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Towards a practical and scientifically sound tool for measuring time and risk preferences in pension savings decisions

Jan Potters, Arno Riedl and Paul Smeets

DESIGN 59

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DESIGN PAPER 59

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TOWARDS A PRACTICAL AND SCIENTIFICALLY SOUND TOOL FOR MEASURING TIME AND RISK PREFERENCES IN PENSION SAVINGS DECISIONS

Abstract

We present a recently developed experimental method to estimate individuals' time and risk preferences and test it for its suitability in the pension context. Participants allocate money between an account that pays out at an earlier date and an account that pays out at later dates. Money allocated to the earlier date is paid out with certainty, while the money allocated to the later account is paid out with varying probabilities. This reflects the trade-off between certain immediate consumption and saving for uncertain future consumption. We test if time and risk preferences are different in the pension context as compared to a neutral context. Our main finding is that estimated discount rates are close to actual market interest rates if allocation decisions involve a long term period and involves a trade-off between receiving money one year from now and receiving money shortly after the expected retirement age. The elicited discount rates from our long-term decisions are therefore useful for pension funds that are interested in knowing the internal discount rates of their clients. We also estimate time and risk preferences on an individual level. These estimates indicate that, after further tests

and when suitably adopted, the tested method could lead to an 'easy-to-use' tool for creating personalized profiles regarding clients' time and risk preferences, generally as well as specifically in the context of pensions.

1. Introduction

In this paper, we propose a method to jointly estimate time and risk preferences of pension fund clients. For European financial institutions, it is mandatory to create client profiles that include risk and time preferences (MiFID, 2014). However, the current methods to estimate these preferences are of insufficient quality, according to a report of the Netherlands Authority for the Financial Markets (Autoriteit Financiële Markten, 2014). Here we discuss an 'easy-to-use' and scientifically sound method that can help pension funds in creating better client risk and time preference profiles. Important advantages of the proposed method are that it allows to measure time preferences and risk attitudes on the individual level, has strong scientific foundations, and can be easily tailored to the context of pensions.

For good client-centered pension fund policies and advice, it is crucial to know clients' time and risk preferences. In Defined Contribution (DC) pension systems, individuals are largely responsible for their own retirement savings decisions. They decide how much to save, how to distribute their investments across different asset classes, and which investment funds to pick. Thus, DC clients clearly benefit from well-calibrated client profiles and advice on the optimal portfolio given their personal profile. Defined benefit (DB) plans make many decisions on behalf of their clients. Hence, for DB funds, knowing their clients' preferences is of invaluable importance when devising investment decisions and when communicating with their clients.

Time preferences underlie the trade-off that individuals make between consumption now and consumption in the future. These preferences determine many economic decisions and are particularly important for retirement (savings) decisions, which for the longer part of a person's lifetime involve the trade-off between consumption now or in the near future and consumption many years ahead. Research, mainly among US Americans, has shown that a large group of individuals appears to strongly and often irrationally prefer earlier consumption to later consumption and consequently save too little for retirement (Laibson et al., 1998; Diamond and Köszegi, 2003; Hershfield et al., 2011). Consequently, as reported by Munnell et al. (2007), 43% of US households fell at least 10% short of target replacement rates. Also in the Netherlands, it has been reported that about a fifth of the population cannot afford their minimal expenditures when retired, even if they draw down housing wealth (de Bresser and Knoef, 2015).

Risk preferences underlie the trade-offs between 'lotteries', that is, monetary payoffs that are paid out only with some likelihood. For example, a person's risk preferences can tell us whether or not she prefers investments in equity with a high expected return and high volatility over investments in bonds with a lower expected return and lower volatility. Risk-averse individuals will be less likely to invest in equities (Dorn and Huberman, 2005; Dohmen et al., 2011). Pension-savings decisions also involve risk components, not only because returns on savings and investments are uncertain but also because of other lifetime risks, such as life expectancy and health status at old age. Thus, knowledge of risk preferences is of utmost importance for retirement and pension savings decisions.

In that respect it is important to allow for probability weighting, which can be captured by non-linear decision weights of the prospect theory introduced by Kahneman and Tversky (1979). Probability weighting is a well-known phenomenon and describes the tendency of people to overweight small probabilities and underweight large probabilities. For example, most people overweight the chance that they will win the jackpot in a lottery or the chance that they will suffer an accident. In the pension context, individuals may tend to put more or less weight on the likelihood of certain pension-related outcomes, which in turn will influence their retirement savings preferences. For instance, Heimer et al. (2015) show that young people in particular overestimate the probability that they will die early, which affects their financial decisions.

This paper has three main contributions. First, we investigate the effect of the time horizon on time and risk preferences. Most previous studies use relatively short horizons, of up to several months. We not only estimate preferences in these short horizons, but also across a time period that closely matches that of actual retirement decisions. More specifically, an individual in our experiment decides how to allocate a hypothetical windfall gain of €1,000 between consumption within one year from now and consumption in the early years of retirement. It is important to investigate such longer-term decisions, as these are likely to be more relevant for actual retirement decisions. Few previous studies have documented the time horizon effect (Frederick et al., 2002; Dohmen et al., 2012), but these studies still focus on time horizons that are much shorter than those for a typical individual deciding how much to save for retirement.

Second, we investigate the effect of framing long-term allocation decisions as pension savings compared to a neutrally framed long-term allocation decision. A treatment group is presented *with a hypothetical scenario in which participants are asked to allocate a hypothetical windfall* gain of €1,000 between receiving it one year from now and receiving a larger amount in the early years of retirement. The participants in the neutrally framed condition make exactly the same decision, but framed in a neutral way, without referring to pensions. From differences between these treatments we can learn whether individuals tend to be more or less patient and/or more or less risk averse when it comes to pension savings decisions.

Third, we investigate the effect of providing participants with real monetary incentives compared to hypothetical decisions. In the economics literature, time and risk preferences are typically measured using real monetary incentives (e.g. Holt and Laury, 2002; Andersen et al., 2008; Dohmen et al., 2012; Andreoni and Sprenger, 2012a,b). In our experiment, each participant takes part in incentivized decision situations and in equivalent hypothetical decision situations. This allows us to test whether elicited discount rates and risk attitudes are different when using monetary incentives compared to hypothetical choices. For pension funds it is unlikely that incentivized experiments can be used to measure their clients' time and risk preferences profile, specifically when large amounts of money are involved. Therefore, it is important to understand if and how choices differ between incentivized choices involving real monetary consequences and hypothetical choices.

