What to Offer If Consumers Do Not Want What They Need? A Simultaneous Evaluation Approach with an Application to Retirement Savings Products

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Abstract

Traditionally, in economics one considers utility maximizing economic agents. The results provide insight on how consumers should behave. In practice, however, human decisions are influenced by numerous behavioral patterns that result in a deviation between subjective attractiveness and objective utility and hence lead to systematic deviations from rationally optimal behavior. This also applies to decisions in the context of retirement saving, we often find a large difference between theoretically optimal products and observed demand. In the worst case, this can result in substantial pension gaps, and hence in a reduction of the standard of living in in the retirement phase. The aim of this work is to (simultaneously) assess and evaluate the objectively rational utility and the subjectively perceived attractiveness of retirement savings products. Such a combined approach can help to identify or design retirement savings products that create a high (albeit not the maximum possible) objective utility while at the same time being subjectively of high (albeit not maximum possible) attractiveness. We argue that a focus on such products might help consumers make better decisions than currently observed decisions that seem to be driven primarily by subjective attractiveness.

Keywords: Retirement Savings, Old-Age Provision, Utility Maximization, Behavioral Insurance, Prospect Theory, Simultaneous Evaluation

JEL: D14, G11, G22, G41, J26, J32

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1 Introduction

Demographic change poses great challenges for old-age provision systems. Pay-as-you-go systems are particularly affected by this change. The importance of private retirement savings will therefore continue to increase. Although, it is theoretically possible to optimally tailor retirement savings products to individual needs, this comes at the cost of great complexity and individual responsibility.

There is a large amount of literature on the optimal (rational utility-maximizing) design of retirement savings products (e.g., Branger *et al.* (2010), Chen *et al.* (2015)). However, findings from behavioral economics show that numerous human behavioral patterns can cause a deviation between actual and optimal (rational utility-maximizing) decisions (e.g., Benartzi & Thaler (2007) or Richter *et al.* (2019) and references therein). Due to its complexity and its long-term nature, decisions in the context of retirement saving seem particularly prone to such deviations. In addition, non-optimal decisions in this context can result in considerable negative consequences on the the standard of living in retirement phase. Therefore, in recent years, an increasing number of studies have examined the question of how to support individuals to make objectively better decisions. For example, framing, i.e. the way products are presented and explained can possibly be used to make products with high objective utility more appealing (cf., e.g., Brown *et al.* (2013)).

Nevertheless, existing literature typically either analyzes optimal product design from a rational perspective (e.g., Nielsen & Steffensen (2008)) or the question of the perceived attractiveness of retirement savings products at the time of decision making (e.g., Dierkes *et al.* (2010) or Ebert *et al.* (2012)).[1] To the best of our knowledge, there are no (quantitative) approaches (e.g., optimization approaches, specific measures or classification systems) which evaluate both aspects simultaneously. Such an approach could make an important contribution to tailoring

[1] This also applies to other fields of research, for example, in decision making in financial markets (Kliger & Levy (2009)), energy markets (Häckel *et al.* (2017)) or tax evasion (Dhami & Al-Nowaihi (2007)). Similar, for the broadly related stream of literature which focuses on comparing different risk measures, cf., Benoit *et al.* (2013) or Emmer *et al.* (2015).

retirement savings products to individuals' needs while considering biases in individuals' decision making. We argue that ideally, products should be designed in a way that constitutes a suitable compromise between creating a high (albeit not the maximum possible) objective utility and being subjectively appealing. This could help reduce the deviation between the utility of a theoretically optimal and the actually made decision.[2]

Consequently, the main contribution of this paper is an approach which simultaneously considers two different preference formulations; one to asses the preference from a rational point of view, and one to asses the subjective attractiveness at the time of decision making. Our proposed approach is generally applicable (for example with respect to the underlying preference formulations)[3] and is aimed to provide practical aid to identify and design suitable compromises.

We illustrate our approach by analyzing common unit-linked retirement savings products (with and without terminal guarantees as well as with annual lock-in guarantee features) in two different settings which differ only in the choice of the descriptive model to asses the subjective attractiveness of the products. In the first setting, we consider the popular (Cumulative) Prospect Theory (CPT) introduced by Kahneman & Tversky (1979) and Tversky & Kahneman (1992). CPT has been applied by various authors to explain deviations from utility-maximizing decisions in retirement savings.[4] Further, as CPT has certain shortcomings regarding long term investment decisions, we apply in the second setting Multi Cumulative Prospect Theory (MCPT) which can explain observed decisions of long investment horizon-investors more accurately (cf., Ruß & Schelling (2018)).[5] To assess the preference from a rational point of view we consider Expected Utility Theory (EUT) in both settings.

[2]Beyond product design, the approach can also help financial advisors to provide more beneficial support to consumers.

[3]The presented approach can be adjusted also to other applications than investment decisions in the context of retirement savings.

[4]For example, evaluation of gains and losses in relation to a reference point, combined with loss aversion, can explain why retirement savings products with certain guarantees are very popular, even though they are not optimal from a rational point of view (e.g., Døskeland & Nordahl (2008)).

[5]In contrast to CPT, MCPT can explain the demand for products with cliquet or ratch-up guarantees (Ruß & Schelling (2018)), the demand for so-called life-cycle funds which decrease their risk exposure over time (Graf *et al.* (2019)), and the demand for traditional participating life insurance products which make use of collective return smoothing elements (Ruß & Schelling (2020)).

