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Pension risk preferences

A personalized elicitation method and its impact on asset allocation

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DESIGN 62

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DESIGN PAPER 62

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PENSION RISK PREFERENCES

Abstract

Pension plan managers are increasingly expected to demonstrate that the risk preferences of plan participants are adequately reflected in the asset allocations of their plans. Yet, it remains unclear whether managers should elicit the subjective risk preferences of individual participants to achieve this goal, or instead rely on objective and more readily available indicators, such as the socio-demographic characteristics of participants. To address this question, we have developed an augmented lottery choice method, tailored to the pension domain, to measure the risk preferences of individuals. Results from 7,894 participants from five different Dutch pension plans show that risk preferences vary substantially, but that only a small fraction of this heterogeneity can be explained by directly observable characteristics. We show that variations in risk preferences, along with individual characteristics and market conditions, generate differences in optimal asset allocations among plans. However, the risk preferences to be elicited for a pension plan depend on the composition of the participant population, as well as on expected market conditions. We provide a framework that pension plan managers can use to gauge the value of elicitation of risk preferences in the population of their funds, so that they can perform their own cost-benefit analysis of the exercise. We illustrate how this framework can be applied by Dutch pension plan managers in deciding on whether to elicit the risk preferences of participants or not.

1. Introduction

Pension capital constitutes a major component of the savings of many persons worldwide. The investment decisions of pension plan managers significantly impact the retirement income and retirement risk of large segments of the population (OECD, 2013a). Pension plan managers are faced with the complex task of allocating plan assets across many different investment options. Optimal asset allocation depends primarily on the outcome of a rigorous financial optimization process that takes into account pension plan-specific variables, such as the current and projected retirement age of plan participants as well as the targeted replacement ratio (Bodie and Treussard, 2007; Sundaresan and Zapatero, 1997). Pension plan managers are also expected to guarantee that plan asset allocation adequately reflects the risk preferences of individual pension plan participants (EIOPA, 2013; Frijns, 2010; Rozinka and Tapia, 2007). The latter requirement is challenging, since these risk preferences are not directly observable and must instead be derived from preference models or elicited from individuals through surveys. However, eliciting preferences in the pension domain is challenging as well, as beliefs are not always accurate. Wrong beliefs tend to distort choices, biasing the elicitation of preferences (Brown and Weisbenner, 2014).

The literature shows that individuals differ in their investment risk preferences (Holt and Laury, 2002; Harrison et al., 2007; Van Rooij et al., 2007; Kapteyn and Teppa, 2011) and that these differences also imply different optimal asset allocations among their investments (Bodie et al., 1992; Campbell et al., 2003; Viceira, 2001). Despite this research, many pension plan investment strategies in practice follow a one-size-fits-all approach that ignores risk preference heterogeneity and pools the investments for all participants (Frijns, 2010). For example, pension plans that are offered collectively commonly pool investments at the industry or employer level without taking differences at individual level into account (Clark and Bennett, 2001).

Heterogeneity in risk preferences can often be partially explained by directly observable differences among individuals, such as gender (Powell and Anisc, 1997; Jianakoplos and Bernasek, 1998; Schubert et al., 2000), age (Deakin et al., 2004; Yao et al., 1997; Bagliano et al., 2014), and income and wealth (Ali, 1977; Binswanger, 1980; Kachelmeier and Shehata, 1992). These characteristics may vary systematically among industries. However, large heterogeneity among individuals may remain, due to unobserved individual or environmental factors (Cesarini et al., 2009; Grable et al., 2004). In addition, despite research on the investment consequences of age heterogeneity among pension plan participants (Bikker et al., 2012; Molenaar and Ponds, 2012), it remains unclear to what extent other forms of heterogeneity (explained and unexplained) in the risk preferences of pension plan participants affect optimal allocation of assets in real-world settings.

The pension domain differs from other domains in several respects, necessitating a domain-specific analysis of this problem. In particular, we address three critical refinements to the general finance literature. First, choices in the pension domain are mostly made by delegation. Pension fund participants need not have the financial literacy that is necessary to make adequate investment choices for retirement savings (Lusardi and Mitchell, 2007; Balloch et al., 2014), but their preferences still need to be taken into account in the portfolio of a pension fund. This calls for a measurement instrument that appropriately balances normative theory and participant preference heterogeneity. Second, government policy may strongly interfere with the impact of risk preferences on optimal investment portfolios. In particular, the presence of a low-risk state pension and the income taxes charged on pension benefits may influence investment decisions (Fischer and Jensen, 2014), thus calling for a highly contextual analysis. Third, in many countries, participation in a specific pension fund is mandatory. As participants in these pension funds cannot vote with their feet, there is an increasing call for other ways to incorporate participant preferences in pension fund investment decisions. However, the costs of doing so are relatively high, and the impact of heterogeneity on investments in the pension domain is not well understood. This paper is the first to address this important empirical question.

Our research contributes to the finance literature by providing both important new empirical insights and a new methodological approach to measure the risk preferences of pension plan participants. For our empirical contribution, we analyze how optimal pension plan allocation relates to explained and unexplained heterogeneity in risk preference. We do so by using unique data from 7,894 participants in five Dutch pension plans. These provide real-world empirical insight into the degree of explained as well as unexplained heterogeneity in the risk preferences of pension plan participants. We use a simulation model to derive the optimal pension plan asset allocation for each individual, based on their observed risk preferences, income, and age (Viceira, 2001; Campbell et al., 2003). For our methodological contribution, we introduce an augmented lottery choice method that is tailored to individual pension risk preference elicitation. In particular, the lottery choice questions (Holt and Laury, 2002) are personalized to each individual's pension income, based on current income and age (i.e., years to retirement), to accurately reflect risk versus return trade-offs. In addition, the method combines information from the lottery choice method with that from two other risk preference elicitation methods (Kapteyn and Teppa, 2011; Van Rooij et al., 2007) in order to reduce the level of random error in the risk preference measure. The responses to the three measures are integrated into a single composite risk preference score that expresses each individual's relative risk aversion. Thus, the proposed method addresses several shortcomings (i.e., dominated choices, domain dependency, and white noise) that were observed in earlier research on lottery choice-based risk preference elicitation (Harrison et al., 2007; Dave et al., 2010; Weber et al., 2002).

Using the augmented lottery choice method, this paper investigates whether the pension risk preferences of individual participants should be elicited so as to ensure an adequate match of plan asset allocation with participant preferences. This question is vital because pension plan participants may face substantial retirement welfare losses in case of a mismatch between their risk preferences and the plan's asset allocation. This may imply, for example, that participants incur a much higher risk of low income than they wish to have, or that they lose out on the risk premium that they prefer. We investigate whether the pension risk preferences of participants can be accurately predicted using directly observable variables. If this is possible, then there is no need for elicitation of preferences from the participants. In addition, we study the practical impact of heterogeneity (explained and unexplained) on pension asset allocations. If this impact is only very small, then plan management may largely ignore differences in preferences among participants in setting the plan's asset allocation. In both instances, pension plan managers can avoid costly, time-consuming risk preference elicitation.

