is focussed towards biases. Together these criteria indicate to what extent noise and biases affect revealed risk preferences and thereby reduce the accuracy of the measurements.

Criteria:

1. Elicitation methods should have a high correlation with the underlying latent variable, in this case pension domain risk preferences.

2. Elicitation methods should not be sensitive to the (in)ability of respondents to understand the question. Therefore, there should be no strong correlation with financial literacy/education while controlling for other relevant factors, such as human capital.

Unfortunately, the first criterion is difficult to assess, since latent variables are, by definition, not directly observable. The latent variable risk preferences are estimated from the available risk preference elicitation results using principal component factor analysis (CFA) with varimax rotation (Kapteyn and Teppa, 2011). Higher correlations with the factor indicate observed risk preferences that are closer to the latent risk preferences.

In addition, by retaining a second factor and including the level of education in the analysis, the latent variable (financial) literacy, or understanding of the question, is estimated besides the latent variable risk preferences. Elicitation methods that have a higher correlation with this factor are less reliable, since more respondents are likely to not fully understand the question. For observed risk preferences to be in line with latent risk preferences, an elicitation method should have a low correlation with the literacy factor and a high correlation with the risk aversion factor.

A second method to assess the accuracy of elicitation methods is by applying Item Response Theory (IRT). The advantage of IRT is that it allows for a joint estimation of the different samples, since it can cope with missing values. This way, different manipulations can be analysed simultaneously, which allows for a better comparison. Again, all available risk preference elicitation methods are included, including the different MLC method manipulations. The two relevant outputs from IRT are the discrimination and difficulty coefficients.

Incorporating the information

Using the information of different elicitation methods gives richer insight into the risk preferences of pension plan members, since measurement noise and method-specific biases are reduced. When measurement noise and biases are not (perfectly) correlated, combining multiple methods will lower their impact on the data. However, to make the information useful, the results of different elicitation methods should be combined into a single measure of risk preferences.

First, a selection needs to be made for the relevant variables to be included in the composite risk preferences score. Principal component factor analysis with varimax rotation is used for this purpose, in line with Kapteyn and Teppa (2011). Variables are included in the composite score if they have a loading higher than 0.40 (Kapteyn and Teppa, 2011). The factor analysis analyses the joint correlation of separate variables. If these variables describe the same latent variable, but with noise, the noise is (partially) eliminated and the joint correlation will better describe the latent variable.

Second, IRT is used to retrieve latent variable risk aversion from the different methods. In particular, a graded response model is implemented, to connect to the multiple options in each elicitation method that reveal increasing levels of risk aversion. With respect to factor analysis, IRT has two main advantages: It can cope with missing variables; therefore, the MLC method manipulations can be included as separate variables, allowing the separate analysis of each sample. Additionally, IRT explicitly allows for the separate variables to have different ranges. While some measures are better at distinguishing between risk-averse respondents, other measures are better at distinguishing between risk-seeking respondents, as the options of the different questions may be relatively tilted to either risk-seeking or risk-aversion [3]. By applying each method on the range where it is most valuable, IRT will give more precise estimates of the latent variable than a factor-weighted or an unweighted composite score, since, for each respondent, most of the weight is placed on the measures that are most relevant to the respondent's domain. Including the four manipulations of the MLC method, seven methods in total are included in the IRT analysis. The result of this analysis is an empirical Bayes mean predicted value for the latent variable theta (θ). Because all four elicitation methods have strong correlations to

[3] For example, some measure can have all risk-seeking individuals selecting one option, while risk-averse individuals select one the of the remaining options. This measure better distinguishes between risk-averse individuals (defines multiple levels of risk aversion) than risk-seeking individuals (defines only one level of risk-seeking).

the latent variable, this variable can be assumed to be risk aversion, since all four methods are designed to measure risk aversion. For a full description of the graded response model and IRT, see Cohen and Kim (1998), Embretson and Reise (2013), and Van der Linden and Hambleton (2013).

Two outputs from IRT are used. First, the discrimination coefficient indicates the extent to which a question can distinguish between different levels of relative risk aversion. Second, the estimates of the difficulty coefficients provide the range in which the measure can reliably estimate relative risk aversion. Measures with a high discrimination coefficient can very accurately distinguish between risk aversion levels within the difficulty range. However, given the amount of options within the measure, a higher discrimination coefficient normally means a smaller difficulty range. Risk aversion levels that are higher than the highest difficulty or lower than the lowest difficulty cannot be reliably estimated. This result implies that a trade-off exists and that, given the amount of options (i.e. choices), measures can be either precise over a small range or less precise over a larger range. Combining multiple measures can thereby add value by combining the best of both types of measures.

3.2.6 Framing effects in the MLC method

In addition to creating a composite score, I assess the individual methods, particularly the framing effects in the MLC question. Therefore, the respondents were distributed in four samples, each being presented a specific manipulation of the MLC question (see Section 3.2.2). Given that the samples are selected randomly and that the sample size is sufficiently large, the differences between the four samples reflect differences in framing due to the manipulations. A Kolmogorov–Smirnov test for the equality of distributions is used to formally test whether these differences are significant and thus whether there are framing effects. Summary statistics show how manipulations influence the mean risk aversion results and their variance. Finally, differences in discriminative power and the range of covered values of theta (θ) resulting from IRT reflect how effective each manipulation is in eliciting normative risk preferences in the pension domain.

3.3 Data

3.3.1 Survey response

Data were collected with a dedicated online survey that was distributed to the members in four pension plans, including the plans' retirees and the employees of five companies. A total of 34,477 members (employees and retirees) were invited to take the survey; 9,891 clicked on the survey link, for a response rate of 28.7%.

Respondents were included in the analysis when they answered at least the MLC question, which required answering the preceding sociodemographic information questions. A total of 656 (6.6%) respondents did not answer this question and were eliminated from further analysis. Another 1,315 (13.3%) respondents had at least one missing answer but are included in the analysis as much as possible. Comparing this group with the group that completed the entire survey shows that the incomplete survey group is slightly less educated and younger and has a lower income. The results are thus not fully representative of the population that accepted the invitation or, likely, the population as a whole. However, this is not problematic, since heterogeneity in responses, rather than representativeness, is important for this research. Table 3.2 shows the number of members and respondents and the response rates for the different pension plans and for active members and retirees. The response rates range from 23% to 52% for the different pension plans. Generally, the response rates are a few percentage points higher for the active population than for the retired population.

Table 3.2: Response rates

Plan	**Population**			**Response**			**Response rate**		
	Active	Retired	Total	Active	Retired	Total	Active	Retired	Total
1	18,058	7,366	25,424	4,972	1,654	6,626	27.5%	22.5%	26.1%
2	2,999	1,568	4,567	966	371	1,337	32.2%	23.7%	29.3%
3	3,137	477	3,614	658	165	823	21.0%	34.6%	22.8%
4	718	154	872	379	70	449	52.8%	45.5%	51.5%
Total	24,912	9,565	34,477	6,975	2,260	9,235	28.0%	23.6%	26.8%

Summary data are presented in Table 3.3. The pension plans members differ extensively in terms of average age, gender, average income, and average level of education. Plan 1 has the largest active population and the lowest average income and plan 4 has the youngest active population, the highest level of education, and the highest average income. There are also notable differences between the active population and the retired population. Generally, retired members are more often male and have a higher income and a slightly lower level of education.

Table 3.3: Summary data

Plan	Avg. Age		% Male		Avg. Income		Avg. Education	
	Active	Retired	Active	Retired	Active	Retired	Active	Retired
1	50.1	69.9	56.5%	80.1%	2.636	3.057	4.56	4.05
2	44.9	69.8	78.5%	90.0%	2.975	3.930	5.12	4.90
3	48.0	65.3	69.4%	71.8%	2.806	2.936	3.74	3.58
4	41.9	72.1	73.7%	81.4%	4.229	5.271	5.20	4.63
Total	48.8	69.6	61.7%	81.1%	2.785	3.260	4.59	4.18

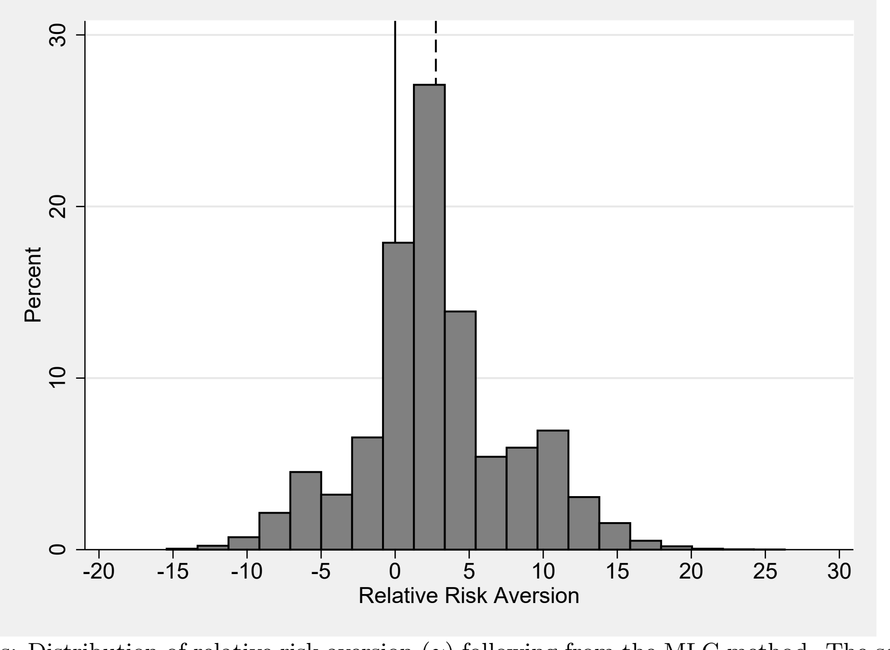
3.3.2 Elicitation methods

The results for the MLC method are presented in Table 3.4. This table shows the point at which the respondents switched from one pension plan (lottery) to the other, dependent on the specific manipulation the respondent faced (Table 3.1). Manipulations 2 to 4 were assigned to 10% of the members each, while the first manipulation was presented to the remaining 70%. Due to non-response and dropouts, the response rates differ slightly across manipulations. Because there are no substantial differences in dropouts for or just after the MLC question, these should not influence the results. Using the method described in Section 3.2.2, the responses are transformed into a distribution of γ. The resulting distribution, depending on the manipulation, is presented in Figure 3.2; γ is distributed between -15 and 26, with a mean of 2.84.

Table 3.4: Responses for the MLC sample

Switching point (p =)	**Sample 1** *Standard*	**Sample 2** *Alternate values*	**Sample 3** *Opposite direction*	**Sample 4** *Different starting value*
10%	648 (9.9%)	174 (19.9%)	55 (6.2%)	-
30%	219 (3.3%)	51 (5.8%)	41 (4.6%)	-
50%	686 (10.4%)	155 (17.8%)	100 (11.3%)	172 (18.9%)
65%	696 (10.6%)	115 (13.2%)	241 (27.2%)	94 (10.3%)
80%	1,740 (26.5%)	173 (19.8%)	152 (17.2%)	251 (27.5%)
90%	887 (13.5%)	83 (9.5%)	96 (10.8%)	127 (13.9%)
95%	295 (4.5%)	19 (2.2%)	32 (3.6%)	52 (5.7%)
99%	415 (6.3%)	29 (3.3%)	64 (7.2%)	61 (6.7%)
100%	979 (14.9%)	74 (8.5%)	104 (11.8%)	155 (17.0%)
Total	**6,565**	**873**	**885**	**912**

Figure 3.2: Distribution of relative risk aversion



Notes: Distribution of relative risk aversion (γ) following from the MLC method. The solid line represents risk neutrality ($\gamma = 0$) and the dashed line represents mean γ.

The responses to the two seven-point Likert scale self-description questions and the responses to the simplified portfolio choice are presented in Table 3.5. All four methods have strongly heterogeneous results.

Table 3.5: Responses to elicitation methods

Stated risk aversion			Careful			Bond allocation		
Likert scale	Freq.	%	Likert scale	Freq.	%	Allocation(%)	Freq.	%
			Not			0	130	1.5
Seeking			careful			10	47	0.6
1	209	2.6	1	129	1.6	20	204	2.4
2	335	4.2	2	481	6.0	30	334	4.0
3	1,189	14.9	3	880	11.0	40	409	4.8
4	1,349	16.9	4	1,763	22.1	50	1,214	14.4
5	1,426	17.8	5	1,740	21.8	60	739	8.8
6	2,149	26.9	6	2,115	26.5	70	1,435	17.0
7	1,343	16.8	7	873	10.9	80	1,350	16.0
Averse			Careful			90	1,377	16.3
						100	1,197	14.2
Total	8,000	100.0	Total	7,981	100.0	Total	8,436	100.0

3.4 Measuring normative risk preferences

As previous research has frequently shown, elicited risk preferences tend to depend on the measure of elicitation used (e.g. Harrison et al. (2007); Kapteyn and Teppa (2011)). Therefore, to measure latent risk preferences as closely as possible, one should combine multiple relevant measures of risk preferences (Kapteyn and Teppa, 2011; Menkhoff and Sakha, 2016). By analysing the joint correlation of different methods, one eliminates measurement noise and method-specific biases and the accuracy of elicited risk preferences increases. Principle component factor analysis can be used to study the joint correlation of risk preferences measured with different elicitation methods.

3.4.1 Principle component factor analysis

The results of the principle component factor analysis are presented in Table 3.6. Two factors are retained in this factor analysis, with eigenvalues of 2.18 and 1.21 respectively. For the first factor, four variables, which are the four different risk preference variables, have a loading higher than 0.4. Since the primary factor variable scores for all four methods designed to measure risk aversion, this factor is now identified as the latent variable risk aversion. The second factor has two variables with a loading higher than 0.4: education and self-estimated financial literacy. This factor is identified as financial/questionnaire literacy.

Table 3.6: Principal component analysis

Variable	**Factor 1** (Risk aversion)	**Factor 2** (Literacy)	**Uniqueness**
MLC (γ)	0.6799	0.2632	0.4685
Stated aversion	0.8482	-0.1964	0.2420
Allocation to bonds	0.8019	-0.2648	0.2868
Careful	0.4363	0.1913	0.7730
Education	-0.1545	0.7095	0.4728
Financial literacy	-0.1509	0.7172	0.4629

Notes: This table shows the results of the CPA analysis with varimax rotation and two retained factors (eigenvalues greater or equal to one). The first factor is identified as risk aversion and the second factor as financial literacy. Variable loadings greater or equal to 0.4 are in gray.

All four risk aversion variables have a loading higher than the threshold, indicating that all four variables add relevant information about the latent variable risk aversion. In addition, the risk aversion variables do not have loadings greater or equal to 0.4 for the second factor, which shows that financial literacy has only a limited effect on these risk preference elicitation methods. However, the loadings are substantially different from zero, with both positive and negative signs. So, financial literacy does influence individual risk preference elicitation methods, but in different directions, stressing the importance of combining multiple elicitation methods.

3.4.2 Item response theory

The loadings on the two factors of the principle component analysis show that the four risk preference elicitation methods applied adequately measure the same latent variable, identified as risk aversion. Although individual measures are influenced by the cognitive abilities of the respondents, the results show that combining the available measures gives a more reliable estimate of risk aversion, because measurement noise and individual elicitation method biases - which go both ways for different methods - are reduced.

Therefore, to estimate the composite score (of the latent variable θ), the results of our four measures are combined by applying IRT. IRT can be used to estimate the latent variable (θ) using multiple measures with different locations (the range covered of the latent variable) and discrimination (measure precision).

Table 3.7: IRT results

Measure & Manipulation	Discrimi-nation	Difficulty (range) min	max	Correlation composite score all measures	minus measure#
MLC	1.004	-2.596	3.009	0.484	0.400
Standard	(0.031)	(0.078)	(0.089)		
MLC	0.936	-1.786	3.600	0.470	0.382
alternate values	(0.086)	(0.161)	(0.329)		
MLC	0.892	-3.746	2.534	0.455	0.357
Opposite direction	(0.076)	(0.321)	(0.221)		
MLC	1.061	-1.681	2.749	0.544	0.416
Different starting value	(0.084)	(0.133)	(0.208)		
Stated aversion	6.061	-1.999	0.966	0.969	0.710
	(0.767)	(0.039)	(0.022)		
Careful	0.479	-8.835	4.494	0.239	0.205
	(0.024)	(0.457)	(0.224)		
Allocation to bonds	2.269	-2.763	1.346	0.791	0.662
	(0.069)	(0.060)	(0.027)		

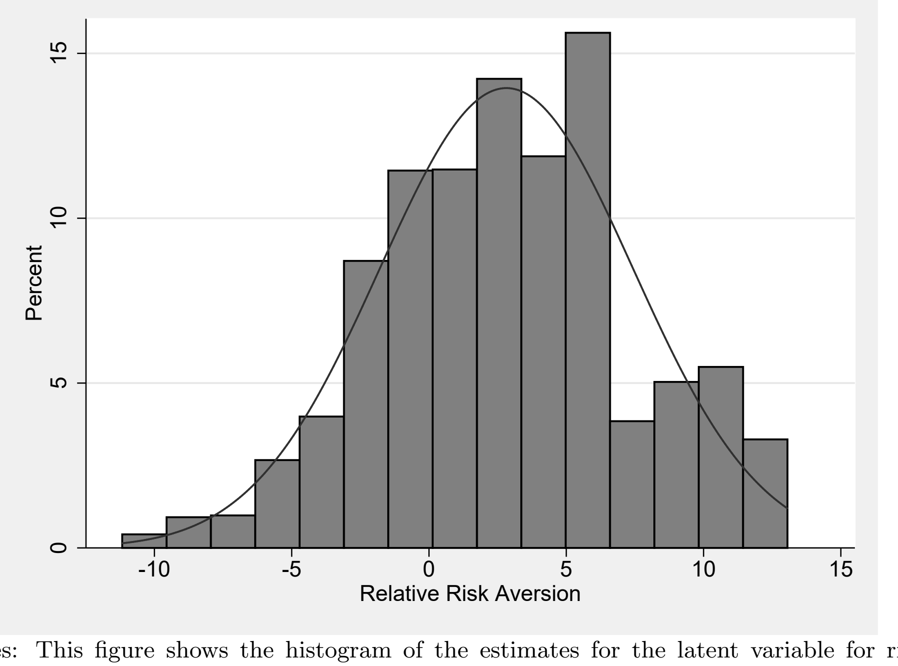
Notes: This table shows the results for IRT. The number of observations is 9,235. # indicates correlation with a composite score composed of all the other measures.

The results of the IRT analysis in Table 3.7 show relatively minor changes in the location and discriminative values of the different manipulations of the MLC method. The stated aversion and allocation to bonds measures have greater precision but (therefore) also cover a smaller range of risk aversion. The careful measure has the least precision and the largest range of risk aversion covered.

The results of our IRT analysis can be used to estimate the latent variable. These estimations (θ) are rescaled to the domain of relative risk aversion using the distribution of the MLC method (linear transformation). The reduction of measurement noise and method specific biases by combining the information of multiple methods in the composite score reduces the standard deviation with 9.89%. For the composite score, relative risk aversion is therefore distributed with a mean of 2.82 and a standard deviation of 4.62. The estimates are presented in the histogram in Figure 3.3.

The estimate θ has a high correlation with all the measures except for the self-description variable *Careful*. The correlation coefficients decrease only slightly if the correlation is analysed for the composite score composed of all measures except for the measure under analysis, indicating the robustness of the results. The correlation coefficients show that both adjustments to the relevant domain and keeping the questions as simple as possible increase the accuracy of the results (a higher correlation with θ). However, for application in financial problems, some quantitative value of risk aversion is required, necessitating more quantitatively oriented (and therefore more difficult) methods, such as the MLC question. The best manipulation of this specific method is analysed in Section 3.5.

Figure 3.3: Estimates of the latent variable θ



Notes: This figure shows the histogram of the estimates for the latent variable for risk aversion θ. The values are rescaled to the domain of relative risk aversion using the results of the MLC method. Line represents fitted normal distribution.

3.4.3 Predicting normative risk preferences

Regressing the augmented risk preferences on sociodemographic information and pension plan membership provides insight into the extent to which individual pension plan members' risk preferences can be estimated. This is relevant information, since it could avoid the need for eliciting risk preferences. If risk preferences can be predicted closely enough, delegated decision makers can save on costly risk preference elicitation. In addition, the accuracy of the results can be assessed by analysing the regression results of risk aversion following the MLC method and risk aversion following IRT (the composite score). If the signs and sizes of the coefficients are in line with earlier findings, they are more reliable and the results are more robust. The results of the regression analyses are presented in Table 3.8.

First, regarding the accuracy of the risk aversion results, the coefficients from model 2 (composite score) are mostly larger and more often significant than for model 1 (MLC). The coefficients of income and home ownership (higher income/owns a house, less risk averse) and education (higher education, less risk averse) are in line with earlier findings (Harrison et al., 2007; Holt and Laury, 2002) and significant at the 5% level for the composite score but not for MLC risk aversion. In addition, the predictive value (R^2) is far higher for the composite (13.5%) score than for the MLC method (1.7%). These findings suggest that the risk aversion from the composite score is more reliable and thus more accurate than MLC risk aversion.

Although the predictive power of the composite score (13.5%) is far higher than for the MLC method, it is not high enough to replace the elicitation of individual risk preferences. The vast majority of variation remains unexplained, for example, because of genetic variation (Zyphur et al., 2009), and elicitation is necessary for a reliable estimate of risk aversion. On average, the results indicate that younger persons, persons with a higher income or who own a house, men, and higher-educated persons are less risk averse, which is in line with earlier findings (Harrison et al., 2007; Holt and Laury, 2002; Jianakoplos and Bernasek, 1998; Yao et al., 2011). Although older individuals are more risk averse, retirement on its own has no significant effect. Being retired (less human capital) therefore does not seem to influence risk aversion.

Table 3.8: Regression analysis results

Variables	(1) Risk aversion MLC		(2) Risk aversion Composite score	
Age	0.031***	(0.006)	0.042***	(0.005)
Retired	-0.185	(0.183)	-0.081	(0.152)
Income ($1,000)	-0.068	(0.054)	-0.361***	(0.049)
House	0.129	(0.166)	-0.333**	(0.130)
Gender:[a]				
Female	-0.972	(0.594)	-0.576	(0.460)
Male	-1.867***[b]	(0.592)	-2.565***[b]	(0.459)
Education:				
Pre-vocational education	-1.553	(1.256)	-1.541	(0.987)
Secondary vocational education	-0.837	(1.251)	-1.729*	(0.984)
Senior general secondary education	-0.857	(1.248)	-2.054**	(0.984)
Professional education	-0.939	(1.244)	-2.310**	(0.981)
Academic education	-0.865	(1.247)	-3.086***	(0.985)
Pension plan:				
2	0.567***	(0.143)	0.051	(0.133)
3	0.752***	(0.202)	0.401**	(0.163)
4	-1.258***	(0.233)	-3.246***	(0.235)
Constant	3.732***	(1.409)	6.177***	(1.114)
R^2	0.017		0.135	

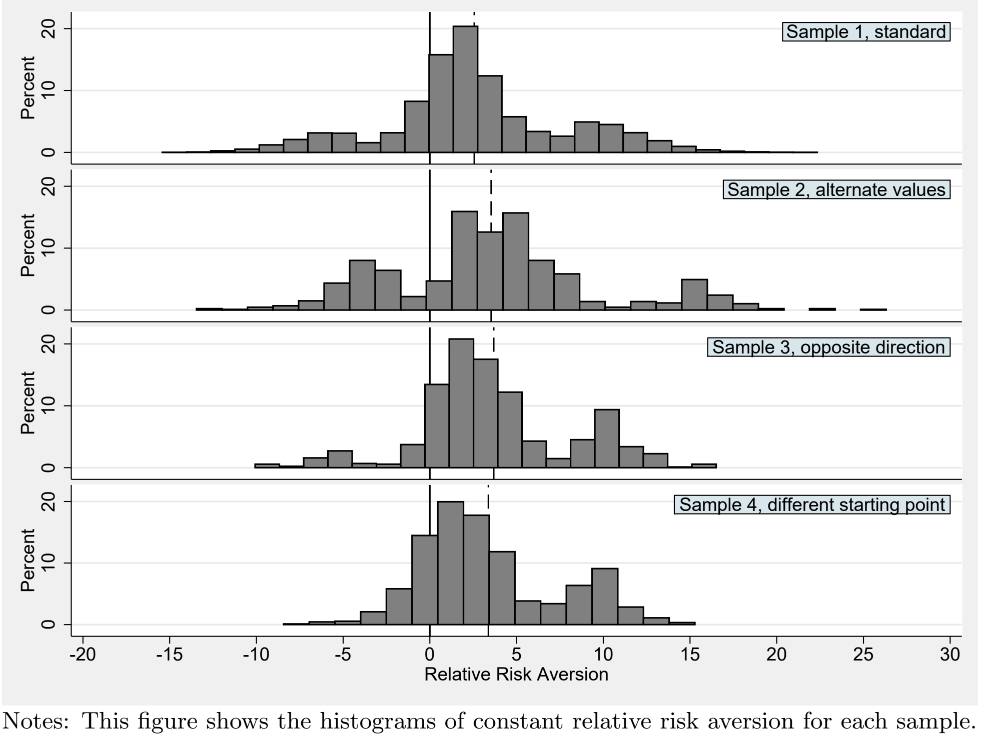
Notes: This table shows the results of the regression analysis of observable characteristics on relative risk aversion, with robust standard errors. The superscript [a] indicates compared to the group ($N = 98$) that did not report gender; [b] indicates significantly different ($p < 0.01$) from gender being female. Standard errors are in parentheses, N = 9,235, * p<0.10, ** p<0.05, *** p<0.01.

3.5 Framing effects in the MLC method

Now that the latent variable for risk aversion has been estimated in the previous section, the results can be used to assess the reliability of the different manipulations of the MLC method. The respondents are randomly assigned to one of four samples, each of which received the MLC question in a distinct framing. The distribution of the implied relative risk aversion resulting from the MLC question, given framing, is presented in Figure 3.4.

Figure 3.4 clearly shows that changes in the framing of the question influence the implied distribution of relative risk aversion. The mean value of γ (indicated by the red line in Figure 3.4) is 2.56 for the baseline question, 3.54 for the question with alternate values, 3.68 for the reversed question, and 3.38 for the question with a later starting point. Also, the standard deviation changes with manipulation (5.19, 6.00, 4.41 and 4.03 respectively).

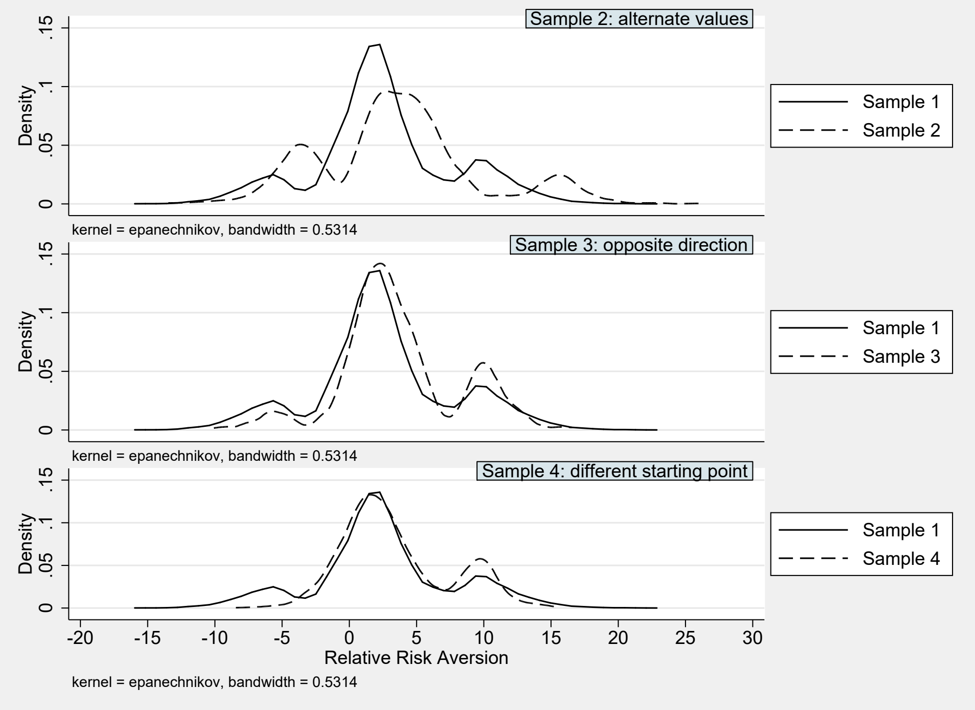
Figure 3.4: Distribution of relative risk aversion



Notes: This figure shows the histograms of constant relative risk aversion for each sample. The solid line represents risk neutrality ($\gamma = 0$) and the dashed line represents the sample mean.

A Kolmogorov–Smirnov test for the equality of distribution functions shows that the latter three samples differ significantly from the first sample. Figure 3.5 presents the kernel density estimates for the latter three samples compared to the first sample. The largest differences are between the sample with alternate amounts (sample 2) and the baseline sample (sample 1). This manipulation results in higher values of risk aversion, which are also more widely distributed (greater variation). The effects of the other two samples are smaller, despite the results shifting towards higher risk aversion, the overall form of the distribution is quite similar across samples.

Figure 3.5: Kernel density estimates



Notes: Kernel density estimates for relative risk aversion for each sample, comparison with Sample 1: standard

As the previous analysis showed, applying manipulations to the MLC method results in significantly different risk aversion results. This method is thus not impervious to manipulations in amounts, probabilities, and sequence. However, so far, it remains unclear what manipulation of the MLC method provides the most reliable elicitation method or, put differently, which manipulation yields values closest to (the estimation of) the latent variable risk aversion.

Analysing the correlation between the results of the MLC method and the composite score shows the extent to which the MLC method corresponds to the estimation of the latent variable risk aversion. The higher the correlation, the more valuable the method is in estimating true risk preferences. Table 3.9 shows the correlation with the composite score and properties resulting from the IRT analysis. Sample 4, a different starting point, has the highest correlation and the highest discrimination coefficient. This measure thus allows for a relatively reliable estimation of risk aversion. However, due to the high discrimination and limited number of options, the descriptive range of this manipulation is limited. The standard question (sample 1) has both a relatively high correlation and discrimination and, compared to the fourth sample, a larger range. Samples 2 and 3, despite having large ranges, are less reliable and therefore not optimal for measuring risk preferences. The best measure (sample 1 or 4) depends on the characteristics of the preferences measured. Since pension domain risk preferences are on average more risk averse (Van Rooij et al., 2007), the different starting point manipulation (sample 4) is selected as the preferred measure, since its range better covers pension domain risk preferences.

Table 3.9: Framing effects

Manipulation		**Correlation**	**IRT**	
			Coefficient	**Range**
1	Standard	0.484	1.004	-2.596 - 3.009
2	Alternate values	0.470	0,936	-1.786 - 3.600
3	Opposite direction	0.455	0,892	-3.746 - 2.534
4	Different starting point	0.544	1,061	-1.681 - 2.749

Notes: This table shows the properties of different manipulations of the MLC questions following from the correlations and IRT analysis.

3.6 Base pension framing

Another type of framing that was included in the survey was the inclusion or exclusion of the base pension. The base pension in the Netherlands (2016) is between $862 and $1,696 a month, depending on the presence and situation of a partner. For low- to medium-income groups, this is a substantial part of the total retirement income (40–79% of the expected retirement income for median-income groups) and, since this base pension is almost risk free, this should have consequences for the risk taken in one's occupational (second pillar) pension. More specifically, for the distribution of total retirement income to be in line with risk preferences, occupational pension income should be invested more aggressively in the presence of a base pension, to offset the lack of risk in this part of retirement income.

For two of the four pension plans[4], half the population is presented the entire survey in the context of only occupational pension (excluding the base pension). This creates

[4]This manipulation was exclusively added to the survey of the respondents of pension plans 1 and 3.

two groups that differ only in the extent of the framing of the questions with or without the base pension. Table 3.10 shows the results of the estimation of pension income and the evaluation of the members' different pension incomes. On average, the members expect to receive an extra $434 (monthly, net of taxes) with the inclusion of the base pension. Comparing this to a (gross) base pension between $862 and $1,696 shows that the members, on average, do take base pension into account, but imperfectly. In addition, the base pension is not considered to be risk free by everyone. When the base pension would be considered as risk free the difference between leaving it out, or including it in the question should be the same irrespective of the state, as the base pension does not depend on the state (it is risk free). However, since the differences between both samples increase with more favourable estimations (states), it can be concluded that the base pension is not considered to be risk free. Members who have a partner exhibit, on average, smaller differences, in line with lower base pensions for married individuals.

Table 3.10: Pension income expectations

Estimated pension:	**Base pension**			**Partner**	**No partner**
	With	Without	Difference	Difference	Difference
Expected	2,259	1,825	434	366	480
Very low	1,495	1,157	338	331	358
Low	1,723	1,374	349	334	390
Neither low nor high	1,993	1,633	360	340	417
High	2,260	1,887	373	345	449
Very high	2,638	2,260	378	313	590

Notes: This table shows the expectations of pension income, with and without a base pension, the difference between both forms of framing, and the difference for those with and without a partner.