These applications illustrate how products that constitute a suitable compromise between objective utility and subjective attractiveness can be identified or designed. We perform a detailed analysis for various parametrizations of the underlying preference formulations, e.g., with respect to the individual's risk aversion and loss aversion. The results in the first setting (EUT/CPT) show that loss aversion has a significant influence on the "favorable" compromise. For medium loss aversion the favorable product combines features of the optimal EUT and the preferable CPT product, which are low terminal guarantees and high stock ratios. For no or low loss aversion a pure stock investment, which is also the optimal EUT product, is favorable in most cases, while for a high loss aversion the favorable product is more similar to the preferable CPT product, which is a product with a terminal guarantee. In the second setting (EUT/MCPT), we find, similarly to the first setting, that for medium and no loss aversion the favorable product combines features of the optimal EUT and the preferable MCPT product, which are low annual guarantees and high stock ratios. For high loss aversion, the favorable compromise is very similar to the preferable MCPT product.

Overall, the results show in various settings that the proposed approach identifies suitable compromises which create a high (albeit not the maximum possible) objective utility while being subjectively appealing. However, in some cases (particularly for high loss aversion), the compromise has an objective utility which is far from the maximum. Therefore, our findings have two implications. Firstly, the focus on reducing loss aversion by information, framing, etc. is important. Secondly, products should be created in such a way that they represent an acceptable compromise. We are convinced that this approach can contribute to the design of retirement savings products which lead to better consumer decisions with respect to their old-age provision.

The remainder of this paper is organized as follows. In Section 2, we motivate and discuss important aspects of a simultaneous evaluation of different preference formulations. Further, we present our simultaneous evaluation approach. In Section 3, we state the considered preference formulations as well as the capital market and the underlying products. In Section 4, we illustrate the two applications and discuss the main findings. In Section 5, we present sensitivity analyses for both applications. Section 6 summarizes and gives an outlook for future research.

2 Model Formulation

2.1 Motivation

Standard economic models of rational decision making provide information on how people should decide.[6] They are based on normative statements (which is why they are often referred to as normative models) and can be applied to a broad field of applications. While standard economic models can explain a wide selection of phenomena, cf., e.g., Arrow (1951) and Hens & Rieger (2016), they also face challenges in explaining individuals' decision making, cf., e.g., Allais (1953) and Tversky & Kahneman (1981). Discrepancies between optimal decisions and observed behavior indicate boundaries of the predictive and explanatory power of standard economic models. Unfortunately, due to the complexity of human decision making, there is not a single coherent alternative model which can generally describe actual decision making precisely. The field of behavioral economics suggests various approaches which are based on many different hypothesis (which are sometimes even contradictory), cf., Tversky & Kahneman (1992) or Shefrin & Statman (2000). The resulting descriptive models must therefore be applied and tested with great care to specific applications.[7] However, if applied carefully, descriptive models can provide us with more accurate information on human decision making. Consequently, these models can be used to better predict and explain actual behavior. In a nutshell, standard economic models tell us which choices (e.g., retirement savings products) should objectively be chosen in order to meet specific needs (e.g., ensure a desired standard of living in old-age), while descriptive models tell us which choices are subjectively attractive at

[6]We use the notion "standard economic models of rational decision making" to refer to models which are based on the rationality assumptions in the neoclassical sense. In these models preferences are often described by their (expected) utility as an ordinal number. Hence, in the remainder of this work, we will often use the term "utility" when we speak about preference relations. However, our approach is not restricted to preference formulations in terms of utility.

[7]Besides the models already mentioned, there are numerous others, e.g., the Regret Theory (Loomes & Sugden (1987)), the Generalized Expected Utility Theory (Machina (1982)), the Rank-Dependent Expected Utility Theory (Quiggin (1982)), or the Realization Utility Model (Shefrin & Statman (1985) and Barberis & Xiong (2012)), to name just a few.

the time of decision making and therefore will be chosen (and possibly regretted later because they were not a good objective choice).

Although to the best of our knowledge this has not been considered in the existing literature, it seems natural to combine these insights in order to identify and develop choices which create a high (albeit not the maximum possible) objective utility while at the same time being subjectively of high (albeit not maximum possible) attractiveness at the time of decision making.

2.2 The Simultaneous Evaluation Approach

For the sake of simplicity, we assume a set $\mathcal{C}$ of $n \in \mathbb{N}$ different choices (e.g., products) c_i for $i = 1, \ldots, n$.[8] Let P_1 and P_2 denote two preference formulations. In the remainder of this paper we consider the case that P_1 specifies a normative model and P_2 a descriptive model.[9] Further, we assume that under both preference formulations we can derive unique finite real valued certainty equivalent values (e.g., a fixed amount, a fixed annual return, etc.) for all $c_i \in \mathcal{C}$. We denote the certainty equivalent values of c_i by $r_i^{P_l}$ for $l = 1, 2$. We say that choice c_i *dominates* c_j if $r_i^{P_1} \geq r_j^{P_1}$ and $r_i^{P_2} \geq r_j^{P_2}$ with at least one of the relations being strict.

Further, we denote the *combined preference function* for the simultaneous evaluation by $K : D_{P_1} \times D_{P_2} \to I$, where D_{P_1}, D_{P_2} and I are intervals in $\mathbb{R}$. We then use the notation $K(c_i) := K(r_i^{P_1}, r_i^{P_2})$ for the *K-value of choice* c_i. We say that c_i is *strictly preferred* over c_j (denoted as $c_i \succ c_j$) if $K(c_i) > K(c_j)$ and call the relation as *indifferent* if $K(c_i) = K(c_j)$ (denoted as $c_i \sim c_j$). Before we discuss a possible explicit formulation for K, we introduce some desirable properties:

1. *Completeness*, i.e., for all $c_i, c_j \in \mathcal{C}$ we have either $c_i \succ c_j$, $c_i \sim c_j$, or $c_j \succ c_i$.