We make use of the so-called Convex Time Budget (CTB) method introduced by Andreoni and Sprenger (2012a,b). In this method, participants allocate a monetary endowment between an account that pays out some amount at an earlier date and an account that pays out a larger amount at a later date. Participants are free to allocate their endowment between these two accounts.[1]

1 As a first step, and for organizational reasons, all our participants are students. Although the behavior of students is also relevant since they are (future) pension fund clients, they also differ in many respects from the typical client. In our conclusions, we come back to this potential limitation regarding external validity. There we also propose extending our study to actual pension fund clients.

An important advantage of the CTB is that it allows, on the one hand, for the simultaneous estimation of time preferences (internal discount rates) and, on the other hand, for risk preferences (utility curvature and probability weighting). In the different CTB choice sets, we vary the probability with which the later amount will be paid out, while the early payment is always paid out for sure. This allows us to estimate time preferences and risk preferences together, which matters because decisions involving the future are inherently risky (Andersen et al., 2008; Andreoni and Sprenger, 2012a,b). In the pension context, investments in retirement accounts are risky for several reasons, such as varying interest rates, equity returns volatility, and changing personal circumstances of individuals over time.

The CTB method can be used to estimate time and risk preferences not only on the aggregate level but also at the individual level. The latter estimates can be related to demographic and socio-economic background variables to explore how risk and time preferences vary with age, gender, family composition, income class, etc. The estimates can also be related to economic and financial decisions made by individuals. One can then explore, for instance, whether individuals who are estimated to have a relatively low aversion to risk are also those who tend to hold relatively risky assets, or whether those with a high discount factor also save more for retirement. A discrepancy between estimates and actual decisions could then be a cause for concern. It could be, for instance, that the current investment portfolio is no longer a good match with the preferences of individuals and thus a reason to reconsider their portfolio.

The most important practical application of the CTB method is that it could be used to create reliable client profiles. The individual-level estimates indicate how a person's preferences compare to those of the population distribution. Thus, one can assess precisely whether an individual is below or above the median, and if so, by how much. This is very useful information for setting up life cycle plans and individual asset liability management.

Our main findings of implementing the method with a student sample can be summarized as follows. First, we find little difference between financially incentivized and hypothetical decisions. The discount rates in the incentivized treatment are nearly identical to the discount rates in hypothetical decisions. This suggests that, in the investigated context, providing real monetary incentives is not a prerequisite for estimating discount rates.

Second, discount rates are substantially lower in the case where participants decide between an early payment and a payment that occurs around their retirement age, compared to a choice in which they decide between an early payment and a later payment that occurs one or two months from now. The implied annual discount rate in the hypothetical short-term decision is 23.4%, but is only 2.3% for long-term decisions. The latter discount rate comes close to current interest rate levels and seems therefore quite realistic for actual retirement decisions. Our estimated discount rate is thus much lower, and closer to market interest rates, than those reported in any other study that we are aware of in the literature. A particular concern with many previous studies is that the resulting yearly discount rates often exceed 100%. The fact that our estimated discount rates are much lower and more realistic is due to a combination of three factors. First, we control for risk preferences (utility curvature and probability weighting) and thus for real and perceived uncertainty, which reduces estimated discount rates. For instance, Andreoni and Sprenger (2012a), who control for utility curvature, estimate a yearly discount rate of about 35%, which is substantially lower than that of most other studies.[2] Second, we use relatively high stakes and that reduces the widely documented 'magnitude effect' which says that small outcomes are discounted more heavily than large ones (see e.g. Frederick et al., 2002). Third, the larger delay until retirement age in comparison to the commonly used delays of several weeks or months apparently also contributes to a more realistic estimate of discount factors.

A third finding is that the pension framing of the long run intertemporal decision does not significantly change the estimated discount rate (1.9%) compared to the neutral framing (2.3%). However, the utility curvature of participants in the pension framing decision is significantly larger than the curvature of participants in the neutral framing. This suggests that risk aversion increases when participants can allocate part of (windfall) money to supplement their pension income during retirement, compared to a neutrally framed condition. We also find that participants in the pension frame condition overweight the probability that they will not get paid in the long term compared to participants in the neutrally framed condition. This suggests that the mere thought about retirement makes individuals more pessimistic about the probability that they will get paid out in the future.

Other studies that investigate preferences related to retirement decisions mainly focus on risk preferences. For instance, Goldstein et al. (2008); Dellaert and Turlings (2011); and Donkers et al. (2012, 2013) discuss how the measurement of risk profiles in the context of pension decisions can be improved. Another stream of literature shows that individuals often have difficulties identifying with

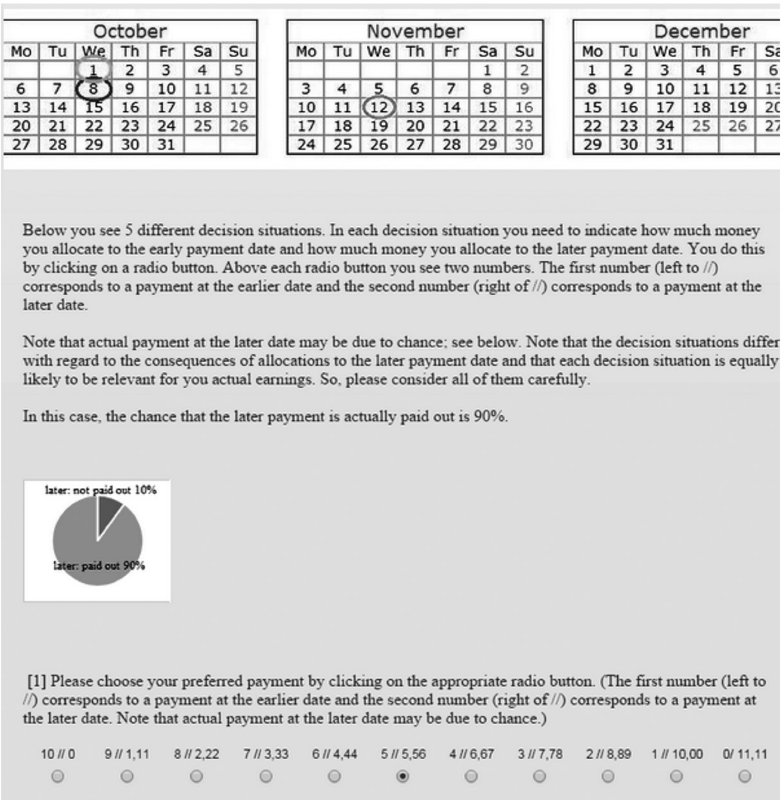
2 This estimate is, however, still much higher than the historical average return on equity, which is below 10% (Benartzi and Thaler, 1995).