The effect of framing questions with or without the base pension on elicited risk preferences can be estimated with regression analysis. The results of the MLC question are explained using regression analysis for the full model of explanatory variables (Table 3.8) and a dummy is included to indicate the exclusion of a base pension (i.e. inclusion acts as the reference). This analysis shows that excluding the base pension increases relative risk aversion (from the MLC question) by 0.269 ($p = 0.028$).[5] Although the effect size is relatively weak, it is counterintuitive. Since individuals have a base pension (outside of the scope of the study), this would suggest that individuals can take more risk with their pension income; however, the opposite effect is found.

[5]Including interaction with income did not produce significant results

Both in the case of the counterintuitive effect or in the case of no effect, the shifts in observed risk preferences are not in line with rational risk preferences. Given this finding, it is important that the survey is framed as closely to the actual situation of the respondent as possible, as deviations from the actual position, such as leaving out the base pension, are not correctly processed. This distorts the measurement of (risk) preferences. In the case of pension domain risk preferences, this means eliciting risk preferences for total retirement income, net of taxes, since this is closest to the members' perception.

3.7 Conclusion

I use a combination of risk preference elicitation methods and manipulations to analyse latent risk preferences in the pension domain. Since different methods tend to give different results, I combine the results of different methods into a composite score using IRT. Principle component factor analysis shows that the four methods applied describe, to various degrees, a common latent variable, which is identified as risk aversion. Comparing the composite score to the separate methods shows that the composite score is less affected by measurement noise and method-specific biases. In addition, the explanatory power of several well-studied sociodemographic characteristics (e.g. income, age, and gender), is greater for the composite score.

Using the composite score as a proxy for latent risk preferences, I assess the effect of four manipulations of the MLC method. All four methods influence the resulting distribution of risk aversion, but the effect of changing the direction or the starting point of the questions has a smaller effect (shift towards risk aversion) than changing the amounts (shift towards risk aversion and larger variation). Given that individuals tend to be more risk averse in the pension domain (Van Rooij et al., 2007), a later starting position increases the accuracy of the results.

A second manipulation, the exclusion of a base pension, shows that respondents incompletely take the relevant factor into account and risk preferences are not adjusted appropriately. Therefore, risk preferences should be elicited as closely as possible to the practical situation, thus including a base pension in the case of retirement income.

The results show that revealed risk preferences differ with different elicitation methods or with manipulations of elicitation methods. Revealed risk preferences are therefore not equal to latent risk preferences, that is, the risk preferences that represent an individual's true interests. Using a combination of augmented measures, including framing the methods closely to the relevant real-life situation, improves the reliability of the results and therefore provides the best estimation of latent risk preferences.

Appendix 3.1: Survey questions

All survey questions are exported from the online platform and translated to English. Elements in *Italics* present dynamic response questions. Questions that were added at the request of the participating pension funds are not included.

Question 1a: What is your monthly income after taxes?

- Less than €1,000
- €1,000 - €1,100
- €1,100 - €1,200
- €1,200 - €1,400
- €1,400 - €1,600
- €1,600 - €1,900
- €1,900 - €2,200
- €2,200 - €2,600
- €2,600 - €3,000
- €3,000 - €3,500
- €3,500 - €4,000
- €4,000 - €4,600
- €4,600 - €5,200
- €5,200 - €5,900
- €5,900 - €6,600
- €6,600 - €7,400
- €7,400 - €8,200
- €8,200 - €9,100
- €9,100 - €10,000
- More than €10,000

Question 1b: What is your age?

___

Question 1c: What is your gender?

- Man
- Woman
- I don't want to disclose

Question 2: Do you have a partner?

- Yes,
- No, I don't have a partner
- I don't want to disclose

If Question 2 = "Yes" → **Question 2b**: What situation is best applicable to your partner?

- My partner has no income
- My partner works part-time (less than 36 hours per week)
- My partner works full-time (36 hours per week or more)
- My partner is retired
- My partner is receiving social security benefits
- I don't want to disclose

Question 3: What is the highest level of education you attended?

- Primary education
- Pre-vocational education
- Secondary vocational education
- Senior general secondary education
- Professional education
- Academic education

Question 4: Do you own the house you live in?

- Yes
- No

If Question 4 = "Yes" → **Question 4b**: Do you expect to have paid of your mortgage (at least 80%) at the time you retire?

- Yes
- No

Question 5: Do you expect to have other sources of income besides the pension plan from your employer and the base income? (multiple options possible)

- None
- Pension plan from a different employer
- Income from your partner (for example (retirement) income)
- Savings
- Investments
- Expected heritage
- Sale of house
- Other

Question 6: Did you ever invest your money?

- Yes
- No

If Question 6 = "Yes" → **Question 6b**: Which of the following investments products did you make use of? (multiple options possible)

- Investment funds
- Shares and/or bonds
- Options, futures, and/or turbo's, speeders, or sprinters
- I make use of other investment products

Be aware: This is an introductory question and is purely hypothetical.

Question 7a:

Assume you are at a travel agency. You can buy only two packages. The packages contain relatively cheap holidays, with a certain chance on a more expensive holiday. The costs of both packages are the same. The table below describes both packages, which one do you prefer?

	Package A	**Package B**
You get for sure:	Campground in southern France	Simple campground in the Netherlands
In addition you have a probability of:	***<list>%***	***<list>%***
To receive a holiday to:	Luxury hotel in Greece	All inclusive hotel at Hawaii

Package A **Package B**

Question 7b:

You have indicated that your after-tax monthly income is between €<*min*> and €<*max*>. The amounts in this question are based on this income level. They represent monthly net income levels, including the state old age pension and after taxes.

The probabilities changes with your choice. Which plan do you prefer?

	Plan A	**Plan B**
Your guaranteed income is:	€*<60% income >*	€*<40% income >*
In addition you have a probability of: To receive an additional income of:	***<list>%*** €*<10% income >*	***<list>%*** €*<40% income>*
So there is a **10%** probability of a total pension income of:	€*<70% income >*	€<90% *income >*

Plan A **Plan B**

You have indicated that your after-tax monthly income is between €<min> and €<max>. For this question you assume that prices and your income remains the same.

Question 8:

What income do you expect to receive at retirement:

___ per month after taxes (<*including/excluding*> base pension)

Very bad: ___ per month after taxes (<*including/excluding*> base pension)

bad: ___ per month after taxes (<*including/excluding*> base pension)

Neither good nor bad: ___ per month after taxes (<*including/excluding*> base pension)

Good: ___ per month after taxes (<*including/excluding*> base pension)

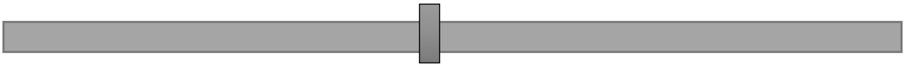
Very good: ___ per month after taxes (<*including/excluding*> base pension)

Question 9: Assume you can decide how your contributions are invested. You can choose between saving or investing in an investment fund.

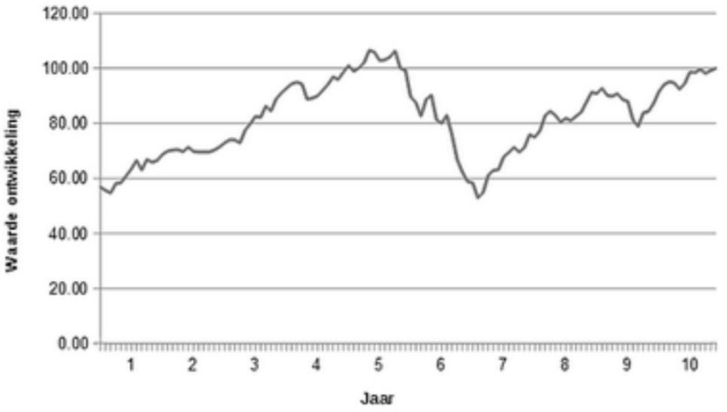
Please take into account:

- Saving is riskless and has a **guaranteed** annual return of **2%**
- Investing in an investment fund includes risk and has an **expected** annual return of **6%**, but can also be lower, and even negative.

You can use the slider to indicate what share of your contributions should be invested in risky assets.

% 

Question 10: We want to know your expectations for a risky investment. Below we show the development of an investment fund over the past 10 years.



How do you assess the risk of this investment?

Very low ○○○○○○○ Very high

Question 10b: The value of this investment fund is €100. What do you think the value will be in a year time?

My expectation of the value in a year: ___ euro

Question 10c: What do you think the lowest possible value will be in a year time? (the value for which there is only a very small probability that the actual value is lower)

My expectation of the lowest possible value in a year: ___ euro

Question 10d: What do you think the highest possible value will be in a year time? (the value for which there is only a very small probability that the actual value is higher)

My expectation of the highest possible value in a year: ___ euro

Question 11: Are you willing to take a risk with your pension?

Certainly not ○ ○ ○ ○ ○ ○ ○ Certainly

Question 12: Please indicate to what extend the following statements apply to you:

I have much knowledge about taking financial decisions.

Totally disagree ○ ○ ○ ○ ○ ○ ○ Totally agree

My friends describe me as a careful person.

Totally disagree ○ ○ ○ ○ ○ ○ ○ Totally agree

Each year I thoroughly analyse my pension overview.

Totally disagree ○ ○ ○ ○ ○ ○ ○ Totally agree

I have difficulty making choices concerning the future because I don't know what my future will look like.

Totally disagree ○ ○ ○ ○ ○ ○ ○ Totally agree

Question 12: Do you have any remarks about your pension, pension fund or about this survey?

Chapter 4

X-efficiency and economies of scale in pension fund administration and investment[1]

Pension funds' operating costs come at the cost of benefits, so it is crucial for pension funds to operate at the lowest cost possible. In practice, we observe substantial differences in costs per member for Dutch pension funds, both across and within size classes. This paper discusses scale inefficiency and X-inefficiency using various approaches and models, based on a unique supervisory data set, which distinguishes between administrative and investment costs. Our estimates show large economies of scale for pension fund administrations, but modest diseconomies of scale for investment activities. We also find that many pension funds have substantial X-inefficiencies for both administrative and investment activities. The two kinds of inefficiency differ across types of pension funds. Therefore, most pension funds should be able to improve their cost performance, and hence increase pension benefits.

[1] This chapter is based on the paper: Alserda, Bikker, and Van der Lecq (2017) X-efficiency and economies of scale in pension fund administration and investment. *DNB Working Paper No. 547.*

4.1 Introduction

Pension funds have an important role in economies worldwide in consumption smoothing and preventing old age poverty. More precisely, they prevent their members from under-saving for retirement and can mitigate the problem of myopic loss aversion (Benartzi and Thaler, 1995, 2013). Pension fund members can benefit from economies of scale in investment (Bikker and De Dreu, 2009) and (intergenerational) risk sharing (Gollier, 2008; Bovenberg and Mehlkopf, 2014). However, operating a pension fund is not without costs, and excess costs reduce pension capital and thus members' final benefits. Pension fund cost levels appear to vary widely. A simple calculation shows that a 1% variance can reduce pension capital, *i.e.*, benefits, by 27% (Bikker and De Dreu, 2009).

Pension funds' operating expenses can be broken down into administrative costs and investment costs. Administrative costs include file keeping members' entitlements, managing the cash flows of contributions and benefits, performing actuarial calculations, submitting regular reports to external supervisors, and providing customer services for plan members. Investment costs include development and implementation of the strategic asset allocation, selecting and monitoring internal and external fund managers, providing regular performance evaluations, assessing the risk and return profiles of asset classes, and supporting the fund's investment committee. Bikker et al. (2012) find that administrative costs vary widely across countries, pension fund types, pension fund sizes and the ratio of active fund members to total members. Bikker and De Dreu (2009) find that both administrative and investment costs differ widely between pension funds, mainly due to unused economies of scale, while type of pension fund and type of pension plan also influence execution costs.

Larger pension funds may benefit from economies of scale, they can spread their fixed costs (*e.g.* following from IT, reporting, policy development, risk management) across a larger number of members and have more negotiating power in investments. They can also benefit to a larger extent from more internal investment management (which is three times less expensive than external management) and receive more invitations to co-investments (Bikker et al., 2012).

At the same time, larger pension providers may also suffer from costs that increase more than proportionally with their scale: they can have more severe price impacts with their trades (Bikker et al., 2007), they may have on average poorer investment ideas (as the better ideas are chosen first) and may encounter hierarchy costs as well as budget-maximizing bureaucracies (Chen et al., 2004; Dyck and Pomorski, 2011; Niskanen, 1974). The relationship between size and costs can be different across specific ranges of size. For example, bargaining power may require a minimum size, while bureaucracy will only be relevant for larger size pension funds (Chen et al., 2004). Most authors find that economies of scale dominate diseconomies of scale for pension funds of all current sizes (Bikker and De Dreu, 2009; Dyck and Pomorski, 2011). This would imply that there is value to be gained by increasing the size of pension funds, by merging for example.

In addition to scale inefficiency, average pension fund costs can also be higher due to X-inefficiency. X-inefficiency represents the managerial ability to choose the input set, given input prices, and the output mix, which minimizes costs, for all given scales. Where competitive pressure is insufficient or even absent, there is insufficient incentive to keep inefficiency down. The Netherlands, as well as many other countries, has mandatory participation in employer pension funds (Van Rooij et al., 2011). This means that pension fund members cannot leave the pension fund (unless they change employer), and pension funds face little competitive pressure. Competitive pressure in the pension domain may therefore fall short as a result of the institutional setting. In addition, the complexity of the choices involved (such as asset allocation), makes most members unable to compare pension fund performance (Iyengar and Kamenica, 2006; Beshears et al., 2008). Note, however, that employers are allowed to choose a pension fund, if they are active in one of the (few) sectors where industry funds are not mandatory.

The issue of pension fund efficiency is especially relevant as pension capital represents a large proportion of household capital in the Netherlands. In that country, pension capital amounted to over EUR 1,159 billion in 2013, which equals 71% of total household wealth and 252% of GDP (DNB, 2015a). Even small cost inefficiencies would therefore have large effects in absolute terms. This paper measures X-inefficiency and scale inefficiency in the Dutch pensions sector and, in a next step, indicates to what extent X-inefficiency and scale inefficiency is affected by pension fund characteristics such as size and pension plan type.

The measurement approach of these types of efficiency is discussed in Section 4.4, but we will first give a brief description of the Dutch pension system in Section 4.2 in order to explain the context of our research Section 4.3 presents the data. We separate the activities of pension funds into administration (Section 4.5) and investment management (Section 4.6). For both activities we use two different methods that are often applied in the literature to calculate efficiency. Each method has advantages and disadvantages that depend on the nature of the data. On the basis of the empirical results, we select the method that is most suited for the specific activity. Next, we investigate for the parametric approach five different cost functions to find the one that best describes the data. Using the preferred method, we determine pension fund X-efficiency and assess economies of scale. We also analyse developments over time to see the effects of changes in the institutional setting of pensions and analyse two clearly defined components of administrative costs: auditing costs and management costs, which may have distinct distributions of X-efficiency and economies of scale. Section 4.7 combines administrative and investment costs to total costs and analyses how the combination of the two interact with pension fund size. Section 4.8 presents our conclusions.

4.2 Brief description of the Dutch pensions system

The Dutch pensions system is based on the three-pillar structure. The first pillar comprises a pay-as-you-go state pension, which is not means tested (Bruil et al., 2015). Average retirement income from the first pillar represents about 54% of total retirement benefits (Bruil et al., 2015). The second pillar consists of occupational pension plans, collectively managed by pension funds, insurance companies, and other types of plan managers. Second-pillar pensions account for 40% of retirement benefits. The third pillar consists of tax-deferred savings that can be accrued on an individual basis, representing the remaining 6% of retirement benefits. These individual accounts are managed by banks, life insurance companies and retail asset managers.

Three types of pension funds are distinguished: industry-wide; company, and professional group funds. Industry-wide pension funds cater to employees from several companies operating within the same industry. Some industries have mandatory membership of their industry pension fund, while others have voluntarily membership (non-mandatory). Company pension funds have members deriving from a single employer, or from several entities in case of a multinational firm. Professional group pension funds cater to members with specific professions, such as doctors and dentists. Industry-wide pension funds have the best opportunities to benefit from economies of scale, as they can facilitate members from many employers. They cover 85% of the market. However, these pension funds are more distantly connected to the companies than company pension funds, meaning that they can benefit less from direct support by the sponsoring companies. In addition, a more fragmented employer base will increase costs. Professional group pension funds lack both the large number of members creating economies of scale, and the advantage of a single employer. Actually, their members are often self-employed and have varying incomes. These pension funds are expected to operate at relatively high costs.

In recent years the Dutch pensions sector saw a consolidation trend. The number of pension funds fell to 365 in 2014 from 1,060 in 1997 (DNB, 2015b), while the total of life insurers decreased to 40 in 2013 from 90 in 1995. This raises the question as to what extent consolidation has affected the costs, and more specifically the efficiency, of pension funds.

For a full overview of the Dutch pensions sector, we refer to Bikker (2017).

4.3 Data

This paper is based on a unique (non-public) supervisory data set of all Dutch pension funds between 1992 and 2013. These pension funds all operate in the second pillar (occupational pension). We ignored pension funds that report zero or negative costs, which is probably due to their termination. Pension funds that have 10 or fewer members were also omitted from further analysis, as many of them do not represent collective pension arrangements, but rather provide a tax vehicle for senior management.

Figure 4.1 shows the number of pension funds, their average number of members and their average costs over time. The increasing average number of members per pension fund is due to both the decline in the number of pension funds and the growth in the labor force. Given the growing size of pension funds, we may expect lower costs per member. However, we observed increasing (inflation-adjusted) administrative and investment costs over time. This may indicate increased demands on pension funds in terms of reporting and regulatory requirements and the use of more complex asset categories.

Figure 4.1: Pension fund characteristics over time (1992-2013)

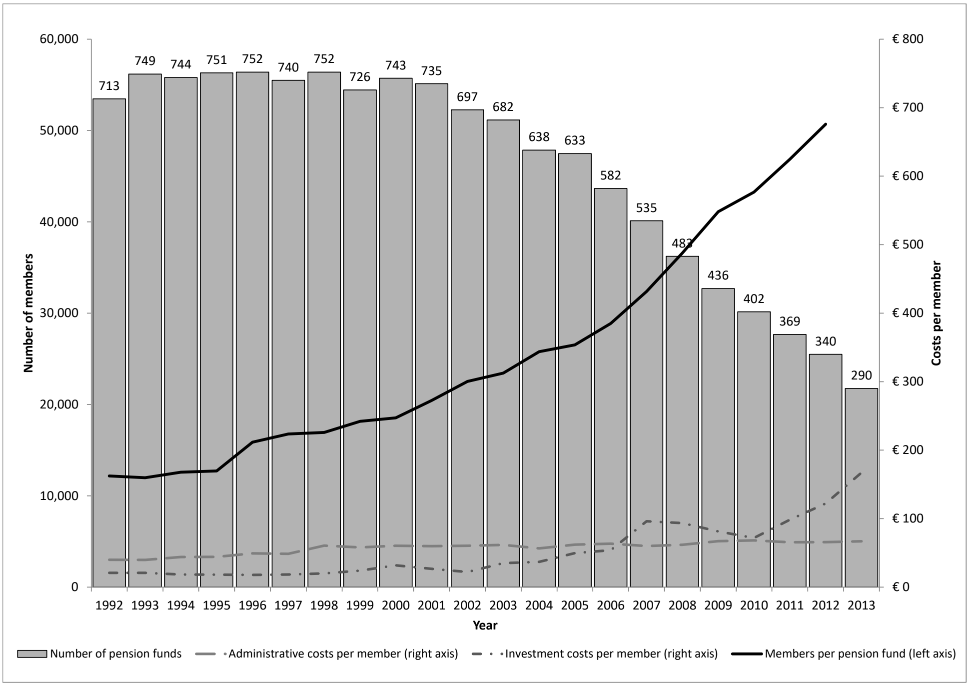


Figure 4.2 shows the 10th, 25th, 50th, 75th and 90th percentile of administrative costs per member for 10 size classes expressed in the number of members. The figure shows that there are strong economies of scale in administrative costs per member. The 10% largest pension funds have administrative costs per member that are about 10 times higher in the median than they are for the 10% smallest pension funds in terms of the number of members.

Figure 4.2: Administrative costs per member in size classes 2002-2013 (2013 prices)

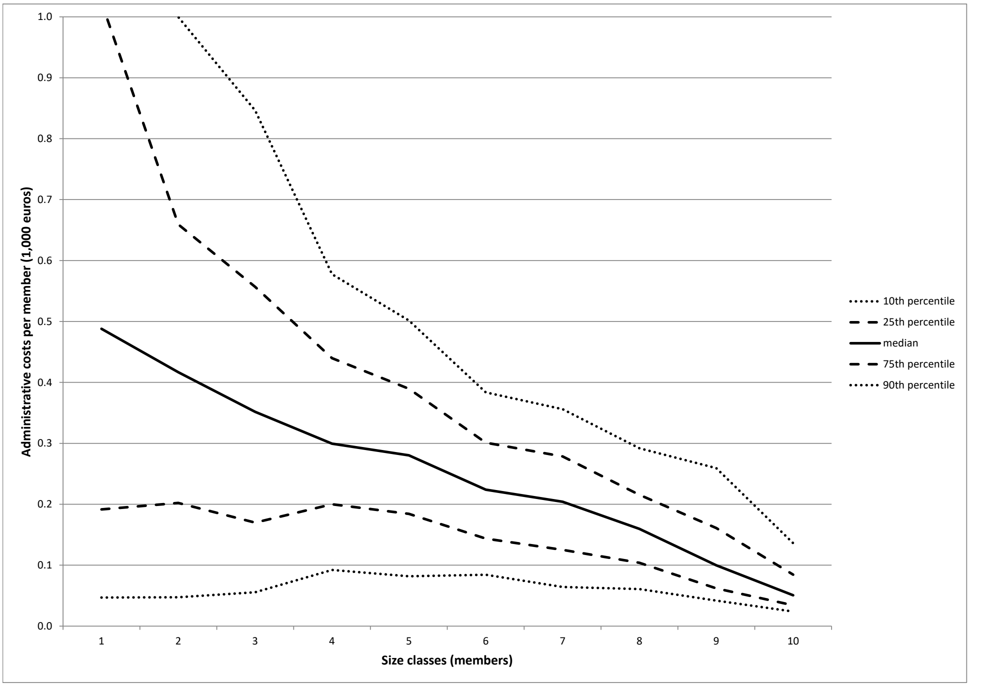
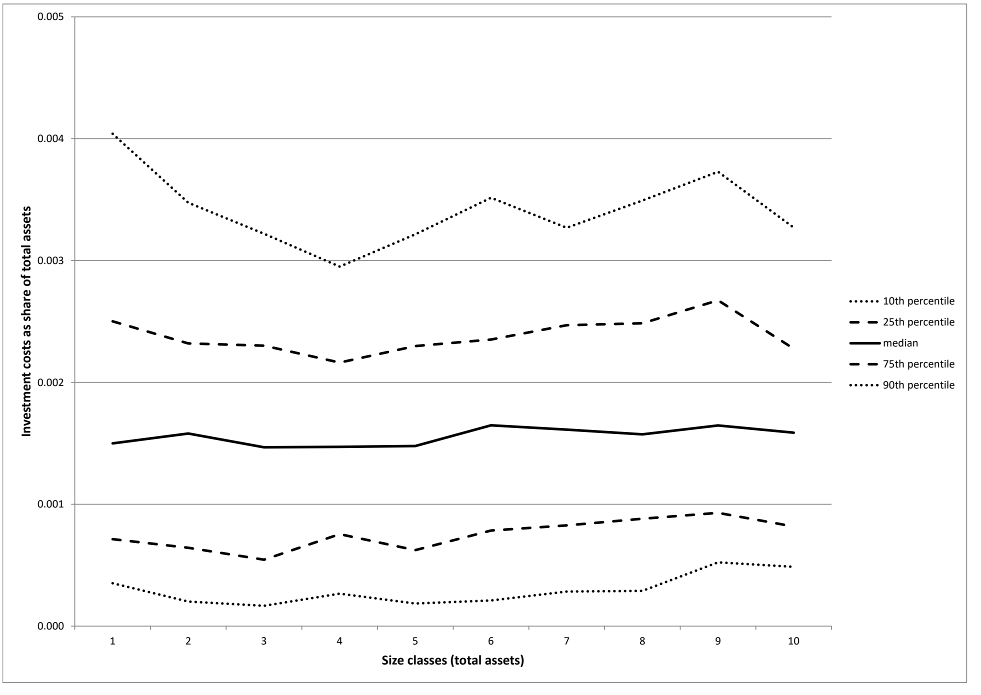


Figure 4.3 shows the same information for investment costs with size expressed as total assets of the pension fund. Contrary to administrative costs, there are no clear economies of scale visible for investment costs. According to Bikker (2017) this may be because larger pension funds tend to invest a higher relative proportion of assets in complex assets classes. These more complex assets tend to have higher costs, and therefore increase median costs for larger pension funds, but they also give higher expected returns (Bikker, 2017). Due to presence of fixed costs it is likely that in principle scale economies are present for investment costs.

Table 4.1 presents the summary of the relevant variables for four time periods. These variables are relevant for the models that we will estimate. The table clearly show the consolidation of pension funds and the increase in both administrative and investment costs per member, as explained above. The proportion of inactive members increases over time, due to increased labour mobility across sectors, while the proportion of retirees remains fairly stable. Total assets per member increase over time, reflecting

Figure 4.3: Investment costs as proportion of total assets 2002-2013 (2013 prices)



pension fund wealth growth. On top of that, total assets per fund increased even more, reflecting consolidation. The number of members with defined contribution plans increased substantially. This shows that pension risks are increasingly shifting towards members. From 2002 onwards, the share of administration that is outsourced has increased substantially, partly due to new regulations and partly because of the splitting of pension funds and pension delivery organizations. Investment data shows that over the past two decades, the proportion of fixed-income investments has decreased, mostly in favour of equity. The proportion of real estate investments has remained fairly constant and the share of alternative investments fell between the first and the second period and has increased since then. We expect that investment costs increase with the proportions of equity and real estate, as investment analyses and risk management in these areas are more complicated.

Some pension funds report administrative costs that are substantially lower than those of others. Examples are zero wage or accommodation costs, which are espe-

Table 4.1: Summary of key pension fund data for four periods: averages

Time period	**1992-1996**	**1997-2001**	**2002-2007**	**2008-2013**
Administrative costs per member	44	58	61	57
Investment costs per member	19	25	52	103
Number of pension funds	742	739	628	387
Members per fund	13,081	18,163	26,297	43,319
Active members (%)	49	46	41	35
Retirees (%)	19	19	19	23
Inactive members (%)	32	35	40	42
Total contributions (€billion)	32.8	65.3	154.2	185.0
Total assets per fund *(discounted, €million)*	331	750	1,090	2,093
Total liabilities per fund *(discounted, €million)*	286	579	863	1,997
Assets per member *(€)*	25,276	41,319	41,461	66,955
Defined contribution (% members)	2.8	2.2	7.8	9.2
Mandatory industry fund *(% members)*	81	82	84	84
Non-mandatory industry fund *(% members)*	1.8	2.3	1.5	1.4
Company fund *(% members)*	12	13	14	13
Professional fund *(% members)*	0.6	0.5	0.4	0.5
Outsourcing/administration costs (%)	24	24	35	60
Reinsurance premiums/total premiums (%)	10	4	2	3
Investments (%):				
Fixed income	57	47	45	50
Equity	24	40	41	34
Real estate	12	10	10	10
Other assets	7	3	4	6

Note: Values are expressed in 2013 prices.

cially observed for smaller, company specific, pension funds. These pension funds are often administered by the sponsoring company, so that specific costs in some cases are not or not fully accounted for. This kind of under-reporting is specifically taken into account in the remainder of this paper. As long as under-reporting typically has an inverse relation to size, scale economies and the potential cost benefits of consolidation are underestimated. Due to stricter data provision requirements prompted by regulatory reporting duties since the introduction of the financial assessment framework for pension funds (Financieel toetsingkader FTK) in the Netherlands in 2006, data from 2007 onwards is more reliable.

4.4 Measuring efficiency

Efficiency has many different definitions: productive; technical; allocation; scale, and X-efficiency. Productive efficiency represents efficiency gained by combining different inputs in the optimal mix (minimizing average costs). Technical efficiency is achieved when average costs are minimised given the mix of inputs, and allocative efficiency is achieved when prices of output are equal to the marginal costs of producing this output. X-efficiency is the difference between theoretical minimum costs and actual costs incurred, (Leibenstein, 1966). X-inefficiency may exist due to a lack of competitive pressure, allowing pension funds to survive while operating at higher costs. Finally, a pension fund is scale efficient if any change in size will make it less efficient, as measured by average costs. These different types of efficiency can overlap. Firms that have X-inefficiency or scale inefficiency will also be technically inefficient and technical efficiency is required for allocative efficiency, as otherwise price cannot equal marginal costs (Tirole, 1988; Charnes et al., 1978). Plotting the number of members and administrative costs for the X-efficient funds (or total assets and investment costs) gives the cost frontier. Deviations of observed costs from the cost frontier represent X-inefficiency, as the other categories of efficiency are included in the cost frontier. The frontier itself illustrates the relation between size and costs and can therefore be used to assess economies of scale.

Pension funds are not obliged to report all their activities, but only the costs of these activities, such as pension administration and investment outlays. This means that there is no information about the exact activities undertaken (such as the amount of hours spent on membership administration) and the price of that activity (such as wages of pension fund employees). Consequently, productive efficiency cannot be estimated, and pension fund efficiency is only differentiated between X-efficiency and economies of scale, which overlap with technical efficiency.

We investigate and compare two different measurement approaches to efficiency, a parametric method and a non-parametric method. Non-parametric methods use mathematical programming techniques to calculate the frontier representing the optimal ratio of inputs to costs. We apply two different variations of non-parametric efficiency measurement, the Full Disposal Hull (FDH) reference technology, and Order$-\alpha$. Parametric methods start with a pre-defined cost function which is fitted to the data. Again we apply two variations, the Linear regression model (LRM), which measures economies of scale and not X-inefficiency, and stochastic cost frontier analysis (SCFA)[2]. In the non-parametric method, efficiency is calculated by comparing the input to output ratio of the pension funds to the best practice pension funds (determined by selecting the most efficient one for each possible pair of pension funds). The parametric and non-parametric methods are discussed in detail in Sections 4.4.2 and 4.4.3. However, before efficiency can be estimated, we must specify the fund's production process. This means that we have to know the relevant inputs and outputs of pension funds.

4.4.1 Inputs and outputs

Inputs for pension administration and investment are factors such as labour, premises and equipment, IT, energy, etc. As these inputs, and their prices, are not reported, we took administrative and investment costs as indicators for inputs in the administration and investment processes, in line with Bikker (2017). Given the amount of outputs, pension funds should minimise costs, thereby optimising their inputs.

Outputs for pension administration and investment are factors such as processed changes, messages sent and processed investment returns, etc. As these outputs, and their prices, are not reported, we took the number of members and total assets as indicators for output respecively in the administration and investment processes, in line with Bikker and De Dreu (2009). Administration offers services to members, and most services are proportional to the number of members. The number of members was therefore selected as the relevant measure of output. Investments are usually managed on an aggregate level, irrespective of the number of members: the number of investment activities (such as transactions) depends on the total size of these investments. Therefore, total assets, discounted for inflation, is taken as the output measure for investment activities .

Pension fund members in the Netherlands are not free to choose their own pension fund, so Dutch pension funds are unable to use retail marketing to influence the number of members or the value of total assets they manage. This means that pension funds are input-oriented: they will try to minimise inputs (*i.e.* costs), given their output levels. We follow this input orientation for the efficiency analysis instead of the output orientation, as this only marginally influences efficiency estimates, but makes the interpretation of the results more intuitive, *i.e.,* allows us to express efficiency

[2]Contrary to non-parametric methods, parametric methods use a pre-defined functional form of costs to model efficiency.

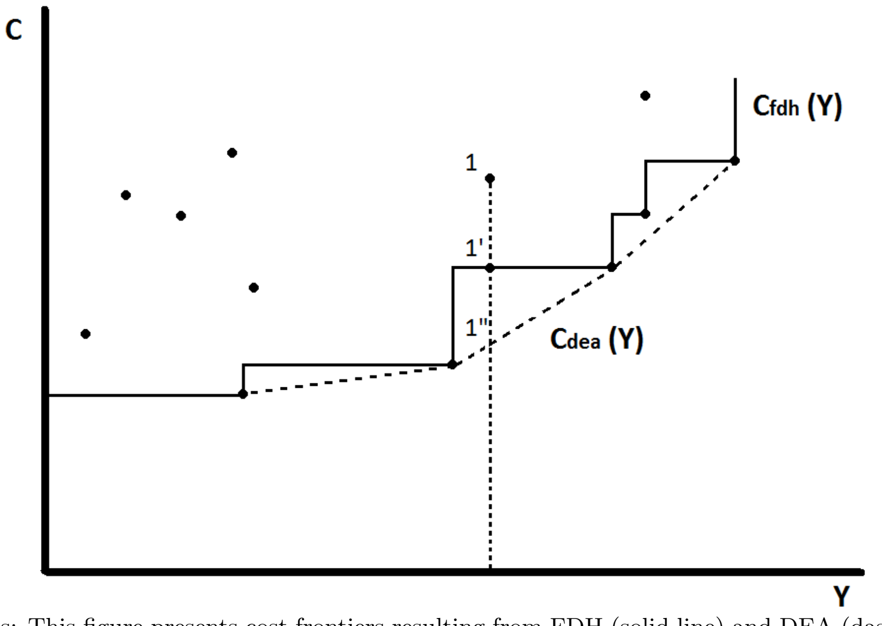
in terms of costs. Although pension funds cannot directly influence the number of participants they serve, or their value of assets under management, they try to optimize investment returns (given risk). Therefore, with respect to investment costs, pension funds may be partially output oriented, and higher costs may be allowed, to some extent, to increase investment returns.