2. *Transitivity*, i.e., for all $c_i, c_j, c_k \in \mathcal{C}$ it holds that if $K(c_i) \geq K(c_j)$ and $K(c_j) \geq K(c_k)$

[8] Note that under some additional assumptions the approach can also be extended to a setting with infinitely many choices.

[9] Note that our approach is not restricted to this consideration. Moreover, also normative models could be used as descriptive models. For example, one could specify both P_1 and P_2, under EUT, but with different specifications or subjective beliefs (which is often referred to as Subjective Expected Utility Theory, cf., Savage (1954)).

then $K(c_i) \geq K(c_k)$.

The properties 1) and 2) ensure that the relation $\succ$ defines a *preference order*.

3. K prevails *preference dominance*, i.e., for all $c_i, c_j \in \mathcal{C}$ it holds that if c_i dominates c_j then $K(c_i) > K(c_j)$, and if $r_i^{P_1} = r_j^{P_1}$ and $r_i^{P_2} = r_j^{P_2}$ then $K(c_i) = K(c_j)$. Note that this property also includes monotonicity. Consequently, the preference function K suggests only choices which lay on the "efficient frontier", i.e., a choice that is dominated by some other choice can never be the overall favorable choice.

4. *Convexity*, i.e., the resulting indifference curves are (strictly) convex. Strictly convex preferences ensure that choices with medium certainty equivalent values under P_1 and P_2 are preferred over choices with a very high value in one component and a very low value in the other.

5. *Independence of other choices*, i.e., the relation between c_i and c_j will not change if other choices are added to or removed from the set of choices $\mathcal{C}$.[10]

A natural starting point for the choice of the combined preference function K could be the weighted average or a simple transformation of it. However, it can easily be shown, that this - as well as other "simple" functions - would violate some of the stated properties. In what follows we show the combined preference function used in the remainder of this paper which fulfills all five properties defined above. While we consider the suggested formulation of K appropriate for the applications, we do not claim that it is the only suitable or the best (in whatever sense) formulation.

[10]Formally, this means for all sets of choices $\mathcal{A}$ and $\mathcal{B}$ with $c_i, c_j \in \mathcal{A} \cap \mathcal{B}$ it holds that if $K^{\mathcal{A}}(c_i) \square K^{\mathcal{A}}(c_j)$ then $K^{\mathcal{B}}(c_i) \square K^{\mathcal{B}}(c_j)$ with $\square \in \{>, =\}$. We say that the preference function K specifies preferences which are independent of other choices if this is true for all possible pairs c_i and c_j. The effect that the inclusion of a dominated choice affects the preference order of the remaining choices is documented in the literature as "attraction effect", "decoy effect" or "menu effect", cf., e.g., Huber *et al.* (1982). Note that, while the order of two choices under standard models of rational choice cannot be influenced by the set of choices, this may be different for specific descriptive models, e.g., Prospect Theory (if the reference point or the probability distortion depends on the set of choices), cf., e.g., Guevara & Fukushi (2016) for an overview and other examples. Under such a descriptive model, property 5 will be violated (independent of the choice of K).

We define K as

$$K(c_i) := \begin{cases} (1-\omega)\left(r_i^{P_1} - b\right)^{\beta} + \omega\left(r_i^{P_2} - b\right)^{\beta}, & \min\left(r_i^{P_1}, r_i^{P_2}\right) \geq b \\ -\infty, & \text{else} \end{cases}$$

with preference weight $\omega \in [0,1]$ and with $b \in \mathbb{R}$.[11] Note that introducing b can be interpreted as an additional constraint which defines the minimal acceptable certainty equivalent value.[12] If not stated otherwise, in the remainder we set $b = 0$ and $\omega = 0.5$ which in many applications represents natural choices. Further, $\beta \in (0,1)$ determines the degree of convexity of the indifference curves[13] and we focus on the case $\beta = 0.5$. It is straightforward to show that for a constant b the properties 1 - 5 hold for all c_i with $K(c_i) > -\infty$.

3 Applications for Retirement Savings Products

In this section, we apply our approach to retirement savings products. For the sake of comparability we use the same model framework and products as in Ebert *et al.* (2012) and Ruß & Schelling (2018).[14] We consider a five-year time horizon and products without guarantees, with simple guarantees and with complex guarantees. In the first application, we use CPT as the subjective preference function while in the second application MCPT is used.[15]

3.1 Preference Formulations

In this section, we briefly introduce and discuss the considered normative and descriptive models.[16] In all considered models we can derive certainty equivalent returns (CE values) which describe the fixed annual return that an investor would regard equally desirable as the consid-

[11]Note that in this definition of K, the certainty equivalent values of both preference formulation should represent the same figure, e.g., fixed annual returns.

[12]Note that if b depends on the set of choices (e.g., max or min) property 5 could be violated. This can be seen with similar arguments as used to show that, e.g., descriptive models with a choice-depended reference point (to which gains and losses are evaluated) can explain the attraction effect, cf., e.g., Simonson & Tversky (1992).

[13]The lower β, the stronger the emphasis on a well balanced compromise.

[14]If not stated otherwise, we follow Ebert *et al.* (2012) and Ruß & Schelling (2018) in this section.

[15]Note that the applications are presented in a rather simple model framework and therefore their aim is not to give actual advise for specific products but rather to illustrate the approach.