2. Eliciting pension plan participant risk preferences

During their working lives, pension plan participants contribute a substantial fraction of their income to pension capital. Pension plan managers (e.g., pension fund trustees and pension asset managers) invest this pension capital to let it grow over time. At retirement, the pension capital is converted to monthly benefits, either by regular withdrawals or through purchase of a lifelong annuity. Besides participant income and the contribution rate, final pension benefits depend to a large extent on asset allocation. Higher-risk asset allocations (such as investments in equities) yield higher expected returns than lower-risk investments (such as fixed income securities), but they are more volatile (Dimson et al., 2003). For pension benefits, this means that high-risk asset allocations can lead to higher retirement benefits, but with a wider distribution of possible outcomes (i.e., greater risk).

The optimal asset allocation for an individual depends on the individual's risk preferences (Bodie et al., 1992; Campbell et al., 2003; Viceira, 2001). In pension plans, the asset allocation decision is normally at the discretion of the pension plan manager, but it has a strong impact on the retirement income and retirement income risk of pension participants (OECD, 2013a). Research shows that individuals differ significantly in terms of the ways in which they trade off (expected) returns with the risk of financial investments in general (Holt and Laury, 2002; Weber et al., 2002; Tversky and Kahneman, 1992). Therefore, pension plan participants are likely to also differ in terms of the extent to which they trade off (expected) pension benefits and the risk level of those benefits. This implies that the optimal pension asset allocation is likely to differ among plan participants.

Furthermore, Weber et al. (2002) find that risk preferences are domain-dependent, meaning that individuals differ in their risk preferences depending on which domain their choice refers to. Van Rooij et al. (2007) show that pensions are cognitively classified as a separate risk-decision domain by individuals, and that financial risk aversion is highest in the pension domain compared to other types of investment. For pension plan managers, this implies that risk preferences should be elicited within the context of the pension domain to be relevant for their decision-making.

2.1 A formal measure of individual pension risk preference

To express the pension risk preferences of participants, we constructed a metric that is based on a commonly used financial measure of risk preferences, namely the (constant) relative risk aversion (r) coefficient of individuals, (Chiappori and Paiella, 2011; Beetsma and Schotman, 2001). This metric expresses how risk-averse an individual is relative to wealth or income. It captures risk aversion in a single coefficient that is independent of an individual's wealth and that can be easily used to assess distributions of (pension) outcomes. Positive values of r 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 will be willing to accept a risky investment. In the expected utility (or EU) framework, risk aversion depends on the concavity of the utility function (Arrow, 1965; Pratt, 1964) and can therefore can be defined as:

$$r_i = P_i * \frac{-U''(P_i)}{-U'(P_i)} \tag{1}$$

where r_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 equation, it is clear that the value of r 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 utility function (Holt and Laury, 2002; Harrison et al., 2007):

$$U_i(P_i) = \frac{P_i^{1-r_i}}{1-r_i} \qquad (2)$$

where U_i is utility, P_i is pension income, and r_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 highest EU is the option that gives the highest utility to an individual on average over all possible outcomes, given the individual's relative risk aversion:

$$EU_i = \sum_{j=1}^{n} P_j * U_{ij} \qquad (3)$$

where EU_j is expected utility of total pension income and U_{ij} is utility of total pension income for individual *i*, with p_j the probability of state of the world *j*.

Although EU can be used to select the optimal option per individual, it does not allow for intuitive comparison of the welfare of individuals between two options. For this we use the certainty equivalent, the amount that is obtained with probability 1 (certainty), the same utility as the EU of an option, and that therefore allows for comparison of different options in monetary amounts.

$$CE_i = (EU_i(1-r_i))^{\frac{1}{1-r_i}} \tag{4}$$

where CE_i is the certainty equivalent of the uncertain total pension income, EU_i the expected utility of total pension income and r_i the (constant) relative risk aversion for individual i.

This framework can be used to assess an individual person's pension asset allocation. The asset allocation that gives the highest EU is the option that is expected to be optimal for the pension plan participant. The difference among asset allocations can be compared via the certainty equivalent, which translates the differences to annual pension benefits while removing the uncertainty. This provides pension plan managers a metric to calculate the match between the pension plan's asset allocation and the risk preferences of participants if these preferences are known.

However, March and Shapira (1987) show that managers tend to make risk-return investment decisions primarily on the basis of performance targets (e.g., return and liquidity). These performance targets may not represent the preferences of the participants, at least not perfectly. To prevent such potential mismatch, supervisors, such as central banks, increasingly require that pension plan managers guarantee that their pension plan asset allocation adequately reflects the risk preferences of individual pension plan participants (EIOPA, 2013; Frijns, 2010; Rozinka and Tapia, 2007). Pension plan managers can match the asset allocation to the risk preferences of participants only if these risk preferences are known. Nevertheless, it is unclear whether plan managers should elicit the risk preferences of individual participants as input for this process, or whether they should apply the common practice in the industry of relying on other indicators, such as socio-demographics and industry sector employment (i.e., to include industry sector selection effects) to project the risk preferences of project participants (Bikker et al., 2012). To disentangle the determinants of pension risk preference, we have developed a measurement instrument for risk preferences of individuals that is tailored to the pension domain, to observe the heterogeneity of preferences of participants in five large Dutch pension funds.

2.2 A tailored individual pension risk preference elicitation method

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 preferences elicitation method (Dohmen et al., 2011; Andersen et al., 2008; 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 the bad state for the "risky" lottery. For the first question (see Figure 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 such individual switches to the risky lottery. Therefore the higher the risk premium (i.e., the expected value of the risky lottery minus the expected value of the safe lottery) will be that this individual demands for accepting the risk of the bad outcome (i.e., the bad state with the risky lottery).

Although the MLC method is well accepted and frequently used, it is cognitively demanding for the respondent, thus frequently leading to bias. First, the results from this method are often noisy and 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, Weber et al. (2002) find that individuals have different risk preferences depending on which domain a risky choice refers to.

In our study we tailor the MLC method to the pension domain and augment its results with information from additional measures to overcome the previously mentioned concerns (i.e., domain dependency, white noise, and selection of dominated options). First, the amounts of both lotteries relate to the pension domain and are denoted in monetary units (euros), including the state old age pension and after tax. The amounts presented to the respondents are derived from their income 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 (rounded to 10 euro). The state old age pension and tax deductions are included in these amounts

Figure 1: Example of adjusted MLC question

You have indicated that your after-tax monthly income is between €1,800 and €2,000. The amounts in this question are based on this income level. They represent monthly net income levels, including the state old age pension. The probabilities changes with your choice.
At which probability would you switch from Plan A to Plan B?