their future selves and therefore have little intention to save for retirement (e.g. Hershfield et al., 2011; Brüggen et al., 2013). Yet, these studies do not directly elicit discount rates. Previous studies that do elicit discount rates do not specifically take the pension context into account (Frederick et al., 2002; Andersen et al., 2008; Laury et al., 2012; Dohmen et al., 2012; Andreoni and Sprenger, 2012a,b). The fact that our method measures time and risk preferences in the context of retirement decisions increases the practical applicability for pension funds and addresses fundamental issues for the measurement of such preferences for different decision domains.

2. Methodology

We implement the method of Convex Time Budgets (CTB) developed by Andreoni and Sprenger (2012a,b) and apply it amongst others in the pension context. An important advantage of this method is that it allows us to measure time preferences and risk preferences simultaneously. This is especially important in a pension context, because pension-related decisions always

Figure 1: Example of a decision situation



involve the future and pension payments are inherently uncertain. In relation to the latter, it is important to not only take into account the standard notion of risk attitudes (utility curvature) but to also allow for probability weighting, as argued in the Introduction.

In our experiment, participants receive real and hypothetical money endowments respectively and are confronted with several decision situations that are characterized by two main features. First, money needs to be allocated between an earlier and a later payment date, where the later payments are always higher and vary relative to the early payment. Second, some of the later payments are made uncertain by varying the probability with which they are paid out. Together, this allows the (joint) estimation of the earlier versus later trade-off (time preferences) and the certain versus risky trade-off (risk preferences).[3] Figure 1 shows an example of an allocation decision faced by participants in our experiment. The decision situation shown corresponds to decision number 6 in Table 1.

3 We do not measure present bias because previous studies using the CTB method do not find evidence for a (strong) present bias (Andreoni and Sprenger, 2012a; Sun and Potters, 2015). Using a different method, Wölbert and Riedl (2013) also do not find evidence for a present bias. A reason for this may be that in these (as in our) setups also the early payment was not immediate but paid out with at least one day delay.

3. Experiment design

Reliable estimates of time and risk preferences require a trade-off between providing monetary incentives to increase the internal validity and using hypothetical choices that allow for more realistic stakes and time horizons regarding retirement decisions (pension realism). The use of monetary incentives maximizes the likelihood that participants reveal their true preferences, because it minimizes what is known as 'hypothetical bias'. However, it is difficult if not impossible to provide financial incentives in the magnitude of real pension savings, and it is impractical to pay participants many years in the future.

With our design, we therefore explore whether a possibility exists to bridge the gap between providing monetary incentives and pension realism. We do so by running a number of treatments that allow us to explore how the measurement of time and risk preferences changes when moving from small stakes and short-time horizons in a neutral frame to large stakes and long-time horizons in a pension frame. Below we describe the treatments in some detail.

T1: Incentivized – small stakes, short horizon – neutral frame. In this treatment participants are paid according to their decisions. The actual average earnings are relatively small, but (in expectations) over-compensate for the opportunity costs of participating in the experiment (ca. €10 for students). The early payment date is always one week from 'today', the day of the experiment. The time delay between the earlier and the later payment dates is four or eight weeks, depending on the decision situation, and thus relatively short. The likelihood that the later payment is actually paid out depends on the decision situation and varies between 50, 70, 90, and 100 percent. The framing of the decisions is neutral, using the terms "earlier and later payments" without reference to any specific economic activities. Participants have to make choices in forty decision situations.

Table 1 shows all important parameters and their values for treatment T1. In the table t denotes the time delay from 'today' (i.e., the date of the experiment) to the earlier payments (always 7 days), k is the extra time delay to the late payments (28 or 56 days), a_t is the value of payment in € at the early date, a_{t+k} is the value of payment in € at the later dates, $1 + r$ is the implied gross interest rate, and 'daily r' and 'annual r' are the implied gross interest rates on a daily and annual basis respectively. In some situations the late payments are risky: p_{t+k} denotes the likelihood with which late payments are actually paid out. For instance, when p_{t+k} is 0.7, then the late payment is paid out with a chance of 70%, and nothing is paid out with a chance of 30%. The column denoted $1 + r'$ shows the implied interest rates when gross interest rates are adjusted for these risks. The last two columns, 'daily r'' and 'annual r'', report the risk-adjusted interest rates on a daily and annual basis, respectively.

T2: Hypothetical – small stakes, short horizon – neutral frame. This treatment is exactly the same as T1, except that all decisions are hypothetical. This allows us to identify any differences in behavior between incentivized and non-incentivized decisions in the given environment.

T3: Hypothetical – large stakes, long horizon – neutral frame. This treatment is the same as T2, except that the payments are substantially increased and that the time horizon is substantially longer. Specifically, the amount to be allocated between an earlier and a later payment date is €1,000. The early payment date is always one year from 'today', the day of the experiment. The later payment dates and associated payments are calibrated to the age of the participant. In half of the decision situations, the later payment date corresponds to a date shortly after the participant's legal retirement age. In the other half of decision situations, the later payment date lies halfway between one year from today and the date shortly after participant's retirement. This treatment allows us to identify any differences in hypothetical decisions when substantially increasing the time horizon to the later payment dates and the associated payments.

T4: Hypothetical – large stakes, long horizon – pension frame. This treatment is the same as T3, except that a mild pension frame is added. Specifically, the following text is added to the instructions:

> *To help you make decisions, you can imagine the following scenario. You have a windfall gain (e.g. from a lottery or an inheritance) and you have to decide which part you wish to have paid out to you one year from now (the blue date) and which part you wish to invest and have paid out to you later (the red date). For some decisions this later date will be in between the current date and your retirement age; in other decisions the later date will be shortly after your retirement age, in which case you can use it to supplement your pension. Bear in mind though that the payment at the later date will be uncertain in some decision situations.*

With this treatment we can test if changing the frame from a neutral to a mild pension frame affects the participants' decisions.