[16]A more detailed description is given in Appendix A.

ered contract, cf., Appendix A.[17]

We use EUT with power utility function $u(x) = x^\gamma$ as a normative model which implies constant relative risk aversion (CRRA) for a risk aversion parameter $\gamma \in (0, 1)$. The evaluation under CPT, the first considered descriptive model, is based on two main components: Firstly, an S-shaped value function, which allows to distinguish between gains and losses with respect to a certain reference point (which in our case is set to the initial premium paid). The risk attitude is controlled by the parameter a and the loss aversion by the parameter λ. Secondly, a probability distortion function with distortion parameter ζ which particularly takes into account that small probabilities are overweighted in decision making.

Although CPT can explain human behavior that cannot be explained by EUT in many circumstances, it frequently fails to explain observed behavior of long-term investors. In particular, there are many very popular long-term investment products which neither an EUT-investor nor a CPT-investor would buy (cf., Ebert *et al.* (2012), Ruß & Schelling (2018) or Graf *et al.* (2019)). Ruß & Schelling (2018) show that the demand for these products can be explained by taking into account potential interim value changes. To capture this effect, they have introduced MCPT which essentially uses CPT with multiple reference points and evaluation periods and assumes that potential future value fluctuations affect a product's subjective attractiveness already at the time of decision making. Since the difference between CPT and MCPT becomes larger for an increasing investment horizon, MCPT is particularly useful to explain and predict actual behavior for multi-period investment decisions. We therefore use MCPT as our second descriptive model.

3.2 Financial Market and Considered Products

In both applications, we assume a Black & Scholes (1973) financial market model with a risky asset S following a geometric Brownian motion with drift $\mu > r \geq 0$ and volatility $\sigma > 0$, where r denotes the constant interest rate. The portfolio value process V invests the fraction $\theta \in [0, 1]$

[17] Note that the following results would be very similar for nominal certainty equivalent values.

in the risky asset S, and the fraction $1-\theta$ in the risk free asset B with fixed annual return r. We assume continuous rebalancing.[18] The portfolio value process is the basis for all considered products. For all products, we assume a fixed maturity date T and a single premium of 1 paid at the beginning of the contract. The product that invests in the underlying V without guarantee is referred to as *constant mix (cm)* product. For the guaranteed contracts, the investment premium α describes the fraction of the premium that is allocated to the investment V, while the remaining part $1-\alpha$ is used to finance the guarantee, where the guarantee rate is denoted by g. We will only consider fair contracts with an identical initial arbitrage free price of 1.[19]

We consider three different types of guarantees, where one has a terminal guarantee and two have annual guarantee features. The payoff at maturity T of a product with a (terminal) roll-up guarantee feature is given by

$$A_T^{rol} := \max\left(e^{gT}, \alpha V_T\right) = \alpha V_T + \left[e^{gT} - \alpha V_T\right]^+ .$$

The roll-up is a frequently offered guarantee feature, e.g., in the context of variable annuities (cf., e.g., Bauer *et al.* (2008)).

Further, we consider products with annual guarantee features which aim to protect interim gains. The so-called *ratch-up* guarantee feature is defined by the following payoff:

$$A_T^{rat} := \max\left(e^{gT}, \alpha V_1, \ldots, \alpha V_T\right)$$

This product essentially pays the highest portfolio value at any annual lock-in date or a roll-up with rate g, whichever is higher.

[18]For details on the financial market model we refer to Ruß & Schelling (2018).

[19]To be in line with Ebert *et al.* (2012) and Ruß & Schelling (2018) we only consider products with $\alpha \geq 0.6$ and use closed form solutions to calculate the fair annual guaranteed rate g for a given α. For more details and closed form solutions for the arbitrage free prices of the different products we refer to Ruß & Schelling (2018).

Moreover, we define the *cliquet* guarantee feature by the payoff:

$$A_T^{cli} := \alpha \prod_{i=1}^{T} \max\left(e^g, \frac{V_i}{V_{i-1}}\right).$$

In each period, this product earns the greater of the guaranteed rate and the performance of the underlying portfolio.

4 Numerical Analysis

4.1 General setting

For the sake of comparability with Ebert *et al.* (2012) and Ruß & Schelling (2018), we consider a five-year investment horizon ($T = 5$) and the following financial parameters unless stated otherwise: $\mu = 0.06$, $\sigma = 0.3$, $r = 0.03$.[20] In all subsequent figures and tables, a product without guarantee is denoted by $\circ$, a roll-up product is denoted by $+$, a ratch-up product is denoted by $\Diamond$ and a cliquet product is denoted by $*$. We investigate 41 stock ratios θ between 0% and 100% in steps of 2.5%. For products with a guarantee, we consider for each $\theta > 0$ eight levels of α between 0.6 and 0.95 in steps of 0.05. Thus, we investigate 41 different products without guarantee and $40 \cdot 8 = 320$ different products for each guarantee type.[21] All results are based on Monte-Carlo simulations with sample size of 20,000.

4.2 Results Application 1

In the first application, we use CPT and EUT. Our results when separately considering CPT or EUT are in line with the results of Ebert *et al.* (2012) and show that for a CRRA EUT investor with reasonable risk aversion parameter, guaranteed contracts are never optimal.[22] In contrast, a loss averse CPT investor prefers a product with a positive terminal guarantee and a high stock

[20] Detailed descriptions of the product characteristics (guaranteed rates, distribution of terminal values, distribution of annual value changes etc.) can be found in Ebert *et al.* (2012) and Ruß & Schelling (2018).

[21] Note that ratch-up features are not possible for all combinations of θ and α, cf., Ruß & Schelling (2018) for more details.