4.4.2 Non-parametric method

Non-parametric methods use mathematical programming techniques to calculate the cost frontier representing best-practice pension funds. Given scale, the pension funds with the lowest costs-to-output ratios constitute the cost frontier (De Borger and Kerstens, 1996). This means that pension funds are only X-efficient if neither a smaller nor a larger pension fund have lower costs-to-output ratios (dependent on the exact non-parametric method used). Plotting the X-efficient pension funds, and drawing a connecting lines between these best practice pension funds, gives the cost frontier. The deviation with the cost frontier is X-inefficiency, while the difference between the cost frontier and the lowest costs-to-output ratio (irrespective of size) represents scale inefficiency. An important advantage of a non-parametric methods is that they do not need assumptions about the functional form of a cost model, like parametric approaches do (De Borger and Kerstens, 1996). A drawback of non-parametric methods is that they are extremely sensitive to outliers (*e.g.*, errors in measured inputs), as these may influence the cost frontier and thereby the efficiency estimates (Cummins and Weiss, 2013; Tauchmann, 2012). Large negative errors in input costs (*e.g.*, under-reporting of costs) would for example shift the cost frontier upwards, hugely increasing X-inefficiency (difference between actual performance and cost frontier) estimates.

Several non-parametric methods have been suggested in the literature. Data Envelopment Analysis (DEA) is most commonly used, and calculates the cost frontier by comparing all observations with all other observations, the pension fund in each size category that has best practices (Charnes et al., 1978; Färe et al., 1985; Seiford and Thrall, 1990; Favero and Papi, 1995; Coelli, 1996; De Borger and Kerstens, 1996). Although DEA is often used, the necessary computational power of the model increases exponentially with the number of observations (Ji et al., 2010), which makes the method unfeasible for large datasets. Free Disposal Hull (FDH) reference technology is very similar to DEA. Where DEA uses linear interpolation between the best-practice pension funds to constitute a minimum cost frontier, FDH builds a step-wise cost frontier between the best practice pension funds, which requires less computational power (De Borger and Kerstens, 1996). Due to this stepwise function X-efficiency estimates can be slightly higher, as the stepwise cost frontier will always be lower or equal to the DEA cost frontier (De Borger and Kerstens, 1996). This is illustrated in Figure 4.4, where the difference between $1'$ and $1''$ represents the difference between DEA and FDH X-inefficiency. Given the large dataset, we chose to use FDH rather than DEA, in order to keep our computations manageable.

Figure 4.4: Example of a cost frontier resulting from the FDH or DEA method



Notes: This figure presents cost frontiers resulting from FDH (solid line) and DEA (dashed line). The X axis gives output Y and the Y axis gives costs C. The dots represent pension funds. Dot 1 gives an inefficient DMU. FDH effiency for this dot is value of C for 1' divided by that of 1, while DEA efficfiency is value of C for 1" divided by that of 1. Source: De Borger and Kerstens 1996, p. 150

So far, pension funds have been designated as best-practice pension funds if neither a smaller nor a larger pension fund has lower costs-to-output ratios, in order to allow for variable returns to scale. However, by repeating the analysis, but only designating the pension fund with the single lowest costs-to-output ratio as best practice (not controlling for size), gives efficiency values with constant returns to scale[3]. Efficiency in this case is lower than (or equal to) the efficiency estimates in the case of variable returns to scale, as the cost function will be lower in the case of constant returns to scale. The difference between efficiency under variable returns to scale and constant returns to scale represents economies of scale, while the remainder represents X-efficiency. The implicit assumption is that by incorporating best practices, all pension funds should be able to achieve an X-efficiency score of 1.[4] For a detailed description of FDH, including an illustration of separating X-inefficiency and scale inefficiency, we refer to De Borger and Kerstens (1996).

As noted, a major disadvantage of the non-parametric methods discussed so far is their sensitivity to outliers. To deal with this problem, partial frontier approaches have been developed. Partial frontier approaches, such as Order$-\alpha$ (Aragon et al., 2005) and Order$-m$ (Cazals et al., 2002) efficiency, allow for superefficient observations, which are below the cost frontier. Superefficient observations can represent random shocks (luck) or measurement noise, but do not necessarily represent sustainable best practices. The cost frontier is formed by the selecting the x^{th} percentile most efficient pension funds, where x depends on the level of α or m used. The cost frontier is therefore not formed by the most extreme efficiency values, which makes it less sensitive to outliers (Tauchmann, 2012). In the case of Order$-\alpha$, the lowest cost frontier is defined as the α% most efficient observation, given size. Order$-\alpha$ is equal to FDH if $\alpha = 100$ (Tauchmann, 2012). Order$-m$ compares pension funds to the best performance in a random sample of m peers, based on the sample at hand. As this sample does not necessarily include all the pension funds in the sample at hand, including the pension fund being analysed, X-efficiency can be higher than 1. This paper uses Order$-\alpha$ and set $\alpha = 95\%$ in order to reduce the problems caused by the most extreme outliers. Lower values of α would cause large proportions of superefficient pension funds.

4.4.3 Parametric method

Parametric methods define a cost function, which explains costs by explanatory variables, such as output, input prices and – in our case – other pension fund character-

[3]In this case the frontier will be a linear line from the origin to the observation with lowest costs-to-output ratio and further.

[4]Efficiency is by definition between (or equal to) 0 and 1, where 0 represents total inefficiency (no output) and 1 total efficiency (lowest possible costs-to-output ratio)

istics. The model parameters can be estimated, constituting a median cost frontier, which is comparable to Order$-\alpha$ with $\alpha = 50\%$ in the sense that about half of the observations is more efficient and the other half less efficient than the 'median' observations. The error terms of the cost function describe measurement errors of the variables, specification errors (relating to the functional form among other things) and omitted variables. Inefficiency may be one of the omitted variables. We refer to this model as the linear regression model (LRM).

An alternative approach is to assume that the error term consists of two components, measurement errors or random shocks (as in the LRM) and inefficiency. In the stochastic cost frontier analysis (SCFA), these two components are distinguished by attributing a non-negative statistical distribution for inefficiency besides a normal distribution for the random shock. This method is also frequently applied, although not for pension funds (Hardwick, 1997; Bishop and Brand, 2003; Latruffe et al., 2004; Fenn et al., 2008). Pitt and Lee (1981) define the cost function's error term ε as:

$$\varepsilon_{i,t} = u_i + v_{i,t} \tag{4.1}$$

The first disturbance, inefficiency u_i, is one-sidedly distributed ($u \geq 0$), for instance half-normal, with mean zero. The second disturbance, uncontrolled random shocks $v_{i,t}$, is normally distributed, also with mean zero. Sub-indices i and t refer to pension fund i and time period t.

Parametric methods are based on a cost function. Shaffer (1998) explains how sensitive scale economy estimates are on the specification of the relationship between costs and output or size. A log-linear relationship between cost and pension fund size would imply a constant cost elasticity and hence a scale economy estimate that is constant over sizes. The quadratic Translog cost function (TCF), frequently applied in economic literature, assumes a U-shaped unit cost, *i.e.*, costs per member, function. This allows for large but declining scale economies for pension funds to below the optimal size, but forces equally strong diseconomies of scale for pension funds above that optimal scale. To allow for permanently decreasing costs per member, or for asymmetry around the optimal scale, more flexible functional forms are needed. Shaffer (1998) proposes the unrestricted Laurent function (ULF)[5] and the hyperbolically-adjusted Cobb Douglas (HACD) function[6] also applied to pension

[5]ULF (Equation 4.2) adds two inverse (log) terms to the TCF, making parabolic costs per member more flexible.

[6]HACD (Equation 4.3) is the most simple model, it describes constant economies (or disec-

funds by Bikker (2017). Equations 4.2 and 4.3 shows the structure of, respectively the ULD and HACD model:

$$ULF: lnAC(o) = \alpha + \beta_1(ln\, o) + \beta_2(ln\, o - \overline{ln\, o})^2 + \beta_3/(ln\, o) + \beta_4/(ln\, o)^2 + \beta_5(pension\, fund\, characteristics) \tag{4.2}$$

$$HACD: lnAC(o) = \alpha + \beta_1(ln\, o) + \beta_2/o + \beta_3(pension\, fund\, characteristics) \tag{4.3}$$

Note that the TCF follows from equation 4.2 if $\beta_3 = \beta_4 = 0$[7]. This paper applies another, even more flexible method, the quadratic spline cost function (QSF), which may also incorporate possible breaks in the output cost relationship (Diewert and Wales, 1992). QSF add one or more breakpoints to the quadratic output term of the TCF. Equation 4.4 shows a quadratic spline model of pension fund efficiency with a single quadratic spline. The location of the breaking point (where output is x_1) is chosen by minimising Akaike's information criterion (AIC)[8] of the model over a grid of possible values of x_1. Appendix 4.8 shows the model specifications for the double and triple quadratic spline models, and provides first derivatives of these quadratic spline cost functions, *i.e.*, cost elasticities as functions of size.

$$QSF: lnAC(o) = \alpha + \beta_1(ln\, o) + \beta_2[(ln\, o - ln\, x_1)^2|_{o \leq x_1}] + \beta_3[(ln\, o - ln\, x_1)^2|_{o > x_1}] + \beta_4(pension\, fund\, characteristics) \tag{4.4}$$

where β_2 is conditional ($||$) on the output being being before the break–point x_1, and β_3 conditional on the output being after the break–point x_1. In addition to the

onomies) of scale with only one single inverse term of members to allow for fixed costs.

[7]To avoid multicollinearity, we also applied a simplified ULF (SULF) model with $\beta_4 = 0$

[8]AIC gives information about the goodness of fit of a function, given the sample. Lower values of AIC represent better model fits. For more information we refer to Akaike (1974).

variables to capture the relationship with size, we included as explanatory variable of costs: type of pension fund, type of pension scheme, ratio of active, inactive, and retired members to total members, assets per member, proportion of reinsured liabilities, and the outsourcing of administration (as proportion of administrative costs paid to third parties).

Below, we will apply the two variations of the parametric method, and the two variations of the non-parametric method, on administrative costs. The estimation results will show which method is most suitable for describing pension fund efficiency.

4.5 Empirical results for administrative costs

This section presents the estimation results of the various approaches and functional forms for administrative costs, while Section 4.6 presents the empirical results for investment costs. We start by selecting the best approach, parametric or non–parametric, and next investigate what the best functional form is. We will then discuss the corresponding effects of separate pension fund characteristics on costs, and possible changes in these effects across different periods. Finally, we will examine the available separate components of administrative costs.

4.5.1 Parametric estimation results

Table 4.2 presents the results of a first exploration of SCFA and LRM over the 2002 - 2013 period. Our main interest is in SCFA which allows for estimation of inefficiency, but we will also show LRM for comparison. For both variations we specify a TCF, as this is most often applied in the literature and resembles a number of alternative cost functions. The most general specification with annual values for inefficiency had difficulty to converge, and the error term tends to be fully attributed to random shocks v. Therefore we assume for the SFCA that X-efficiency is fixed over time, opposed to the random shocks that vary each year (Greene, 2008). A side effect is that the impact of possible under-reporting of costs on efficiency estimation is reduced, as non-persistent under-reporting will be attributed to the random shocks term v. For both methods substantial economies of scale exist for the pension fund with (geometric) mean size (in terms of the number of members): cost elasticities are 0.74 and 0.81, respectively, indicating that costs increase substantially less than proportionally to size. As pension funds never or almost never change in terms of type, this type of variable, and other variables that are constant over time, cannot be included in the SCFA model, because they cannot be distinguished from the (also constant) X-inefficiencies[9]. The results for LRM show that mandatory industry-wide funds face the lowest costs (-29%), while professional group funds face the highest cost (+75%).[10] We will discuss the parameter estimates in the section on functional forms. On average, pension fund X-efficiency is low (0.212), with 75% of funds having an X-efficiency score of lower than 0.271. Note that this inefficiency may be overestimated due to the under-reporting errors and the omission of pension fund type dummies. Overall, the parameter estimates of both methods are similar, but as SCFA allows for the estimation of X-inefficiency, it is preferred over LRM.

[9] Similar as in the case of a fixed effects model

[10] In all regression analyses the pension fund types are compared to a group of none defined pension funds

Table 4.2: Results of parametric models for administrative costs (2002 - 2013)

Variables	(1) LRM Cost elasticity		(2) SCFA Cost elasticity	
Members (*in logarithms*)	0.736***	(0.008)	0.807***	(0.019)
Members^2 (*ln, mean dev.*)	0.005**	(0.002)	0.034***	(0.006)
Industry fund (mandatory)	-0.341***	(0.079)		
Industry fund (non-mandatory)	-0.029	(0.098)		
Company fund	0.134**	(0.065)		
Professional group fund	0.559***	(0.111)		
Pension plan: defined contribution	-0.131***	(0.036)		
Outsourcing	0.670***	(0.047)	0.270***	(0.037)
Reinsured	-0.112***	(0.021)	-0.034***	(0.012)
Assets per member (€million)	0.534***	(0.049)	0.082**	(0.038)
% Pensioners	0.408***	(0.075)	1.665***	(0.129)
% Inactive members	-0.554***	(0.079)	0.440***	(0.076)
Constant	-0.140	(0.088)	-4.362***	(0.148)
σ_u^2 (*inefficiency*)			10.501	(0.625)
σ_v^2 (*random shocks*)			0.234	(0.005)
R^2	0.702		0.660	
Akaike's IC	16,609		11.921	
First derivatives	$(0.736 + 2 * 0.005 * (lnp - \overline{lnp})$		$(0.807 + 2 * 0.034 * (lnp - \overline{lnp})$	
Cost elasticity at $\overline{lnp}$	0.736		0.807	
X-efficiency:				
Average			0.212	
25th percentile			0.103	
Median			0.166	
75th percentile			0.271	

Notes: p = number of members, number of observations = 6,087, number of pension funds = 799, $\overline{lnp} = \ln(2{,}316)$. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

4.5.2 Non-parametric results

This section explores two variations of the non-parametric method: FDH, and an Order$-\alpha$ model with $\alpha = 95\%$. Table 4.3 presents summary data of the efficiency estimates for both models and the results of a regression analysis explaining these efficiency estimates. We will see how efficiency can be explained from pension fund characteristics. The robustness of these results may help to assess the validity of the X-efficiency estimates

The median X-efficiency following from the FDH model at 0.010 is extremely low. Applying Order$-\alpha$ yields considerably higher X-efficiency estimates (with a median value of 0.471). The same is true for the 25th and 75th percentile, with X-efficiency estimates of 0.005 and 0.029 for FDH respectively and 0.311 and 0.797 for Order$-\alpha$ respectively. These results suggest that the data has measurement errors, among other things due to under-reporting of costs, which particularly for the FDH strongly influences the X-efficiency estimates. The sensitivity to outliers can be clearly observed in Figure 4.5, which shows the frontiers resulting from FDH and order$-\alpha$. As Order$-\alpha$ is less sensitive to outliers (see Section 4.4.2), this approach is much more suitable to this situation. The levels of X-inefficiency for FDH and Order$-\alpha$ deviate hugely, but remarkably, the Spearman rank correlation (0.652) shows that both methods yield similar rankings of pension fund-time observations. Also in explaining the inefficiency estimates from both non-parametric models we observed similar parameter estimates, also suggesting that the inefficiencies from both approaches resemble each other. Also the comparison of these non-parametric X-inefficiencies with the SCFA X-efficiencies show high values of Spearman rank correlation (between 0.652 and .750), indicating that the rank in X-efficiency is relatively robust for the choice of method.

Explaining the inefficiency estimates from pension fund characteristics reveal that mandatory industry-wide pension funds on average have the highest X-efficiencies, while, professional group funds are least X-efficient. Defined contribution plans are more X-efficient and pension funds that have less outsourcing,[11] more reinsurance, and more pensioners also tend to be more X-efficient. These results are in line with Table 4.2 in the sense that pension fund characteristics which go with the lowest cost levels now show the highest efficiencies. The economic impact of population effects

[11] Outsourcing costs are included in administrative costs. As they are easily observable they are less likely to be underreported. Outsourcing can therefore in this sense act as a negative proxy for under-reporting

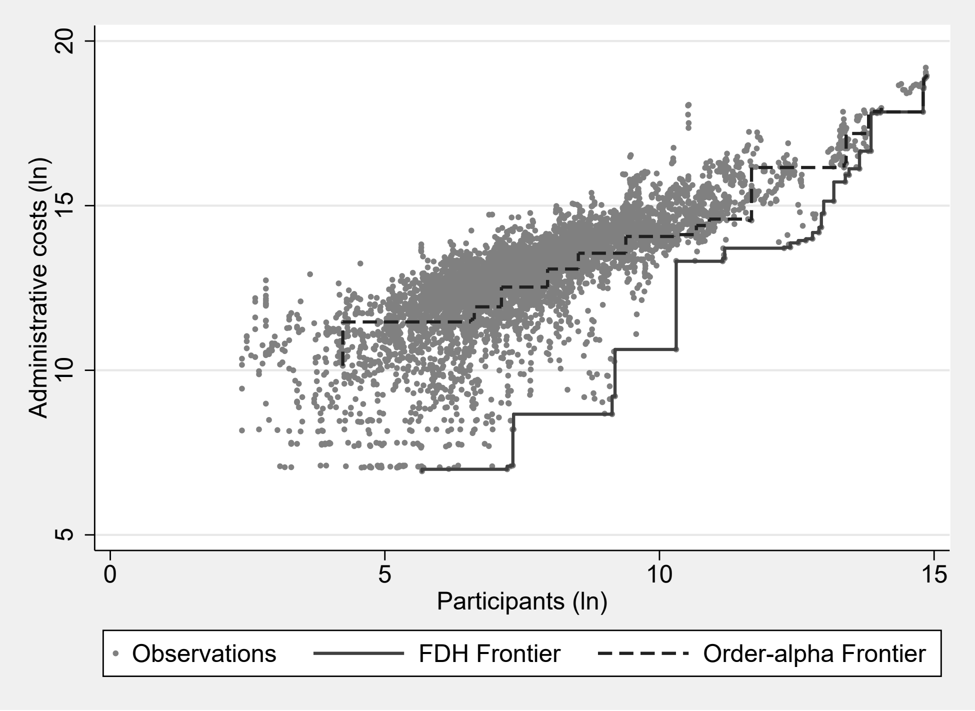
is relatively small, as administrative costs change by up to 0.3% with a standard deviation change in the ratio of pensioners and up to 4.5% for a standard deviation change in the ratio of inactive members.

Table 4.3: Explaining non-parametric estimates of X-efficiency for administrative costs (2002-2013)

	(1)		(2)	
Variables	**FDH**		**Order-α**, $\alpha = 95$	
X-efficiency:				
Average	0.058		0.546	
25th percentile	0.005		0.311	
Median	0.010		0.471	
75th percentile	0.029		0.797	
Members *(in logarithms)*	0.014***	(0.001)	-0.015***	(0.002)
Members^2 (*ln, mean dev.*	0.011***	(0.000)	-0.001	(0.001)
Industry fund (mandatory)	0.001	(0.009)	0.154***	(0.023)
Industry fund (non-mandatory)	-0.012	(0.011)	-0.025	(0.028)
Company fund	-0.002	(0.008)	-0.072***	(0.019)
Professional group funds	-0.034***	(0.013)	-0.181***	(0.032)
Pension plan: defined contribution	0.011**	(0.004)	0.051***	(0.010)
Outsourcing	-0.047***	(0.006)	-0.185***	(0.013)
Reinsured	0.006**	(0.003)	0.033***	(0.006)
Assets per member *(€million)*	-0.030***	(0.004)	-0.091***	(0.011)
% Pensioners	-0.039***	(0.009)	-0.067***	(0.021)
% Inactive members	0.018*	(0.009)	0.210***	(0.022)
Constant	-0.072***	(0.011)	0.703***	(0.025)
Adjusted R^2	0.389		0.127	

Notes: Number of observations = 6,087, pension funds = 799, $\overline{lnp}$ = ln(2,316). Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

Figure 4.5: Non-parametric estimates of administrative cost frontiers



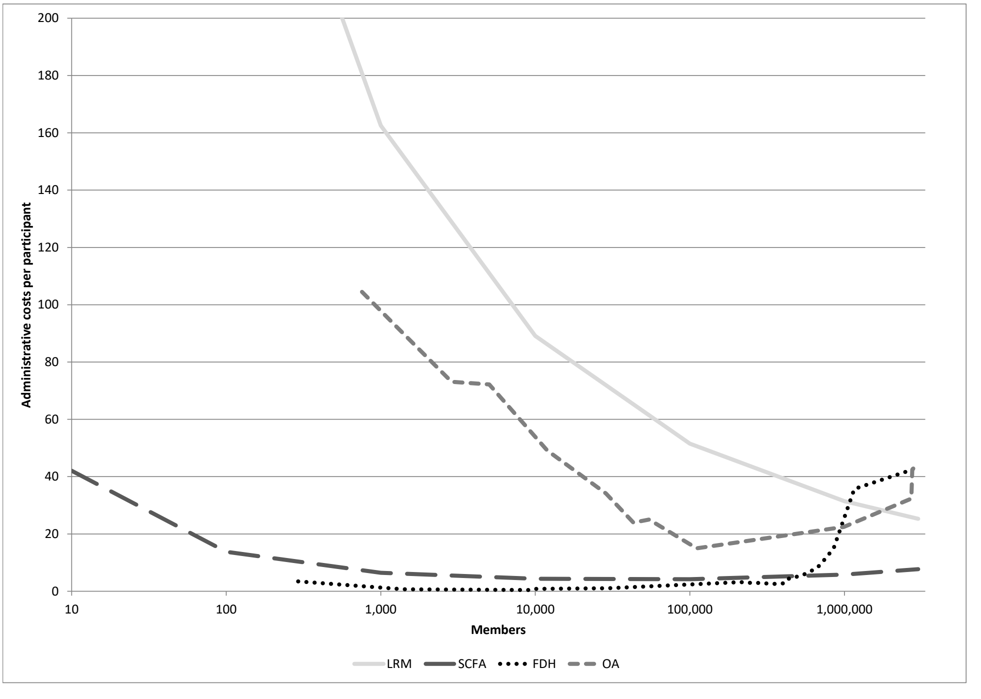
4.5.3 Method

The parametric and non-parametric approaches of the previous two sections result in distinctively different cost frontiers, as shown in Figure 4.6. This figure shows the cost frontier for each pension fund size, expressed as the (lowest) costs per member. Please note that the frontier following from LRM is the average (and not absolute) cost frontier, whereas the frontier following from Order$-\alpha$ represents the 95^{th} percentile of the efficiency distribution. The remaining frontiers (SCFA and FDH) represent fully efficient or best-practice pension funds: pension fund costs can therefore theoretically be on or above the cost frontier. SCFA allows for model errors and hence lies above the FDH curve. The plotted frontiers of LRM and SCFA are the estimated effect of the output (that is, number of members) variables from Table 4.2 on administrative costs per member. For example the SCFA cost frontier equals: $(0.807 * ln\, particants + 0.034\,(ln\, particants - \overline{ln\, particants})^2)/members$. The plotted frontiers of FDH and

Order-α are costs per member and number of members of X-efficient pension funds (X-efficiency = 1) for pension funds sorted by their number of members, where the dots or observations are connected by interpolation.

As the number of observations drops sharply for very large pension funds, the non-parametric methods have different properties at this point. This results in increasing estimated costs per members.[12] In our sample, the LRM frontier shows continuously decreasing costs per member while the other three approaches reveal increases for the largest pension funds, but not necessary statistically significant one.

Figure 4.6: Cost frontier estimates from four model approaches (2002 - 2013)



Contrary to the other three methods, LRM does not allow for the calculation of X-efficiency, and serves only for comparison. As said, the X-efficiency calculated for the remaining three methods show high values of Spearman rank correlation (between 0.652 and 0.750), indicating that the rank in X-efficiency is relatively robust for the choice of method, though the median estimated value of X-inefficiency varies hugely.

[12] As the number of observations drops, so does the expected value of the minimum cost frontier.

As FDH and Order$-\alpha$ are more sensitive to the presence of outliers (including underreporting), due to ignoring of the possibility of measurement and specification errors, we choose the SCFA approach for the remainder of this paper to measure X-efficiency in the pension sector. An additional argument for selecting SCFA is that it can incorporate a number of pension fund characteristics in explaining costs, so that the X-inefficiency measurement is not disturbed by these other costs determinants.

4.5.4 Functional form specification

Table 4.4 investigates several cost functions for the preferred SCF approach: TCF, ULF, SULF, HACD and QSF (see Section 4.4.3). We use AIC to find the functional forms that best fits the data . QSF with a single break point at ln(members)= 5.5 or 245 members is the preferred model[13]. The results show that there are vast unused economies of scale for small pension funds which decrease with pension fund size. Beyond the breakpoint of ln(members)= 5.5 small, constant economies of scale remain. Three other specifications, (S)ULF and HACD, confirm that large cost disadvantages exist for small pension funds, likely because of the presence of substantial fixed costs. These models have roughly the same AIC value and do not differ statistically significantly from the QSF. The model coefficients and the other statistics hardly differ across these four functional forms. The popular TCF, however, is rejected firmly in favour of the alternative specifications. This has a great impact on the conclusions drawn from the model, as is illustrated by Figure 4.7 below.

Figure 4.7 shows the cost elasticity (CE) over pension fund sizes for different functional forms (see left axis). The cost elasticity of four functional forms, ULF, SULF, HACD, and QSF, are relatively similar. These functional forms show large unused economies of scale for small pension funds (particularly below $< 1,000$ members) and small economies of scale for larger pension funds. The most important result is that these functions have cost elasticities below 1, so that no optimal scale exists: scale economies remain limited to exits without upper size limit. The only exception is the QSF, which touches the CE $= 1$ line, but only at the outer range of the sample and within the confidence interval (not shown in Figure 4.7), so that no conclusions can be drawn. TCF, however, gives deviating results, and is the only functional form that crosses the CE $= 1$ line firmly and results in substantial dis-economies of scale within

[13] In Appendix 4.8 we show model specifications for QSF with up to three break points. The results in that section show that the QSF with one break point at ln(members)= 5.5 has the lowest AIC value.

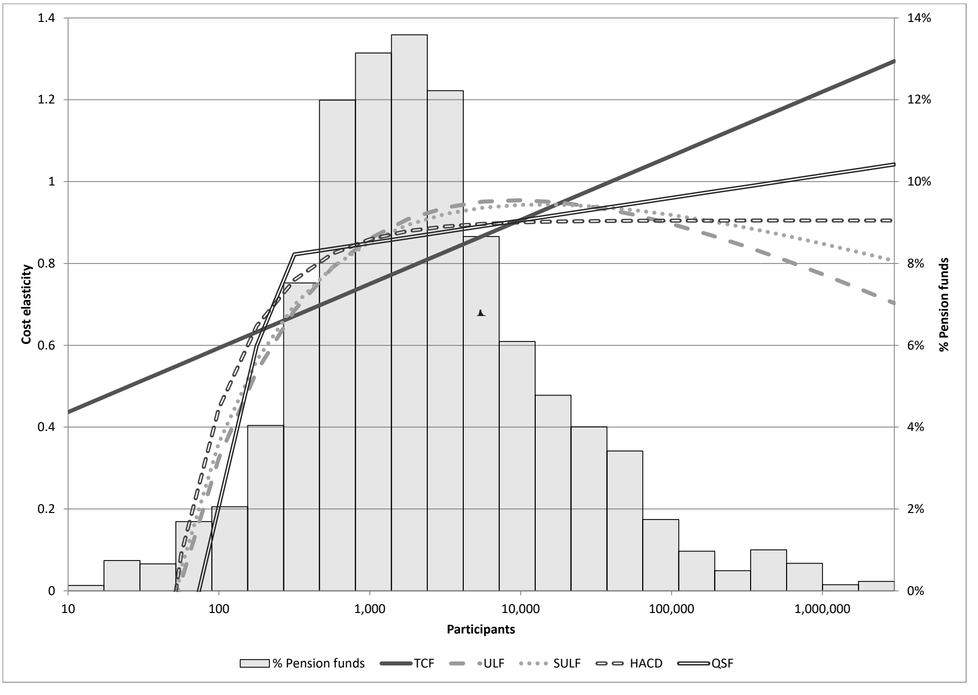
Table 4.4: Estimates of five functional forms of administrative costs (2002 - 2013)

Variables	(1) **TCF**	(2) **ULF**	(3) **SULF**	(4) **HACD**	(5) **QSF**
Break point					$lnx_1 = 5.5$
Members	0.807***	1.525***	1.299***	0.905***	0.816***
(in logarithms)	(0.019)	(0.314)	(0.078)	(0.022)	(0.042)
Members^2	0.034***	-0.045*	-0.027**		
(ln, mean dev.)	(0.006)	(0.026)	(0.011)		
1/(ln members)		42.992	23.469***		
		(26.442)	(3.569)		
1/(ln members)^2		-26.557			
		(35.765)			
1/ members				45.853***	
				(4.346)	
Members^2					0.340***
(ln, x_1 dev. $\vert p < x_1$)					(0.041)
Members^2					0.012*
(ln, x_1 dev. $\vert p \geq x_1$)					(0.007)
Outsourcing	0.270***	0.270***	0.270***	0.273***	0.270***
	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
Reinsured	-0.034***	-0.035***	-0.035***	-0.034***	-0.035***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Assets per member	0.082**	0.064*	0.065*	0.066*	0.064*
(€million)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
% Pensioners	1.665***	1.718***	1.716***	1.714***	1.727***
	(0.129)	(0.128)	(0.128)	(0.128)	(0.127)
% Inactive members	0.440***	0.453***	0.450***	0.453***	0.441***
	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)
Constant	-4.362	-14.951	-11.116	-5.017	-4.387
	(0.148)	(5.247)	(1.049)	(0.174)	(0.269)
σ_u^2 (inefficiency)	10.501	10.053	10.055	9.981	10.056
	(0.625)	(0.602)	(0.602)	(0.593)	(0.600)
σ_v^2 (random shocks)	0.234	0.234	0.234	0.234	0.234
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
R^2	0.672	0.674	0.673	0.673	0.654
Akaike's IC	11,921	11,889	11,887	11,889	11,881
Wald test[a]	119***	195***	199***	227***	240***
First derivatives	$0.807 + 2 * 0.034 * (lnp - \overline{lnp})$	$1.525 - 2 * 0.045 * (lnp - \overline{lnp}) - 42.992/(lnp)^2 + 2 * 26.557/(lnp)^3$	$1.299 - 2 * 0.027 * (lnp- - \overline{lnp} - 23.469/(lnp)^2$	$0.905 - 45.853/p$	$0.816 + (0.340 \vert p < x1) * (lnp - lnx_1) - (0.012 \vert p \geq x_1) * (lnp - lnx_1)$
Cost elasticity at $\overline{lnp}$	0.807	0.866	0.908	0.885	0.870
X-efficiency:					
Average	0.213	0.222	0.221	0.221	0.221
25th percentile	0.103	0.110	0.110	0.111	0.110
Median	0.166	0.177	0.176	0.178	0.176
75th percentile	0.271	0.287	0.285	0.284	0.283

Notes: p = number members. Number of observations = 6,087, number of pension funds = 797, $\overline{lnp}$ = ln(2,316). Break point $ln\, x_{1,p} = 5.5$ is equal to 235 members. [a]Wald test for Constant Returns to Scale Hypothesis: coefficient of ln(partipants) and ln(total assets) = 1 and coefficient(s) of non-linear term(s) of ln(members) and ln(total assets) and the interaction term = 0. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

the sample size range. This outcome illustrates how the restrictive parabolic TCF forms may wrongly dictate the existence of an optimal scale, and hence diseconomies of scale beyond that size, which is our key reason for using more flexible alternative cost functions.

Figure 4.7: Cost elasticity across pension fund size classes for five administrative cost functions (2002 - 2013)



Notes: Cost elasticities below 1 indicate economies of scale. Grey bars give frequency distribution of observed pension fund sizes.

The impact of pension fund characteristics on costs

The SCFA model with a single quadratic spline functional costs form has the lowest AIC. This section discusses the corresponding estimation results in Table 4.4, Column 5, to explain the effect of pension fund characteristics on administrative costs. Although SCFA was selected as the preferred method, most outcomes deviate hardly or not at all from those of the other functional forms, indicating that the results are robust for the selected functional form of costs.

For the (geometric) average number of members, administrative costs increase on average by 0.87% if the number of members increase by 1%, resulting in lower average costs per member. Beyond the breakpoint of 245 members the quadratic effect of the number of members is no longer significant at the 5% level ($p = 0.072$), indicating that no evidence exists that the cost elasticity changes with size beyond this point.

Pension funds that outsource more of their activities have higher reported costs. As oursourcing costs will be administered more accurately than internal costs, it is likely that this effect indicates that outsourcing goes hand in hand with less under-reporting, rather than showing a true cost effect. As under-reporting will mostly affect small, company, pension funds (especially wages and rents of premises, which are sometimes allocated to the sponsoring company), true economies of scale may be even larger. In addition, pension funds that re-insure larger parts of their liabilities have lower average costs. According to the regression results costs in the cost frontier are higher for inactive and retired members. Although higher proportions of inactive or retired members may represent inactive funds (which can be relatively more expensive to operate), the effect-sign is not intuitive and the results are inconsistent. Analysing the variation of these variables shows that the variation between pension funds is far larger than for a given pension fund over time. It is likely that part of this age distribution effect is captured by the time constant X-inefficiency estimates. We will therefore also analyse the correlation of X-efficiency with the type of pension fund member (*e.g.*, active, passive or retired) below.