	Plan A	**Plan B**
Your guaranteed income is:	€ 1,140	€ 760
In addition, you have a probability of of receiving additional income of:	**10%** € 190	**10%** € 950
So you have a **10%** probability of a total pension income of:	€ 1,330	€ 1,710

Plan A Plan B

Notes. Example for a participant with a net monthly income between €1,800 and €2,000. This example represents the first choice out of a sequence of ten in which the probability (bold figures) systematically increases for the additional pension income.

to keep as close to the actual situation as possible. An example of the resulting question is presented in Figure 1.

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) 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, presented in Table 1, are irrespective of income (as the options are constant shares of income).

Table 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
0	10%	$r < -4{,}82$
1	20%	$-4{,}82 < r < -3{,}00$
2	30%	$-3{,}00 < r < -1{,}82$
3	40%	$-1{,}82 < r < -0{,}86$
4	50%	$-0{,}86 < r < 0{,}00$
5	60%	$0{,}00 < r < 0{,}85$
6	70%	$0{,}85 < r < 1{,}76$
7	80%	$1{,}76 < r < 2{,}85$
8	90%	$2{,}85 < r < 4{,}46$
9–10	100%	$4{,}46 < r$

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

To obtain an unbiased estimate of the distribution of relative risk aversion, responses are randomly distributed within the implied ranges, using a uniform distribution (to prevent underestimation of variance). For the first and last switch point, these are, in first instance, set equal to the upper and lower bound of their respective ranges. Since this will underestimate the variance, the open ranges are, in turn, re-estimated using the upper and lower tail of the normal distribution with the mean and standard deviation found in the preceding setting. This procedure (which increases the variance) is repeated until there is sufficient convergence (change from re-estimating becoming smaller than 0.00001% of the standard deviation).

Next, in line with Kapteyn and Teppa (2011), the results from the MLC method are combined with the results of two alternative methods into a single composite score to 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. Although the results of these methods can therefore not be used directly to define an investment portfolio, these methods are less time-consuming and cognitively less demanding than the MLC method (Abdellaoui et al., 2011; Kapteyn and Teppa, 2011; Van Praag, 1991). These methods involve, first, two self-description tasks ("Stated tolerance"[1] and "Careful", based on Kapteyn and Teppa, 2011) with the question: "Are you willing to take risk with your pension?" and the statement "My friends describe me as a careful person", answered on a seven-point Likert scale ("Totally disagree" = 1 to "totally agree" = 7) and, second, a simplified portfolio choice question ("Portfolio choice", based 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).

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 can be used to verify whether all elicitation methods load on one common underlying risk preference factor, and only elicitation methods that do so are used in calculating the composite score. 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 results of the MLC method (i.e., switch points) are transformed into a percentile score before they are standardized. The composite measure is thus the average of

1 This method was inverted to "Stated aversion" such that higher values, in line with the other methods, indicate more risk

the available and the relevant standardized elicitation results. We assume that noise in the measurement of risk aversionis Independent and identically distributed. The composite score will therefore contain substantially less measurement noise than the individual methods, although such noise will not be completely absent.

As 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 rescaled to the domain of relative risk aversion by regressing the relative risk aversion measure of the MLC method (see previous section) on the composite score. The parameter estimates in this regression allow us to calculate a less noisy measure of relative risk aversion for each individual, which is based on the composite score. We thus obtain a more robust risk preferences method, which can be defined in terms of relative risk aversion and can therefore be used to determine optimal asset allocation.

3. Participant risk preference heterogeneity at five Dutch pension plans

In this section we discuss the results of a large-scale data collection that we conducted to empirically assess the effect of heterogeneity in risk preferences on optimal asset allocation. Data were collected through an online survey with pension plan participants of five Dutch pension plans. The survey was administered by a consultancy firm with several of its clients, i.e. companies with pension plans. Before the survey was sent out, it was first tested with a paper version for a small representative population and then tested online with the consultancy firm's own employees (N = 172). After some minor adjustments, the questionnaire was sent to the active members of five pension plans of five companies from different industries (i.e., transportation, manufacturing, automotive, and leisure). All plan members were invited via regular mail and/or email, depending on their channel preferences and the contact possibilities of the companies' pension plans. Participants were informed that their responses would be used for future decision-making by the management of the pension plan in which they participated, with the aim of making more informed decisions about how to bring the pension plan's investment policy in line with participants' preferences. The surveys were conducted in the first half of 2013.

Table 2 presents the summary data for the populations as a whole and for the response for each pension plan separately. Males and elderly people had a higher response rate and are therefore slightly overrepresented in the results. Other reasons for differences in response rate may be differences in the method of inviting respondents and in the efforts that companies put into requesting participants to complete the survey.

Table 2: Summary data

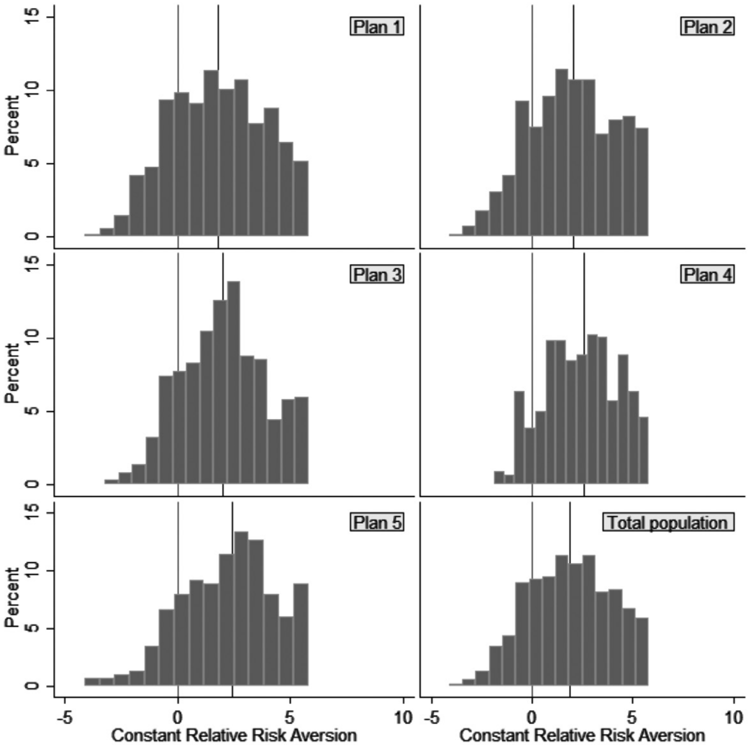
Plan	Response		Response rate	% Men		Average age		Average income (in €)		Average education	
	Sample	Total	Sample	Sample	Total	Sample	Total	Sample	Total	Sample	Total
1	5,094	29,738	17.1%	86%	78%	50.1	47.4	1,952	–	3.8	–
2	1,176	11,093	10.6%	90%	85%	53.8	51.3	1,613	–	3.0	–
3	873	2,057	42.4%	80%	76%	44.8	45.1	1,668	1,460	3.5	–
4	437	8,015	5.5%	25%	20%	52.2	47.6	1,395	–	4.5	–
5	314	4,211	7.5%	66%	55%	48.5	43.1	1,922	2,191	4.1	–
Total	7,894	55,114	14.3%	82%	69%	50.1	47.8	1,843	–	3.7	–

Notes: Number of observations, response rates, percentage of men, average age, average monthly net income and average education (ranging from 1 (primary school) to 6 (university)) for total population and the sample.