Table 1: Parameters in decision situation in T1

						interest (unadjusted for risk)			risks
decision	set	t	k	a_t	a_{t+k}	1 + r	daily r (%)	annual r (%)	p_{t+k}
1	1	7	28	10	10.00	1.00	0.00	0	1
2	1	7	28	10	10.10	1.01	0.04	14	1
3	1	7	28	10	10.40	1.04	0.14	62	1
4	1	7	28	10	10.90	1.09	0.31	170	1
5	1	7	28	10	11.60	1.16	0.53	386	1
6	2	7	28	10	11.11	1.11	0.38	226	0.9
7	2	7	28	10	11.22	1.12	0.41	259	0.9
8	2	7	28	10	11.56	1.16	0.52	370	0.9
9	2	7	28	10	12.11	1.21	0.69	600	0.9
10	2	7	28	10	12.89	1.29	0.91	1024	0.9
11	3	7	28	10	14.29	1.43	1.28	2117	0.7
12	3	7	28	10	14.43	1.44	1.32	2254	0.7
13	3	7	28	10	14.86	1.49	1.42	2695	0.7
14	3	7	28	10	15.57	1.56	1.59	3531	0.7
15	3	7	28	10	16.57	1.66	1.82	4914	0.7
16	4	7	28	10	20.00	2.00	2.51	11575	0.5
17	4	7	28	10	20.20	2.02	2.54	12055	0.5
18	4	7	28	10	20.80	2.08	2.65	13552	0.5
19	4	7	28	10	21.80	2.18	2.82	16242	0.5
20	4	7	28	10	23.20	2.32	3.05	20408	0.5
21	5	7	56	10	10.00	1.00	0.00	0	1
22	5	7	56	10	10.10	1.01	0.02	7	1
23	5	7	56	10	10.40	1.04	0.07	28	1
24	5	7	56	10	10.90	1.09	0.15	69	1
25	5	7	56	10	11.60	1.16	0.27	138	1
26	6	7	56	10	11.11	1.11	0.19	89	0.9
27	6	7	56	10	11.22	1.12	0.21	99	0.9
28	6	7	56	10	11.56	1.16	0.26	133	0.9
29	6	7	56	10	12.11	1.21	0.34	197	0.9
30	6	7	56	10	12.89	1.29	0.45	300	0.9
31	7	7	56	10	14.29	1.43	0.64	528	0.7
32	7	7	56	10	14.43	1.44	0.66	554	0.7
33	7	7	56	10	14.86	1.49	0.71	637	0.7
34	7	7	56	10	15.57	1.56	0.79	784	0.7
35	7	7	56	10	16.57	1.66	0.91	1014	0.7
36	8	7	56	10	20.00	2.00	1.25	1983	0.5
37	8	7	56	10	20.20	2.02	1.26	2048	0.5
38	8	7	56	10	20.80	2.08	1.32	2248	0.5
39	8	7	56	10	21.80	2.18	1.40	2596	0.5
40	8	7	56	10	23.20	2.32	1.51	3118	0.5

risk adjusted interest		
1 + r′	daily r′ (%)	annual r′ (%)
1.00	0.00	0
1.01	0.04	14
1.04	0.14	62
1.09	0.31	170
1.16	0.53	386
1.00	0.00	0
1.01	0.04	14
1.04	0.14	62
1.09	0.31	170
1.16	0.53	386
1.00	0.00	0
1.01	0.04	14
1.04	0.14	62
1.09	0.31	170
1.16	0.53	386
1.00	0.00	0
1.01	0.04	14
1.04	0.14	62
1.09	0.31	170
1.16	0.53	386
1.00	0.00	0
1.01	0.02	7
1.04	0.07	28
1.09	0.15	69
1.16	0.27	138
1.00	0.00	0
1.01	0.02	7
1.04	0.07	28
1.09	0.15	69
1.16	0.27	138
1.00	0.00	0
1.01	0.02	7
1.04	0.07	28
1.09	0.15	69
1.16	0.27	138
1.00	0.00	0
1.01	0.02	7
1.04	0.07	28
1.09	0.15	69
1.16	0.27	138

Table 2: Summary of experimental treatments

Treatment	Incentivized	Stakes	Time horizon	Frame
T1	Yes	Small	Short	Neutral
T2	No	Small	Short	Neutral
T3	No	Large	Long	Neutral
T4	No	Large	Long	Pension

Table 2 summarizes the experimental treatments and their main differences.

The treatments are implemented using a combined within-subjects and between-subjects design. Specifically, each subject participates in a combination of T1 and one of the other treatments. We will call this combination of treatments a 'condition'. In condition T1T2, participants first make choices in T1 followed by T2 and similarly for conditions T1T3 and T1T4. In condition T2T1, participants first make choices in T2 followed by T1. It was explained to the participants that the experiment consisted of two parts, that they would first receive information about the first part, and that detailed information about the second part would be provided after the first part was finished.[4] These conditions (treatment combinations) allow us to compare T1 and T2 within subjects and for reversed order. Furthermore, between-subject comparisons can be made for the 'hypothetical decisions' treatments T2, T3, and T4, after subjects have experienced the incentivized treatment T1. Additionally, we can compare T1 with T3 and T4 respectively between subjects.

4 In the experiment instructions the term 'treatment' was not used in order to minimize a potential experimenter demand effect. Instead, participants were informed that the experiment consists of two 'parts'.

4. Experiment procedures

The experiment was conducted on May 18, 2015 via Internet, using Qualtrics, Version May 2015. Student participants were recruited from the Maastricht University Behavioral and Experimental Economics laboratory (BEElab) subject pool using ORSEE (Greiner, 2015). A few hours before the experiment started, for each of the conditions T1T2, T1T3, T1T4, and T2T1, 200 potential participants were informed by email that they would shortly receive an invitation to participate in a decision-making experiment using Qualtrics. In this email, it was also announced that (a) participants would be able to earn money with their decisions, and that (b) payment would take place via bank transfer, implying that they would need to enter their name, IBAN bank account number and email address. At 0:01 AM on May 18, 2015, they received the invitation via Qualtrics, which contained a link to the starting page of the experiment. Subjects could go through the experiment at their own pace but could only participate on that day. The links to the experiment were automatically deactivated after 11:59 pm.