X-efficiency of administrative costs

The average X-efficiency of pension funds for the QSF specification is 0.221. Hence, most X-inefficiency estimates are very large. In interpreting this high level we should realise that these estimates incorporate all pension fund characteristics which differ across pension funds, but are (mostly) constant over time. We will therefore take a closer look at X-efficiency and the effect of these constant characteristics on X-efficiency.

X-inefficiency in this case not only covers managerial inabilities (reflecting less optimal input and output choices, as in the classic interpretation) but also heterogeneity across pension funds in terms of complexity of pension plans, defined benefits versus defined contribution, service level for members, etc. Inefficiencies also include institutional obstacles to achieving the lowest possible cost levels, such as pension fund types mandated by collective labour agreements. Finally, any under-reporting of costs may also affect X-inefficiency estimates.

X-efficiency estimates presented in Table 4.4 are substantially lower than those found for most other financial institutes such as banks (Mester, 1996) and mutual funds (Annaert et al., 2003), where under-reporting is most probably more limited. And strong links with other institutes, like company pension funds have with their sponsors are absent. X-efficiency is higher on average for pension funds with defined contribution schemes (0.218) than for those with defined benefit schemes (0.222). mandatory industry-wide funds are on average most X-efficient (0.291), followed by non-mandatory industry funds (0.217), company funds (0.215), and professional group funds (0.169).

Figure 4.8 shows the average X-efficiency for different size categories. Interestingly, both the smallest and largest pension funds in terms of members have the highest X-efficiency. Pension funds that are in between (the majority of pension funds) are least X-efficient. We do not have clear explanations for these phenomena. A general argument may be that medium-sized pension funds are more heterogeneous. These pension funds more often vary in the type of fund and the type of pension plan they offer, which may also lead to larger discrepancies in terms of performance.

Figure 4.8: Average X-efficiency for different size categories

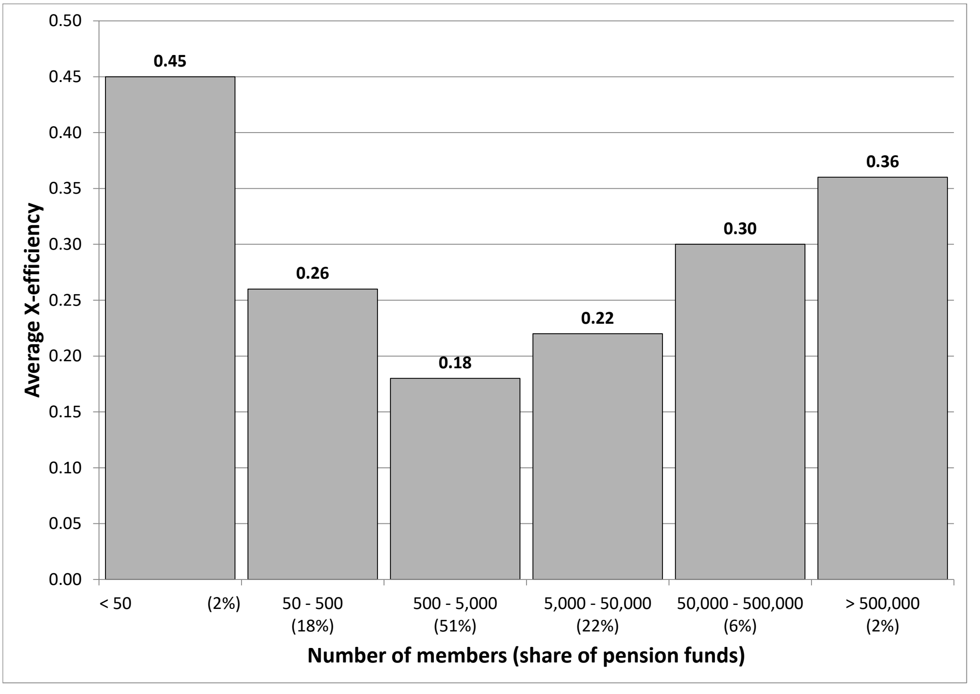


Table 4.5 shows regression results of various pension fund characteristics on X-efficiency estimates. As said before, characteristics that are (mostly) constant over time cannot be adequately distinguished from X-inefficiency in our model. The type of pension fund, and type of pension fund member, only change very little over time for a given pension fund, and are consequently included in the X-inefficiency estimates. Industry funds on average have higher X-efficiency estimates than professional group funds and company funds, and are therefore less expensive to operate, which may reflect the complexity of operating different types of pension funds (Bikker et al., 2012). Pension funds with higher ratios of pensioners and inactive members are on average more X-efficient. Combining these results with those in Table 4.4 gives mixed results, meaning that we are unable to make any strong statements about pension fund members. The number of members has both substantial within variation and between variation. So in addition to the effect of economies of scale, larger pension funds tend to be more X-efficient. These pension funds are likely to be more closely supervised, and therefore are, on average, closer to best practice performance.

Table 4.5: Administrative costs X-efficiency explained (2002-2013)

Members (*in logarithms*)	-0.011***	(0.001)
Members^2 (*ln, mean dev.*)	0.007***	(0.000)
Industry fund (mandatory)	0.088***	(0.014)
Industry fund (non-mandatory)	0.061***	(0.017)
Company fund	0.039***	(0.011)
Professional group fund	0.043**	(0.019)
Pension plan: defined contribution	0.014**	(0.006)
Outsourcing	-0.098***	(0.008)
Reinsured	0.013***	(0.004)
Assets per member (€*million*)	-0.053***	(0.006)
% Pensioners	0.225***	(0.013)
% Inactive members	0.230***	(0.013)
Constant	0.134***	(0.015)
R^2	0.194	

Notes: Number of observations = 6,087, $\overline{lnp}$ = ln(2,316). Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

4.5.5 Developments in inefficiency over time

Over the past two decades, pension funds faced a number of changes. The number of pension funds has decreased rapidly, and given the growing population of pension beneficiaries, the average number of members per pension fund has increased even faster as a result. Pension funds also faced changes in regulations and new production technologies, particularly IT developments, and mass communication through the internet. This may have lowered marginal costs, and raised fixed costs, thereby pushing the optimal size to a higher level. Applying the preferred approach (SCFA) and functional form (QSF), Table 4.6 presents regression results for four sub-periods over the past two decades to illustrate possible changes in inefficiency over time, while Figure 4.9 shows the cost elasticities that follow from the regression results for a range of pension fund sizes.

The optimal break point (that corresponds with the lowest value of AIC) varies across the different sub-periods, which confirms that the shape of the cost function has changed over time. Average X-efficiency is lower (σ_u^2 higher) in the two most recent periods, which may indicate that either inefficiency or heterogeneity has increased. For the three most recent periods, the cost elasticities are somewhat similar, while the first period differs strongly, with large economies of scale for small pension funds and large diseconomies of scale for larger pension funds. We see that most coefficients of pension fund characteristics fluctuate over time, without showing a clear trend. The coefficient for outsourcing has become insignificant in the most recent period, this coincides with the introduction of the FTK in 2006, which went hand in hand with stricter data reporting requirements.

In the regressions of Table 4.6, X-efficiency is assumed to be constant for the sub-periods of between five and six years, instead of the 12 years for the main analysis. This less restrictive assumption results in lower X-inefficiency estimates. The correlation results in Table 4.6 show that X-efficiency of pension funds more or less correlates over two subsequent periods (10-12 year). However, these correlations become smaller or even negative when periods are more apart, indicating that the X-efficiency levels are on average not maintained for longer periods than 10 to 12 years.

Figure 4.9: Cost elasticity for four sub-periods

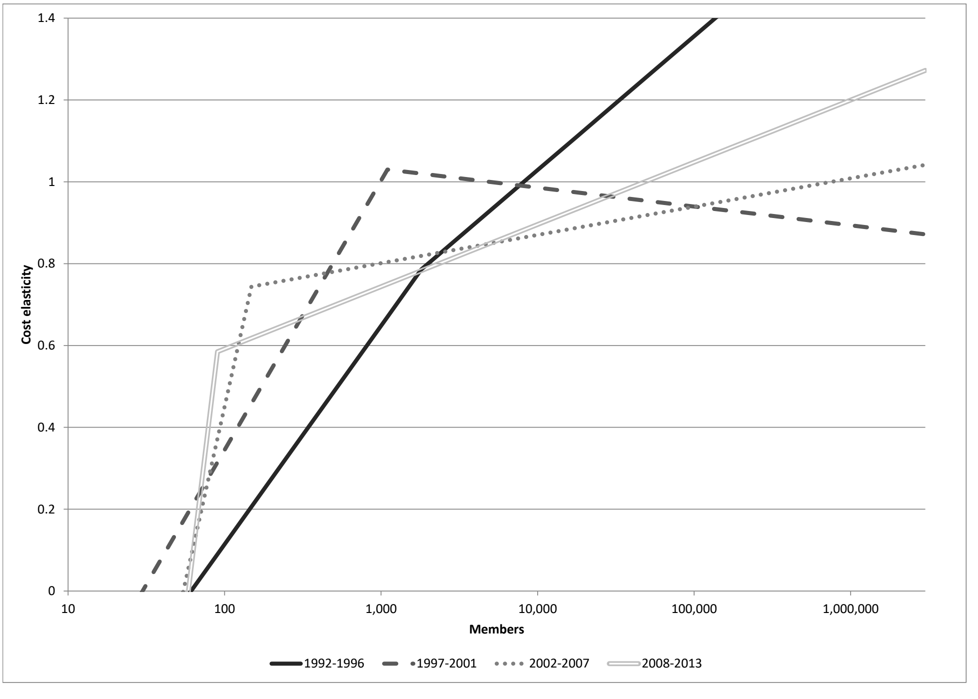


Table 4.6: Administrative costs estimation for four sub-periods

Variables	(1) **1992-1996**#	(2) **1997-2001**	(3) **2002-2007**	(4) **2008-2013**
Break point	$lnx_1 = 7.5$	$lnx_1 = 7.0$	$lnx_1 = 5.0$	$lnx_1 = 4.5$
Members	0.786***	1.030***	0.744***	0.585***
(in logarithms)	(0.047)	(0.048)	(0.054)	(0.081)
members^2	0.116	0.143***	0.371***	0.684
(ln, x_1 dev. $\mid < x_1$)	(0.013)	(0.016)	(0.071)	(0.511)
Members^2	0.071***	-0.010	0.015*	0.033***
(ln, x_1 dev. $\mid \geq x_1$)	(0.012)	(0.013)	(0.008)	(0.010)
Outsourcing	0.493***	0.987***	0.377***	0.048
	(0.077)	(0.084)	(0.058)	(0.045)
Reinsured	0.048	-0.434***	-0.153***	-0.009
	(0.060)	(0.061)	(0.029)	(0.008)
Assets per member	1.315***	1.229***	1.178***	-0.066***
(€million)	(0.125)	(0.155)	(0.152)	(0.025)
% Pensioners	0.508***	1.275***	1.250***	1.157***
	(0.133)	(0.191)	(0.186)	(0.227)
% Inactive members	-0.075	0.372***	0.158	0.101
	(0.119)	(0.139)	(0.103)	(0.135)
Constant	-4.488***	-5.950***	-3.781***	-2.637***
	(0.334)	(0.345)	(0.333)	(0.513)
Number of observations	3,549	3,696	3,767	2,320
Number of pension funds	852	900	785	495
σ_u^2 (*inefficiency*)	8.182	6.855	9.698	11.642
	(0.459)	(0.430)	(0.620)	(0.895)
σ_v^2 (*random shocks*)	0.226	0.355	0.214	0.088
	(0.006)	(0.010)	(0.006)	(0.003)
R^2	0.753	0.634	0.650	0.695
Wald test[a]	676***	193***	121***	45***
First derivatives	0.786	1.030	0.744	0.585
$p \leq x_1$	$+2*0.116*$	$+2*0.143*$	$+2*0.371*$	$+2*0.684*$
	$(lnp - lnx_1)$	$(lnp - lnx_1)$	$(lnp - lnx_1)$	$(lnp - lnx_1)$
$p > x_1$	$+2*0.071*$	$-2*0.010*$	$+2*0.015*$	$+2*0.033*$
	$(lnp - lnx_1)$	$(lnp - lnx_1)$	$(lnp - lnx_1)$	$(lnp - lnx_1)$
Cost elasticity at $\overline{lnp}$	0.786	1.020	0.819	0.783
X-efficiency:				
Average	0.439	0.483	0.378	0.388
25th percentile	0.259	0.340	0.260	0.291
Median	0.412	0.466	0.370	0.388
75th percentile	0.604	0.617	0.483	0.478
Correlation X-efficiency:				
1992-1996	-	0.412	-0.248	-0.303
1997-2001	0.412	-	0.188	-0.315
2002-2007	-0.248	0.188	-	0.400
2008-2013	-0.303	-0.0315	0.400	-
2002-2013	-0.307	-0.015	0.883	0.732

Notes: p = number of members, $\overline{lnp}$ = ln(2,316). Break points $ln\,x_1 = 4.5$, $ln\,x_1 = 5.0$, $ln\,x_1 = 7.0$ and $ln\,x_1 = 7.5$ are equal to 90, 148, 1,097 and 1,808 members respectively. [a]Wald test for Constant Returns to Scale Hypothesis: coefficient of ln(partipants) = 1 and coefficient(s) of non-linear term(s) of ln(members) = 0. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

4.5.6 Auditing and management costs

Administrative costs are related to activities, such as administration of members' entitlements and received premiums, communication with members, and the board of the pension fund. Pension funds in our data set were asked to report to the external supervisors a number of separate administrative cost components, among which their auditing and management costs, internal and external administration costs and wage and other staff costs.

Separate cost components may have their own X-efficiency and economies of scale levels. Table 4.7 presents the estimation results for two clearly defined cost components[14] Not all pension funds reported costs for these two separate components, meaning that the number of observations for these components is lower than for total administrative costs. Both auditing and management costs show unused scale economies of about four times larger at the mean size than those for total administrative costs. Both types of costs are associated with substantial fixed costs, such as the minimum size of a pension fund board and the minimum activities of external accountants, which explains the existence of substantial economies of scale. The effects on costs of other pension fund characteristics are very similar to the effect on total administrative costs, with outsourcing acting as a negative proxy for under-reporting and without consistent trends for the other characteristics.

Median X-efficiency estimates for these costs components are substantially higher than they are for total administrative costs. Possibly, these subcategory activities are more homogeneous. We also expect that these cost components are less affected by under-reporting, as pension funds were included in the sample only if they report these costs. Note that under-reporting concerns particularly wages and rents of premises.

[14] Other cost components, such as wage and other costs, vary widely between pension funds, which probably indicates that these cost categories do not encompass the same activities for each pension fund.

Table 4.7: Auditing and management costs estimation (2002-2013)

Variables	(1) **Auditing costs**		(2) **Management costs**	
Break point	$lnx_1 = 5.5$		$lnx_1 = 6.0$	
Members *(in logarithms)*	0.750***	(0.042)	0.365***	(0.072)
Members^2 *(ln, x_1 dev. $\mid < x_1$)*	0.454***	(0.093)	-0.063	(0.099)
Members^2 *(ln, x_1 dev. $\mid x_1 - x_2$)*	-0.032***	(0.005)	0.020*	(0.011)
Outsourcing	-0.367***	(0.005)	0.509***	(0.093)
Reinsured	0.000	(0.014)	0.015	(0.023)
Assets per member (€million)	0.058*	(0.032)	2.917***	(0.242)
% Pensioners	1.788***	(0.119)	2.081***	(0.252)
% Inactive members	0.679***	(0.084)	0.947***	(0.1956
Constant	-2.748	(0.262)	-2.938	(0.531)
Number of observations	5,445		3,003	
Number of pension funds	739		473	
σ_u^2 (*inefficiency*)	3.685	(0.261)	4.351	(0.399)
σ_v^2 (*random shocks*)	0.300	(0.006)	0.781	(0.022)
R^2	0.637		0.708	
Wald test[a]	1,259***		375***	
First derivatives	0.750		0.365	
$p \leq x_1$	$+2 * 0.454 * (lnp - lnx_1)$		$-2 * 0.063 * (lnp - lnx_1)$	
$p > x_1$	$-2 * 0.032 * (lnp - lnx_1)$		$+2 * 0.020 * (lnp - lnx_1)$	
Cost elasticity at $\overline{lnp}$	0.542		0.435	
X-efficiency:				
Average	0.451		0.593	
25th percentile	0.277		0.379	
Median	0.410		0.657	
75th percentile	0.614		0.812	

Notes: p = number of members, $\overline{lnp} = \ln(2{,}316)$. Break points $ln\, x_1 = 5.5$ and $ln\, x_1 = 6.0$ are equal to 235 and 403 members respectively. [a]Wald test for Constant Returns to Scale Hypothesis: coefficient of ln(partipants) = 1 and coefficient(s) of non-linear term(s) of ln(members) = 0. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

4.6 Investment costs

Management of investments is a core task of pension funds, besides administration. These activities are often outsourced to specialist investment managers, but we will analyse investment costs irrespectively of whether investments are managed internally or externally. Explaining investment costs requires a different model: scale in investments is best described by total assets under management, as investment activities are related to the asset portfolio rather than the number of members. In addition, investment allocation to different asset classes is expected to influence costs and may therefore be an important determinant. More complex asset classes, such as equity, hedge funds, commodities and real estate, will have higher expected returns, but they also have higher fund selection and risk management costs compared to fixed income investment (Bikker, 2017). This means that higher costs are not necessarily bad, but this makes it more difficult to estimate an optimal size with respect to investment costs, as higher costs may go accompanied by higher returns. Most other pension fund-specific characteristics included in our previous analysis may remain relevant for investment costs analysis. As some pension funds do not report investment costs, the number of observations for investment costs is lower. Key statistics of the relevant variables are summarised in Table 4.1. We followed the strategy from Section 4.5, first investigating parametric and non-parametric approaches, and then examining functional forms. Table 4.8 presents for investment costs the SCFA and LRM estimation results, similar to Table 4.2 for administrative costs. Table 4.9 presents the non-parametric estimation of investment costs: FDH and Order$-\alpha$, similar to Table 4.3 for administrative costs.

The estimation results for LRM and SCFA are again quite similar, with an approximately equal cost elasticity at the mean (0.988 and 0.952 respectively), and fairly equal optimal sizes (€223 and €220 million respectively). LRM can include variables that are constant over time, such as pension fund type.

For the non-parametric results, FDH X-efficiency is strongly affected by size, but is not significantly correlated with most other pension fund characteristics. Also FDH X-efficiency is again very low on average, so comparable to the administrative costs results. The results for investment costs are presumably affected by the presence of under-reporting for some pension funds, *e.g.*, for some pension funds the external asset managers have netted investment costs with investment returns. Order$-\alpha$ (with $\alpha = 95$) results in higher X-efficiency scores and more significant variables.

X-efficiency estimates are relatively robust for the selected method, with Spearman rank correlations ranging between 54% and 67%. As we did for administrative costs, we again selected SCFA as our preferred method for estimating investment costs. It is least sensitive to outliers (*e.g.*, due to under-reporting) and can incorporate pension fund characteristics, in particular the asset allocation variables into the cost function, which are therefore not included in the inefficiency term.

Table 4.8: Results of parametric models for investment costs (2002-2013)

Variables	(1) **LRM**		(2) **SCFA**	
Total assets *(€1,000, in logarithms)*	0.988***	(0.012)	0.952***	(0.022)
Total assets^2 *(in ln, mean dev.)*	0.011***	(0.003)	0.045***	(0.005)
Industry fund (mandatory)	-0.438***	(0.107)		
Industry fund (non-mandatory)	-0.322**	(0.132)		
Company fund	-0.341***	(0.132)		
Professional group fund	0.298**	(0.146)		
Pension plan: defined contribution	0.111**	(0.051)		
Assets per member *(€million)*	-0.066	(0.099)	-0.202	(0.143)
% Pensioners	0.163	(0.111)	0.178	(0.184)
% Inactive members	0.606***	(0.114)	0.565***	(0.143)
Investments:				
Equity	0.421***	(0.135)	-0.147	(0.139)
Real estate	1.577***	(0.326)	0.730*	(0.408)
Fixed income	0.209*	(0.112)	0.264**	(0.110)
Constant	-6.916***	(0.184)	-8.361***	(0.261)
σ_u^2 (*inefficiency*)			3.042	(0.259)
σ_v^2 (*random shocks*)			0.661	(0.016)
R^2	0.746		0.738	
First derivatives	$0.988 + 2 * 0.011 * (lnta - \overline{lnta})$		$0.952 + 2 * 0.045 * (lnta - \overline{lnta})$	
Cost elasticity at $\overline{lnta}$	0.988		0.952	
X-efficiency:				
Average			0.372	
25th percentile			0.213	
Median			0.337	
75th percentile			0.484	

Notes: ta = value of total assets. Number of observations = 4,498, number of pension funds = 646, $\overline{ln\,ta}$ = ln(€1,291 million). Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

Table 4.9: Results of non-parametric models for investment costs (2002-2013)

Variables	(1) FDH		(2) Order$-\alpha$, $\alpha = 95$	
X-efficiency:				
Average	0.057		0.446	
25th percentile	0.004		0.188	
Median	0.010		0.314	
75th percentile	0.034		0.689	
Total assets *(€1,000, in logarithms)*	-0.021***	(0.001)	-0.009***	(0.003)
Total assets ^{2} *(in ln, mean dev.)*	0.015***	(0.000)	0.012***	(0.001)
Industry fund (mandatory)	0.025***	(0.012)	0.171***	(0.030)
Industry fund (non-mandatory)	-0.018	(0.015)	0.102***	(0.037)
Company fund	0.022**	(0.011)	0.125***	(0.027)
Professional group fund	-0.019	(0.017)	-0.049	(0.041)
Pension plan: defined contribution	0.009	(0.006)	-0.008	(0.041)
Assets per member *(€million)*	0.009	(0.011)	0.050	(0.028)
% Pensioners	-0.003	(0.013)	0.003	(0.031)
% Inactive members	0.013	(0.013)	-0.216***	(0.032)
Investments:				
Equity	-0.005	(0.015)	-0.101***	(0.038)
Real estate	-0.056	(0.037)	-0.329***	(0.092)
Fixed income	-0.015	(0.013)	-0.119***	(0.032)
Constant	0.257***	(0.021)	0.595***	(0.052)
Adjusted R^2	0.270		0.063	

Notes: Number of observations = 4,498, number of pension funds = 646, $\overline{ln\,ta}$ = €1,291 million. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01

4.6.1 Functional form of investment costs

As in the administrative costs analysis in Section 4.5.4, we applied TCF, (S)ULF, HACD and QSF to investment costs. The results are presented in Table 4.10, where the number of break points and their locations are selected by minimising AIC. Figure 4.10 shows the cost elasticities that follow from the five cost functions. Both the average X-efficiency that follows from the five functional forms of investment and the implied cost elasticities differ only slightly across the specifications. The results are therefore relatively robust for the choice of functional form of investment costs.

Using AIC we found that QSF, with a single break point at total assets of €800 million total assets, best describes investment costs. This functional form suggests that the cost elasticity of investment costs increases up to the break point, and decreases after this point (the coefficient after the breakpoint is not significantly different from zero). The majority of pension funds (55.7%) investment activities operate under implied decreasing returns to scale (cost elasticity > 1), which is markedly different from administrative activities. The coefficients of type of member and investment allocation give non-intuitive results. These variables vary between pension funds, but relatively little over time for a given pension fund. The effect of these variables is therefore difficult to distinguish from inefficiency, which is also assumed to be constant over short periods. As the combined results (of u and v) give ambiguous results, no strong conclusions can be made from them. These characteristics are analysed in the next section (X-efficiency of investment costs). The value of average assets per member does not appear to be relevant for pension fund investment costs.

The cost elasticity at the mean level of total assets is 1.002, and higher for larger portfolio's due to the quadratic effect. This means that increases in total assets will give, although not statistically significant, a more than proportional increase in investment costs. However, larger pension funds may invest in more complex assets, and may invest more actively. This has higher costs, but also yields higher (expected) returns. Higher costs due to more complex investments by larger pension funds therefore does not necessarily imply that larger funds have lower efficiency.

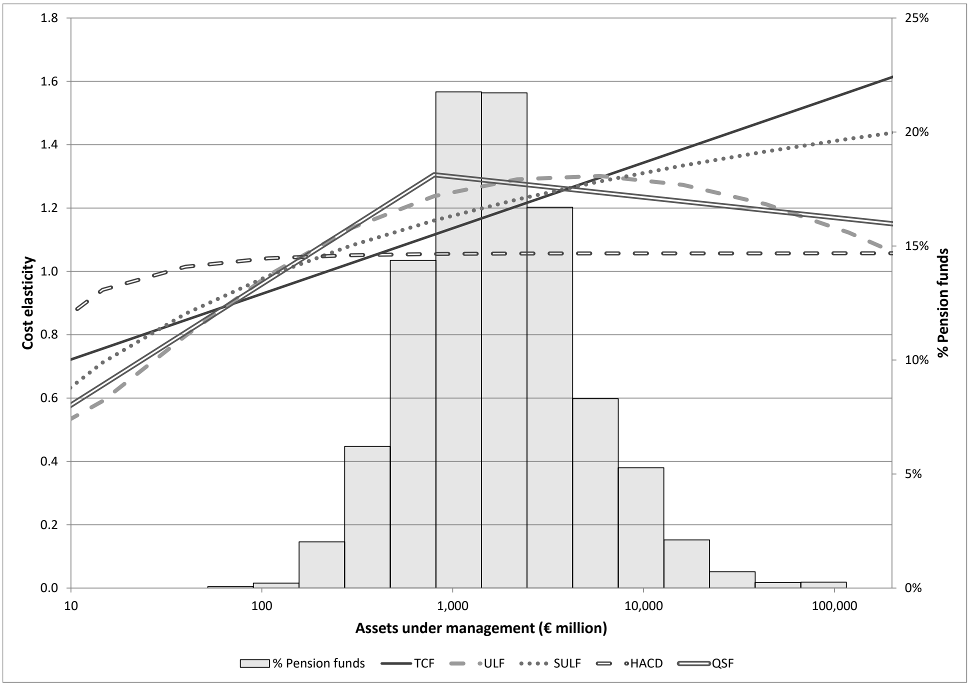
As the cost elasticity for investment costs is markedly different from that of administrative costs, pension funds may have economies of scale in administrative costs, while facing diseconomies of scale in investment costs. Section 4.7 analyses total costs, using both the number of members and total assets as output indicators to obtain an overall view on the optimal scale.

Table 4.10: Estimates of five functional forms of investment costs (2002 - 2013)

Variables	(1) **TCF**	(2) **ULF**	(3) **SULF**	(4) **HACD**	(5) **QSF**
Break point					$ln\, x_1 = 20.5$
Total assets	0.952***	5.466***	1.513***	1.057***	1.305***
(€1,000, in logarithms)	(0.022)	(1.433)	(0.212)	(0.025)	(0.048)
Total assets^2	0.045***	-0.151**	0.008		
(in ln, mean dev.)	(0.005)	(0.060)	(0.015)		
Total assets^2					0.083***
(ln, x_1 dev. $\mid < x_1$)					(0.010)
Total assets^2					-0.014
(ln, x_1 dev. $\mid x_1 - x_2$)					(0.019)
1 / (ln total assets)		1,088.582***	70.768***		
		(366.860)	(26.497)		
1 / (ln total assets)^2		-2,779.579***			
		(1,005.218)			
1 / total assets				1,688.651***	
				(310.788)	
Assets per member	-0.202	-0.200	-0.181	-0.205	-0.193
(€million)	(0.143)	(0.143)	(0.143)	(0.144)	(0.142)
% Pensioners	0.178	0.158	0.165	0.098	0.167
	(0.184)	(0.182)	(0.182)	(0.184)	(0.182)
% Inactive members	0.565***	0.559***	0.560***	0.485***	0.557***
	(0.143)	(0.142)	(0.142)	(0.142)	(0.142)
Investments:					
Equity	-0.147	-0.105	-0.135	-0.178	-0.111
	(0.139)	(0.138)	(0.139)	(0.141)	(0.138)
Real estate	0.730*	0.601	0.643	0.817**	0.583
	(0.408)	(0.412)	(0.410)	(0.407)	(0.412)
Fixed income	0.264**	0.270**	0.261**	0.233**	0.267**
	(0.110)	(0.110)	(0.110)	(0.112)	(0.110)
Constant	-8.361	-133.982	-20.975	-9.417	-12.849
	(0.261)	(40.815)	(4.739)	(0.309)	(0.623)
σ_u^2 *(inefficiency)*	3.042	2.995	2.996	2.981	2.966
	(0.259)	(0.252)	(0.255)	(0.256)	(0.251)
σ_v^2 *(random shocks)*	0.661	0.661	0.661	0.670	0.660
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
R^2	0.733	0.731	0.733	0.734	0.730
Akaike's IC	12,340	12,328	12,336	12,380	12,325
Wald test[a]	106***	97***	105***	30***	96***
First derivatives	$0.952 + 2* 0.045 (ln\,ta - \overline{ln\,ta})$	$5.466 - 2* 0.151 (ln\,ta - \overline{ln\,ta}) - 1,088.582/(ln\,ta)^2 + 2* 2,779.579/(ln\,ta)^3$	$1.513 + 2* 0.008 (ln\,ta - \overline{ln\,ta}) - 70.768/(ln\,ta)^2$	$1.057 - 1,688.651/ta$	$1.305 + [2* 0.083 (ln\,ta - x_1) \mid ta \le x_1] - [2* 0.014 (ln\,ta - x_1) \mid ta > x_1]$
Cost elasticity at mean	0.952	1.017	1.004	1.057	1.002
X-efficiency:					
Average	0.372	0.381	0.378	0.377	0.382
25th percentile	0.213	0.214	0.211	0.216	0.217
Median	0.337	0.339	0.341	0.343	0.341
75th percentile	0.484	0.504	0.496	0.494	0.509

Notes: ta = value of total assets. Number of observations = 4,498, number of pension funds = 646, $\overline{ln\,ta}$ = ln(€1,291 million). Break point $lnx_1 = 20.5$ is at €800 million total assets. [a]Wald test for Constant Returns to Scale Hypothesis: coefficient of ln(total assets) = 1 and coefficient(s) of non-linear term(s) of ln(total assets) = 0. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01

Figure 4.10: Cost elasticity for five investment cost functions (2002-2013)



X-efficiency of investment costs

Table 4.11 below shows a regression analysis explaining X-inefficiency output from the QSF estimation. The type of pension fund, which could not be included in the cost function, shows that industry funds are more X-efficient while professional group funds are least efficient. Average X-efficiency is 0.341, which is higher than that for administrative costs (0.221). This indicates that investment costs are more level between pension funds than administrative costs.

Table 4.11: Investments X-efficiency explained (2002-2013)

Total assets *(€1,000, in logarithms)*	-0.008***	(0.002)
Total assets^2 *(in ln, mean dev.)*	0.009***	(0.001)
Industry fund (mandatory)	0.164***	(0.019)
Industry fund (non-mandatory)	0.114***	(0.024)
Company fund	0.134***	(0.017)
Professional group fund	0.034	(0.027)
Pension plan: defined contribution	-0.026***	(0.009)
Assets per member *(€million)*	-0.055***	(0.018)
% Pensioners	0.097***	(0.020)
% Inactive members	0.055***	(0.021)
Investments:		
Equities	-0.058**	(0.025)
Real estate	-0.022	(0.059)
Fixed income	0.008	(0.020)
Constant	0.293***	(0.033)
R^2	0.091	

Notes: Number of observations = 4,498, $\overline{ln\,ta}$ = ln(€1,291 million). Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

4.7 Total costs

The previous two sections show that administrative and investment costs have different optimal sizes. To find the overall results we combined both cost categories and analysed total costs. As both output measures, the number of members and total assets, are relevant in explaining total costs, we included them in the total cost function. In line with the previous findings, we applied a QSF SCFA for total costs, using the optimal break-points for the number of members (245 members; $ln\,x_{1,p}$) and total assets (€800 million; $ln\,x_{1,ta}$) obtained in the previous sections. In order to allow for possible output interaction effects we included an additional variable:

$$\text{Interaction members x total assets} = (ln\,p - ln\,x_{1,p}) * (ln\,ta - ln\,x_{1,ta}) \quad (4.5)$$

Table 4.12 shows the resulting coefficients for the quadratic spline function of total costs. The coefficients for total costs are all of similar sign and magnitude as found before. Average total costs initially rise substantially with increases in the number of members and/or total assets and smooth out with increases beyond both breaking points. The negative coefficient of the interaction effect shows that costs increase relatively stronger if one of the two output measures, number of members or total assets, outpaces the other

The cost elasticity at the average number of members (2.136) and for average total assets (€129 million) is 0.990, which indicates approximate constant returns to scale (not significantly different from 1). Average X-efficiency is 0.475 which indicates that the deviation in performance is smaller for total costs than for its two components (0.221 for administrative costs and 0.382 for investment costs).

Figure 4.11 shows a 3D graph of cost elasticity dependent on the number of members (Z axis) and total assets (X axis). Cost elasticity depends most strongly on the number of members and shows strong economies of scale for pension funds with a number of members or total assets up to the breaking points. After the breaking points cost elasticity is close to 1, indicating that there are few benefits to further increases in size.