Respondents' risk preferences were elicited using three different risk elicitation methods: the MLC method, the Likert scale self-description method with two questions, and the portfolio choice method. Principal component analysis 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). The general self-description question *Careful* had a loading of only 0.39 on this factor, which we considered to be insufficiently strong (below our predetermined limit of 0.40); this item was therefore eliminated from further consideration in calculating the composite score. The three elicitation methods were then combined into a single composite score and rescaled to relative risk aversion (see Section 2.2). The resulting values of the rescaled composite score are presented in Figure 2.

Relative risk aversion has a mean value of 1.92 and a standard deviation of 2.15. This mean value is categorized by Holt and Laury (2002) as highly risk averse. This confirms that risk preferences

Figure 2: Histograms of relative risk aversion



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

are relatively high in the pension domain. The high standard deviation indicates that individuals are strongly heterogeneous in their risk aversion; this we investigate next.

3.1 Drivers of heterogeneity in pension risk preferences

We now analyze to what extent the observed heterogeneity in pension risk preferences is predictable, and whether plan managers can use risk-preference models to approximate risk-preference heterogeneity in their plan participants. To do so, first an ordinary least squares regression is utilized, with risk preference as the dependent variable and pension plan dummies as independent variables, to represent the current system, in which heterogeneity is facilitated only at pension plan level (i.e., a common asset allocation for all pension plan participants). Column 1 of Table 3 shows both economically and statically significant heterogeneity in the risk preferences of the populations of different pension plans. Adding the available socio-demographic information in column 2 greatly increases the explanatory power of the model (i.e., R-squared increases from 0.007 to 0.056) and reduces the size of pension plan dummy effects. We can therefore conclude that heterogeneity in risk preferences is present mainly at the individual level, and to a far lesser extent at the pension plan population level (i.e., among pension plans). More specifically, Table 3 (column 2) shows that relative risk aversion correlates negatively with income and positively with age. Both effects decline with higher levels of income and age, respectively.

These findings are in line with previous results reported by Dave et al. (2010), Bellemare and Shearer (2002), Pålsson (1996), and Riley Jr and Chow (1992), who all found similar effects of income and age. With increase in income, also disposable income rises, which in turn increases the ability and willingness of individuals to accept greater risk (Riley Jr and Chow, 1992, p.35). Higher age leads to a shorter period until retirement. This reduces the number of options for a participant to make up for low investment returns (e.g., by increasing savings) and therefore reduces the participant's ability and willingness to accept greater risk. In addition to the effects of income and age on relative risk aversion, the optimal level of risk in the optimal asset allocation may be affected by other effects, such as the state pension leverage effect and the reduction of the investment horizon. These effects are included in the following analysis.

Including all these variables, the model has an explanatory power (R-squared) of 0.056, meaning that the model explains approximately 5.6% of variation in risk preference. Although additional variables could be added to this model, it is unlikely that such a model could ever adequately predict risk preferences, since a substantial amount of heterogeneity is non-measurable (i.e., either inherited or acquired (Cesarini et al., 2009)).

The results reported in this section show that there is large heterogeneity in the risk preferences of pension plan participants and that only a relatively small part of this heterogeneity can be explained by available socio-demographic information (5.6%). Thus, confirming Van Rooij et al. (2007), we find that financial risk aversion is relatively high in the pension domain. We add to these authors' insights by demonstrating that pension risk preferences are quite heterogeneous. Further, we show that only some of this heterogeneity can be predicted using socio-demographic information. A substantial fraction of the heterogeneity is unexplained and random (inherited or acquired) at the individual level. Our conclusion is therefore that pension plan managers can accurately know the risk preference heterogeneity of pension plan participants only by eliciting it directly from the participants themselves. Yet to be determined is what the effect of this heterogeneity is on optimal asset allocation of pension plan participants. We evaluate this issue in Section 4 below.

Table 3: Results of regression analysis

Variables	(1) Relative risk aversion	(2) Relative risk aversion
Constant	1.841*** (0.027)	2.444*** (0.518)
Plan 2	0.176*** (0.061)	−0.054 (0.063)
Plan 3	0.238*** (0.070)	0.062 (0.070)
Plan 4	0.595*** (0.095)	0.148 (0.105)
Plan 5	0.393*** (0.110)	0.347*** (0.109)
Income (€1,000)		−0.455*** (0.053)
Income (€1,000)		0.033*** (0.004)
Age		0.054** (0.022)
Age		−0.001** (0.000)
Male		−0.498*** (0.063)
Has partner		0.145** (0.063)
Owns house		−0.225*** (0.061)
Education 2		−0.303* (0.178)
Education 3		−0.452** (0.176)
Education 4		−0.394** (0.186)
Education 5		−0.625*** (0.182)
Education 6		−1.070*** (0.191)
R-squared	0.007	0.056

Notes. Results of regression analysis of observable characteristics on relative risk aversion. Standard errors in parentheses, N = 7,894,
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4. Impact of risk preference heterogeneity on pension asset allocation

We analyzed the effect of risk preference heterogeneity on optimal asset allocation using a simulation model. In this model, pension incomes are simulated for an individual defined contribution plan without annuitization at the retirement date. Pension plan members invest their pension capital with a simplified asset allocation consisting of different shares of fixed income and equity. Asset returns are simulated using the model of Koijen et al. (2010) and the parameters found by Draper (2014). During retirement, each year a portion equal to the expected average of pension capital for the remaining years is withdrawn from pension capital. Using a CRRA power utility function (Holt and Laury, 2002), pension incomes are translated to utility from pension income. Taking the average utility over 10,000 simulations provides us with an expected utility from pension income, which is used to compare different asset allocations. The asset allocation with the highest expected utility is considered to be the optimal asset allocation. For a more detailed description of the simulation model specifications we refer to Alserda et al. (2016).

4.1 Optimal asset allocation

The results of the asset allocation model are presented in Table 4. This table shows the result for our baseline model (income €38,000). Column 1 shows the results when a risk-free state pension is granted, in this case the state pension of the Netherlands. When a state pension is granted, the allocation to equity is maximized for the majority of participants (more than half a standard deviation from the mean), but it decreases substantially with further increases in relative risk aversion.