In total we have observations from 47 participants in T1T2, 48 in T1T3, 41 in T1T4, and 44 in T2T1.[5] The average earnings amounted to €10.37 and very similar in all treatments. The median duration it took participants to complete the experiment ranged from 24.2 to 26.7 minutes, indicating that most of them made their choices without long interruptions.[6]

5 In T1T2, 50 participants started the experiment, but 3 stopped before the end of the instructions. In T1T3 this happened for 1 out of 49 and in T2T1 for 5 out of 49. In T1T4, 46 participants started the experiment, of which 5 stopped before the end of the instructions and 1 stopped before the very last screen. For the latter we have all data and use it in the analysis.

6 There are, however, a few outliers who took (much) longer to complete the experiment. This ranged from 44.5 to 1348.6 minutes.

5. Results

Recall that T1 stands for the treatment with monetary incentives, small stakes, a short time horizon and a neutral decision frame and T2 for the treatment with hypothetical decisions that is otherwise identical to T1. T3 is the same as T2 except that the stakes are large, and T4 is equivalent to T3 except that the neutral frame is replaced by a pension frame (cf. Table 2).

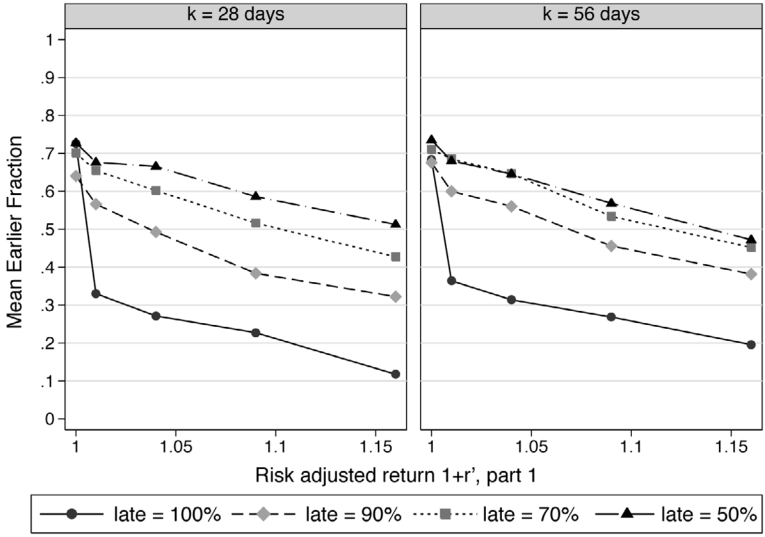
Recall also that, for convenience, we refer to the treatment combinations T1T2, T1T3, T1T4, and T2T1 as *conditions*. Moreover, T1.1 and T1.2 refer to treatment T1 being run in part 1 of a condition (T1T2, T1T3, T1T4) and in part 2 of a condition (T2T1), respectively. T2.1 and T2.2 are defined similarly. Recall that treatments T3 and T4 are always run in the second part of a condition.

5.1 Effect of risk-adjusted interest rate

One would expect the fraction of the budget allocated to the earlier date to decrease in the risk-adjusted interest rate $1 + r'$. Figure 2 illustrates that this is indeed the case. The figure uses the data from treatment T1.1 (i.e. the first part of treatments T1T2, T1T3, and T1T4).

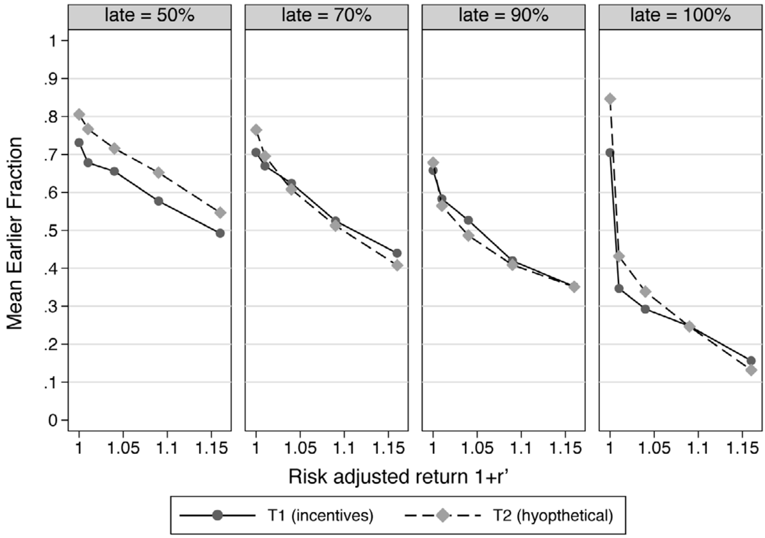
The figure displays decisions separately for the shorter and the longer delay (i.e. 28 and 56 days, respectively), and separately for the various probabilities with which late payments are actually paid out (100%, 90%, 70%, and 50%, respectively). It is clear from the figure that the average fraction allocated to the earlier date decreases with increasing probability of later payments ('late' in the figure legend). When the future payment is less uncertain (i.e. 'late' is higher), on average more income is allocated to the later date and less to the earlier data.

Figure 2: Fraction of budget allocated to earlier date as a function of risk-adjusted return for the different probabilities of late date payment and the two different delays until late payment (all T1.1 data)



One would also expect that a longer delay to the later payment date would decrease the fraction of income allocated to the later date. Comparison of the two panels shows that this is generally the case. Holding the late payment probability and the risk adjusted return value $1 + r'$ fixed, the fraction of income allocated to the earlier date is higher for the longer delay (k = 56 days) than for the shorter delay (k = 28 days) in almost all cases. Only when the payment probability for the late payment is lowest (50%) is the effect of the delay less clear-cut.