Figure 4.11: 3D graph of cost elasticity for total costs

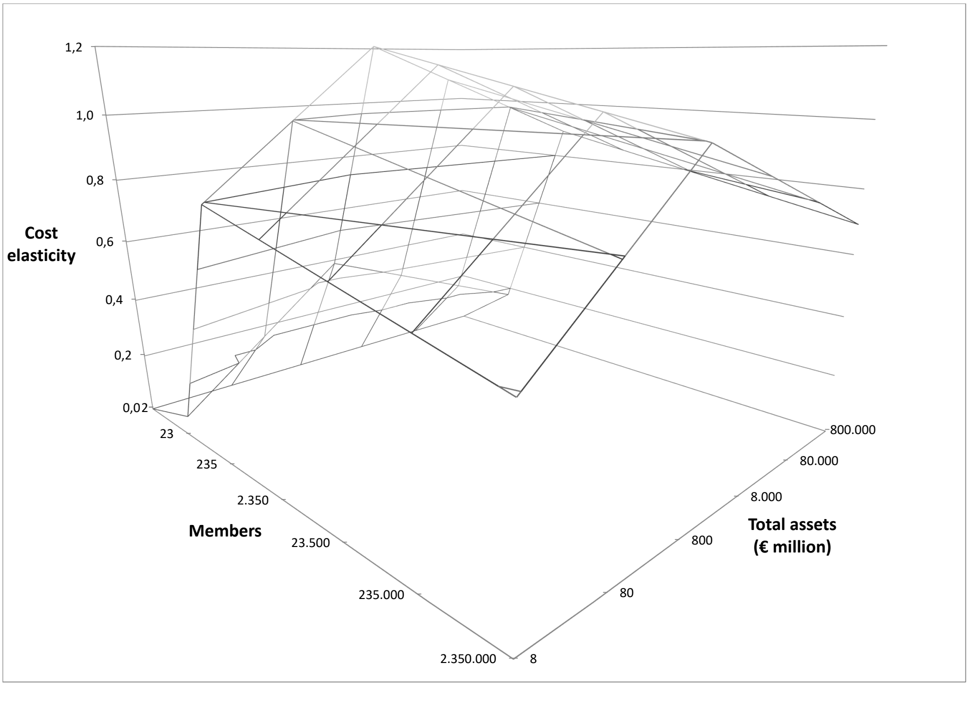


Table 4.12: Total costs quadratic spline estimation (2002-2013)

Variables	**SCFA**	
	$ln\, x_{1,p} = 5.5$	$ln\, x_{1,ta} = 20.5$
Members *(in logarithms)*	0.134*	(0.073)
Members^2 *(ln, $x_{1,p}$ dev. $\mid \leq x_{1,p}$)*	0.189***	(0.042)
Members^2 *(ln, $x_{1,p}$ dev. $\mid > x_{1,p}$)*	0.020**	(0.009)
Total assets *(€1,000, in logarithms)*	1.066***	(0.063)
Total assets^2 *(ln, $x_{1,ta}$ dev. $\mid \leq x_{1,ta}$)*	0.075***	(0.009)
Total assets^2 *(ln, $x_{1,ta}$ dev. $\mid > x_{1,ta}$)*	0.009	(0.017)
Interaction members x total assets *(ln, x_1 dev.)*	-0.062***	(0.012)
Outsourcing	0.307***	(0.034)
Reinsured	-0.014	(0.010)
% Pensioners	0.690***	(0.121)
% Inactive members	0.180**	(0.072)
Investments:		
Equities	-0.385***	(0.069)
Real estate	0.264	(0.182)
Fixed income	0.180***	(0.055)
Constant	-9.382***	(0.590)
σ_u^2 (*inefficiency*)	1.955***	(0.164)
σ_v^2 (*random shocks*)	0.132***	(0.003)
R^2	0.769	
Wald test[a]	5,007***	
First derivative	$1.200 + 2*0.189*(ln\, p - ln\, x_{1,p} \vert p \leq x_{1,p}) +$ $2*0.020*(ln\, p - ln\, x_{1,p} \vert p > x_{1,p}) +$ $2*0.075*(ln\, ta - ln\, x_{1,ta} \vert ta \leq x_{1,p}) +$ $2*0.009*(ln\, ta - ln\, x_{1,ta} \vert ta > x_{1,p}) -$ $0.062*(ln\, p - ln\, x_{1,p}) - 0.062*$ $(ln\, ta - ln\, x_{1,ta})$	
Cost elasticity at $\overline{ln\, p}$ and $\overline{ln\, ta}$	0.990	
X-efficiency:		
Average	0.475	
25th percentile	0.334	
Median	0.465	
75th percentile	0.612	

Notes: p = number of members, ta = value of total assets. Number of observations = 4,498, number of pension funds = 646, $\overline{lnp}$ = ln(2,316), $\overline{ln\, ta}$ = ln(€1,291 million). Break points $ln\, x_{1,p} = 5.5$ and $ln\, x_{1,ta} = 20.5$ are equal to 235 members and €800 million total assets respectively. [a]Wald test for Constant Returns to Scale Hypothesis: sum of coefficients of ln(partipants) and ln(total assets) = 1 and coefficient(s) of non-linear term(s) of ln(members) and ln(total assets) and the interaction term = 0. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

The analysis of total costs shows that small pension funds (below the breaking points) can benefit from reduced average costs by increasing the number of members and/or total assets, preferably both. Although the economies of scale smooth out after the breaking points, we found no (global) substantial diseconomies of scale for any size observed in our sample. Although there is no optimal size, the benefits of increasing pension fund size, either in the number of members or in the value of total assets, diminish towards the breaking points (235 members and €800 million total assets).

4.7.1 Total costs X-efficiency

Table 4.13 explains total costs X-efficiency by pension fund characteristics, which allows us to include pension fund type dummies and pension scheme dummies, which could not be estimated in the prior analysis. Mandatory industry pension funds and company pension funds are relatively X-efficient in terms of total costs, while professional group pension funds are again least efficient. Defined contribution plans are significantly less efficient (more costly) than defined benefit plans. The effect of size (in terms of number of members and value of total assets) follows a very flat inverse U-shaped relation. Initially, larger pension funds are more X-efficient, but later on (dependent on the interplay between the number of members and total assets) size decreases average X-efficiency again. For the other characteristics we found similar coefficients as for the administrative and investment costs models.

Table 4.13: Total costs X-efficiency explained (2002-2013)

Members (in logarithms)	0.061***	(0.012)
Members^2 (ln, x_1 dev. $\mid < x_1$)	0.020***	(0.005)
Members^2 (ln, x_1 dev. $\mid x_1 - x_2$)	-0.001	(0.001)
Total assets (€1,000, in logarithms)	0.015	(0.013)
Total assets^2 (ln, x_1 dev. $\mid < x_1$)	0.007***	(0.002)
Total assets^2 (ln, x_1 dev. $\mid x_1 - x_2$)	-0.023***	(0.002)
Interaction members x total assets *(ln, x_1 dev.)*	0.007***	(0.002)
Industry fund (mandatory)	0.081***	(0.017)
Industry fund (non-mandatory)	0.046**	(0.020)
Company fund	0.088***	(0.014)
Professional group fund	0.042*	(0.022)
Pension plan: defined contribution	-0.036***	(0.008)
Outsourcing	-0.026***	(0.010)
Reinsured	0.012***	(0.004)
% Pensioners	0.347***	(0.017)
% Inactive members	0.105***	(0.018)
Investments		
Equities	0.014	(0.020)
Real estate	0.244***	(0.049)
Fixed income	0.039**	(0.017)
Constant	-0.430***	(0.101)
R^2	0.323	

Notes: Number of observations = 4,494, $\overline{lnp}$ = ln(2,316), $\overline{ln\,ta}$ = ln(€1,291 million). Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

4.8 Summary and conclusion

Pension benefits not only depend on pension fund investment returns, but also on the costs incurred during the accumulation of pension capital. Higher costs reduce pension capital, and therefore depress final benefits. Substantial differences are found in per capita pension fund costs. We expect that these cannot be fully attributed to differences in quality of the services and thus may represent differences in efficiency of running the pension funds. We analysed the efficiency of the administrative and investment activities of Dutch pension funds by comparing the cost-output ratio of pension funds with best practice pension funds. The number of members and value of total assets were chosen as proxies for the output of the administration and investment activities respectively.

We measured X-efficiency by means of both a parametric method and a non-parametric method. SCFA was selected as preferred research method for both administrative and investment activities as it can explicitly incorporate random noise, such as measurement error, and allows for incorporation of pension fund characteristics, such as type of member and reinsurance of pension rights. Five functional cost models were applied to investigate the complex relation between size and output. For both activities the estimation results are relatively robust across functional forms; a QSF with a single break-point best describes administrative and investment costs.

For administrative costs we found a cost elasticity of below 1 for the vast majority of pension fund sizes, indicating economies of scale on administrative costs. Only 11 pension funds (118 observations) are above the implied optimal size of 52,650 members. We found that industry funds are the most efficiency and professional group funds are the least efficient. Higher levels of outsourcing and reinsurance correlate with higher and lower costs, respectively. Outsourcing may indicate under-reporting, so that the coefficient of outsourcing partly acts as a negative proxy to under-reporting. Note that under-reporting means that economies of scale are even larger than observed, leaving the recommendation of consolidation unchanged.

Auditing and governance costs, two components of administrative costs, have larger unused scale efficiencies, and lower average X-inefficiencies. They have large fixed costs components and therefore benefit more strongly from scale increases. From the perspective of administrative costs, pension funds would benefit from consolidation.

For investments costs we found substantially higher cost elasticities. This implies that the majority of pension funds (pension funds with total assets below €127 million) have disecononomies of scale for investment activities. However, as larger pension funds may invest in more complex asset classes (which have higher costs, but also higher expected returns), this may not necessarily be a bad situation. The same as for administrative costs industry funds have the lowest investment costs, and professional group funds the highest.

As administrative and investment costs have different economies of scale estimates we also analysed their sum: total costs. We found a cost elasticity close to 1 for average sized pension funds (in terms of members and total assets). Smaller funds have unused economies of scale, pension funds beyond the breaking points (235 members and €800 million total assets) fluctuate around constant returns to scale.

From the perspective of efficiency, it seems desirable for smaller pension funds to consolidate, but for medium-sized and larger pension funds, no scale-economy benefits can be achieved. Within each size class, large differences in efficiency remain, however.

Appendix 4.1: Quadratic spline cost functions

This appendix briefly discusses the functional forms and empirical results of the quadratic spline functions (QSF) with one, two and three break-poins.

Appendix 4.1.1: Functional forms

Single spline

The single quadratic spline cost function has a spline at x_1. This gives the following cost function:

$$lnAC(o) = \alpha + \beta_1(ln\,o) + \beta_2[(ln\,o - ln\,x_1)^2|_{o\leq x_1}] + \beta_3[(ln\,o - ln\,x_1)^2|_{o>x_1}] \\ + \beta_4(plan\,characteristics) \tag{4.6}$$

The first derivative (cost elasticity) with respect to o gives:

$$= \beta_1 + [2\beta_2(ln\,o - ln\,x_1)|_{o\leq x_1}] + [2 * \beta_3[((ln\,o - ln\,x_1)|_{o>x_1}] \tag{4.7}$$

Double spline

For the double quadratic spline cost function a constraint is necessary to prevent the cost elasticity from being discontinuous in x_2.

$$\triangleright With \quad \beta_2 = (\beta_4 - \beta_5) * (ln\,x_2 - ln\,x_1) * 2 \\ lnAC(o) = \alpha + \beta_1(ln\,o) + \beta_2(ln\,o|_{o>x_2}) + \beta_3[(ln\,o - ln\,x_1)^2|_{o<x_1}] + \\ \beta_4[(ln\,o - ln\,x_1)^2|_{x_1<o<x_2}] + \beta_5[(ln\,o - ln\,x_1)^2|_{x_2>o}] + \beta_6(plan\,characteristics) \tag{4.8}$$

This equals:

$$lnAC(o) = \alpha + \beta_1(ln\, o) + \beta_2[(ln\, o - ln\, x_1)^2|_{o \leq x_1}] + \beta_3[(ln\, o - ln\, x_1)^2|_{x_1 < o \leq x_2}] + [2(\beta_3 - \beta_4)(ln\, x_2 - ln\, x_1)](ln\, o|_{o > x_2}) + \beta_4[(ln\, o - ln\, x_1)^2|_{x_2 > o}] + \beta_5(plan\, characteristics) \tag{4.9}$$

And gives the first derivative:

$$= \beta_1 + 2\beta_2[(ln\, o - ln\, x_1)|_{o \leq x_1}] + 2\beta_3[(ln\, o - ln\, x_1)|_{x_1 < o \leq x_2}] + [2(\beta_3 - \beta_4)(ln\, x_2 - ln\, x_1)|_{o > x_2}] + 2\beta_4[(ln\, o - ln\, x_1)|_{x_2 > o}]) \tag{4.10}$$

Triple spline

Finally, two constraints are necessary to prevent points of discontinuity in the triple quadratic spline function in x_2 and x_3 respectively.

$$\triangleright With \quad \beta_2 = (\beta_5 - \beta_6) * (ln\, x_2 - ln\, x_1) * 2, \quad and$$
$$\triangleright With \quad \beta_3 = \beta_2 + (\beta_6 - \beta_7) * (ln\, x_3 - ln\, x_1) * 2$$
$$lnAC(o) = \alpha + \beta_1(ln\, o) + \beta_2(ln\, o|_{x_2 < o < x_3}) + \beta_3(ln\, o|_{o > x_3}) + \beta_4[(ln\, o - ln\, x_1)^2|_{o < x_1}] + \beta_5[(ln\, o - ln\, x_1)^2|_{x_1 < o < x_2}] + \beta_6[(ln\, o - ln\, x_1)^2|_{x_2 < o < x_3}] + \beta_7[(ln\, o - ln\, x_1)^2|_{x_3 > o}] + \beta_8(plan\, characteristics) \tag{4.11}$$

Rearranging this gives:

$$\begin{aligned} lnAC(o) = \alpha + \beta_1(ln\, o) + \beta_2[(ln\, o - ln\, x_1)^2|_{o \leq x_1}] \; + \beta_3[(ln\, o - ln\, x_1)^2|_{x_1 < o \leq x_2}] + \\ [2(\beta_3 - \beta_4)(ln\, x_2 - ln\, x_1)](ln\, o|_{x_2 < o \leq x_3}) + \beta_4[(ln\, o - ln\, x_1)^2|_{x_2 < o \leq x_3}] + \\ . \quad [2(\beta_3 - \beta_4)(ln\, x_2 - ln\, x_1) + 2(\beta_4 - \beta_5)(ln\, x_3 - ln\, x_1)](ln\, o|_{o > x_3}) + \\ \beta_5[(ln\, o - ln\, x_1)^2|_{x_3 > o}] \; + \beta_6(plan\, characteristics) \end{aligned} \tag{4.12}$$

And the first derivative is:

$$\begin{aligned} = \beta_1 + 2\beta_2[(ln\, o - ln\, x_1)|_{o \leq x_1}] \; + 2\beta_3[(ln\, o - ln\, x_1)|_{x_1 < o \leq x_2}] + \\ [2(\beta_3 - \beta_4)(ln\, x_2 - ln\, x_1)|_{x_2 < o \leq x_3}] + 2\beta_4[(ln\, o - ln\, x_1)|_{x_2 < o \leq x_3}] + \\ [2(\beta_3 - \beta_4)(ln\, x_2 - ln\, x_1) + 2(\beta_4 - \beta_5)(ln\, x_3 - ln\, x_1)|_{o > x_3}] + 2\beta_5[(ln\, o - ln\, x_1)|_{x_3 > o}] \end{aligned} \tag{4.13}$$

Appendix 4.1.2: Empirical results

Administrative costs QSF results

Table 4.14 shows the regression results for administrative costs of the TCF and three QSF with 1, 2 and 3 break points respectively. The QSF with a single break point at $lnx_1 = 5.5$ (235 members) has the best model fit (lowest AIC).

Investment costs QSF results

Table 4.15 shows the regression results for administrative costs of the TCF and three QSF with 1, 2 and 3 break points respectively. The QSF with a single break point at $lnx_1 = 5.5$ (€800 million total assets) has the best model fit (lowest AIC).

Table 4.14: Quadratic spline administrative cost functions (2002 - 2013)

	(1)	(2)	(3)	(4)
Variables	**TCF**	**Single spline**	**Double spline**	**Triple spline**
Break point(s)	no spline	$lnx_1 = 5.5$	$lnx_1 = 5.5$	$lnx_1 = 5.5$
			$lnx_2 = 8.0$	$lnx_2 = 8.0$
				$lnx_3 = 9.5$
Members	0.657***	0.816***	0.852***	0.843***
(in logarithms)	(0.034)	(0.042)	(0.043)	(0.043)
Members ($\mid x_2 - x_3$)			-0.023***	-0.023***
			(0.007)	(0.007)
Members ($\mid > x_3$)				-0.006
				(0.011)
Members^2	0.034***	0.340***	0.360***	0.355***
(ln, x_1 dev. $\mid < x_1$)	(0.006)	(0.041)	(0.041)	(0.042)
Members^2		0.012*	0.009	0.008**
(ln, x_1 dev. $\mid x_1 - x_2$)		(0.007)	(0.007)	(0.007)
Members^2			0.013**	0.012***
(ln, x_1 dev. $\mid x_2 - x_3$)			(0.006)	(0.007)
Members^2				0.010**
(ln, x_1 dev. $\mid > x_3$)				(0.007)
Outsourcing	0.270***	0.270***	0.269***	0.269***
	(0.037)	(0.037)	(0.037)	(0.037)
Reinsured	-0.034***	-0.035***	-0.035***	-0.035***
	(0.012)	(0.012)	(0.012)	(0.012)
Assets per member	0.062**	0.048*	0.049*	0.048*
(€million)	(0.029)	(0.029)	(0.029)	(0.029)
% Pensioners	1.665***	1.727***	1.715***	1.717***
	(0.129)	(0.127)	(0.127)	(0.127)
% Inactive members	0.440***	0.441***	0.430***	0.437***
	(0.076)	(0.076)	(0.076)	(0.076)
Constant	-3.093***	-4.116***	-4.329***	-4.277***
	(0.222)	(0.269)	(0.276)	(0.278)
σ_u^2 (*inefficiency*)	10.501	10.056	10.104	10.142
	(0.624)	(0.599)	(0.600)	(0.604)
σ_v^2 (*random shocks*)	0.234	0.234	0.233	0.233
	(0.005)	(0.005)	(0.005)	(0.005)
R^2	0.660	0.654	0.654	0.653
Akaike's IC	11,921	11,881	11,873	11,871
First derivatives:	0.657..	0.816..	0.852..	0.834..
$p \leq x_1$	$+2 * 0.034$	$+2 * 0.340$	$+2 * 0.360$	$+2 * 0.355$
	$*(lnp - lnx_1)$	$*(lnp - lnx_1)$	$*(lnp - lnx_1)$	$*(lnp - lnx_1)$
$x_1 < p \leq x_2$)	id.	$+2 * 0.012$	$+2 * 0.009$	$+2 * 0.008$
		$*(lnp - lnx_1)$	$*(lnp - lnx_1)$	$*(lnp - lnx_1)$
$x_2 < p \leq x_3$)	id.	id.	$-0.023 + 2 * 0.013$	$-0.023 + 2 * 0.012$
			$*(lnp - lnx_1)$	$*(lnp - lnx_1)$
			-0.023	-0.023
$p > x_3$	id.	id.	id.	$-0.006 + 2 * 0.010$
				$*(lnp - lnx_1)$
				-0.006
Cost elasticity at mean	0.810	0.870	0.892	0.879

Notes: p = members. Number of observations = 6,087, number of pension funds = 799, $\overline{lnp}$ = ln(2,316). Break points $ln\,x_1 = 5.5$, $ln\,x_2 = 8.0$, and $ln\,x_3 = 9.5$, are equal to 235, 2,981 and 13,360 members respectively. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01.

Table 4.15: Quadratic spline investment cost functions (2002 - 2013)

Variables	(1) **No spline** =TCF	(2) **Single spline** $lnx_1 = 20.5$	(3) **Double spline** $lnx_1 = 20.5$ $lnx_2 = 21.5$	(4) **Triple spline** $lnx_1 = 20.5$ $lnx_2 = 21.5$ $lnx_3 = 22.5$
Total assets	1.117***	1.305***	1.324***	1.312***
($1,000, in logarithms)	(0.018)	(0.048)	(0.053)	(0.055)
Total assets ($\|x_2 - x_3$)			-0.007	-0.007
			(0.009)	(0.009)
Total assets ($\| > x_3$)				0.031***
				(0.011)
Total assets^2	0.045***	0.083***	0.086***	0.084***
(ln, x_1 dev. $\| < x_1$)	(0.005)	(0.010)	(0.011)	(0.011)
Total assets^2		-0.014	-0.008	-0.035
(ln, x_1 dev. $\|x_1 - x_2$)		(0.019)	(0.009)	(0.023)
Total assets^2			-0.004	-0.031
(ln, x_1 dev. $\|x_2 - x_3$)			(0.009)	(0.024)
Total assets^2				-0.041*
(ln, x_1 dev. $\| > x_3$)				(0.024)
Assets per member	-0.202	-0.193	-0.193	-0.207
(€million)	(0.143)	(0.142)	(0.142)	(0.141)
% Pensioners	0.178	0.167	0.162	0.146
	(0.184)	(0.182)	(0.182)	(0.182)
% Inactive members	0.565***	0.557***	0.556***	0.550***
	(0.143)	(0.142)	(0.142)	(0.141)
Investments				
Equities (%)	-0.147	-0.111	-0.111	-0.107
	(0.139)	(0.138)	(0.138)	(0.138)
Real estate (%)	0.730*	0.583	0.584	0.594
	(0.408)	(0.412)	(0.411)	(0.411)
Fixed income (%)	0.264**	0.267**	0.266**	0.262**
	(0.110)	(0.110)	(0.110)	(0.110)
Constant	-10.459***	-12.849***	-13.084***	-12.927***
	(0.264)	(0.623)	(0.685)	(0.700)
Sigma u^2	3.042	2.966	2.948	2.952
	(0.259)	(0.251)	(0.250)	(0.250)
Sigma v^2	0.661	0.660	0.661	0.660
	(0.016)	(0.016)	(0.016)	(0.016)
R-squared	0.733	0.730	0.730	0.729
Akaike's IC	12,340	12,325	12,326	12,321
First derivatives:	1.117..	1.305..	1.324..	1.312..
$ta \leq x_1$	$+2*0.045$ $*(lnta - lnx_1)$	$+2*0.083$ $*(lnta - lnx_1)$	$+2*0.086$ $*(lnta - lnx_1)$	$+2*0.084$ $*(lnta - lnx_1)$
$x_1 < ta \leq x_2$)	id.	$-2*0.0014$ $*(lnta - lnx_1)$	$-2*0.008$ $*(lnta - lnx_1)$	$-2*0.035$ $*(lnta - lnx_1)$
$x_2 < ta \leq x_3$)	id.	id.	$-2*0.004$ $*(lnta - lnx_1)$ -0.007	$-2*0.031$ $*(lnta - lnx_1)$ -0.007
$ta > x_3$	id.	id.	id.	$-2*0.041$ $*(lnta - lnx_1)$ $+0.031$
Cost elasticity at mean	0.953	1.002	1.010	1.006

Notes: ta = total assets. Number of observations = 4,498, number of pension funds = 646, $\overline{ln\,ta}$ = €1,291 million. Break point $lnx_1 = 20.5$, $lnx_1 = 21.5$ and $lnx_1 = 22.5$ are at €800, €2,217 and €5,911 million total assets respectively. Standard errors in parentheses, $P > |t|$ = * <0.10, ** <0.05, *** <0.01

Chapter 5

The occurrence and impact of pension fund discontinuity[1]

Collective pension arrangements tend to yield higher risk-adjusted pension benefits than individual plans due to intergenerational risk sharing and the lack of annuity conversion risk. These benefits pose the implicit assumption that the pension fund has an infinite horizon, while we observe that many pension funds discontinue. Using case studies of six discontinued pension funds, in combination with a simulation model, this paper analyses the occurrence and impact of pension fund discontinuity. Although discontinuity tends to increase the volatility of pension benefits, median benefits in most institutional settings increase after discontinuing the fund. We find that both the occurrence and impact of discontinuity depends strongly on the institutional setting of the pension fund. Stricter regulations, such as more conservative discount rates, increase the financial stability of the pension fund; however, they may reduce membership support through lower replacement rates. This poses a trade-off in the design of the pension system.

[1] This chapter is based on the paper: Alserda, Steenbeek, and Van der Lecq (2017) The Occurrence and Impact of Pension Fund Discontinuity. *ERIM report series research in management Erasmus Research Institute of Management No. ERS-2017-008-F&A.*

5.1 Introduction

Several European countries have experienced a decline in the number of pension funds in the past decade. During the period 2005-2015, the number of pension funds declined 60% in the Netherlands and Denmark, 52% in the United Kingdom, 33% in Switzerland, 27% in Norway, and 4% in Germany (OECD, 2015b). The pension fund decline in these countries is the result of mergers, closures, and liquidations (with a transfer to a different entity) of pension funds. Sometimes, it is in the interest of plan members to discontinue the fund, as continuation may result in lower or more volatile benefits. However, closing the plan may impose risks as well, such as a conversion risk caused by continuation with another pension fund. The discontinuation of a substantial number of pension funds raises the question of whether discontinuity poses a risk to the stakeholders of the pension fund and, in particular, to the members of the pension funds.

A discontinuity event can be a risk to pension fund members because risks that are meant to be shared between generations (intergenerational risk sharing) may all fall upon the last generation present in the pension fund at the moment of discontinuity. When rights are not transferred to a different entity, the last generation will become residual claimants, increasing rather than decreasing the riskiness of their pension benefits. The possibility that an existing pension fund might go into runoff (*i.e.*, closure of the fund to all new contributions, while existing rights remain in the pension fund) may discourage new generations from joining the pension fund, which may trigger a discontinuity event on its own (Beetsma et al., 2012). Please note that when the pension fund discontinues, the pension plan may continue in a different entity, in which case the pension fund will not go into runoff. We take the option of runoff as the default option at a discontinuity event, but we will discuss these alternative options (that give rise to amongst others conversion risk) at a later stage. While a discontinuity event is likely to increase the riskiness of pension benefits, it may also release any potential buffers in the pension fund, which may increase retirement income in the wake of a discontinuity event. Therefore, in this paper we analyse the impact of discontinuity risk, as pension fund discontinuity can have both a positive and negative effect on pension fund members.

Discontinuity events in pension funds can be triggered by financial and social circumstances. When the financial position (*i.e.*, solvency) of a pension fund becomes too weak, financial supervisors or sponsoring employers may force the pension funds to discontinue. Alternatively, when participation is not mandatory, present and/or future members can force the pension fund to discontinue (*e.g.*, by leaving the pension fund) when they lose trust. This can happen when the replacement rate of the pension is lower than promised or when contributions are too high. However, both triggers are strongly linked. Pension funds can improve their financial position by cutting pension rights, but this will diminish their social position (membership trust), as members will face lower benefits. However, at the same time a poor financial position will also diminish the social position, as members will expect that pensions will not be fully paid in the future. Therefore, both a strong and weak financial position can undermine the social position of the fund. The opposite may also hold, as in situations where sponsors and plan members remain confident, while the fund is underfunded. These situational combinations motivate the case studies that follow.

Discontinuity can be triggered both internally and externally. Internal triggers (*e.g., pension cuts*) are at the discretion of pension fund boards, while external triggers (*e.g.*, bankruptcy of the sponsoring employer) are not. This creates four different categories of discontinuity triggers. Although discontinuity can have different triggers, the result is the same: the fund ceases to exist. All members become inactive, and no new contributions will enter the pension fund. The existing members will remain in the pension fund, now in runoff, until they die or until their pension rights are transferred (liquidation). As the discontinuity event does not depend on the type of trigger, in this paper we will analyse a single discontinuity event, although the financial and social positions at discontinuity will differ.

Discontinuity risk is strongly linked to the institutional setting of pensions. Institutional factors (*e.g.*, such as regulations of the discount factor for pension liabilities, the cost structure of pensions, legal options to cut pensions, and population characteristics) impact the perceived financial position of the fund, which in turn influences pension fund discontinuity. The extent to which participation in a plan is mandatory also directly effects discontinuity risk in a pension plan, as it determines whether pension plan members can leave when they want to and thereby trigger a discontinuity event. This implies that pension funds with the same asset value and pension liabilities can have different exposures to discontinuity risk, depending on their institutional setting.

This paper builds upon a stream of recent literature analysing discontinuity risk of collective funded pension funds, including: Beetsma and Bovenberg (2009); Bovenberg et al. (2007); Bovenberg and Mehlkopf (2014); Molenaar et al. (2011); and literature discussing intergenerational risk sharing in collective pension funds, including: Bonenkamp and Westerhout (2014); Chen et al. (2016); Cui et al. (2011); Gollier (2008); Ponds and Van Riel (2009); Teulings and De Vries (2006). This paper builds on this literature by explicitly focusing on the occurrence and impact of discontinuity events. We quantify both the occurrence of discontinuity events and their impact on replacement rates. In addition, we analyse the dependency of the institutional setting on the occurrence and impact of pension fund discontinuity events. By using a practical simulation model with a long time period ranging up to 250 years, we can estimate and visualize the effect of discontinuity on a continuously changing population, with multiple generations. In addition, it allows us to assess the effect of a number of properties, (*e.g.* such as accumulation and contribution, discount rules, cost structures, and life expectancy shocks) on the impact of discontinuity.

After discussing the concept of discontinuity risk in pension funds, we will describe six recent cases of pension funds in the Netherlands that have faced a discontinuity event. This will give information about the causes of discontinuity and the development of relevant indicators of pension funds in runoff, such as the coverage rate and indexation (*i.e.*, pension funds that have no active members and therefore receive no new contributions). This information is used to calibrate a simulation model that we will use to both simulate the occurrence of discontinuity events and development of pension funds after the event.

This paper shows that discontinuity events, both in practice and in theory, are not as infrequent as intergenerational risk sharing may require (Beetsma et al., 2012). Discontinuity events become relevant when one considers the long horizons that pension funds have. Pension fund boards give various reasons that motivate their decision to discontinue, most often citing high costs per member due to a lack of access to economies of scale. The case study shows that while pension funds choose different ways to continue the pension plan after discontinuation of the fund, the result is not unilaterally bad for the members in all cases. The simulation model also shows that discontinuity can have both positive and negative effects for pension fund members, but the impact depends strongly on the institutional setting of the pension fund and its members.

5.2 Theory

5.2.1 Intergenerational risk sharing

One of the core reasons for collective pension arrangements is the possibility of benefiting from intergenerational risk sharing. Intergenerational risk sharing allows generations that face long term economic downturns to be compensated by generations that face better economic times. In this way all generations face less risk, increasing expected risk-adjusted returns (Bovenberg and Mehlkopf, 2014; Cui et al., 2011; Gollier, 2008). When economic circumstances are good, part of the excess returns are transferred to the future by higher buffers, while in the case of economic downturns, benefits will be reduced less than proportionally by allowing for lower or even negative buffers.

However, for intergenerational risk sharing to work, two requirements have to be met. First, the current generation should believe that future generations will join the system. Without the future generation, any deficit present in the buffers will be fully attributed to the current generation, who may be unwilling to join if they have to make large transfers to older generations (Westerhout, 2011). Second, risks should be shared symmetrically, in two-sided solidarity. Both negative and positive buffers should be shared; otherwise, support for intergenerational risk sharing will soon diminish (Ponds, 2003). This requires both commitment and restraint from the current generation, especially in the case of economic prosperity.

5.2.2 Discontinuity risk

Intergenerational risk sharing implicitly assumes that pension funds have an infinite horizon. If a pension fund doesn't have an infinite horizon and ceases to exist at a certain point, the previous generation cannot share the risks with any future generation. If there is no future generation to share risks with, pension fund members will not be willing to make the expected transfers to older generations if the pension fund has a deficit (Westerhout, 2011).

The possibility of a discontinuity event decreases the value of risk sharing for pension funds. In practice, pension funds discontinue on a regular basis (Alserda et al., 2017; Bikker and De Dreu, 2009). For example, over the period 2005–2015, more than half of the Dutch, Danish, and British pension funds discontinued (OECD, 2015b). It is therefore important to analyse discontinuity of pension funds and its implications for pension fund members.

There are a number of options available for pension plans that discontinue. When rights are not transferred, a pension plan that discontinues goes into runoff. This implies that no new contributions are paid to the pension fund and all active members become inactive. The pension fund continues to exist until the last member dies or the last rights are transferred. A pension fund that goes into runoff is used in the remainder of this paper to simulate the impact of discontinuity, as this is, contrary to the other options, not dependent on any negotiations with external parties.

Pension funds have a number of alternative options when they face discontinuation. One option is to merge with another pension fund, which can be a company pension fund, industry-wide pension fund, or a general pension fund. This will increase the size of the newly formed pension fund, potentially lowering costs in the presence of economies of scale and improving the benefits of risk sharing (when there is no ring fencing, which would otherwise keep risk sharing unchanged).