Table 4: Optimal allocation of pension assets to equity

(1) Total pension including state pension				(2) Total pension without state pension			
RRA	25	46	67	RRA	25	46	67
0.0	100	100	100	0.0	100	100	100
0.5	100	100	100	0.5	100	100	100
1.0	100	100	100	1.0	100	100	100
1.5	100	100	100	1.5	100	100	100
2.0	100	100	100	2.0	83	78	78
2.5	100	100	100	2.5	69	64	62
3.0	100	100	100	3.0	59	55	52
3.5	100	100	100	3.5	52	47	44
4.0	95	95	98	4.0	46	42	39
4.5	90	89	90	4.5	42	38	34
5.0	86	84	83	5.0	38	34	31
5.5	82	79	77	5.5	35	31	28
6.0	78	75	72	6.0	33	29	26

Notes. Allocation to equity (in %), given a specific starting age and relative risk aversion. Results are presented for total pension including a state pension (in the Netherlands) and for total pension without a state pension. Results are given for different starting ages and levels of relative risk aversion (RRA). Starting income is fixed at €38,000.

An increase of relative risk aversion of one standard deviation (beyond the threshold) can reduce the optimal allocation to equity by up to 25% in this case. In addition we find a negative, but economically minor, effect of age on the optimal allocation to equity.

Traditionally, the research on asset allocation focused exclusively on the risk-bearing part of pension income, normally the second-pillar occupational pension (Viceira, 2001; Campbell et al., 2003). However, many countries have systems that include a risk-free first-pillar pension (e.g., France, the Netherlands, and the USA), such as a state pension (e.g., the American social security system). The amount that is relevant for people is their total retirement income, including both risk-bearing pension and the state pension (after taxes). This is the amount that people can use for consumption and which determines their standard of living (Merton et al., 1987). Therefore, the survey in this paper focuses on total retirement income, and relative risk aversion scores are valid for the combined retirement income.

Table 4, column 2, shows the results in the absence of a risk-free state pension (which may apply for countries such as in Chile). Without a state pension, optimal asset allocation becomes substantially less risky, with allocation to equity declining by as much as 45%. Although a large share of participants still have a maximum allocation to equity, the threshold occurs before the mean. Also the reduction in allocation to equity with risk aversion is stronger than when a state pension applies. Separate analysis shows that the effect of (progressive) income taxes is negligible. The reason is that the reduction in income resulting from taxes compensates for the reduction in risk that stems from taxes.

It is worth noting that the effect of the state pension depends on the income of the participant. As income increases, the relative importance of the state pension declines, same as the relative size of the risk-free part of retirement income. As a result, the participant will need to take relatively less risk in the second pillar to get total retirement income at the desired level of risk. This result is presented in Table 5. Therefore, if income goes to infinity, the asset allocation converges to the optimal asset allocation in a system without a state pension. The effect of higher levels of income is similar to reductions in the state pension, with the relative importance of the first pillar (certain or otherwise) declining along with the allocation to equity.

Table 5: Optimal allocation of pension assets to equity

(1) Income: €23,000				(2) Income: €38,000				(3) Income: €54,000			
RRA	25	46	67	RRA	25	46	67	RRA	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	100	100	100	2.0	100	100	100	2.0	100	100	100
2.5	100	100	100	2.5	100	100	100	2.5	100	100	100
3.0	100	100	100	3.0	100	100	100	3.0	99	97	99
3.5	100	100	100	3.5	100	100	100	3.5	91	89	88
4.0	100	100	100	4.0	95	95	98	4.0	85	82	78
4.5	100	100	100	4.5	90	89	90	4.5	79	76	71
5.0	100	100	100	5.0	86	84	83	5.0	74	71	65
5.5	100	100	100	5.5	82	79	77	5.5	70	66	59
6.0	100	100	100	6.0	78	75	72	6.0	67	62	55

Notes. Allocation to equity (in %) for different levels of (starting) income. Results are given for different starting ages and levels of relative risk aversion (RRA). A gross monthly state pension of €1,104.95 is reflected in the analysis.

Our findings provide a refinement of the research by Bucciol and Miniaci (2015) because of our finding that, due to the dampening effect of state pensions, higher benefits may lead to less risk taking (in particular for individuals who are averse to risk). For individuals who are willing to take risk, higher benefits may lead to stable, even high risk taking.

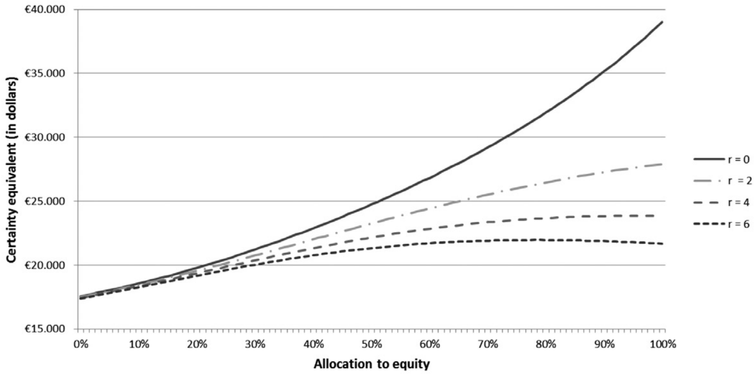
4.2 Value of optimal asset allocation

We now use the certainty equivalent concept to determine in monetary terms how much EU is lost when a pension plan manager selects a suboptimal asset allocation for the pension plan participants population. This allows us to obtain a monetary value for matching participant risk preferences in the five pension plans studied. We can thus determine the financial impact of the observed risk preference heterogeneity when a pension plan with a uniform asset allocation policy switches to a policy that incorporates risk preference heterogeneity.

Figure 3 shows the certainty equivalents for a participant who joins the pension plan at age 25 with an initial income of €38,000, for different levels of relative risk aversion. The graph shows that a suboptimal asset allocation can reduce the expected value of pension benefits by 55.0%, while it can reduce the certainty equivalent of pension benefits by 20.9% for an individual with $r = 6$. The loss in certainty equivalent increases exponentially with larger deviations in asset allocation.