Figure 3: Fraction of budget allocated to earlier date as a function of risk-adjusted return for incentivized and hypothetical decisions respectively and the different probabilities of late date payment (T1.1 and T2.1 data)

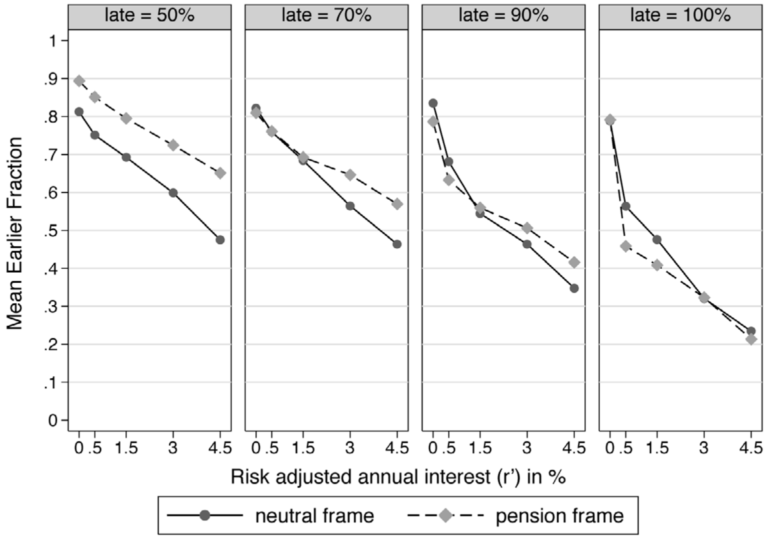


5.2 Effect of monetary incentives

By comparing treatments T1 and T2 we can see whether the provision of monetary incentives, in contrast to hypothetical decisions, has a discernible effect on allocations. Here we concentrate on T1.1 versus T2.1, which delivers the cleanest comparison. Figure 3 displays average allocations in T1 and T2 by the different values of the probability of payment at the later date ('late' is 50%, 70%, 90%, and 100%, respectively). For convenience, the data of the two delays of 28 days and 56 days are pooled.

The figure shows a small difference only when the risk of the later payment is high (late = 50%). In that case, participants in the incentivized T1 seem to be more willing to take risk by allo-

Figure 4: Fraction of budget allocated to earlier date as a function of risk-adjusted annual interest rate for respectively neutrally framed decisions and decisions framed in pension terms and the different probabilities of late date payment (T3.2 and T4.2 data) return



cating a smaller fraction to the earlier date where the payment is always certain. Overall, however, no strong differences are visible between the two versions. We take this as evidence that in our experiment it does not matter much whether decisions are incentivized with money or not.

5.3 Effect of pension frame

We now proceed to a comparison of the two treatments with high stakes and long time horizons, and ask whether the addition of the pension frame in treatment T4 has an effect relative to the neutrally framed treatment T3. For convenience, we again pool the values of the two delays ('halfway until retirement age' and 'until retirement age', respectively). It can be seen from Figure 4 that the pension frame (the lighter dashed lines) tends to lead to an allocation of larger income shares to the earlier payment date, but only if the uncertainty about the later payment is high ('late' = 50% or 'late' = 70%). Apparently, participants are bothered more about future risk when decisions are framed in terms of post-retirement or pre-retirement incomes than when they are framed neutrally.

5.4 Aggregate parameter estimates

We use two-limit Tobit likelihood regressions to estimate the preference parameters for time delay (discount factor δ), risk aversion (utility curvature α), and likelihood sensitivity (probability weighting β). Table 3 reports parameter estimates for the four different versions of the experiment.

Several results are notable. First, the estimated daily discount factors δ in T1 and T2 are very close to 1. Since these are applied 365 times in a year, they still amount to considerable annual discount rates: $(1/\delta)^{365} - 1$. The discount factors in T3 and T4 are lower, but since these are already yearly discount factors, the implied annual discount rates $(1/\delta - 1)$ are substantially lower than in T1 and T2. In fact, with 2.3% and 1.9% in T3 and T4, respectively, the estimated annual discount rates in these treatments can be considered to be reasonable.

Second, estimated utility curvature α is close to 1 for T1 and T2, implying a near-linear (thus, risk-neutral) utility function. This is reasonable for stakes in the order of magnitude implemented in these treatments, varying from receiving €10 in one week to receiving €23 in nine weeks. It is also consistent with the relatively large fraction of corner choices in T1 and T2 (66% and 67%, respectively). In T3 and T4 the estimated utility curvature is higher

Table 3: Discounting, curvature, and probability weighting parameter estimates

	T1 Low – Real	T2 Low – Hypo	T3 High – Neutral	T4 High – Pension
Discount factor δ	1.000	0.999	0.978	0.981
	(0.0002)	(0.0003)	(0.0046)	(0.0199)
Annual discount rate	0.150	0.234	0.023	0.019
	(0.091)	(0.120)	(0.005)	(0.005)
Utility curvature α	0.987	0.990	0.933	0.889
	(0.001)	(0.001)	(0.013)	(0.020)
Probability weighting β	1.144	1.124	1.605	2.21
	(0.020)	(0.024)	(0.266)	(0.273)
Log L	−13,900	−6,847	−4,033	−4,063
Observations	7,200	3,640	1,920	1,640
Left censored	2,441	1,165	471	294
Right censored	2,321	1,287	790	539
Clusters	180	91	48	41

Note: two-limit Tobit estimators, based on the assumption that $w_t = w_{t+k} = 0.01$ and $\pi(p) = p^{\beta}$; parameter for δ refers to days in T1 and T2 and to years in T3 and T4; the annual discount rate is based on the estimated δ. Clustered standard errors are stated in parentheses.

(i.e. a lower α). This holds especially for T4 with the pension frame. This suggests the interesting interpretation that participants make more risk-averse choices when the (windfall) money can be used to supplement their pension during retirement.

Third, the estimated probability weighting value of β is larger than 1 in all treatments. This gives rise to a convex probability weighting function $\pi(p) = p^{\beta}$, implying that the probability of payment at the later date will be weighted less than linearly: $\pi(p_{t+k}) < p_{t+k}$. Participants thus underweight the probability of getting paid out in the future. This is consistent with the general

Table 4: Individual Estimates for Treatments T1 and T2 combined

	N	Median	5th percentile	95th percentile	Min	Max
Discount factor δ	140	.9998	.9946	1.0102	.9845	1.0225
Annual discount rate	140	.0639	−.9758	6.2964	−.9997	294.4672
Utility curvature α	140	.986	.8983	.9993	.6682	1.0795
Probability weighting β	140	1.1493	.5403	1.9609	−.7586	3.5734

finding in the literature on decision making under risk that larger probabilities (roughly $p > 1/3$) are underweighted and small probabilities are overweighted. Moreover, it is notable that probability underweighting is substantially stronger when the later payment is framed in pension terms. For example, with $\beta = 2.21$, a payment probability of 50% is weighted as only 22% ($0.5^{2.21}$) in the pension frame treatment, compared to 33% ($0.5^{1.61}$) in the neutral frame treatment. Hence, specifically in the pension frame, participants appear overly pessimistic regarding the chance of receiving their payment in the future. This strong weighting of risk is the reason behind the strong preference for early payment that we observed for the pension frame relative to the neutral frame in Figure 4 (especially for the low payout probabilities of 50% and 70% at the later dates).