Another option is to transfer rights to an insurance firm. This will increase the security of pension rights, as insurance firms are not allowed to cut benefits. However, the premium for collective pension insurance contracts usually does not allow for indexation, and this increases the inflation risk for the plan members. When rights are transferred to an insurance company, the total value of the pension's entitlements strongly depends on the interest rate (as well as the solvency requirements for insurance firms). In a low interest rate environment, this option is very expensive. Thus, the additional security of the insurance company may require a cut in pension entitlements at the transfer moment.

5.2.3 Discontinuity triggers

There are numerous types of discontinuity triggers. We distinguish four types of triggers: internal and external, financial and social. Internal triggers originate from within the pension fund itself, while external triggers originate from outside the influence of the pension fund. Both internal and external triggers can be financial and social triggers. Financial triggers are related to the financial position, in particular the solvency, of the pension fund, which will be monitored by financial supervisors, while social triggers are connected to the trust of members and sponsors, including trade unions.

Internal triggers

Most papers find that collective pension funds, due to the possibility of intergenerational risk sharing, give higher expected benefits or lower risk (Gollier, 2008; Beetsma and Bovenberg, 2009; Westerhout, 2011). However, if collective pension funds have substantially large negative buffers, individual members may prefer funds with individual accounts, which by definition have no buffers (Teulings and De Vries, 2006; Bovenberg et al., 2007; Beetsma et al., 2012). This implies that when the negative buffer (which lowers expected benefits) is large enough and participation is not mandatory, new members are no longer willing to join the fund and current members apply to leave *i.e.*, the members vote with their feet. The remaining members can no longer share risks with the next generation and become residual claimants. The negative buffer can therefore act as a trigger for a discontinuity event.

Another potential internal trigger for a discontinuity event is the replacement rate. Making use of a survey Binswanger and Schunk (2012) find that members have a minimum level of monthly spending at retirement below which they do not want to fall. These minimum spending levels, denoted in relation to working income (the replacement rate), vary strongly between members and between different income quantiles. However, the authors conclude that the net certainty equivalence value of retirement income should exceed 70% of net annual working-life income. If the expected replacement ratio decreases below this threshold (*e.g.*, because current retirees have low pensions, or because future pension cuts are expected), plan members may no longer be willing to pay the contributions. Pension funds are thus limited in the amount of pension cuts they can impose that fund members will accept. However, net replacement rates in general exceed gross replacement ratios due to savings, tax brackets, and owner-occupied housing (Brady, 2010). Gross replacement rates may thus be somewhat lower (*e.g.*, than 70%), depending on the tax system in a specific country (*e.g.*, in countries that have lower tax bracket for retired individuals).

In the case of a discontinuity event, the last generation present will bear all residual risks[2], increasing rather than decreasing the riskiness of pension benefits. Pensions of this generation will depend very strongly on the deficit (downside risk) or surplus (upside risk) of the pension plan at the moment of discontinuity. The very expectation that future generations may be unwilling to participate can therefore make current generations (*i.e.*, younger workers) unwilling to participate, as they fear becoming the residual risk bearers. Discontinuity can become a self-fulfilling prophecy: Once future members believe that it may happen, they will have incentives to trigger it themselves by refusing to join the fund.

External triggers

External triggers are factors outside the pension fund that affect pension fund discontinuity. Although the factors may originate from outside the pension fund (*e.g.*, asset return, interest rate, inflation, and changes in life expectancy), they can be mitigated by pension fund management. Applying financial instruments (hedges) can, for example, mitigate the effect of asset return shocks. Without hedging these risks, asset return shocks can decrease assets or increase liabilities, resulting in solvency problems indicated by the coverage rate.

Other external triggers, like changes in life expectancy, can only be hedged at high costs. A change in life expectancy increases the number of years that pension benefits must be paid. This increases pension fund liabilities, again decreasing solvency.

Discontinuity can also be triggered by the population. If it is substantially skewed (*e.g.*, when the population mainly consists of older, retired, members), the pension fund does not fully benefit from the risk-decreasing effect of new contributions. This makes the financial position more volatile and might put constraints on the asset allocation. Both the higher volatility and lower flexibility in the asset allocation makes the pension plan less valuable to the members, making discontinuity more likely. The same is true if the population size decreases (*e.g.*, because the sponsoring company downsizes or disappears, or the industry declines or disappears), which will make the financial position more volatile and increase the effect of fixed costs on pension fund management.

Discontinuity is immediately triggered when the active population disappears in its entirety. This can happen when the company or industry of that pension fund dis-

[2] Some risks, like that of setting contributions too low, may disappear, but these are much less in impact.

appears (*e.g.*, by bankruptcy or merger of the company, or development of a new industry that makes the old industry obsolete), or when the company or industry either transfers the pension accumulation to a different provider or discontinues the pension plan. This will make all the active members inactive, effectively putting the pension fund in runoff.

Finally, discontinuity can be triggered by regulatory changes. New regulations can either force a pension fund to discontinue or make it practically impossible to continue. Examples include more elaborate reporting standards (*e.g.*, increasing costs per member, especially for smaller funds) and higher board member competence level standards, thus making it more difficult to fill board positions.

5.2.4 Modelling discontinuity

Although there are many triggers that effect discontinuity, it always comes down to one of two types.
The first type of trigger is discontinuity due to financial problems. In this case, pension funds become insolvent when deficits (*i.e.*, liabilities surpass assets) become too high. For this reason, financial supervisors or the sponsoring company may force pension funds to discontinue, as contributions to restore the financial position might become too high.
The second type of trigger is connected to membership support. When participation is not mandatory, which makes support from (future) members uncertain, current members may choose to exit the pension fund, or new members may decline to join the pension fund. Eventually this may lead to the discontinuation of the pension fund. Membership support is difficult to measure, but other variables like opt-outs (*e.g.*, the number of members who refuse participation) and survey responses can be used to measure it. Relevant causes for declining membership support include expected retirement income (replacement rate) falling below the acceptable minimum; expected income from other plans (*e.g.*, individual pension plans) giving higher expected income; riskiness of retirement income becoming too high (*i.e.*, the chance of falling below the minimum becomes too high); lack of support in the pension fund board; or disagreement with changes in the plan characteristics. These two causes *i.e.*, financial and social causes) represent a trade-off in pension fund management. Applying pension cuts, increasing contributions, and increasing the riskiness of assets improve the (expected) financial position of the pension fund but may lower mem-

bership support and therefore increase the probability of social discontinuity. When, for example, the number of members becomes very low, which increases average cost of running the pension plan, the pension fund can either choose to lower benefits, thus decreasing membership support, or allow the financial position to deteriorate, which might or might not be a problem, depending on the available buffer.

In this paper, we leave the possibility of increasing pension contributions out of the analysis. Depending on local legislation, pension funds in many countries can, or are obliged to increase contribution levels, which helps to solve solvency problems. However, the maximum level of contributions is often limited, and increases in contribution levels will lower membership support. In addition, in many countries the sponsor pays a part of the contributions. When the contribution (including repair payments) exceeds a certain point this will cause difficulties for the sponsor. Contributions in our model can be assumed to be set at the maximum accepted level. Therefore, further increases are not an option in the model.

5.2.5 Institutional setting

Discontinuity events are highly dependent on the institutional setting of a country. By an institutional setting, we refer to the regulations, cost structures, population characteristics, and other institutional factors that may influence pension fund performance. Circumstances that in one setting will lead to a discontinuity event may have no effect in another setting. Therefore, it is important to connect the literature of discontinuity risk to the institutional setting.

An important institutional property is the calculation of liabilities, particularly the discount rate used to discount future payouts. Countries like the Netherlands that use a conservative discount factor, will force pension funds to acknowledge relatively high liabilities, which imply a lower coverage rate. Pension funds in countries like the United States that allow for higher discount rates will report lower liabilities and higher coverage rates. This implies that reported solvency may differ from the actual solvency. For two comparable pension funds (equal actual solvency) which are active in different countries one can have reported solvency problems and face discontinuity, while the other has no solvency problems at all.

The same holds true for the extent to which pension funds are allowed to run coverage deficiencies. Countries differ in the deficit that pension funds are allowed to run before they have to apply pension cuts. Furthermore, the size of pension cuts differ, as well as the number of years over which the pension cuts can be divided. When pension cuts are more likely, members will distrust the plan and become inclined to trigger a discontinuity event. The pace at which pension cuts have to be applied determine which generation is most affected. Fast pension cuts will mainly impact older pension fund members, but slow pension cuts will more strongly impact new and younger fund members. Some pension funds (*e.g.* in the United States) are not allowed at all to cut pension benefits. These pension funds can continue with large (implicit) deficits, which can make them look closer to a pay-as-you-go plan than a funded plan. And while pension cuts may be legally allowed, the willingness of the population to act against it (*e.g.*, strike) can still make them very difficult to enact.

The distribution of age categories may also influence pension fund discontinuity. Age distributions tend to differ across countries (*e.g.*, low birth rates) and industries (*e.g.*, disappearing industries). Pension funds that have relatively many retirees ("sinking giants") become more vulnerable, as these funds will have fewer options available to restore the financial position, and any potential deficit present will tend to magnify for these funds (Frijns, 2010; Kocken and Potters, 2010). Therefore pension fund discontinuity becomes more likely.

Another important difference between countries is whether pension fund participation is mandatory. When pension fund participation is mandatory, members cannot trigger a discontinuity event by leaving the pension fund. When participation is quasi-mandatory (*i.e.*, mandatory for employees of a certain company or industry), members cannot leave the pension fund easily. If they want to leave the pension fund, they should find another job or motivate social partners or the employer(s) to force a discontinuity event. As leaving the fund becomes more difficult, discontinuity events are less likely to occur. When participation is completely free, members are most likely to leave the pension fund and trigger discontinuity for the pension fund. In these cases, the fund usually has strong DC-elements.

Finally, the first pillar and taxes can be relevant for discontinuity events. Pension fund members in countries that have high base pensions and progressive taxes will be less sensitive to differences in their risk-bearing (*e.g.*, occupational) pension (Chapter 2). In addition, in some countries taxes and the base pension tend to be adjusted in line with purchasing power developments. When country-wide pension benefits decline (*e.g.*, due to an asset return shock), the government can compensate purchasing power by reducing taxes or by increasing the base pension. In these circumstances, members will be less inclined to leave the pension fund and performance becomes a relative matter: Pension funds are more easily able to cut pension benefits as long as other funds also cut pensions.

Table 5.1: Institutional setting and pension fund discontinuity

Setting	Institutional factor	
	High	**Low**
Membership obligation	More difficult for members to leave the pension fund, making discontinuity less likely.	Members can leave when they have a better alternative. Discontinuity is more likely.
Conservative discount rate	Low discount rate results in higher value of liabilities, and a lower coverage rate. Solvency problems are more likely.	Solvency problems are less likely, but members may distrust the financial position of the pension fund.
Maximum allowed coverage deficiency	Pension cuts are less likely, members will be less inclined to leave the pension fund, as replacement rates increase.	Pension cuts are more likely, alternatives, such as an individual plan, will become more attractive in the case of deficits.
Pace of pension cuts	Impact on younger members is relatively lower, so they are less likely to leave the pension fund.	Young and new members will incur more pension cuts, making them less likely to continue membership or join.
Fixed costs	Pension funds become more sensitive to population shocks, discontinuity will become more likely.	Average costs are more constant, discontinuity is less likely.
Height of base pension	Volatility and importance of risk-baring pension decreases, discontinuity is less likely.	Risk-baring pension is more important and members will be sooner inclined to look for alternatives.
Progressivity of income taxes	Volatility in outcomes are reduced by income taxes. Lower volatility reduces discontinuity events.	Higher volatility for pension benefits, discontinuity is more likely.

The impacts of the most important institutional factors on pension fund discontinuity risk are summarized in Table 5.1. These factors represent a paradox in pension fund discontinuity. Stricter pension regulations, like more conservative discount factors, smaller allowed deficits, and faster pension cuts, increase the financial stability of pension funds. However, at the same time they tend to stimulate pension fund discontinuity. More conservative discount rates, smaller allowed deficits, and faster pension cuts increase the probability and size of pension cuts, which will lower membership support. Depending on the freedom of pension fund members to leave the fund, this may induce a discontinuity event. These kinds of effects are therefore relevant for pension fund discontinuity. This suggests that a trade-off may exist in pension fund discontinuity. More stricter regulations will make pension funds more robust, but will lead to lower perceived solvency, which might trigger discontinuity.

5.3 Case study

In this section we will analyse six cases of pension funds that faced a discontinuity event. The cases are selected from a list of discontinuity events in the Netherlands presented by the Dutch pension funds association (Pensioenfederatie). Cases are selected in order to represent different types of pension funds that discontinue (*i.e.*, company and industry-wide pension funds) and different reactions to the discontinuity event (*i.e.*, transfer to a company fund, industry-wide fund, general fund, or insurer). Availability of pension fund data and motivation of choices are also factors in case selection.

The six cases that are selected are the industry-wide pension fund for miners (consisting of Algemeen Mijnwerkersfonds van de Steenkolenmijnen en Beambtenfonds voor het Mijnbedrijf), the company fund of Elsevier publishers (Stichting Pensioenfonds Elsevier-Ondernemingen), the industry-wide fund for the plastic and rubber industry (Bpf Kunststof- en Rubberindustrie, KRI), the company fund of telecom provider KPN (OPF KPN), the company fund of RBS bank (RBS NL Pension fund), and the company fund of ING bank (ING Pensioenfonds). The analysis of these case studies is based on the information retrieved from annual reports and press statements. The information therefore presents stated motivations, which can leave out other relevant motivations. So, although these case studies (summarized in Table 5.2) give us valuable insight into pension fund discontinuity, we should keep in mind that there might be other motivations for the discontinuations of the discussed pension funds.

The pension funds for miners (AMF and BFM) went into runoff after the closure of the mines in the Netherlands in the 70's. During the next few decades, the pension funds continued to exist without active members while the total number of members declined. By cooperating, they managed to continue their operation, but the declining membership made their pension fund increasingly expensive to operate. The lack of active members put more limitations on their asset allocation. It also made the pension funds less attractive to merge with industry-wide funds, as they would not contribute any future members. Therefore, the choice was made to transfer the pension rights and assets of both funds to the insurance firm Aegon in 2014. Pension rights were incremented upon transfer, but will not be indexed (or cut) in the future (AMF-BFM, 2016). By choosing for an insurance firm, despite the low interest environment, reflected the preferences of the funds for security.

The company fund of Elsevier choose to discontinue because a decreasing number of employees (members), in combination with more stringent regulations, led to increasing costs. The rights were transferred to PGB, an industry-wide fund. The alternative, transferring rights to an insurance firm, was considered too costly due to the low interest rate in 20152016. The sponsoring company made a one-off payment to get the coverage rate of the liquidated fund equal to the coverage rate of the new fund (PGB) (Stichting Pensioenfonds Elsevier-Ondernemingen, 2015).

KRI, the industry-wide fund for plastic and rubber companies, formerly reinsured their pension rights with an insurance firm. Due to the low interest rate, the company considered it too expensive to renew the reinsurance contract at the end of 2016 and decided to liquidate the fund. Although the existing rights are serviced by the same insurance firm, new rights are accrued at a different industry-wide fund (PGB) (Bpf Kunststof- en Rubberindustrie, 2015).

The fourth case concerns the merger of two company pension funds of KPN. The pension fund OPF KPN, the fund that services those employees who are not covered by the collective labour agreement, is liquidated and merged with PF KPN. The main reasons for the merger are simplicity of the pension scheme and lower costs for fund members. As the two pension funds were very similar to begin with, no significant changes were caused by the merger, and the main effect for the members is the lower operating costs due to economies of scale (KPN Pensioen, 2015).

After ending its operations in the Netherlands, RBS chose to transfer its pension rights to the relatively new vehicle of a general pension fund ("Algemeen Pensioen Fonds"). A general pension fund allows a pension fund to run multiple pension plans, which can, or cannot, be separated from each other (ring fencing). As all members became inactive after their dismissal by RBS, the pension fund went into runoff. The prospect of a decreasing membership and higher costs per member put the generous nature of the pension plan into jeopardy. Therefore, the rights were transferred to a general pension fund, which can operate multiple pension plans, thereby benefiting from economies of scale while also keeping the relatively generous nature of the pension plan intact (RBS NL Pension fund, 2015).

Table 5.2: Observation matrix pension funds with discontinuity

	AMF / BFM	SPEO	KRI	OPF KPN	RBS	ING
Before discontinuation:						
Company fund		X		X	X	X
Industry wide fund	X[a]		X			
After discontinuation:						
Company fund				X		X[a]
Industry wide fund		X	X (new)			
General fund					X	
Insurer	X		X (former)			
Reason discontinuity:						
Declining number of members	X	X			X	
Costs per member	X	X	X	X		
Regulatory pressure	X	X			X	
Security of pension benefits	X			X		
Simplicity of scheme				X		
Sponsor event	X				X	X
Effects:						
Benefits short run	One time increase	One time addition to assets	–	–	–	One time addition to assets
Benefits long run	No indexations / pension cuts	Higher benefits due to lower costs	–	Higher benefits due to lower costs	Higher chance future indexations	–
Security of pension benefits	Increases	Decreases, no more additions by sponsor	Decreases, end reinsurance	Increases	–	Decreases, no more additions by sponsor
Net effect:						
Active members	NA	+	+/-	+	+	NA
Passive members	+/-	+	0	+	+	+/-
Retired members	+	+	0	+	+	+/-
Number of members [b]**:**	±28,000	8,574	7,215	1,895	1,893	71,563
Coverage rate (%):						
2012	109 / 103	96	107	115	129	119
2013	112 / 106	104	106	112*	137	125
2014	114* / 107*	102	106		139	130[a]
2015		97*	106		131	133[a]
Indexation:						
2012		0%	1.8%		2.5%	2.5%
2013	0% / -7.0%	-3.3%	1.8%		3.0%	4.5%
2014	0% / -0.6%	-1.4%	0%		1.4%	0.8%[a]
2015	11.0% / 13.7%		0%		0.04%	2.2%[a]

Notes. Sources: annual reports & newsletters of AMF-BFM; Stichting Pensioenfonds Elsevier-Ondernemingen; Bpf Kunststof- en Rubberindustrie; KPN Pensioen; RBS NL Pension fund and ING Pensioenfonds. *Last available coverage rate, [a]Pension fund in run off, [b] most recent available number.

In the final case, after separating the banking activities (ING) and the insurance activities (NN) of ING, the decision was made to discontinue the current pension fund (Pensioenfonds ING) as of January 1, 2014, and create two new pension funds (ING CDC Pensioenfonds and NN CDC Pensioenfonds) to match the pension funds with the new companies. Another reason was for the employer to remove the company from the responsibility for the financial position of the pension plan, which due to recent regulations forced the employer to report a liability in its own accounts. As a compensation, ING paid a one-off contribution to the old pension fund now in runoff. Although these changes increased the probability of a pension cut in the future, they also improved the financial position of the fund in the short run (ING Pensioenfonds, 2015).

Table 5.2 gives an overview of the six cases, including relevant pension fund properties. The table presents the type of pension vehicle both before and after the discontinuity event. The reasons given for discontinuation can be classified into six categories, all of which fall within the external category: (a) a declining number of realized or anticipated members, (b) the prospect of lower costs per member after discontinuation, (c) regulatory pressure, including restrictions on the asset allocation and increasing difficulties to find board members, (d) an improved anticipated security of pension benefits, (e) improved simplicity of the pension plan (*i.e.*, diminishing the amount of overhead) and (f) external pressure from the sponsoring company. In addition, the anticipated effect of discontinuity for the short and long term and for different types of members is presented, along with some summary statistics.

The six cases represent pension funds in the single institutional setting of the Netherlands. In this setting pension fund participation is quasi-mandatory, as pension fund members are not allowed to leave the pension fund. Discontinuity events were not triggered by financial problems in any of the cases, although in many cases the reasons associated with preventing future financial problems are reported. In most cases costs, often associated with low or decreasing membership, are reported as one of the reasons for liquidating the pension fund. Also, the effect of increasing regulatory pressure is often cited as a reason to discontinue, including a decreasing availability of competent and suitable (*i.e.*, "fit and proper") board members, and the risk for the sponsor of being confronted with large deficits of the company pension fund. These case studies suggest that pension funds discontinue for a variety of reasons such as declining membership, the prospect of lower average costs and regulatory pressure. These reasons originate from external pressures, and to address them pension funds are discontinued. Although both the starting and the end situation differ between pension funds, not one of the studied pension funds discontinuity events was unilaterally bad for the pension fund members. In some cases, all members benefited by lower costs and reduced complexity, while in other cases, the effect depended on whether the status of the member was active, inactive, or retired. Improving the prospect of pension fund members was often stated as one of the primary reasons motivating discontinuity, although this can also represent the effort of pension plan boards to pressure members to leave. Depending on the situation at hand, the discontinuity event has advantages and disadvantages for different types of members (*i.e.*, active, passive or retired). In the cases discussed, the prospect of discontinuity should therefore not, on its own, put pressure on members to leave the pension fund, assuming they were allowed to. However, the dynamics discussed in these cases may depend on the institutional setting of the pension fund. In the following sections, we will describe and apply a simulation model to assess the discontinuity risk and the effect of the institutional setting on the discontinuity risk.

5.4 Simulation study

The case studies showed that discontinuity does not necessarily negatively affect pension fund members. However, the effects of pension fund discontinuity are likely to depend on the institutional setting of the pension fund. Therefore, we apply a simulation model in which we can account for institutional factors to analyse the occurrence and impact of pension fund discontinuity events. The simulation model is built on the asset return model of Koijen et al. (2010), using parameter estimates of Draper (2014)[3]. The asset returns, interest rates, and inflation that follow from this are used to simultaneously simulate a collective pension plan and an individual pension plan, so that the benefits from the collective plan can be compared with the pension benefit that would follow from an individual account. This difference may be relevant as an individual plan will act as the main alternative to the collective plan.

For the sake of parsimony we abstracted from country-specific designs of pension plans and created both collective and individual pension plans that are not dependent on specific, or local, regulations. Also, for the simulated population, we tried to keep

[3]Asset returns are simulated using the Tilburg Finance Tool, which can be found via the following URL: `https://drive.google.com/file/d/0B5OYmOQ9iDtbdWdVYUpWVlFueFU/view?usp=sharing`

the model as simple as possible in order to keep all the relevant mechanisms visible. In Section 5.5.4, we present the most relevant sensitivity analyses, which describe various institutional settings.

5.4.1 Population

The simulated population of pension fund members consists of 10,000 individuals that become members of the pension fund at a randomly estimated year during the simulation. Members join the fund between the ages of 20 and 60 and are active members for a period of one to 47 years, dependent on the simulated years in employment. When members become inactive (*e.g.*, retire or find a job with a company that has a different pension fund), they continue as a passive member. Members cannot transfer their pension accumulation to another provider. The retirement age is fixed at 67 and the members pass away at random ages between 80 and 90. Given these assumptions, the pension fund has on average 1,050 members during the simulation. All members have a fixed, inflation-corrected income of $30.000, replacement rates (representing 40 years of membership) are adjusted for the period that the members are active in the pension fund.

5.4.2 Collective pension plan

The collective plan takes the form of a collective-defined contribution plan. This means that the sponsor (employer) does not share the investment risk with the pension fund, but that members share the risk among themselves (both intra- and intergenerational).

Members receive an inflation-corrected retirement entitlement of 2% of average income for each year that they are members of the pension fund. The contribution is progressive and is based on the actuarial value of the new entitlements. The relation between contribution / accumulation and age varies across countries and pension schemes. We choose contributions that are progressive with age[4] as this is most common and because this matches the value of contributions to the value of entitlements, giving practically no redistributions between age groups. Section 5.5.4 shows a sensitivity analysis of this choice, by showing the implications of choosing a constant contribution instead of a progressive contribution. When the coverage

[4]Equal to the actuarial value of accrued entitlements given age.

rate is below 85% (*i.e.*, 15% deficit), pension entitlements are lowered. In this case, entitlements are lowered by the deficit, divided over 10 years (*e.g.*, a coverage rate of 80% means that entitlements are lowered with 2%, this continues until the coverage rate exceeds 85%). The same mechanism applies to coverage rates of over 115% (*i.e.*, 15% surplus), entitlements are in this case increased by the surplus divided over 10 years. Coverage rates between 85% and 115% imply that there are no increases or decreases in the entitlements, except indexation[5]. Pension capital is invested for 40% in equity and for 60% in fixed income over the entire lifespan[6], with a duration of 16 years. Costs are equal to $10 per member and 0.3% of assets (based on Chapter 4). Contributions and asset returns are added to pension capital (*i.e.*, total assets) while costs and benefits are deducted. Total liabilities consist of the accumulated benefits discounted with the expected investment return (3.27% + inflation)[7], taking the expected years in retirement for the different age groups into account. Section 5.5.4 presents the results of alternative specifications, including discounting with the long-term, 30 year real interest rate. The coverage rate is equal to total assets divided by total liabilities; as the real interest rate is used in the calculation of liabilities, this coverage rate represents the real coverage rate. After retirement age and pension cuts and indexations are calculated, members receive an income equal to their accumulated benefits; however, this can change from year to year in line with the plan's indexation policy.

5.4.3 Individual pension plan

In the individual pension plan, members contribute the same progressive premium to their individual pension account. During working life, the contributions–together with individual asset returns (using the same asset allocation)–are added to the pension capital, while costs, which are the same as for collective plans, are deducted. If pension members become inactive, their contributions stop, but asset returns and costs remain relevant for their pension capital. At retirement age, the pension capital is converted to an annuity, based on the expected return[8] (using the annuity formula and the general expected life expectancy at retirement age).

[5]Real pension cuts that are smaller than the inflation can be considered as partial indexation of nominal pensions.

[6]A common asset allocation in the Netherlands (Chapter 2)

[7]Which follows from Draper (2014); this return is neutral for the different generations in the sample.

[8]In Section 5.5.4, we analyse the sensitivity of using the actual long-term interest rate

5.4.4 Time path

Pension plan members join the pension fund in year 1. This implies that the number of members accrues gradually during the first years. As there are only a few members and no retirees, the coverage rate, and therefore indexation policy, will be relatively volatile during these first years. This effect evens out while the pension fund reaches a state in which the number of members joining the fund is approximately equal to the number of members leaving the pension fund by passing away. We start measuring performance indices (*i.e.*, replacement rates, coverage rates, volatility of retirement entitlements, and indexation) from the start, but differentiate between the start-up phase (approximately 100 years) and the stationary phase. At year 180, we simulate an external discontinuity event (no correlation with membership support or the coverage rate); at this time, all active members become inactive and no new members will join the fund. Although we described four different causes for a discontinuity event (internal or external, and social or financial), the result is the same: The pension fund goes into run-off. Therefore we model a single discontinuity event. At this event, all active members become inactive, and no new members join the fund. During the next few decades, the number of members slowly decreases as members pass away without new members entering. This holds for both the individual and the collective plan. Years 100–250 will be used to analyse the effect of the discontinuity event.

5.4.5 Output

A number of performance indices are used in order to analyse the effect of a discontinuity event. Specifically we use the replacement rate, calculated as the retirement income divided by the final income and adjusted for a 40-year working period; the development of the coverage rate; the volatility of retirement entitlements; and indexations.

5.5 Results

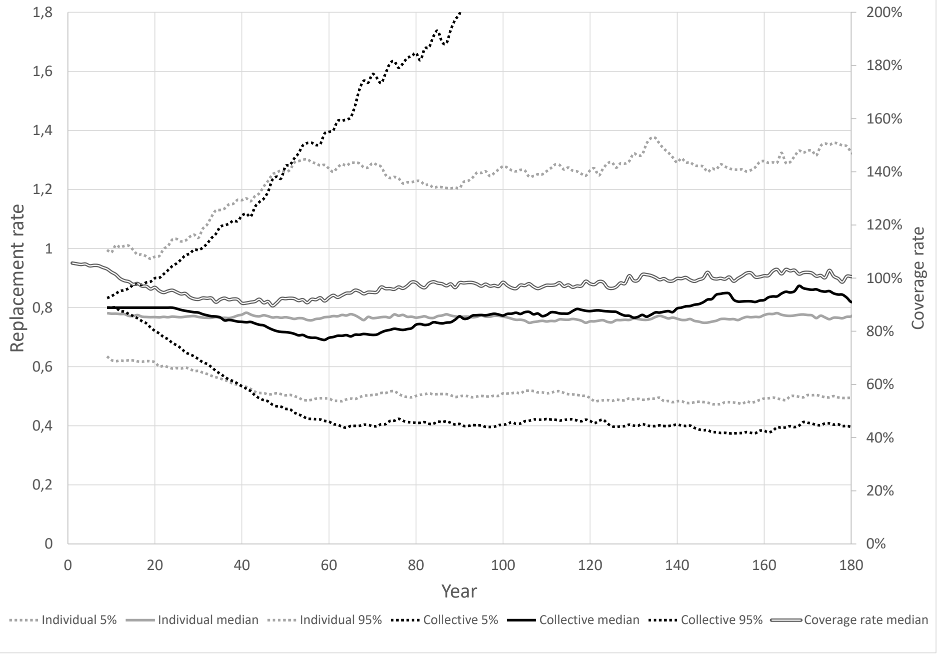
5.5.1 Development

Before we analyse the discontinuity events, we first discuss the development of the collective pension plan and the individual pension plan in our simulations. Figure 5.1 shows the median, 5% and 95% percentiles for both replacement rates (left axis) following from the collective pension plan and the individual pension plan, next to the median coverage rate of the collective plan (right axis). The development of the replacement rates shows a clear distinction between the first 100 years (start-up) and the next 80 years.

In the first period, any excess returns are used to create a buffer. This leads to lower benefits, as part of the contribution is directed to the buffer instead of directly to benefits (such as in the individual plan). However, as the coverage rate is close to 100%, returns that are below expectations can still be partly offset by allowing for deficits. Therefore, volatility of the collective plan in the start-up phase is lower than that for the individual plan.

After the start-up period, most simulations show moderate buffers, and these pension funds give pension rights that are close to the planned benefit entitlement of 80% (40 years of 2%). The returns that these buffers yield, lead to a higher median replacement rate for the collective plan compared with the individual plan. However, some simulations have accumulated substantial deficits, resulting in significant pension cuts and reducing the 5% percentile of the collective plan below that of the individual plan. The opposite occurs at the upside of the distribution. These pension funds have accumulated positive buffers, yielding higher returns and allowing for increases in entitlements due to profit sharing. We can conclude that collective pension plans give higher benefits in the long run, but this is at the cost of lower benefits in the start-up phase and higher long-run volatility. This latter result is surprising, as collective plans, due to intergenerational risk sharing, are normally expected to yield lower risk, given the expected return. However, as the results illustrate, the possibility of having to join a pension fund with a deficit, and the expected pension cuts that are associated with this, increases the downside risk of the collective plan beyond that of the individual plan, so the risk of the collective plan is strongly related to the financial position at the a member joins the pension fund. After the start-up phase, the collective plan gives substantially higher expected retirement incomes. By changing the asset allocation or by using financial hedge instruments, part of this higher result can be used to reduce volatility at the cost of lower (expected) return. This way, the general finding of higher risk-adjusted returns of collective pension plans can remain intact. In this paper, we leave these possibilities outside the scope of our analysis, in order to keep both pension plans comparable to each other.

Figure 5.1: The development of replacement rates



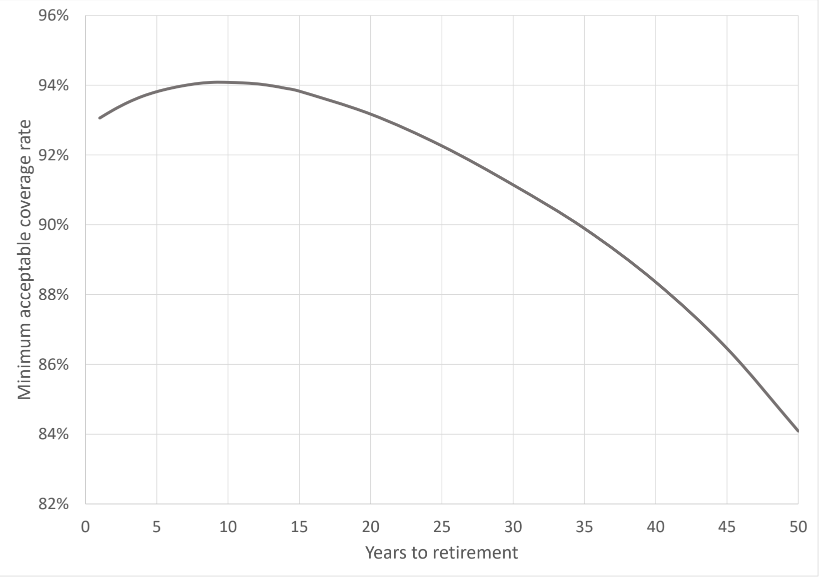
Notes. Development of replacement rates (left axis) from an individual and a collective plan and the median coverage rate of the collective plan (right axis). The replacement rates of the individual plan tend to exceed those of the collective plan for the first 90-100 years as the buffer is accrued, after which the collective plan tends to give the higher replacement rates due to average positive buffer.

5.5.2 Occurrence of discontinuity events

Statistical analysis shows that there is a statistically significant relation between the coverage rate in year t and the replacement rate for all years $t + N$ within our period of analysis (years 100-180). This implies that the expected coverage rate at retirement can, with different degrees of precision, be calculated making use of the present coverage rate. In our model, the explanatory power of the coverage rate is the largest in the 12-13 years before retirement ($R^2 = 70.1\%$). Shorter periods have less explanatory power because the pension cuts / increases have not fully set in, due to their gradual application, while for longer periods other factors, such as asset returns, will diminish the explanatory power of the prediction.