Figure 4 shows loss in certainty equivalents (left axis) for participants in the five company pension plans studied, dependent on the risk preferences of the participants. The certainty equivalents hold for a participant who joins the pension plan at age 25 with an initial income of €38,000. The bars (right axis) present the total percentage of participants in each of the respective ranges of relative risk aversion. The results show that every single asset allocation in our study is too safe given the preferences of their participants, since even the most risk-averse participants prefer more risk (having income losses due to undesirably low allocation to equity). This holds especially for the relatively large fraction of participants who are risk-neutral or have relatively little risk aversion. Increasing the allocation to equity moves all the graphs downward until they eventually turn upward, starting with the most risk-averse individuals. An OLS regression shows that there is a significant ($t = 6.67$, $N = 7{,}895$) effect of measured relative risk aversion on a plan's current allocation to equity ($b = -0.216$). However, in economic terms the size of this effect is relatively

Figure 3: Certainty equivalents

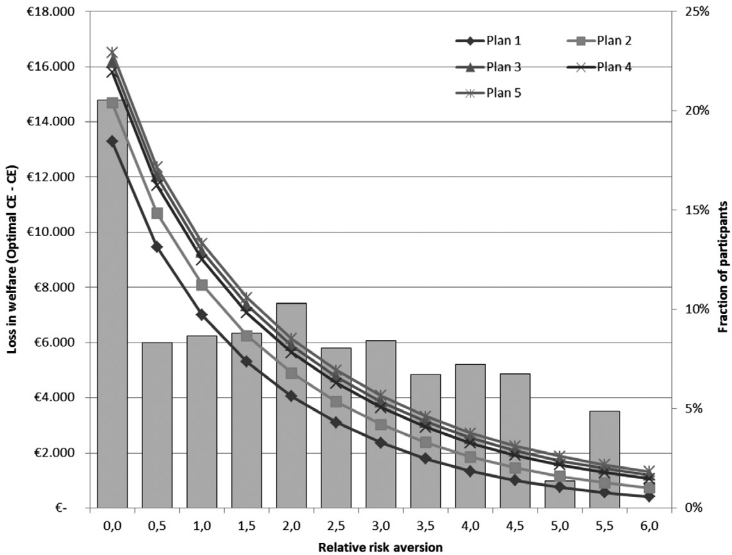


Notes. Certainty equivalent plotted against allocation to equity for a participant enrolling at age 25 with an income of €38,000. The certainty equivalent is given for four levels of relative risk aversion. The certainty equivalent is highest (optimal allocation) for an allocation of 100%, 100%, 95% and 78% for relative risk aversion levels 0, 2, 4, and 6, respectively.

minor. Differences across members in terms of pension domain risk preferences thus do not seem to be an important determinant for the current practice of managers of the five pension funds that we studied in how they establish their plans' asset allocation. This underlines the relevance of our findings for improvement of the match between the risk preferences of pension plan participants and the pension plan allocations in practice.

Finally, Table 6 shows the loss in certainty equivalent for different asset allocations and risk preferences compared to optimal asset allocations. This table shows again that optimal asset allocations (allocations with zero welfare losses) have relatively high allocations to equity. Asset allocations close to the optimal asset allocation have small welfare losses, but the welfare losses increase exponentially as the asset allocation deviates further from the optimal asset allocation

Figure 4: Loss in certainty equivalent



Notes. Loss in certainty equivalent (in €) for levels of relative risk aversion, given asset allocation of the respective company pension funds (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 participant, with initial income of €38,000.

Our simulations show that most of the welfare losses that we find are the result of unduly low allocation to equity. The results for the five pension plans that we studied demonstrate that pension plan managers can satisfy the risk preferences of almost all participants by allocating all capital to equity. A maximum allocation to equity will be optimal for most participants, while the remainder will incur only small welfare losses (see Table 6). We wish to emphasize that these results depend on the parameters assumed, the characteristics of the pension plan, and the characteristics of the participant. We base our parameters on

Table 6: Loss in certainty equivalent

Allocation to equity	R = 0	R = 1	R = 2	R = 3	R = 4	R = 5	R = 6
0%	21,471	14,178	10,400	8,034	6,419	5,341	4,581
10%	20,476	13,202	9,443	7,095	5,496	4,434	3,691
20%	19,266	12,053	8,348	6,052	4,501	3,484	2,781
30%	17,820	10,734	7,142	4,947	3,488	2,552	1,924
40%	16,160	9,293	5,888	3,854	2,532	1,716	1,192
50%	14,298	7,778	4,649	2,836	1,696	1,029	630
60%	12,207	6,216	3,469	1,940	1,016	518	251
70%	9,835	4,632	2,385	1,195	510	185	48
80%	7,101	3,048	1,429	619	181	23	2
90%	3,888	1,493	627	221	21	13	89
100%	0	0	0	0	15	131	282

Notes. Loss in certainty equivalent (in €) of different asset allocations and risk preferences compared to the optimal asset allocation. Values are given for a participant aged 25 with initial income of €38,000.

the historical setting, whereas currently many estimates for risk premium in the future are lower (Draper, 2014; Dimson et al., 2015). Differences in risk premium have a large effect on the allocation to equity, i.e. lower risk premiums reduce the optimal allocation to equity. And if future risk premiums are lower, the impact of risk preference heterogeneity will be larger. In addition, as shown in Section 4.2, the income and age of the participant, as well the amount of the state pension, influence the optimal allocation to equity. For countries with lower state pension levels, the impact of risk preference heterogeneity will also be higher.

5. Discussion

Using an augmented lottery choice method, tailored to the pension domain and adding information from alternative methods, we have introduced a more reliable elicitation method for risk preferences in the pension domain. This reduces several shortcomings, such as dominated choices, domain dependency, and white noise. Risk preferences obtained with the augmented lottery choice method show higher, and more heterogeneous, risk preferences in the pension domain compared to other financial domains. These findings are in line with previous studies, such as by Van Rooij et al. (2007) and Harrison et al. (2007). By combining three methods, our results are more robust while retaining the practical application of risk preferences expressed in RRA.

In accordance with the intentions of pension plans, respondents in our surveys were informed that results from the survey would be used for future decision-making by the management of the pension plan, to enable it to make more informed decisions about how to bring their plan's investment policy in line with participants' preferences. This implies that the questions were at least partially consequential for respondents, thus increasing the external validity of the results compared to purely hypothetical choices (Holt and Laury, 2002). However, respondents' choices did not directly influence their personal pension investments, so that some uncertainty remains with respect to how they interpreted the impact of their responses. Therefore, some caution may still be needed in terms of interpreting participants' risk preferences, as these may depend on how confident participants were that pension plan management would actually incorporate the results from the survey in their plan's investment policy.

The value of an optimal asset allocation goes hand in hand with the value of eliciting risk preferences. The value of eliciting risk preferences for setting the optimal asset allocation depends on a number of factors. These are summarized in Table 7, which shows the maximum welfare losses in the case of the observed median asset allocation of the funds in our sample (i.e., 42% equity). The potential welfare losses are presented as a percentage of total income with optimal asset allocation. Potential welfare losses in this case are the largest for people far away from retirement (i.e., younger people), in case of high income to state pension ratios, with higher risk premiums, and with more variation in risk preferences. In all cases involving risk-bearing pension, there are positive welfare losses, showing that the observed median asset allocation of the funds in our sample is suboptimal. Table 7 again shows that the observed asset allocations of the funds in our sample involve large (potential) welfare losses. Asset allocation for these funds is, from a participant perspective, overly conservative. In Section 6 we will discuss several reasons that may explain this observation.