[22] This is also consistent to the fact that for a CRRA EUT investor, a Merton strategy is optimal (cf., also Merton (1971) or Tepla (2001))

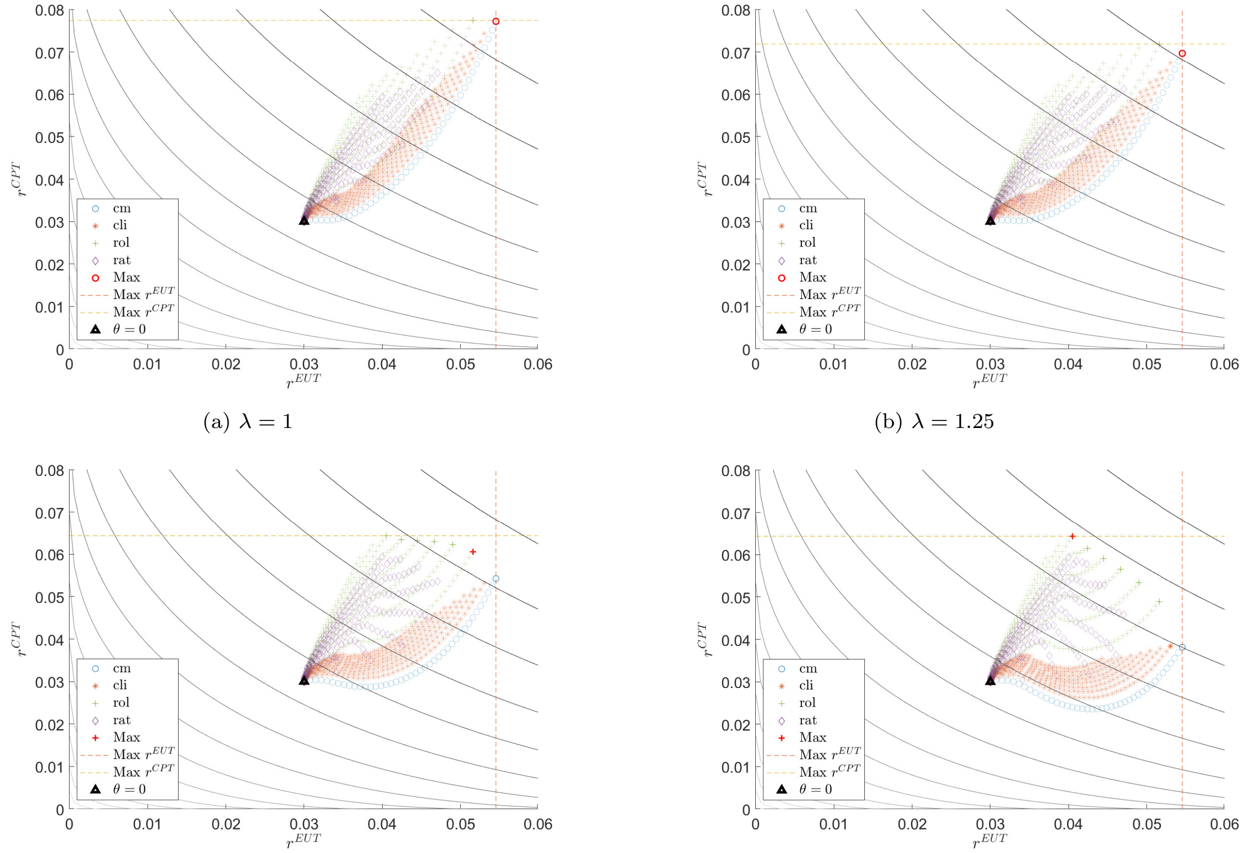
ratio. However, a high stock ratio is only preferred if the guarantee is positive. If the CPT investor is not loss averse, a product with 100% stock ratio and low or no guarantee is preferred.

Based on these results we now investigate favorable compromises under the simultaneous evaluation approach. First, we assume that the risk aversion under EUT coincides with the risk attitude under CPT, i.e., $\gamma = a$, and we fix it at 0.88, as suggested by Tversky & Kahneman (1992).

Figure 1 shows the CPT and EUT CE values of the products for different levels of loss aversion λ. In this figure, we observe that CE values of the products follow certain lines, where one line of symbols represents one level of α and all lines start at the same point (black triangle), where $\theta = 0$ and $r^{EUT} = r^{CPT} = 3\%$. Symbols at the outer end of each line have a higher stock ratio. Moreover, the vertical (horizontal) dotted line shows the highest possible CE under EUT (CPT). The favorable compromise based on the combined preference function K is indicated by a red symbol. Further, the black lines are indifference curves under the K-measure. We observe that for increasing loss aversion the subjective attractiveness of products with low or without guarantees decreases while the subjective attractiveness of products with a positive guarantee remains unchanged. Hence, the favorable compromise also changes with increasing loss aversion.

In case of no or low loss aversion ($\lambda = 1$ or 1.25), the optimal product under EUT (pure stock investment) and the preferred product under CPT (roll-up with a stock ratio of 100% and only a very weak guaranteed benefit of 0.62) are very similar (and hence differ only marginally in their CE values). As a consequence, also the favorable compromise is a pure stock investment.