Using a regression analysis, we can estimate the coverage rate at which the expected replacement rate of the collective pension plan is equal to that of the individual pension plan. This represents the choice than an individual can make with the information available at the moment of joining a pension fund. The estimation of the minimum acceptable coverage rate depends on the time lag that we take for the coverage rate. Differences in time lags lead to different explanatory powers of the estimation, which changes the reliability of the estimation for the pension fund members. Lower reliability, and therefore higher uncertainty, will make the member less willing to leave the fund, *i.e.*, a higher minimum acceptable coverage rate. The magnitude of the coefficients of the coverage rate and the intercept, that also change with different time lags, also influence the minimum acceptable coverage rate. Figure 5.2 presents the relation between the lead (years to retirement) and the minimum expected coverage rate. The minimum acceptable coverage rate first increases with more years to retirement as this increases the expected amount of possible pension cuts, and after reaching its highest value at 9-10 years decreases due to increasing uncertainty that accompanies longer horizons. For prospective and actual members who are within 20 years of retirement, the minimum acceptable coverage rate is between 93.1% and 94.1%. For younger members further away from retirement, the minimum acceptable coverage rate is lower, down to 85.5% for the youngest members (20 years old).

Figure 5.2: Minimum acceptable coverage rate



Notes. Relation between the years until retirement and the minimum acceptable coverage rate. The minimum acceptable coverage rate is the highest and most strict for 9-10 years before retirement (94.1%) and decreases for both shorter and longer periods.

For the average pension fund member (45 years old, 22 years until retirement) the replacement rate can be estimated with this equation, which follows from the regression analysis:

$$Replacement\,rate_{t+22} = -0.626 + 1.585 * Coverage\,rate_t \tag{5.1}$$

This is equal to the expectation of the replacement rate of the individual plan (average replacement rate is equal to 84.6%) when the coverage rate is equal to 92.8%. When the real coverage rate falls below 92.8%, most pension fund members will no longer be willing to join, or continue membership in, the pension fund. When the coverage rate falls below 85.5%, members will prefer an individual plan, won't be willing to be members of the pension fund, and the pension fund will be in runoff. We will use this minimum acceptable coverage rate as the point of discontinuity for a pension fund. When we instead use a power utility function[9] with the average risk aversion

[9] equal to $U_i(P_i) = \frac{P_i^{1-\gamma_i}}{1-\gamma_i}$

$\gamma = 1.926$ (Chapter 2), we find a slightly higher average minimum acceptable coverage rate of 93.6%. Incorporating variation in horizon and risk aversion will again give a lower coverage rate, at which point nobody is willing to join the pension fund. Another possible trigger for discontinuity is the replacement rate itself. Binswanger and Schunk (2012) finds that for the majority of members, the minimum replacement rate is above 70%. Pension funds that have a replacement rate below 70% will therefore be considered insufficient, and members and employers might not be willing to pay the considerable premiums.

In our simulation model, we measure both triggers of internal discontinuity after the start-up period ($t = 100$). We find that in 87% of the simulations, after 80 years, the coverage rate drops below 85.5%, resulting in the members preferring the individual plan over the collective plan. On the other hand, in 71% of simulations, the replacement rate falls below the acceptable minimum (70%). In both cases, the triggers occur in our simulation on average once in 15 years. This shows that discontinuity events are relevant, as well as both of the triggers we describe and illustrates the trade-off that occurs with stricter pension regulations. Stricter regulations will lead to more robust financial positions, but will sooner result in replacement rates that are below the acceptable minimum.

5.5.3 Impact of discontinuity

We have shown that discontinuity events occur, both in our simulation as in the cases discussed. We now focus on measuring the impact of discontinuity events. Figure 5.3 shows the development of the replacement rate for the collective pension plan, including a discontinuity event. The development for the first 180 years ($0 \geq N \geq 180$) is equal to that of Figure 5.1. However, in this case, after 180 years, the pension fund goes into runoff[10], and no new contributions are collected (indicated by a dashed line). After approximately 245 years, all remaining members have died and no liabilities remain.

This figure shows that both the median (mean) replacement rate and its volatility increase after discontinuity. The median replacement is 101% at the point of discontinuity, implying a modest surplus of 1%. Decreasing membership implies that the remaining members can increasingly benefit from this surplus, raising the median re-

[10]This can be interpreted as an external discontinuity event; there is no causal relation from the coverage rate to the discontinuity event

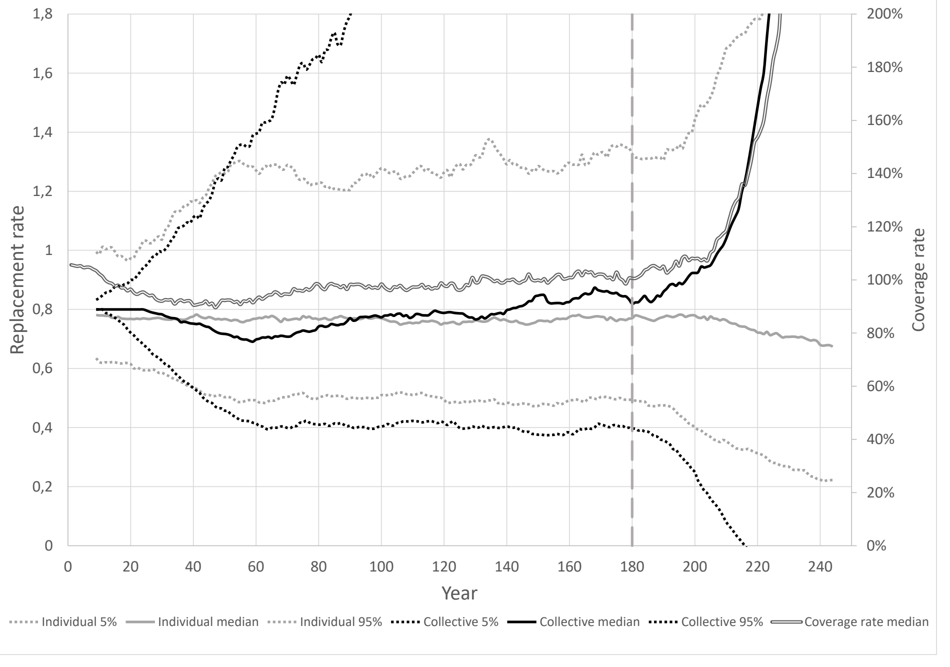
placement rate. However, at the same time, in some simulations (49%), the coverage rate is below 100% at the discontinuity event, implying a deficit. As membership declines, the absolute size of the deficit means that the relative impact for the members increases. In at least 5% of the simulations, assets are completely dissolved before all members have passed away, which is a result of gradual nature of the pension cuts in our model. In these cases, some members will receive no retirement benefits at all. This figure also clearly shows that while median replacement rates rise, downside risk (indicated by the 5% percentile) also rises substantially. Therefore, we confirm that uncertainty of pension benefits increases when a discontinuity event occurs[11].

For the individual plan, we find a small decrease in the median replacement rate after discontinuity, together with an increase in the volatility of the replacement rate, although it's more subtle than that of the collective plan. Both effects are due to the, on average, shorter contribution periods of the members and relatively higher costs relative to assets. Due to the discontinuity event, members in both plans stop contributing to the plan earlier. As contributions have a dampening effect on the replacement rate [12], shorter contribution periods lead to higher volatility of replacement rates.

[11] Please note that in this situation the pension fund is in runoff with the coverage rate at year $t = 180$. In the case of discontinuity events because of low coverage rates, the median replacement rate will drop and downside risk will increase even more

[12] the actuarial fair contributions are equal to 100% of new entitlements, which forces the coverage rate in the direction of 100%

Figure 5.3: Development of the replacement rates with a discontinuity event



Notes. Development of replacement rates from an individual and a collective plan and the median coverage rate of the collective plan (right axis), including a discontinuity event at year $N = 180$ (dashes). Replacement rates are more volatile after discontinuity.

Both the individual and collective plans are affected by the discontinuity event, but the collective plan is affected to a much larger degree, as the collective plan, in contrary to the individual plan, allows for deficits and surplus, which tend to be released at discontinuity. Median (and average) replacement rates rise substantially for the collective plan, but also become very risky. Especially in cases where the coverage rate is below 100%, discontinuity events pose great risks for the members. The preference for an individual or collective plan in the presence of a discontinuity event, therefore, strongly depends on the risk preferences of the members. Risk-neutral or risk-seeking members will prefer the collective plan, while strongly risk-averse members will prefer the individual plan. Please note that the sponsor (employer) does not share investment risk in either the collective or the individual plan, collective plans with sponsors that do share risks (sponsor support) will have less volatile replacement rates (Van der Lecq and Van der Wurff, 2011).

For example, in the last year before discontinuity ($N = 179$), without further information, we can say that an individual will be indifferent towards the collective and individual plan if that person has a risk aversion level of 2.68 (above average (Chapter 2)). As the collective plan has higher volatility, this individual will prefer the individual plan if s/he has higher values of risk aversion. After 20 years in discontinuity ($N = 200$), this value changes to 1.71, which is below average, indicating that more members will prefer the individual plan. So, pension fund discontinuity decreases the group of members that are willing to participate in the collective fund, when they have the option to participate in the individual plan. In this respect, the possibility of a discontinuity event occurring, makes the collective pension plan less attractive, and as a result more members will choose to leave.

5.5.4 The institutional setting and discontinuity risk

So far, the simulation model has shown that discontinuity events are likely to occur. These events will improve expected replacement rates for the collective plan but also will strongly increase replacement rate volatility. In this section, we will analyse the occurrence and impact sensitivity of the discontinuity events on several important characteristics of the pension system, and therefore of the important inputs to our model[13]. The findings of the sensitivity analyses are summarized in Table 5.3, which shows how the occurrence and impact of discontinuity events are related to the institutional setting in which the pension fund is active. In the following sections these institutional settings are discussed in more detail.

[13]Varying the (starting) income, retirement age and age of death (larger interval) did not lead to significant changes in the outcome, expect for making the results less transparent. Therefore, these results are not presented in this paper.

Table 5.3: Sensitivity of pension fund discontinuity to institutional factors

Setting	Discontinuity risk	
	Occurrence	**Impact**
Conservative discount rate	Coverage rate is lower, so more pension cuts and possible discontinuity events at starting-up period, afterwards, pension cuts and discontinuity events become less likely.	Higher (implicit) buffer, so discontinuity events have mostly positive effects due to the release of the buffer.
Constant contribution with age	No effect, conditional on balanced population.	No effect for collective, younger members have paid relatively too much.
Fixed costs	Average costs higher in starting -up phase, therefore higher probability of discontinuity event.	With reduction in the number of members costs increase and replacement rates decline.
Unbalanced population	Volatility increases, so discontinuity becomes more likely.	No effect, conditional on actuarially fair contributions.
Life expectancy shock	Volatility increases, so discontinuity more likely.	Replacement rates decrease.
Discontinuity with deficits	–	Replacement rates decrease sharply.

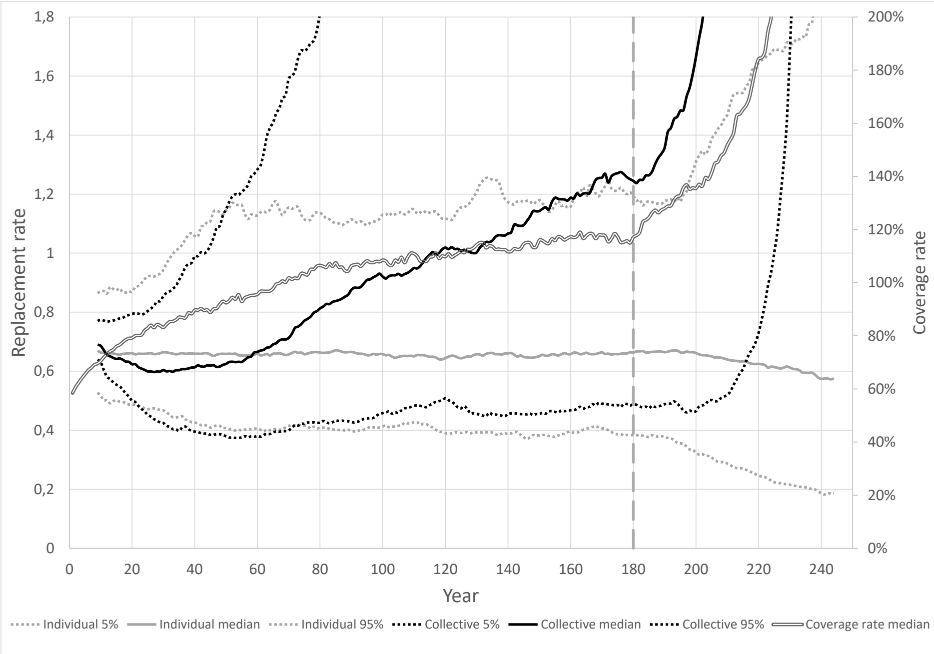
Discount rate of liabilities

Figure 5.4 shows the development of the replacement rate when collective liabilities are discounted with the 30-year risk-free interest rate instead of the expected asset return, which includes an equity premium. This discount rate is normally lower than the expected return; therefore, the present value of liabilities increases and the coverage rate decreases. Due to the lower coverage rate, the collective plan will, in this situation, have more pension cuts in the first years, leading to lower pension benefits (replacement rates), and finally to higher asset values. As asset returns tend to be higher than the discount rate, an implicit buffer is created. The return on this buffer increases the coverage rate, which leads to higher pension benefits.

So, the effect of using a conservative discount rate is that more pension cuts will be applied than necessary, as in a strong majority of the simulations coverage rates would also increase without pension cuts. This is especially the case for the first generations. Future generations benefit from this, as there will be more money available for them (*i.e.*, the part of pensions that is cut, and the return on this), leading to higher pension benefits. This effect is clearly visible in Figure 5.4. Replacement rates tend to be lower in the first 80 years but are higher for the generations that retire in later years. The implicit buffer also decreases the downside risk of the collective plan, which disappears almost completely. The two types of buffers that are often available in this pension plan (coverage rate above 100% (explicit buffer) and the coverage rate being conservative (implicit buffer)) imply that members tend to benefit from a discontinuity event that unlocks these buffers. This might even trigger rational members to force a discontinuity event when possible, as this would serve their interest.

A conservative discount factor makes discontinuity events less likely because reported solvency is lower, but the impact of discontinuity much smaller, as the actual solvency tends to increase due to more previous pension cuts. As the pension funds in our case study (active in the Netherlands) face such discount factor, it may explain why discontinuity is not triggered internally, and why discontinuity tends to be either neutral or positive to the stakeholders.

Figure 5.4: Replacement rates in the case of a risk-free discount rate



Notes. Development of replacement rates from an individual and a collective plan and the median coverage rate of the collective plan (right axis), including a discontinuity event at year $t = 180$ (dashes) and with risk-free discounting and annuitization. Due to the lower discount value, the present value of liabilities increases, leading to more pension cuts and an implicit higher buffer. This in turn increases future pensions. As individual plan replacement rates drop, buying an annuity becomes more expensive.

Interest rate individual annuities

So far, the individual pension capitals where converted to an annuity using the expected return. This is a rather strong assumption, as pension providers in the market will not incorporate both the investment and longevity risk for free. In Figure 5.4, the replacement rates following from the individual plan, with annuities calculated with the risk-free, 30-year interest rate, are presented. As the risk-free interest rate is lower than the expected return, an annuity will become more expensive. Therefore, the replacement rates of the individual plan will shift downwards (including the 5%, 50% and 95% percentiles). In this case, the individual pension plan becomes more unfavourable as compared to the collective pension plan. Dependent on the specific setting (margin of pension providers), the replacement rate of the individual plan will be somewhere between these two possibilities. This implies that pension fund members, facing the trade-off between the collective and the individual plan, will determine their preferences to a large extent on the interest rate that is used for the annuitization of the capital in the individual plan.

Constant contribution with age

Figure 5.5 shows the development of the replacement rate in the case of constant contributions, including a discontinuity event at year 180. The fixed contribution is set equal to the average contribution in our previous simulations, which is equal to 15.2%[14].

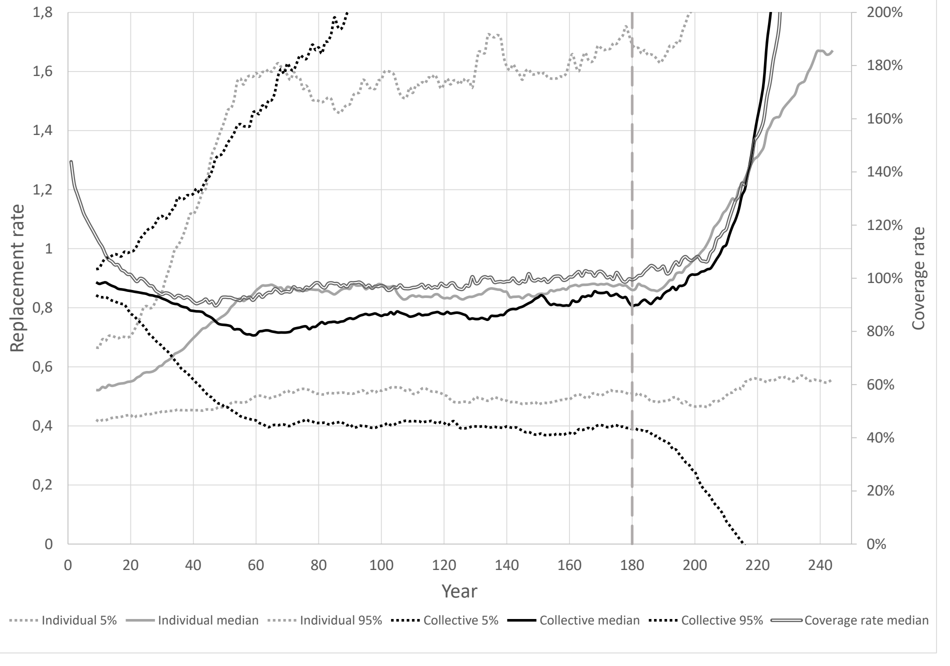
Overall, the effect of the constant contribution is limited. The main effect for the collective plan is that the contribution is higher for the first years, because the average age of members is lower in this period; therefore, the contribution is higher (compared with progressive contributions). Due to the higher contributions in the first period, the coverage rate, and thereby the replacement rate, starts at a higher level and will approach the median path (80% of average income) sooner. Although the effect on the collective pension plan as a whole is limited, the effect on the members can be large, as there will be a shift of contributions from members who leave the fund early towards members who enter the fund later (Van der Lecq and Steenbeek, 2006).

The effects on the individual plan are greater[15]. As contributions are shifted towards earlier years, the actuarial value of contributions increases (higher contributions in first years have more time to accrue). Because of this, the value of retirement benefits increases, and now tends to exceed that of the collective plan. In the first period, when members retire who became member at an older age (as the pension fund didn't exist before), the replacement rate is lower. These members have made relatively lower contributions, resulting in lower benefits. After discontinuity, the opposite occurs, as more members retire who became inactive at younger ages due to a discontinuity event. Because of this, the effect of discontinuity turns around and becomes positive in the median in our simulations.

[14]We do not take changes in average age into account.
[15]Whether this is allowed again depends on the institutional setting of the pension plan.

Having constant contributions instead of progressive contributions results in relatively minor changes for the collective plan. However, they yield significant changes for individual members who have not been members during their entire working life and for members of the individual pension plan.

Figure 5.5: Replacement rates with constant contributions



Notes. Development of replacement rates from an individual and a collective plan and the median coverage rate of the collective plan (right axis), including a discontinuity event at year $t = 180$ (dashes) and with constant contributions. The effect on the collective plan is marginal, while the effect on the individual plan is large, in line with the members' ages at entry into and exit from the fund. The actuarial value of the individual plan increases as contributions are shifted to earlier ages (*i.e.*, longer investment period).

Fixed costs

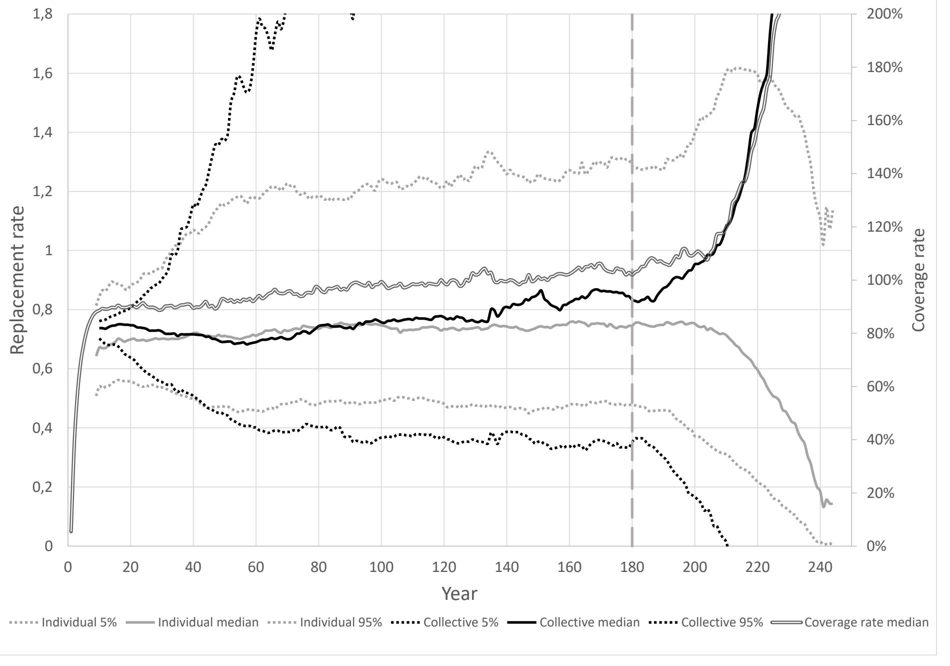
Figure 5.6 presents the development of replacement rates in the presence of fixed costs. For this model, half of the costs[16] is assumed to be fixed, both for the collective and individual plan. In both plans, members are therefore dependent on total fund membership.

Average costs per member are higher in this model for the first and last years, when the number of members is lower than average. The years in between have more members, and therefore lower average costs due to economies of scale. Because of this, the coverage and replacement rates are lower in the start-up period but thereafter exceed those of the baseline model, when the pension fund benefits from lower costs. In the case a pension fund goes in runoff due to a discontinuity event, total membership gradually decreases, as members die without new members joining the pension fund. With fewer members, costs per member increase, and the last members present in the fund are confronted with very high costs, substantially lowering their pension benefits. However, the effects, in particular that of discontinuity, are relatively small for the collective plan, due to the presence of positive and negative buffers, which absorb some of the impact of changing average costs.

For the individual plan, the effect is more pronounced. With fixed costs, the impact of the discontinuity is far more severe. The entire distribution of replacement rates shifts downwards after discontinuity, as the remaining members have to incorporate an increasing share of the fixed costs. This makes discontinuity, particularly in the individual plan, a poor prospect.

[16] Calculated as median costs for the years before the discontinuity event, which depend on the number of members and total assets under management.

Figure 5.6: Replacement rates with fixed costs



Notes. Development of replacement rates from an individual and a collective plan and the median coverage rate of the collective plan (right axis), including a discontinuity event at year $t = 180$ (dashes) and with fixed costs. Effects are marginal for the first 180 years, but fixed costs increase the effects of discontinuity (more volatility). The effect is smaller for the collective fund, due to presence of financial buffers.

Unbalanced population

In many cases of discontinuity, all members become inactive at the same time. Alternatively, when no new members join the pension fund, the pension fund will eventually discontinue as well. This might happen when new members are no longer willing to join the fund (when participation is not mandatory); for example, due to the poor coverage rate. In this case, the population will shift towards older members, as the present members become older without new members joining the pension fund. Table 5.7 shows the development of replacement rates in this situation (at year $t = 140$). The effect is very similar to that of the discontinuity event assumed thus far (instantly in runoff), but spread out over time. As relatively more members become inactive / retired, the volatility increases and median replacement rates increase.

Figure 5.7: Replacement rates with unbalanced population development

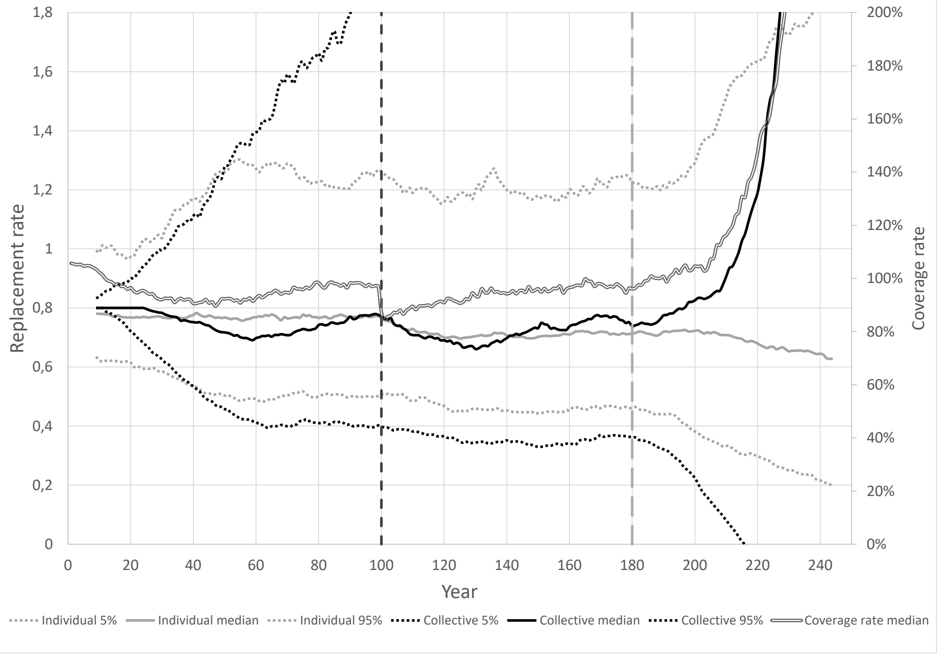
Notes. Development of replacement rates from an individual and a collective plan and the median coverage rate of the collective plan (right axis), including an alternative discontinuity event at year $t = 140$ (dashes), at which point no new members join (but current members remain active). The effect of the discontinuity event is similar to the other discontinuity event, although the effect is more gradual.

Life expectancy shock

In Figure 5.8 the replacement rates are presented with an unexpected upward shock in life expectancy (+2 years) at year $t = 100$. For the individual plan, the cost of the annuity increases, therefore decreasing the total distribution of replacement rates for new retirees (by 7.4%). This effect is gradually visible after the unexpected life shock, as new members go into retirement (at which time the annuity is purchased).

Also, the replacement rates of the collective fund decrease. Due to the shock in life expectancy, liabilities increase, thus decreasing the coverage rate, which leads to lower benefits. Median replacement rates of the individual and collective plans become similar and the negative effect of a discontinuity event increases (lower buffers). As the life expectancy shock will normally be outside of the influence of the pension fund, and will affect all pension funds similarly, members are more likely to accept to negative consequences from this event.

Figure 5.8: Replacement rates with a life expectancy shock



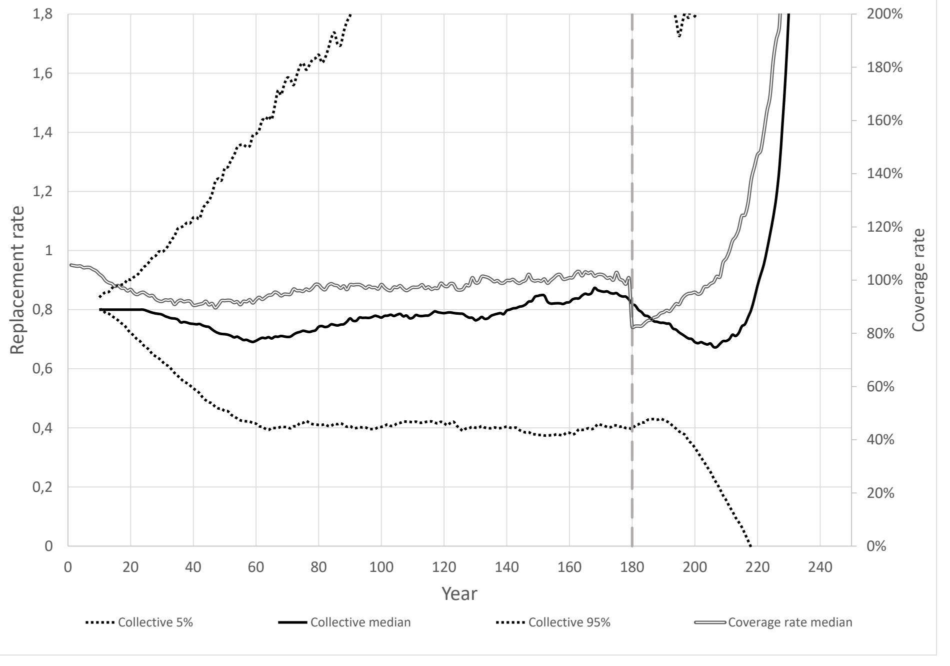
Notes. Development of replacement rates from an individual and a collective plan and the median coverage rate of the collective plan (right axis), including a discontinuity event at year $t = 180$ (dashes) and a life expectancy shock (+2 years) at year ($t = 100$ (smaller dashes). Both replacement rates decrease due to the life expectancy shock, and the impact of discontinuity increases through greater volatility.

Discontinuity with deficits

So far, we have assumed that the discontinuity event was not related to the financial position of the pension fund (*e.g.*, external trigger). However, as we have shown in Section 5.5.2, discontinuity events can also be triggered by the coverage rate, and in these cases there is a strong correlation between the coverage rate and the discontinuity event. In Figure 5.9, we present the development of the replacement rates with a discontinuity event (year $t = 180$) at which point the coverage rate drops to 85.5% (as found in Section 5.5.2). This implies that in the year of discontinuity, pension benefits are instantly cut by approximately 1.45% ($(100 - 85.5)/10$). We do not simulate financial problems for the individual plan, as by definition, these have 100% solvency.

With a financial shock, the replacement rates substantially shift downwards after the discontinuity event. In this case, after the discontinuity event, the median replacement rate decreases rather than increases. The 5% percentile stays relatively stable as these funds were already in financial difficulties. Despite the fact that the replacement rates tend to decrease after the discontinuity event, approximately 30 years after discontinuity they start increasing again. At this time, the buffers are restored, due to various pension cuts, and the continuing members can increasingly benefit from the remaining buffer (in the median path). Discontinuity events that are related to financial problems lead to lower replacement rates and higher volatility than discontinuity events that are uncorrelated to the financial position of the fund.

Figure 5.9: Replacement rates with solvency problems



Notes. Development of replacement rates and the median coverage rate (right axis) from a collective plan, including a discontinuity event at year $t = 180$ (dashes) at which the coverage rate changes to 85.5%. This decreases replacement rates in the short run, but for the last members the presence of financial buffers offsets this effect.

The institutional settings discussed in this section shows that pension fund discontinuity risk is strongly dependent on the institutional setting of the pension fund. The institutional setting can make discontinuity events both likely to occur and impossible to occur. Also, dependent on the institutional setting a discontinuity event can be either very negative or positive to pension fund members. The analysis of discontinuity risk should therefore be closely related to the relevant institutional setting of a pension fund.

5.6 Conclusion

This paper analyses the occurrence and impact of discontinuity events of collective pension funds. Pension funds are often implicitly assumed to have an infinite lifetime, while in practice that European pension funds discontinue. Furthermore, discontinuity events are often described as bad events for the actors involved, but research on the impact of discontinuity events is absent. In addition, discontinuity events may be strongly linked to the institutional setting; but this relation has not been studied before.

This paper intends to fill these gaps. Using a case study combined with a simulation model, we assess the occurrence and impact of pension fund discontinuity and the impact of the institutional setting. We differentiate between four types of discontinuity event triggers. Internal triggers, in contrast to external triggers, originate from within the pension fund itself. These include a lack of trust in the fund and low replacement rates. The prime external trigger is the discontinuation of the sponsoring employer (*e.g.*, bankruptcy). Another distinction is between social and financial triggers. Social triggers originate from the members; lack of support can make them unwilling to participate in the pension fund. Financial triggers, like solvency problems, can also force a pension fund into discontinuation. In this case, the sponsoring company or financial supervisors are more likely to trigger a discontinuity event. These triggers are closely connected. Financial problems, for example, can make members uncertain about their future benefits, thus lowering trust, while external financial shocks can force internal financial problems. The result, however, is the same: The pension fund goes into runoff, all active members become inactive, and no new members will join the pension fund. The trigger of the discontinuity event is therefore of lesser importance, although the correlation with the coverage rate (Section 5.5.4) does influence the impact of the discontinuity event.

The analysis of six pension funds that discontinued shows there is much variation in the start-up situation, motivation, and continuation choices surrounding pension fund discontinuity. However, discontinuity is not unilaterally bad for the stakeholders involved, including pension fund members of the collective pension plans. Most of the cases discussed even showed significant improvements for all the members. In all cases, discontinuity was caused by an external event outside of the influence of the pension fund. However, the cases discussed represent pension fund discontinuity in the institutional setting of the Netherlands, other institutional settings may better allow for internal discontinuity events. Using a simulation model, we analyse the impact of the institutional setting on pension fund discontinuity.