Table 8 shows the potential welfare losses compared to a strategy of optimizing for the mean level of risk preferences (i.e., RRA = 2). This would be an alternative, more simple, approach to measuring risk preferences, but it causes welfare losses in the heterogeneity of risk preferences. The results presented can be interpreted as the value of eliciting risk preferences.

The effect of time to retirement (age) is twofold. First, shorter periods to retirement cause a shift in the optimal asset allocation for the mean risk preferences, i.e., shorter periods to retirement have less offensive optimal asset allocations. This leads, in first instance, to higher potential welfare losses for shorter periods to retirement. However, with shorter times to retirement also the

Table 7: Current potential welfare losses

Variables	Low	Maximal welfare loss (%)					High
Period to retirement	0 years	9.01	17.07	21.83	24.61	26.62	52 years
State pension %	Full state pension	0.00	18.37	21.83	24.24	26.31	Income 4 times state pension
Hetero-geneity	None	6.55	9.35	12.71	16.77	21.83	RRA 0–6 (observed)
Risk premium	1%	8.66	14.98	21.83	29.06	36.53	5%

Notes. Maximum welfare loss as a percentage of total pension income. Values for median observed asset allocation of the funds in our sample (equity = 42%). Values are fixed at income = €38,000, age = 46 years, and risk premium = 5%, unless these are varied for the simulation purpose.

investment period is shorter, reducing the effect of asset allocation and therefore the value of eliciting risk preferences. State pension, compared to total income, determines what fraction of pension income is affected by the asset allocation. Higher incomes, and therefore more risk-bearing pension, increase the influence of asset allocation, and therefore also increase the value of eliciting risk preferences. Higher levels of heterogeneity increase the value of eliciting risk preferences. Intuitively, in the absence of heterogeneity there is no value in elicitation of risk preferences. So depending on the characteristics of the pension plan (i.e., participants and market condition), elicitation of risk preferences may be worthwhile and may lead to greater welfare. Finally, larger risk premiums make the effect of asset allocation more pronounced; however, the optimal asset allocation for the average risk preferences also moves towards more equity. Therefore, in Table 7 the potential welfare losses increase, because the losses of the suboptimal (overly conservative) asset allocation become more pronounced. On the other hand, in Table 8 the effect is the opposite, as the optimal asset allocation moves

Table 8: Value of eliciting risk preferences

Variables	Low	Maximal welfare loss (%)					High
Period to retirement	0 years	3.79	5.25	5.10	4.91	4.99	52 years
State pension %	Full state pension	0.00	2.50	5.10	6.48	8.32	Income 4 times state pension
Hetero-geneity	None	0.00	0.83	2.28	3.75	5.10	RRA 0–6 (observed)
Risk premium	1%	5.84	5.80	5.10	4.11	2.67	5%

Notes. Maximal welfare loss as a percentage of total pension income.
Values compared to optimal asset allocation for mean risk preferences (RRA = 2).
Values are fixed at income = €38,000, age = 46 years, and risk premium = 3%, unless these are varied for the simulation purpose.

towards full allocation to equity, therefore reducing the difference in optimal asset allocations, and thus the value of eliciting risk preferences.

The results are qualitatively summarized in Table 9. This shows that the contribution of eliciting risk preferences depends on the properties of a pension plan's participant population and the pension system involved. Pension funds that have an older population, with many retired participants, will find that the value of eliciting risk preferences is relatively modest. The investment horizon is short, so that the effect of asset allocation is lower. Pension funds with a high income population, or in a country with low state pensions (e.g., Chile) are responsible for a large part of retirement income. Therefore the influence of the asset allocation on retirement income, as well as the value of eliciting risk preferences for these situations, is larger. In pension fund populations with high heterogeneity of risk preferences (such as in industry-wide pension funds), the variance in optimal asset allocations is larger. This makes eliciting risk preferences more valuable.

Table 9: Value of elicitation

Variable	Low	High
Pension 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 the shorter period, the effect is less pronounced.
Income	State pension is paramount, so asset allocation is less relevant. This holds for low-income workers and/or in Beveridgean pension systems.	State pension is less relevant, so asset allocation, and thus risk preferences, become more important. This holds for high income workers and/or in Bismarckian pension systems.
Hetero-geneity	For a homogeneous population, elicitation may not be worthwhile. A sample may suffice. Homogeneous populations may occur in niche industry wide pension funds or in 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.
Market conditions		
Risk premium	Large variety of optimal asset allocations, thus preferences are more important.	Equity is mostly optimal, so risk preferences are not relevant.

Finally, market conditions, especially the risk premium, impact the value of elicitation by influencing the trade-off between equity and fixed income. With high risk premiums, equity becomes dominant, and as all participants invest almost fully in equity, the value of elicitation diminishes.

Our findings thus lead to the conclusion that substantial welfare losses can occur when asset allocations are not adjusted to individual risk preferences. With heterogeneous risk preferences, a system of collective asset allocation will by design yield suboptimal asset allocations to large percentages of the pension plan population. These losses will need to be weighed against the benefits of collective investment, such as the opportunity for (intergenerational) risk sharing (Van Ewijk et al., 2014) and the possibility to overcome constraints on individual investments, such as borrowing constraints (Bovenberg et al., 2007). Although individual welfare losses cannot be prevented with collective investment, elicitation of risk preferences can soften this downside of collective schemes by using the measurement of participants' risk preference to bring the collective asset allocation more in line with preferences on an overall basis. However, this latter goal also raises challenging questions about how different participant preferences should be incorporated. For example, how should the risk preferences of different participants (i.e., age and income groups) be weighed? This is a policy question that we cannot address based on the current study.

6. Implications for the Dutch pension sector

The need for measuring the individual risk preferences of the participants in a pension fund highly depends on the domain and characteristics of the relevant country. Therefore, to facilitate the interpretation and application of our research, in this section we apply our findings and the summary of factors in Table 9 specifically to the Dutch pension sector.

We propose that pension fund managers follow a three-step approach in investigating the likely benefits of eliciting individual participants' risk preferences when it comes to matching the fund's investment strategy to its participant population's preferences. First, the relevant socio-demographic characteristics of the plan's population need to be explored, since the added value of risk elicitation depends on the income and age profiles of the population (cf. Table 9 and 10). Second, market conditions that determine the impact of accommodation of risk preference heterogeneity for investment strategy need to be investigated, so as to determine whether a non-uniform asset allocation is worthwhile. Third, if steps one and two support the elicitation of individual participants' risk preferences, then the method and corresponding costs of risk preference elicitation need to be assessed. Jointly, these steps enable the decision whether or not individual pension participants' risk preferences should be elicited.

When we look at the characteristics of the participant population (step one) for most Dutch pension plans, it is clear that their population is getting older and that the life expectancy of many people is increasing (Worldbank, 2016). This may suggest a slightly higher need for preference elicitation, since the differences between older and younger pension plan participants may become more pronounced.