For a higher loss aversion ($\lambda = 1.75$), the favorable compromise still comes with a stock ratio of 100% but now includes a roll-up with a guaranteed benefit of 0.62. Hence it combines features of the optimal EUT product (100% stock ratio) and the preferable CPT product (guaranteed roll-up benefit albeit lower than for the preferable CPT product). This already illustrates the benefit of the approach. We find that the objectively optimal product (pure stock investment)



(a) $\lambda = 1$

(b) $\lambda = 1.25$

(c) $\lambda = 1.75$

(d) $\lambda = 2.25$

Figure 1: The certainty equivalent values of CPT and EUT for different levels of loss aversion. The diamond ($\Diamond$) corresponds to ratch-up, the star ($*$) to cliquet, the plus ($+$) to roll-up and the circle ($\circ$) to constant mix products, where the symbols are bold if the corresponding product lies on the efficient frontier. The red symbol denotes the favorable compromise based on the function K. The dashed vertical line represents the highest EUT CE, while the dashed horizontal line represents the highest CPT CE.

is significantly less attractive than the preferred product (with a CPT CE of 5.42% instead of 6.43%). Consequently, a consumer would very likely avoid this product (even if it is recommended by an advisor). On the other hand, the preferred product under CPT reduces the expected utility heavily compared to the optimal product (EUT CE of 4.05% instead of 5.46%). The favorable compromise product, however, is subjectively more attractive than the EUT-optimal product (CPT CE of 6.06% as opposed to 5.42%) while providing a significantly higher expected utility than the preferred product under CPT (EUT CE of 5.16% as opposed to 4.05%). Hence, promoting this product could help consumers to make an objectively better (although not optimal) choice.

	EUT optimal	favorable compromise / preferable CPT					
$a = \gamma$		λ	1	1.25	1.75	2.25	2.75
0.6	∘(100, 82.5, −, 4.25, [2.45, −0.06])	K	+(65, 100, 1.04, 3.61, 4.34)	+(65, 100, 1.04, 3.61, 4.34)	+(65, 100, 1.04, 3.61, 4.34)	+(65, 100, 1.04, 3.61, 4.34)	+(65, 100, 1.04, 3.61, 4.34)
		CPT	+(60, 100, 1.07, 3.51, 4.44)	+(60, 100, 1.07, 3.51, 4.44)	+(60, 100, 1.07, 3.51, 4.44)	+(60, 100, 1.07, 3.51, 4.44)	+(60, 100, 1.07, 3.51, 4.44)
0.65	∘(100, 95, −, 4.43, [3.47, −0.07])	K	+(65, 100, 1.04, 3.65, 4.64)	+(65, 100, 1.04, 3.65, 4.64)	+(65, 100, 1.04, 3.65, 4.64)	+(65, 100, 1.04, 3.65, 4.64)	+(65, 100, 1.04, 3.65, 4.64)
		CPT	+(60, 100, 1.07, 3.54, 4.67)	+(60, 100, 1.07, 3.54, 4.67)	+(60, 100, 1.07, 3.54, 4.67)	+(60, 100, 1.07, 3.54, 4.67)	+(60, 100, 1.07, 3.54, 4.67)
0.7	∘(100, 100, −, 4.65, [4.51, −0.03])	K	∘(100, 100, −, 4.65, 4.51)	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)
		CPT	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)	+(65, 100, 1.04, 3.7, 4.96)
0.75	∘(100, 100, −, 4.88, [5.41, 0.09])	K	∘(100, 100, −, 4.88, 5.41)	+(95, 100, 0.62, 4.69, 4.81)	+(70, 100, 1.01, 3.88, 5.22)	+(70, 100, 1.01, 3.88, 5.22)	+(70, 100, 1.01, 3.88, 5.22)
		CPT	+(95, 100, 0.62, 4.69, 5.49)	+(65, 100, 1.04, 3.74, 5.3)	+(65, 100, 1.04, 3.74, 5.3)	+(65, 100, 1.04, 3.74, 5.3)	+(65, 100, 1.04, 3.74, 5.3)
0.8	∘(100, 100, −, 5.1, [6.31, 0.66])	K	∘(100, 100, −, 5.1, 6.31)	+(95, 100, 0.62, 4.87, 5.74)	+(70, 100, 1.01, 3.95, 5.68)	+(70, 100, 1.01, 3.95, 5.68)	+(70, 100, 1.01, 3.95, 5.68)
		CPT	+(95, 100, 0.62, 4.87, 6.37)	+(95, 100, 0.62, 4.87, 5.74)	+(70, 100, 1.01, 3.95, 5.68)	+(70, 100, 1.01, 3.95, 5.68)	+(70, 100, 1.01, 3.95, 5.68)
0.85	∘(100, 100, −, 5.33, [7.19, 1.54])	K	∘(100, 100, −, 5.33, 7.19)	∘(100, 100, −, 5.33, 6.41)	+(95, 100, 0.62, 5.05, 5.46)	+(70, 100, 1.01, 4.01, 6.15)	+(70, 100, 1.01, 4.01, 6.15)
		CPT	+(95, 100, 0.62, 5.05, 7.24)	+(95, 100, 0.62, 5.05, 6.65)	+(70, 100, 1.01, 4.01, 6.15)	+(70, 100, 1.01, 4.01, 6.15)	+(70, 100, 1.01, 4.01, 6.15)
0.88	∘(100, 100, −, 5.46, [7.72, 2.17])	K	∘(100, 100, −, 5.46, 7.72)	∘(100, 100, −, 5.46, 6.97)	+(95, 100, 0.62, 5.16, 6.06)	+(70, 100, 1.01, 4.05, 6.43)	+(70, 100, 1.01, 4.05, 6.43)
		CPT	+(95, 100, 0.62, 5.16, 7.74)	+(95, 100, 0.62, 5.16, 7.19)	+(70, 100, 1.01, 4.05, 6.43)	+(70, 100, 1.01, 4.05, 6.43)	+(70, 100, 1.01, 4.05, 6.43)
0.9	∘(100, 100, −, 5.55, [8.06, 2.62])	K	∘(100, 100, −, 5.55, 8.06)	∘(100, 100, −, 5.55, 7.34)	+(95, 100, 0.62, 5.23, 6.45)	+(85, 100, 0.84, 4.72, 6.03)	+(70, 100, 1.01, 4.08, 6.62)
		CPT	+(95, 100, 0.62, 5.23, 8.07)	+(95, 100, 0.62, 5.23, 7.54)	+(85, 100, 0.84, 4.72, 6.64)	+(70, 100, 1.01, 4.08, 6.62)	+(70, 100, 1.01, 4.08, 6.62)
0.95	∘(100, 100, −, 5.78, [8.9, 3.79])	K	∘(100, 100, −, 5.78, 8.9)	∘(100, 100, −, 5.78, 8.23)	+(95, 100, 0.62, 5.42, 7.41)	+(90, 100, 0.75, 5.12, 6.74)	+(80, 100, 0.91, 4.59, 6.69)
		CPT	∘(100, 100, −, 5.78, 8.9)	+(95, 100, 0.62, 5.42, 8.4)	+(90, 100, 0.75, 5.12, 7.49)	+(75, 100, 0.96, 4.36, 7.09)	+(70, 100, 1.01, 4.14, 7.08)
1	∘(100, 100, −, 6, [9.71, 5])	K	∘(100, 100, −, 6, 9.71)	∘(100, 100, −, 6, 9.1)	+(95, 100, 0.62, 5.6, 8.33)	+(95, 100, 0.62, 5.6, 7.41)	+(90, 100, 0.75, 5.27, 6.99)
		CPT	∘(100, 100, −, 6, 9.71)	+(95, 100, 0.62, 5.6, 9.21)	+(90, 100, 0.75, 5.27, 8.35)	+(85, 100, 0.84, 4.97, 7.78)	+(75, 100, 0.96, 4.44, 7.6)