The results of a long term (250 year) stylized pension fund simulation model shows that internal discontinuity events are likely to occur within the horizon of our simulations, with discontinuity events occurring more often due to lack of membership support than financial problems, although both are strongly connected. However, in line with the results of the case study, our model shows that discontinuity is not necessarily bad for pension fund members. The riskiness of the replacement rate tends to increase after a discontinuity event, but the same is true for the median replacement rate. Whether a discontinuity event is considered bad for a member, therefore, depends on his/her risk aversion and on the institutional setting of his/her pension fund. This poses a trade-off in the design of the pension system. Institutional factors influence both the perceived and actual financial position of the pension fund, but not necessarily to the same extend or in the same direction. Stricter regulations for example, increase the financial stability of the pension fund, but lower the perceived position of the fund. This makes discontinuity more likely, as the perceived financial position is lower, and members and sponsors will be sooner inclined to discontinue the pension fund, but reduces the impact of discontinuity, because the actual financial position will normally increase (*e.g.*, due to higher pension cuts in the past).

Sensitivity analyses show that when pensions use conservative discount rates, the impact of discontinuity events improves due to higher (implicit) buffers. The presence of fixed costs deteriorates the effect of discontinuity due to higher average costs when the number of members decline. A population that is either unbalanced, or which faces a rise in life expectancy, results in more volatile pension benefits and higher occurrence of discontinuity events. Constant contributions, as opposed to progressive contributions, have redistributive effects within the population but do not significantly alter discontinuity risk.

The replacement rate of the collective plan tends to surpass that of the individual plan, although the latter is in most cases less volatile. The on average positive buffer (*i.e.*, surplus) increases expected benefits for future retirees. However, the risk that the collective plan presents for a member to start in a situation with a deficit, increases downside risk. Of course, this can be corrected by adjusting the asset allocation; however, this falls outside the scope of this research. The individual pension plan is especially sensitive to the rules concerning the annuitization of pension capital at retirement age. If annuitization is mandatory and based on the risk-free interest rate, the collective pension plan is practically superior to the individual plan. The main advantages of the collective plan are the options of spreading deficits and surpluses and the possibility of continuing to invest during retirement.

5.7 Discussion

The analysis in this paper shows that discontinuity events are not necessarily bad to pension fund members but that their impact strongly depends on the specific setting of a discontinuity event. In this paper, we have used a case study and a stylized model to describe pension fund discontinuity. Including more of the real life complexity in the (mostly country- specific) model will change the exact impact of discontinuity. We will discuss some of these factors here.

For individual plans, we have assumed a single pension plan with a single asset allocation that does not change within our horizon. Individual plans may have particular value by allowing for customizing the plan to individual preferences and time to retirement (*i.e.*, lifecycles). The value of the individual plan (compared with the collective plan) will therefore be more attractive than in our model (see, for example, Chapter 2).

In our model, we constantly correct for inflation to deal with the long time horizon. Therefore, the results represent the purchasing power of pension fund members, which in our opinion will be most relevant for the members. However, many countries use nominal coverage rates and focus on nominal replacement rates. In addition, most members do not take inflation correctly into account (*i.e.*, money illusion). Inflation might therefore be less relevant to pension fund discontinuity as would be rationally expected.

As the analysis shows, we cannot assume that discontinuity events are either unilaterally bad or good for pension fund members. The analysis of six pension funds that have discontinued showed that the availability of continuation options may abate the impact of discontinuity risk. However, these six cases were active in the same institutional setting of the Netherlands), and results may be different for other institutional settings. The analysis of the impact of discontinuity events, following our discussion of the sensitivity of the institutional setting, should always be related to the specific setting of the pension system under scrutiny, taking institutional factors into account.

Chapter 6

Conclusion

The pension sector is one in which the interests of many stakeholders come together. Choices in the pension sector are often complex, and they tend to affect various stakeholders differently. As the interests of the stakeholders are often not aligned, and the consequences of many choices in this sector unclear, making choices in the pension sector is very complicated. This dissertation studies a number of these choices, in particular those related to pension plan management.

Choices in pension plan management involves, amongst others, the division of pension plan members over pension providers. For example, is it best to allocate all individuals to a single pension fund, so as to benefit from economies of scale, or should individuals be divided over multiple pension funds, so that they are incentivized to operate efficiently? Or should this decision be left with the members themselves? Another relevant decision is whether pension plans should be customized to personal preferences. Adjusting the plan according to personal preferences will improve the value that pension plans give to their members, but it is difficult to obtain the preferences. Furthermore, customizing pension plans is likely to increase costs and also can reduce the possibilities to share risks among members, it is unclear whether the additional benefits of a more tailor-made pension is worth the additional costs. An alternative to customizing pension plans is to pool members with comparable preferences in different pension funds, but this raises the question as to how members should be pooled, as preferences can't be observed directly. Furthermore it remains to be seen whether redistributing members is worth the costs associated to it, as substantial heterogeneity between members is expected to remain even when comparable members are grouped.

These questions are discussed in this dissertation. A combination of empirical data, a case study and stylized simulation models are used to bring real-life data together with situations that have not yet occurred, but which can be relevant in the future. By looking at these problems from different perspectives we get a better understanding of the pension sector and we provide insights that can improve the value of pension plans to different stakeholders, that may, or may not, be in line.

In the following section, the main findings and contributions of the individual chapters are discussed. Then, in Sections 6.2 and 6.3 respectively, the theoretical and practical implications of the dissertation as a whole are presented. Finally, Section 6.4 presents the strengths and limitations of this dissertation, and potential avenues for future research.

6.1 Summary of main findings and contributions

Chapter 2, Individual pension risk preference elicitation and collective asset allocation

In this chapter, the risk preferences of 7,894 pension plan members are elicited with multiple risk elicitation methods. Risk preferences are found to be highly heterogeneous and vary with age, income, education, gender and the industry of the employer. However, a large part of the heterogeneous nature remains unexplained, indicating that risk preferences must be elicited when they need to be known. Combining the information from multiple risk preferences elicitation methods increases the robustness of the results. The chapter uses a pension income simulation model to show that the heterogeneity of the risk preferences is reflected in a heterogeneous optimal asset allocation. Given the expected equity premium, the optimal asset allocation varies with risk preferences, but also with age and income, when a base pension is taken into account. Using a single (one-size-fits-all) asset allocation, therefore, does not do justice to the heterogeneity of members and results in welfare losses for most pension plan members. A practical framework is provided to estimate the value of eliciting risk preferences for pension plan managers when allocating pension fund assets.

Chapter 3, Measuring latent risk preferences –minimizing measurement biases

This chapter focuses on measuring latent (real) risk preferences. An improved online survey (incorporating the feedback from Chapter 2) is used to elicit risk preferences of 9,357 pension plan members with multiple elicitation methods. Factor analysis shows that the elicitation methods describe a common latent variable, identified as risk aversion. The methods, however, also score on a factor identified as financial / questionnaire literacy and the correlations and directions differ, showing that biases influence the measurements ambiguously (two-sided). Item response theory is used to combine the responses of the elicitation methods into a composite score. The composite score is a better approximation of the latent variable and diminishes the impact of measurement noise and ambiguous biases. The addition of two manipulations to the survey shows that revealed risk preferences are highly sensitive to amounts, order and endowment chosen in the framing of the methods. Combining simpler methods with more advanced methods, and framing them closely to the relevant domain yields more accurate risk preferences.

Chapter 4, X-efficiency and economies of scale in pension fund administration and investment

Chapter 4 discusses pension fund administration and investment costs. In particular, economies of scale and X-efficiency are analysed, which are best described by a stochastic cost frontier, with a quadratic spline function. Large economies of scale are found for pension fund administration, while investment activities are described by minor diseconomies of scale. Both administration and investments are characterized by substantial X-inefficiencies. In addition, costs differ over time, for different types of pension funds and with population properties. An analysis of total costs reveals minor, but persistent, economies of scale. The results of this chapter show that, by incorporating best practices (the more X-efficient pension funds' practices), and by operating at more efficient sizes, pension funds should be able to realize substantial cost reductions.

Chapter 5, The occurrence and impact of pension fund discontinuity

This chapter discusses discontinuity of pension funds. Collective pension arrangements tend to yield higher risk adjusted pension benefits than individual plans due to intergenerational risk sharing and the lack of conversion risk. These benefits pose the implicit assumption that the pension fund has an infinite horizon, while we observe that many pension funds discontinue. Using a case study of 6 discontinued pension funds, combined with a simulation model, this chapter analyses the occurrence and impact of pension fund discontinuity. Although discontinuity tends to increase the volatility of pension benefits, median benefits in most institutional settings increase after discontinuing the fund. We find that both the occurrence and the impact of discontinuity depends on the institutional setting of the pension fund. Stricter regulations, such as more conservative discount rates, increase the financial stability of the pension fund, but may reduce membership support because of lower replacement rates, which poses a trade-off in the design of the pension system.

6.2 Theoretical implications

In Chapters 2 and 3, we introduce an augmented risk preference elicitation method. The method combines the information from multiple elicitation methods with the benefits from both simple methods (reliable) and from more advanced methods (that give more information). This method, framed closely to the relevant domain, gives a better approximation of the latent variable risk preferences. In this way our findings contribute to those of Kapteyn and Teppa (2011) and Holt and Laury (2002), improving the methods they propose to elicit risk preferences, and to those of Beshears et al. (2008) by proposing alternative ways to diminish measurement biases.

Using the augmented elicitation method we find risk preferences that are strongly heterogeneous within the same and across different pension fund populations. Risk preferences correlate significantly with socio-demographic information, such as age, income, gender, home-ownership, having a partner and education level. The explanatory power of these socio-demographic variables is higher for our augmented elicitation method than was found in earlier research (*i.a.*Jianakoplos and Bernasek (1998) and Powell and Ansic (1997)).

In Chapter 4 we employ four different methods to measure pension fund cost efficiency for administration and investment. To the best of our knowledge, this paper is the first that applies efficiency analysis to pension funds. We find that the stochastic cost frontier analysis is most suitable to measure cost efficiency in the pension domain. The presence of outliers makes the non-parametric methods too sensitive, while linear regression models do not allow for the differentiation between efficiency and other non-systematic effects. A quadratic spline function, with a single break-point, best describes administrative and investment costs.

The results of Chapter 5 show the importance of modelling long term pension fund performance. As the average horizon of pension plan members is very long (up to 60 years), performance of pension funds should also be analysed long term. The analysis of long term pension fund performance shows developments that are not adequately represented in shorter-term studies. This way, Chapter 5 builds on recent literature (Beetsma and Bovenberg, 2009; Bovenberg et al., 2007; Bovenberg and Mehlkopf, 2014; Molenaar et al., 2011) by using a longer horizon, that allows us to analyse the occurrence of pension fund discontinuity events, and to analyse value transfers from one generation to the other, which requires a multitude of generations in the model.

6.3 Practical implications

Using two large datasets the risk preferences of pension plan members are elicited in Chapters 2 and 3. Risk preferences are found to be highly heterogeneous, and vary with income, age, gender, home-ownership, having a partner, the education level and the employer/industry at which a member is active. However, explanatory power of these variables is too low to accurately predict individual risk preferences. When pension funds want to obtain individual risk preferences eliciting them is unavoidable, as the alternative - accurately predicting the preferences - is not possible. As the heterogeneity within funds (each providing pensions to the employees of a certain company) is smaller than across funds, pension plan members can benefit by organizing pension funds around employers or industries. More similarity within a fund's population will reduce welfare losses due to heterogeneous preferences.

In Chapter 2 we show that heterogeneity in risk preferences also lead to different optimal asset allocations for pension plan members. The optimal allocation to equity depends on the individual risk preferences, age of the member (years to retirement) and on the income. In addition, the optimal allocation is dependent on the institutional setting of the pension fund. Pension funds in countries with high base incomes (social security) should allocate relatively more (of the risk-baring pension) in risky assets. When the base income is sufficiently high, almost all members will want to allocate their risk-baring pension to risky assets, which reduces the value of eliciting risk preferences. Table 2.9 presents a practical framework that can help pension funds to determine the value of eliciting risk preferences of their members.

Chapter 4 presents the cost structure of pension fund administration and investment. Both types of costs are best described with a quadratic spline function. Administrative costs show large scale advantages for sizes up to the break-point (245 members). After the break-point there are only small scale advantages, which decrease slowly with further increases in size. Only the largest pension funds present in the Dutch market suggest diseconomies of scale in administration. The scale effects for pension fund investment are much smaller. Almost all funds operate at a cost elasticity close to one, indicating approximate constant returns to scale. In both cases, the break-point is below the average size, indicating the large diseconomies of scale of especially very small pension funds. Although unused economies of scale decline fast with increases in size (number of members and value of total assets under management) towards the average size, we find persistent, but small, economies of scale for all sizes currently present in the Netherlands.

Comparing pension fund costs, while controlling for size and other relevant factors (*e.g.*, type of fund, composition of the population and plan properties), shows that there are substantial deviations in performance (X-inefficiency). Given the presence of X-inefficiency, most pension funds can reduce costs by incorporating practices of more efficient pension funds (applying best practices). Company and professional group funds tend to be less efficient than industry wide funds, implying that more industry wide funds apply best practices. Defined contribution plans are (on average) cheaper to run than defined benefit plans.

The analysis in Chapter 5 confirms the advantages of (intergenerational) risk sharing in pension plans. Collective pension plans give, on average, higher replacement rates than individual pension plans, (mostly at the costs of the first generation(s), who have to accumulate the first buffer that is used for protection and indexation purposes). However, individual benefits of the collective plan are strongly dependent on the coverage rate. Individual members can estimate their expected replacement rate given the (current) coverage rate. A coverage rate that is below a lower threshold (the acceptable minimum) may make members unwilling to participate in the collective pension plan.

When we consider longer horizons discontinuity events occur frequently. Analysis of six cases shows that pension funds that face a discontinuity event vary in the motivation for the discontinuity event, the continuation choices, and the consequences for the members. Lowering average costs and reducing the complexity of the pension plan are the most important stated motivations for these pension funds. None of the pension funds analysed resulted in a unilaterally negative outcome for all members. Discontinuity events can be endogenous and exogenous to the pension fund, but their occurrence and impact on pension plan members is strongly dependent on the institutional setting of the pension plan. More conservative discounting of liabilities, and lower fixed costs, dampen the effect of discontinuity, and make internal triggers (endogenous discontinuity) less likely. Although stricter regulations tend to increase the stability of the pension fund, it also may lower membership support, as the coverage rate will be lower, and pension cuts are more likely. This poses a trade-off in managing pension fund discontinuity risk. The presence of company pension funds increase the occurrence of external triggers (exogenous discontinuity), as the existence of the pension fund becomes closely attached to operations of the sponsoring company. Given the dependency of the institutional setting, the analysis of risk sharing in the pension domain, and in particular that of pension fund discontinuity risk, should be closely connected to the institutional setting of the pension funds involved.

The conclusions in this thesis suggest that the needs and wishes of plan participants are heterogeneous regarding their financial income over the lifecycle. The question is how to accommodate this heterogeneity. This can be done by moving away from the one-size-fits-all collective funds that are currently dominating many pension landscapes, by introducing modular elements within these collective funds or - in the most extreme event - splitting pension funds. In all cases, a thorough cost-benefit analysis is important, not just in monetary terms.

No matter which way pension plan members are pooled, there will always be heterogeneity in risk preferences within the pension plan. Because of this, a single investment strategy will reduce welfare as it cannot be in line with all members at the same time. This may advocate for customizing pension plans to individual preferences. These plans, according to our research in Chapter 4, tend to be cheaper than defined benefit plans. However, in Chapters 2 and 3 we've shown that members are not perfectly aware of their own preferences, and may not be financial literate enough to decide on their own asset allocation. In addition, customizing individual pensions reduces the opportunities for risk sharing, which can improve replacement rates or lower risk (Chapter 5).

When preferences are significantly heterogeneous, and eliciting preferences prove to be infeasible for pension plan managers, an alternative is to pool members in line with easy to observe characteristics, such as age, gender or industry. Our research shows that these characteristics, imperfectly, correlate with risk preferences. Pooling similar members will therefore reduce heterogeneity within the pension plan, and will therefore lead to lower welfare losses due to heterogeneous preferences. In addition, it may make risk sharing easier as members are more willing to share risks with individuals that are more similar (Van der Lecq and Steenbeek, 2006). Pooling plan members on an industry level therefore reduces heterogeneity within the fund, but also allows for sufficient scale to benefit from economies of scale. And, as we find in Chapter 4, industry funds tend to be more X-efficient. Industry funds, compared to company funds, are less vulnerable to discontinuity events, as they are not dependent on a single employer. However, to prevent individuals (or employers) from not joining the pension fund it may be optimal to make membership mandatory. This will prevent internal discontinuity events (which however may not be necessary bad) and let pension funds fully benefit from the economies of scale of a large number of members.

The appropriate amount of individualisation and pooling of members depend on the institutional setting of pensions. Larger (relative) base pensions, higher fixed costs (*e.g.*, due to higher regulatory pressure) and more conservative discounting (which dampens the discontinuity risk) advocate more pooling of members, while more heterogeneity, higher financial literacy and fewer (potential) members (which reduces competitive pressure) advocate more individualisation of pensions. The optimal design of the pension system is therefore strongly dependent on the specific institutional setting in a country.

6.4 Strengths, limitations, and future research

Datasets The studies in this dissertation make use of three large scale datasets. This data describes actual pension plan members and pension funds. The datasets of Chapters 2 and 3 use survey responses of 7,894 and 9,357 pension plan members respectively. These pension plan members are directly invited by their pension fund, which will increase intrinsic motivation to honestly complete the survey. In addition, respondents were told that their choices would affect pension fund management (consequential incentive), at least one pension fund changed its' asset allocation as a direct result of the survey. The second survey uses the feedback of the first survey to increase validity of the responses. The response rate differs across pension funds, which may influence the representativeness of the results. However, as heterogeneity, and not necessarily representativeness, is the main feature of the study this is not problematic, but is does raises the question how pension funds can reach all members when they want to measure individual risk preferences. The study of Chapter 4 is based on supervisory data of 1,271 pension funds over 22 year. The dataset contains all active pension funds in The Netherlands, which are obliged to report the requested data. Although this is the most reliable dataset available, the presence of some measurement noise makes the domain unfit for non-parametric efficiency measures, that are sensitive to outliers. This problem is reduced in the later years, when data requirements became more strict.

Generalizability of results This dissertation is embedded in the Dutch pension markets. The results apply to the specific pension funds analysed, which may not necessary represent all pension funds (in the Netherlands or globally). The pension system in the Netherlands is characterized by funded pension plans, mostly organized collectively. Funding rates tend to be considerably higher than in many other countries (OECD, 2015c). Participation is semi-mandatory, therefore most individuals cannot choose their own pension fund. This is in contrast to countries like Chile, where individuals have free choice. These factors will change cost structures (*e.g.* competitive pressure and marketing costs), possibilities to customize pensions, and discontinuity risk. In each study we discuss the impact of the institutional setting, which will differ across countries, and the impact of the population, which differs across pension funds. An important insight of this dissertation is the large variety in institutional settings when it concerns pensions. Examining the institutional setting of other countries, and its effect on the important choices concerning pensions, will be an interesting opportunity for future research.

Asset return model Throughout the dissertation we have applied the asset return model of Koijen et al. (2010), using parameter estimates of (Draper, 2014). Although other asset return models, and parameter estimates, are available, we believe that this represents a robust model of asset returns. The analysis of certain deterministic models (*e.g.*, "the Japan scenario") might yield specific information about certain choices and the robustness of results. However, as the purpose of our studies was to quantify results and probabilities we leave this for future research.

Utility function The literature describes and applies a great variety of utility functions. These utility functions differ in the extend to which they describe behavioural and normative preferences, and the choice of an utility function is arbitrary. However, as we attempt to analyse normative (latent) risk preferences, as opposed to revealed preferences, we apply the power utility function, which is considered to be the appropriate utility function to model normative preferences (Quiggin, 2012). Applying utility functions that describe behavioural deviations might improve our understanding of what drives the biases that we, in our studies, try to neutralize.

Quality of pension plan In Chapter 4 we assume that pension funds want to minimize costs, and only partially control for differences in the service level of the pension plan. Differences in the quality of the pension plan (*e.g.*, customization options and the identity of the pension fund) might, to some extend, allow for higher costs. Future research that can better measure, and account for, the quality of the pension plan will improve our understanding of pension fund efficiency and scale effects.

Horizon Special to this dissertation is the long horizon that we consider. As the horizon of pension members tend to be very long, the analysis of pension should be also long term. However, when the horizon of the analysis increases, so does the uncertainty surrounding the analysis. For example, over the longer term parameter uncertainty becomes relevant, as does uncertainty in the institutional setting of the pension sector. However, not taking the longer term into account neglects the effect of intergenerational transfers and other relevant effects, such as discontinuity events.

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Summary

Pensions are important to households as a means to smooth income over lifetime and to the economy by representing a large part of national savings. The organization of pensions differs greatly across, and within, countries, and these differences affect the large number of stakeholders differently. The choices that underlie these differences tend to be very complicated, they affect many aspects, like expected pension benefits, volatility of benefits, saving behaviour, and economic growth, both directly and indirectly. This dissertation aims to contribute to the theory and practice of pension plan management by analysing these choices. These choices are addressed in four studies, each of which focuses on specific choices or applies a different method.

In Chapter 2 and 3 we propose an augmented risk preference elicitation method and apply it to elicit pension plan risk preferences of more than nineteen thousand pension plan members. By combining the results from multiple methods the risk preferences obtained represent latent risk preferences more closely. Risk preferences are found to be heterogeneous within, and across pension plan populations. Heterogeneity in preferences, together with institutional factors such as the base pension, result in heterogeneous optimal asset allocations. We provide a practical framework that can help pension plan managers to assess the value of eliciting risk preferences for their members.

Chapter 4 discusses X-inefficiency and scale effects of pension fund administration and investment. Using a unique supervisory data set we show that there are large economies of scale for pension fund administrations, but modest diseconomies of scale for investment activities. Many pension funds have substantial X-inefficiencies for both administrative and investment activities. Given both types of inefficiency that we observe, pension funds should be able to improve their cost performance, and hence increase pension benefits.

In Chapter 5 we analyse pension fund discontinuity events with a case study and a simulation study. Collective pension plans tend to give higher benefits than individual plans, but this depends on the financial position of the collective pension plan. Volatility in the financial position at accession adds risk in the benefits of collective pension plans. Discontinuity events tend to increase the volatility of pension benefits, while median benefits in most settings increase due to the release of (implicit) buffers. The occurrence and impact of a discontinuity event depends strongly on the institutional setting of the pension fund. Stricter regulations, such as more conservative discount rates, increase the financial stability of the pension plan, but may reduce membership support by lower replacement rates, which poses a trade-off in the design of the pension system.

The findings in this dissertation show that pension plan members can benefit from pooling their pensions. By increasing scale, costs will decrease, while collective plans tend to yield higher (risk adjusted) benefits. Pooling similar individuals, such as within an industry, decreases heterogeneity within the plan, which will reduce welfare losses. Allowing pension plan members to customize their asset allocation may yield further increases in welfare. However, for individuals to be able to select the right asset allocation requires that they first become aware of their latent risk preferences.

These choices strongly depend on the institutional setting. Specific institutional factors, such as the availability of a base pension and pension fund regulations, will alter the costs and benefits associated with these choices, and therefore also alter the preferences for these choices themselves. Together, the studies in this dissertation represent an in-depth discussion of relevant choices in pension management, the dynamics behind these choices, and their impact on the large number of stakeholders involved.

Nederlandse samenvatting

Pensioenen zijn een belangrijk instrument voor huishoudens om inkomen te verdelen over het leven. Daarnaast zijn pensioenen ook belangrijk voor de economie als geheel, doordat pensioenen een groot gedeelte van het nationale spaargeld vormen. De organisatie van pensioenen verschilt sterk tussen en binnen landen, met als gevolg uiteenlopende effecten voor de verschillende betrokkenen. Keuzes in pensioenbeheer zijn veelal erg complex en beïnvloeden vele aspecten, zoals verwachte pensioenuitkeringen, volatiliteit van de uitkeringen, spaargedrag en economische groei, direct en indirect. Dit proefschrift heeft als doel bij te dragen aan de theorie en praktijk van pensioenbeheer door het analyseren van deze keuzes. Deze keuzes worden behandeld in vier studies, waarvan elke focust op specifieke keuzes of gebruikmaakt van andere methodes.

In Hoofdstuk 2 en 3 stellen we een verbeterde uitvraagmethode van risicobereidheid voor en passen deze toe om de pensioengerelateerde risicobereidheid van negentienduizend pensioenfondsdeelnemers te meten. Door de resultaten van verschillende methodes te combineren krijgen we risicovoorkeuren die beter overeenkomen met de latente risicovoorkeuren. Uit de resultaten blijkt dat risicobereidheid verschilt tussen en binnen pensioenfondspopulaties. Heterogeniteit in risicobereidheid, samen met institutionele factoren, zoals eerste pijler pensioen (AOW), leidt tot verschillende optimale asset allocaties. We stellen een praktisch raamwerk voor dat pensioenfondsbestuurders kan helpen om de waarde in te schatten van het meten van de risicobereidheid van hun deelnemers.

Hoofdstuk 4 bespreekt X-inefficiëntie en schaaleffecten van pensioenfondsadministratie en beleggingsbeheer. Met behulp van unieke toezichtdata tonen we grote schaalvoordelen voor pensioenfondsadministratie en kleine schaalnadelen voor beleggingsactiviteiten aan. Veel pensioenfondsen hebben substantiële X-inefficiëntie voor zowel hun administratie als hun beleggingsbeheer. Gegeven beide vormen van inefficiëntie zouden pensioenfondsen in staat moeten zijn om hun kosten te verlagen en zodoende hun uitkeringen te verhogen.

In Hoofdstuk 5 analyseren we pensioenfonds discontinuïteitsrisico met behulp van een casestudie en een simulatiemodel. Collectieve pensioenregelingen hebben over het algemeen hogere uitkeringen dan individuele regelingen, maar dit is sterk afhankelijk van de financiële positie van het collectieve pensioenfonds. De volatiliteit van de financiële positie bij toetreding voegt risico toe aan de pensioenuitkeringen van collectieve pensioenfondsen. Discontinuïteit leidt tot hogere volatiliteit van de uitkeringen, terwijl de mediane uitkeringen in de meeste gevallen stijgen doordat (impliciete) buffers vrijkomen. De frequentie en impact van pensioenfonds discontinuïteit hangt sterk af van de institutionele omgeving van het pensioenfonds. Strengere regelgeving, zoals een lagere disconteringsvoet, verbetert de financiële stabiliteit van het pensioenfonds, maar kan het vertrouwen van de deelnemers verlagen door lagere uitkeringen. Dit vormt een afweging in het ontwerp van het pensioenstelsel.

De bevindingen in dit proefschrift tonen aan dat pensioenfondsdeelnemers baat kunnen hebben van het samenvoegen van hun pensioenen. Grotere schaal leidt tot lagere kosten, terwijl collectieve regelingen hogere uitkeringen opleveren gegeven de mate van risico. Door de pensioenen van vergelijkbare deelnemers samen te voegen wordt de heterogeniteit binnen het fonds kleiner, wat minder welvaartsverlies tot gevolg heeft. Door pensioenfondsdeelnemers keuzevrijheid te geven in hun asset allocatie kan hun welvaart verder verhoogd worden. Echter, deelnemers kunnen pas de juiste asset allocatie selecteren als ze zich bewust zijn van hun latente risicobereidheid.

Deze keuzes zijn sterk afhankelijk van de institutionele omgeving. Specifieke institutionele factoren, zoals de beschikbaarheid van een eerste pijler pensioen en regelgeving, veranderen de kosten en baten van de keuzes en daardoor ook de voorkeur voor de keuzes zelf. Bij elkaar vormen de studies in dit proefschrift een diepgaande analyse van relevante keuzes in pensioenbeheer, de dynamiek achter deze keuzes en hun invloed op de vele belanghebbenden.

About the author

Gosse Alserda (1989) received his propaedeutic Economics & Management from the University of Groningen in 2009 and his bachelor's degree Economics & Business Economics from Utrecht University in 2011. Thereafter he graduated from the Erasmus School of Economics, Erasmus University in 2013, where he received a master degree in Economics & Business, with a specialization in Financial Economics.

In 2013, Gosse started his PhD research at the Erasmus School of Economics (ESE) and Erasmus Research Institute of Management (ERIM) under the supervision of Prof. dr. S.G. (Fieke) van der Lecq and Prof. dr. Onno W. Steenbeek. His main research interests are financial management and experimental economics, in particular related to pensions. As part of his research Gosse joined a research project at De Nederlandsche Bank (Dutch central bank).

Portfolio

Publications

Publications in journals:

Pension risk preferences (2016) Gosse A.G. Alserda, Benedict G.C. Dellaert, Laurens Swinkels, and Fieke (S.G.) van der Lecq. Netspar Design Paper Series 62

Articles under review:

Individual pension risk preference elicitation and collective asset allocation. Gosse A.G. Alserda, Benedict G.C. Dellaert, Laurens Swinkels, and Fieke (S.G.) van der Lecq

Measuring latent risk preferences, minimizing measurement biases. Gosse A.G Alserda

X-efficiency and economies of scale in pension fund administration and investment. Gosse A.G. Alserda, Jaap A. Bikker and Fieke (S.G.) van der Lecq

Articles in progress:

The occurrence and impact of pension fund discontinuity. Gosse A.G. Alserda, Onno W. Steenbeek, and Fieke (S.G.) van der Lecq

Conference presentations and research talks

- Measuring Normative Risk Preferences, Application to the Pension Domain (2016). ESA World Meeting. Jerusalem, Israel.

- Risk preference heterogeneity and optimal pension asset allocation (2016). International Pension Workshop. Leiden, The Netherlands.
- Heterogeneity of risk preferences and optimal asset allocation (2015–2016). Netspar workshop Pension Communication, Mortgages and Pension Investments. Amsterdam, The Netherlands; Netspar workshop Heterogeneity in Pension Systems and Risk Preferences. Amsterdam, The Netherlands.
- From risk preferences elicitation to asset allocation (2014–2016). PE module VBA Investment Professionals. Amsterdam, The Netherlands; Postgraduate program Investment Management, VU Amsterdam, The Netherlands.
- Inefficiency of pension funds (2015). DNB staff seminar. Amsterdam, The Netherlands.
- Pension risk attitude and asset allocation (2014). Netspar Pension Day. Utrecht, The Netherlands.
- Applying risk preferences to asset allocation (2014). IIR ALM congress. Amsterdam, The Netherlands.
- Measuring risk preferences, does it matter? (2013). Euroforum Pensioenforum. Amsterdam, The Netherlands.

Conferences attended

- Workshop Economics and Management of Professional Football. Rotterdam, The Netherlands (2017).
- ESA World Meeting. Jerusalem, Israel (2016).
- International Pension Workshop. Leiden, The Netherlands (2016).
- Netspar workshop Heterogeneity in Pension Systems and Risk Preferences. Amsterdam, The Netherlands (2016).
- Netspar workshop Pension Communication, Mortgages and Pension Investments. Amsterdam, The Netherlands (2015).
- Netspar Pension Day. Utrecht, The Netherlands (2014).
- Foundations of Utility and Risk. Rotterdam, The Netherlands (2014).
- IIR ALM congress. Amsterdam, The Netherlands (2014).
- Euroforum Pensioenforum. Amsterdam, The Netherlands (2013).

Teaching & supervising activities

- Master Seminar Pension Markets: Governance and Institutions, Erasmus School of Economics (ESE), 2013 – 2015.
- Certified Pension Executive, Erasmus School of Accounting & Assurance (ESAA), 2013 – 2014.
- Supervision of bachelor & master theses, Erasmus School of Economics (ESE), 2014 – 2017.
- Guest lecture PE module VBA Investment Professionals, VBA, 2015.
- Guest lecture Postgraduate program Investment Management, VU Amsterdam, 2016.

Doctoral courses

- Applied Econometrics (ERIM)
- Behavioural Decision Theory (ERIM)
- Case Study Research (ERIM)
- Data Analysis with R (ERIM)
- Experimental Economics 1 (CentER)
- Experimental Methods in Business Research (ERIM)
- Industrial Organisation (Tinbergen)
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The ERIM PhD Series

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Dissertations in the last five years

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The organization of pensions differs greatly across, and within, countries, and these differences affect the large number of stakeholders differently. The choices that underlie these differences tend to be very complicated, as they have to be balanced over the interests of different stakeholders over time.

The first two studies of this doctoral thesis analyse heterogeneity in pension plan risk preferences. Using an augmented risk preferences elicitation method, we find strong heterogeneity in latent risk preferences. Together with institutional differences these affect the optimal asset allocation. Therefore, it is worthwhile to elicit risk preferences.

The third study focuses on pension fund administration and investment costs. We show that there are large economies of scale for pension fund administrations, and modest diseconomies of scale for investment activities. Many pension funds have substantial X-inefficiencies for both administrative and investment activities. The study suggests that consolidation of pension funds may be efficiency enhancing.

The fourth study investigates pension fund discontinuity events. The occurrence and impact of these events is strongly dependent on the institutional setting of pensions. Stricter regulations increase the financial stability of the pension fund, but may reduce membership support through lower replacement rates. This trade-off influences the management of pension funds.

Taken together, this dissertation scrutinizes the complexity of choices in pension organization. Choices in pensions depend on the particular institutional setting of pensions and on specific pension plan member characteristics. These choices affect a great many stakeholders of pensions through different channels, both directly and indirectly.

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