5.5 Individual Estimates

For treatments T1 and T2 combined, Table 4 reports median, 5th percentile, 95th percentile, minimum, and maximum of the estimates of the different parameters and for the implied annual discount rate. Table 5 does the same for treatments T3 and T4. It should be noted that, for a fraction of the participants, it is not possible to attain precise point estimates for all parameters with Tobit regressions. This holds for 40 out of 180 participants in treat-

Table 5: Individual Estimates for Treatments T3 and T4 combined

	N	Median	5th percentile	95th percentile	Min	Max
Discount factor δ	69	.99	.9114	1.0555	.8367	3.5626
Annual discount rate	69	.0101	−.0526	.0972	−.7193	.1952
Utility curvature α	69	.907	.5675	1.439	−.2152	2.1788
Probability weighting β	69	1.9437	−3.2472	19.4323	−17.9585	38.1465

ments T1 and T2, and for 20 out of 89 for treatments T3 and T4. Although it is still possible to attain upper or lower bounds for the parameters, we have not included these in the table.

The estimated parameter values are not especially interesting in themselves but because of the applications we mentioned in the Introduction, namely the possibility to derive time and risk preference profiles on an individual basis. Beyond that there are a few more noteworthy results. First, the estimated daily discount factors show relatively little variation across participants but still scale up to implied annual discount rates that vary quite widely. Second, the annual discount rates display less variation in treatments T3 and T4 than in treatments T1 and T2. Thus, scaling up the stakes and time horizons decreases the differences between individuals. Third, for utility curvature and probability weighting the reverse patterns are visible. Individual differences in the estimates of α and β are larger in treatments T3 and T4 than in treatments T1 and T2, respectively. Finally, we can see some 'unreasonable' estimates in the tails of the distributions, such as a minimum value of −0.999 for the annual discount rate. Notably, even such 'unrealistic' estimates reveal information when one is interested mainly in an individual's position in the distribution rather than in the precise value of the estimate.

6. Conclusions

Client profiles are important for pension fund beneficiaries. In this paper, we test a method that jointly estimates time and risk preferences. After further tests and when suitably adopted, this method could lead to an 'easy-to-use' tool for creating personalized profiles regarding clients' time and risk preferences, generally as well as specifically in the context of pensions.

The method makes use of Convex Time Budgets (CTB), where individuals allocate money (real or hypothetical) between an earlier date and later dates. This reflects the trade-off between immediate consumption and saving for later consumption. To test for differences between low-stake and high-stake decisions and between short and long delays in payout, we varied these factors. Moreover, money allocated to the earlier date is paid out with certainty, while the money allocated to the later account is paid out with a varying probability. This mimics pension savings decisions, where payouts during retirement become increasingly uncertain. To test whether in people's minds pension decisions are different from other savings decisions, we explored settings with and without a pension frame.

Our main finding is that estimated discount rates are close to actual market interest rates if allocation decisions involve a long term period that lasts until the retirement age of the individual. Previous studies use shorter-term decisions, which results in discount rates that largely exceed market interest rates and even exceed the historical average return on equity. The elicited discount rates from long-term decisions can be useful for pension funds that are interested in knowing the discount rates of their participants.

The CTB method with long run decisions introduced in this paper could therefore be a useful tool for pension funds, in particular because it allows to estimate discount rates, utility curvature (as a proxy for risk preferences), and probability weighting simultaneously and on an individual basis. In light of this, it is important that we find no difference between discount rates estimated with short-term incentivized choices and short-term hypothetical choices. This evidence suggests that pension funds could use hypothetical decisions when creating investment profiles for their clients.

Our study is limited in one important aspect, which – at the same time – suggests an important avenue for future research. For organizational reasons, all participants in our experiment are students. Although students are also (future) pension fund clients and the results are thus relevant, for more robust results and further insights it would be important to conduct similar experiments with a more representative sample of clients of a pension fund. In such an experiment the individual estimates of time and risk preferences could be linked to actual savings decisions as well as to important personal characteristics such as age, gender, family composition, income class etc. Together this could lead to a detailed client profile that is based on a scientifically sound method and could provide hitherto unprecedented insights. For instance, a client's preferences may change over time, and a discrepancy between the estimated time and risk profile and the current investment portfolio could suggest that there is no longer a good match between the portfolio and the client's actual preferences. Without such information, this is difficult to detect, and the client would likely stick longer than necessary with a sub-optimal portfolio. We hope to find interested pension funds in the near future to cooperate on this project.

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A. Formal decision model

For each decision maker (DM), each decision situation (DS) is characterized by a money endowment m, a date of early payout $t_1 := t$, a time k between early and late payout $t_2 = t + k$, an interest rate r earned between t and t + k, and probabilities p_t and p_{t+k} with which the earlier and later payment, respectively, actually occurs (with probability p_t and $1 - p_{t+k}$, respectively, the payment is zero). The allocation of money (consumption) (c_t, c_{t+k}) between the two points lies on the budget line, $(1 + r)c_t + c_{t+k} = m$. In the experiment, participants make allocation decisions in several DSs, which vary in t, k, and r.

Using the standard model of intertemporal decision making – assuming linear separability in time and exponential discounting – the utility of a DM can be written as

$$\begin{aligned} &U(c_t, c_{t+k}; w_t, w_{t+k}, p_{t+k}) \\ &\quad = \delta^t [p_{t+k}\, u(c_t, w_t) + [1 - p_{t+k}]u(0, w_t)] + \\ &\qquad \delta^{t+k} [p_{t+k}\, u(c_{t+k}, w_{t+k}) + [1 - p_{t+k}]u(0, w_{t+k})], \end{aligned} \tag{A.1}$$

where w_t denotes background income (consumption), δ is the discount factor measuring time preference, and α measures the curvature of the utility function. In standard theory, α measures both the marginal utility (preference for consumption diversification) <u>and</u> risk preferences. Whether α is indeed a good measure of risk preferences is disputed, however. Allowing for probability weighting, $\pi(p_{t+k})$, the above equation changes to

$$\begin{aligned} &U(c_t, c_{t+k}; w_t, w_{t+k}, p_{t+k}) = \\ &\quad \delta^t [\pi(p_{t+k})u(c_t, w_t) + \pi(1 - p_{t+k})u(0, w_t)] + \\ &\qquad \delta^{t+k} [\pi(p_{t+k})u(c_{t+k}, w_{t+k}) + \pi(1 - p_{t+k})u(0, w_{t+k})], \end{aligned} \tag{A.2}$$