Table 1: The favorable compromise based on the combined preference function K for different combination of risk aversion, risk attitude and loss aversion. The investment premium, the stock ratio, the guaranteed terminal value, the EUT CE and the CPT CE are given in the parenthesis, i.e., (α in %, θ in %, $\exp(gT)$, EUT CE in %, CPT CE in %). For the optimal EUT product the CPT CE is given as a range due to different loss aversions. The plus (+) corresponds to roll-up and the circle (∘) to constant mix products. In the blue area the favorable compromise is a pure stock investment. In the red area the favorable compromise is a roll-up with 100% stock ratio and terminal guarantee of 1.04.

If loss aversion is even higher ($\lambda = 2.25$), the subjective attractiveness under CPT of most products with low or without guarantees, including the EUT optimal product, is reduced heavily. As a consequence the preferred product under CPT coincides with the favorable compromise in this setting. This is a roll-up product with a stock ratio of 100% and and a guaranteed benefit above the reference point for loss aversion. The EUT CE of this product is 4.05% and the CPT CE is 6.43%.[23] This result suggests that a promotion of objectively better products alone might not be sufficient if consumer's subjective evaluations are heavily dominated by a rather high degree of loss aversion. However, in view of the results for slightly lower loss aversion, it seems promising to take measures to help consumers reduce their loss aversion at least to some degree and combine these measures with product offerings that constitute a suitable compromise for consumers with a slightly lower degree of loss aversion.[24]

Next, we analyze the favorable compromise for different values of risk aversion (where we adjust the risk attitude under CPT accordingly) and loss aversion. Table 1 summarizes the optimal products under EUT, the preferred product under CPT and the favorable compromise for different combinations of $a = \gamma$ and λ.

It is worth noting that all products in the table come with a stock ratio of 100%. For no or low loss aversion ($\lambda = 1$ or 1.25) and up to a certain degree of risk aversion (blue cells in Table 1) the favorable compromise is a pure stock investment, which is also the optimal EUT product. However, in these cases this product is rather similar to the preferred product under CPT (for no loss aversion and very low risk aversion it is even the preferable CPT product) as losses are not or only slightly penalized.

For a high risk aversion and independent of loss aversion (red cells in Table 1) the favorable compromise is a product with a stock ratio of 100% and a terminal guarantee of 1.04, which is very similar to the preferable CPT products. Due to the high risk aversion, product modifica-

[23]Since the guaranteed benefit of this product is greater than 1, no losses can occur and hence loss aversion has no impact on this product's CE value.

[24]For example, an appropriate use of Framing could be implemented, cf., Tversky & Kahneman (1981).

tions that lead to an increase of EUT CE reduce the CPT CE to a much larger extend and are therefore not favorable under the K-measure.