Average personal income in the Netherlands is above the OECD average (OECD, 2016). At the same time, the Dutch state pension level is also higher (Worldbank, 2016). For the median Dutch participant, the state pension constitutes more than 32% of gross retirement income (OECD, 2013b). This implies that, even for a very low overall pension risk preference, most participants have high assurance about a large portion of their pension income. Hence, participants will be more strongly inclined to prefer more risk taking in the occupational portion of their pension income, meaning an increase of the allocation of equity in the optimal asset allocation. This high impact of even a very small preference for risk taking implies a low need of risk preference elicitation, as most participants will prefer the same (riskier) investment strategy, irrespective of their actual risk preference level.

The heterogeneity within a pension plan population depends on the type of pension plan. Three different pension plan types exist in the Netherlands: industry-wide funds, company funds and occupational funds. The populations of industry-wide funds will differ most in terms of income, education and age, and therefore also in terms of risk preference (Table 3). The populations of the remaining two types will be more homogeneous, and the value of eliciting risk preferences will be lower. The large number of participants that are covered by an industry-wide pension fund in the Netherlands increases the expected heterogeneity between participants within pension funds and makes elicitation of risk preferences more worthwhile.

Step 2 looks at the market conditions for Dutch pension funds. A key factor is that the state pension age is now automatically adjusted to increases in life expectancy. Therefore, the total expected number of years in retirement will remain relatively constant.

As to the risk premium that pension funds in the Netherlands can achieve, it is important to note that they are not obliged to invest in Dutch assets. They can thus fully benefit from foreign investments and do not face a different risk premium compared to pension funds in other countries. However, Draper (2012) suggests that the expected risk premium worldwide will in the near future not be as high as in previous periods. This trend reduces the difference in expected returns between safe and risky allocations, so that fewer participants will prefer a full allocation to equity. In combination with the relatively high amount of state pension, this will increase the variance in optimal asset allocations and make risk preference elicitation more worthwhile (see Table 5).

Based on our empirical analysis, we conclude that a relatively large percentage of Dutch pension participants will thus favor full allocation to equity due to the large role of the state pension income. This preference may shift if returns on equity drop more strongly relative to less risky investments. The aging of the Dutch labor population may also increase the need for eliciting risk preferences, as older employees may seek less risk; hence full allocation to equity may be sub-optimal. Table 10 can be used to assess the usefulness of eliciting risk preferences for Dutch pension funds.

Finally, in step 3 the method and corresponding costs of risk preference elicitation need to be assessed. In this paper, as Dutch pension funds have traditionally used rather ad hoc participant risk preference measures, which were unsuited for determining pension fund allocation decisions (Dellaert and Turlings 2011), we have proposed a new approach that is more reliable and practically feasible, one that has been implemented by

Table 10: Decision framework for Dutch pension funds with respect to participant risk preference elicitation

		Average income of plan population	
		Low	High
Anticipated return on equity	Low	Consider elicitation, especially if participant population is likely to be heterogeneous.	Elicit risk preference. Strong impact of risk preferences on investment strategy.
	High	No elicitation. All participants are likely to benefit from same (high risk and high return) portfolio.	Consider elicitation, especially if participant population is likely to be heterogeneous.

real-world pension fund partners and that is well aligned with the asset investment decisions of pension plan managers. Other approaches have also recently been proposed, but these are more elaborate. For example, Dellaert et al (2016) suggest the Pension Builder tool, which interactively elicits a participant's pension income risk preferences. Such approaches can provide promising new avenues for risk preference elicitation in the future.

7. Conclusion

This study measures risk preferences in the pension domain of 7,894 participants in five Dutch pension plans, using an augmented version of the MLC method via an online survey. Using data from two alternative measures, we assigned personal values of relative risk aversion to the participants in these pension plans and succeeded in overcoming several difficulties related to this method (i.e., dominated choices and white noise).
Our results show that the level of relative risk aversion is high in the pension domain, with high heterogeneity. Heterogeneity in risk preferences is far higher between participants than between the populations of different pension plans. Aside from general differences between pension plans, risk preferences are dependent on income, age, education, and other socio-demographic characteristics. Still, these variables account for only 5.6% of variation, so that modeling of risk preferences with observable socio-demographic information cannot replace the measurement of risk preferences.

Using a simulation, we have investigated the effect of heterogeneous risk preferences on optimal asset allocations of a pension plan (i.e., the asset allocation that gives the highest expected welfare). The results show that risk preferences are an important determinant of optimal asset allocation. In the optimal asset allocation, allocation to equity increases by up to 30% in our baseline model. Inclusion of the state old age pension increases the security of total retirement income, thus it substantially increases the allocation to equity. Other variables that influence optimal asset allocation (given risk preferences) are income, age, and risk premium.

In addition, a suboptimal asset allocation leads to significant welfare losses for pension plan participants. A suboptimal asset allocation can reduce welfare in monetary amounts by up to 55.0% for a risk-neutral (r = 0) individual and up to 20.9% for a highly risk-averse (r = 6) individual. All pension plans measured in this study show substantial welfare losses for all groups of participants.

Finally, the value of eliciting risk preferences depends on a number of pension plan characteristics and market expectations. Firstly, higher levels of income, compared to the state pension, increase the effect of the asset allocation on total pension income, and therefore increase the value of elicitation. Secondly, both lower risk premiums and more heterogeneity of risk preferences increase the variance of optimal asset allocation, and increase the value of elicitation. Lastly, age influences the value of elicitation over the full investment horizon. Shorter periods to retirement cause more variation in optimal asset allocations. However, as the investment period also diminishes, differences due to asset allocation become less pronounced.

All in all, our framework provides insight for the cost-benefit analysis that pension fund managers have to perform. They must assess whether the costs of measuring risk preferences of their plan participants is worth the effort. This can be done via welfare analysis of the asset allocation. The welfare for each individual that can be gained from an optimal allocation can be compared to the uniform allocation that the fund has chosen. The more these two diverge, the more can be gained from measuring risk attitudes and tailoring the asset allocation.

Finally, we wish to emphasize that our study revealed that risk attitude cannot be determined on the basis of population characteristics and individual socio-demographic characteristics alone. Since these factors explain no more than a mere 6 percent of variation, genuine insight into the risk attitude of plan members requires measurement of risk attitudes at individual level.

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Pension risk preferences

Pension plan managers are increasingly expected to demonstrate that the risk preferences of plan participants are adequately reflected in the asset allocations of their plans. Yet, it remains unclear whether managers should elicit the subjective risk preferences of individual participants to achieve this goal, or instead rely on objective and more readily available indicators. To address this question, Gosse Alserda, Benedict Dellaert, Laurens Swinkels (all EUR) and Fieke van der Lecq (VU A) have developed an augmented lottery choice method, tailored to the pension domain, to measure the risk preferences of individuals.

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