In order to identify all preference parameters, we vary the interest rate r to identify α, the delay k to identify δ, and the probability p_{t+k} to identify probability weighting parameters.[7]

Remark 1. *Although the method allows for it, we do not measure present bias because it seems less important for pension decisions. Moreover, recent results question the robustness of the present bias results (Andreoni and Sprenger, 2012a; Wölbert and Riedl, 2013).*

Remark 2. *The parameter estimates are sensitive to assumptions about background income/consumption (w_t, w_{t+k}), which, in principle, could be estimated. The better solution is, however, to get reliable information about it. We use survey questions to gather this information and run robustness checks to explore how sensitive our results are to different assumptions regarding background consumption.*

A.1 Implemented Decision Problem

Each decision problem consists of a choice of (z_t, z_{t+k}), with $z_t + z_{t+k} = 1$, from the set {(1, 0), (0.8, 0.2), (0.6, 0.4), (0.4, 0.6), (0.2, 0.8), (0, 1)}. Choice (z_t, z_{t+k}) implies that the decision maker receives extra income (consumption) $c_t = z_t a_t$ on date t with probability p_t (and 0 with probability $1 - p_t$) and $c_{t+k} = z_{t+k}\, a_{t+k}$ on date t + k with probability p_{t+k} (and 0 with probability $1 - p_{t+k}$). Hence, the parameters of the choice problems are (t, k, a_t, a_{t+k}, p_t, p_{t+k}).

7 In the literature, probability weighting is often specified as $\pi(p) = \exp(-\beta[-\ln p]^{\gamma})$ (Prelec, 1998), which produces an inverted S-shaped probability weighting function. Another popular version is the one-parameter function $\pi(p) = \frac{p^{\gamma}}{[p^{\gamma}+[1-p]^{\gamma}]^{1/p^{\gamma}}}$ ··· (Tversky and Kahneman, 1992).

The parameters a_t and a_{t+k} imply a gross interest rate of $1 + r_k = a_{t+k} / a_t$ over a time period of length k. However, a more reasonable measure of the interest rate is a risk-adjusted or expected interest rate which takes into account that the amounts may not be paid out:

$$1 + r'_k = p_{t+k}\, a_{t+k} / p_t a_t.$$

The constraint $z_t + z_{t+k} = 1$ can be rewritten as:

$$(1 + r)c_t + c_{t+k} = m \text{ with } m = a_{t+k}. \tag{A.3}$$

Consider the following standard CRRA utility function

$$u(x_t) = x_t^{\alpha} \tag{A.4}$$

where x_t denotes income (consumption) from the experiment plus the part of background income (consumption), w_t, that is integrated into the decision problem.

Weighted discounted utility over the two relevant dates, t and t + k is then given by

$$\begin{aligned} &\delta_t[\pi(p_t)[c_t + w_t]^{\alpha} + \pi(1 - p_t)w_t^{\alpha}] + \\ &\quad \delta^{t+k}[\pi(p_{t+k})[c_{t+k} + w_{t+k}]^{\alpha} + \pi(1 - p_{t+k})w_{t+k}^{\alpha}], \end{aligned} \tag{A.5}$$

where the weights π(p) are the decision weights. We consider two prominent weighting functions proposed by Tversky and Kahneman (1992) and Prelec (1998), respectively:

$$\pi(p) = \frac{p^{\gamma}}{[p^{\gamma} + [1 - p]^{\gamma}]^{1/p^{\gamma}}} \tag{A.6}$$

and

$$\pi(p) = exp(-\beta[-\ln p]^{\gamma}). \tag{A.7}$$

Maximization of the expression in (A.5) subject to the budget constraint (A.3) gives the first-order condition

$$\left[\frac{c_t + w_t}{c_{t+k} + w_{t+k}}\right]^{\alpha-1} = \delta^k [1 + r] \frac{\pi(p_{t+k})}{\pi(p_t)}. \tag{A.8}$$

This equation – which for simplicity ignores that the budget set is discrete – can in principle be used to estimate the parameters (α, δ, β, γ, w_t, w_{t+k}) from the choice data (z_t, z_{t+k}) and the design parameters (k, $1 + r$, p_t, p_{t+k}).

Taking the logarithm of the first-order condition (A.8), using the fact that we will have $p_t = 1$ in our design, and rearranging gives

$$\ln\left(\frac{c_t + w_t}{c_{t+k} + w_{t+k}}\right) = \frac{\ln \delta}{\alpha - 1} + \frac{1}{\alpha - 1} \ln(1 + r) + \frac{1}{\alpha - 1} \ln \pi(p_{t+k}). \tag{A.9}$$

Using the probability weighting function (A.7) for $\pi(p)$, and fixing the values for the parameters γ, w_t, and w_{t+k}, makes equation (A.9) linear in the choice data (c_t, c_{t+k}), k, $\ln(1 + r)$, and p_{t+k}. With an additive error structure it can then be conveniently estimated with a two-limit Tobit regression.

In the regressions reported in the main text, we use Tobit regressions to estimate Equation (A.9) because the choice data are censored. Participants cannot choose a payment higher than a_t on date t or a_{t+k} on date t + k, even if they had wanted to at the implied interest rate 1 + r. We also note that when running the regressions we need to fix values for background wealth w_t and w_{t+k} , respectively, as well as for parameter γ in the probability weighting function. For the reported estimates we assume $w_t = w_{t+k} = 0.01$ (i.e. assuming that participants do not integrate the experimental payments with background consumption) and $\gamma = 1$ (i.e. turning the Prelec weighting function into a power function $\pi(p) = p^{\beta}$).

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Measuring pension savings decisions

For European financial institutions, it is mandatory to create client profiles that include risk- and time preferences (MiFID, 2014). However, the current methods to estimate these preferences are of insufficient quality, according to a report of the Authority Financial Markets of the Netherlands. In this paper, Jan Potters (TiU), Arno Riedl (UM) and Paul Smeets (UM) discuss an 'easy-to-use' and scientifically sound method that can help pension funds in creating better client risk and time preferences profiles. Three effects are taken into account: first, the time horizon; second, the effect of framing; and third, the effect of providing participants with real monetary incentives.

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