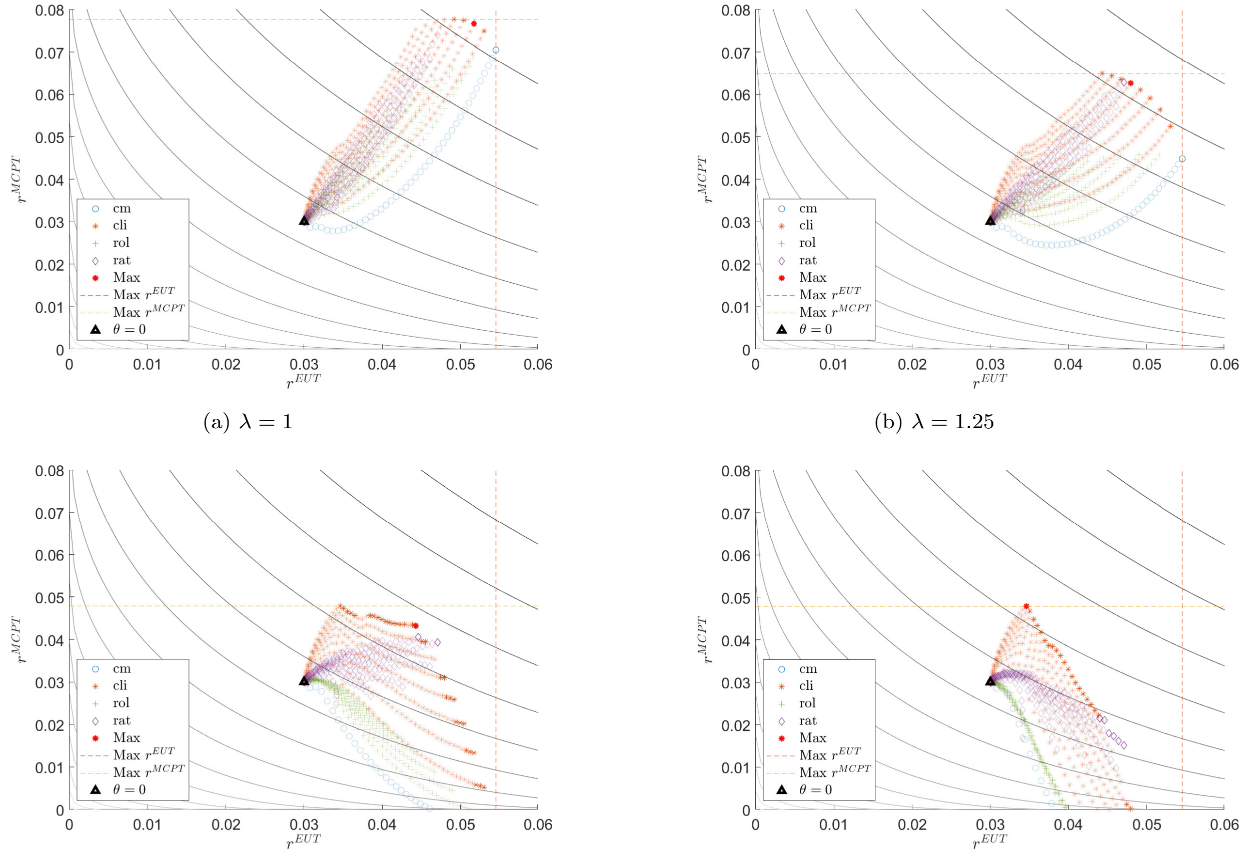
If loss aversion becomes more dominant ($\lambda \geq 1.75$), the favorable compromise is always a product with a simple roll-up guarantee. However, if risk aversion increases, the guaranteed benefit significantly increases from 0.62 to 1.04.[25] However, the favorable compromise mostly has a lower guaranteed benefit than the CPT preferable product. Further, for very high loss aversion and medium risk aversion the favorable compromise is equal to the preferable product under CPT. However, for high or low risk aversion the favorable compromise differs slightly from the preferred CPT product. For lower risk aversion, products with a more volatile return have a higher EUT CE and thus offer a better compromise. On the other hand, for higher risk aversion, products with a higher guarantee have a higher CPT CE and thus are the preferred product under CPT. However, the EUT CE of these products are low and consequently not the favorable compromise.

4.3 Results Application 2

In the second application, we consider the same contracts but apply MCPT instead of CPT. When applying MCPT standalone, more complex guaranteed products, in particular certain cliquet products, are preferred over the other contracts (roll-up and constant mix) in all considered cases, which is in line with the findings in Ruß & Schelling (2018).

Again, we investigate at first which product constitutes the most favorable compromise in the base case with $a = \gamma = 0.88$ and λ between 1 and 2.25. Figure 2 shows the MCPT and EUT CE values of the products under consideration for different levels of loss aversion similar to Figure 1. For $\lambda = 1$ we find that the MCPT CE is mostly increasing in θ (similar to the EUT CE). However, if loss aversion is higher, products which allow for interim losses, due to higher stock ratios or no or weak guarantees, become less attractive under MCPT.

[25] This is due to the combination of high loss aversion and the overweighting of the probability of large gains.



(a) $\lambda = 1$ (b) $\lambda = 1.25$

(c) $\lambda = 1.75$ (d) $\lambda = 2.25$

Figure 2: The certainty equivalent values of MCPT and EUT for different levels of loss aversion. The diamond ($\Diamond$) corresponds to ratch-up, the star ($*$) to cliquet, the plus ($+$) to roll-up and the circle ($\circ$) to constant mix products, where the symbols are bold if the corresponding product lies on the efficient frontier. The red symbol denotes the favorable compromise based on the function K. The dashed vertical line represents the highest EUT CE, while the dashed horizontal line represents the highest MCPT CE.

Without loss aversion, a cliquet product is favorable (stock ratio of 100%, guaranteed rate of -29.15%, i.e., only protecting against very severe annual losses). The stock ratio is the same as for the EUT optimal and MCPT preferable product. However, the guarantee of the favorable compromise is lower than for the MCPT preferable product (-19.58%, i.e., also only protecting against severe annual losses). Compared to the EUT optimal product the EUT CE is slightly lower (5.17% instead of 5.46%) whereas the MCPT CE is higher by about twice the difference (7.66% instead of 7.05%). On the other hand, the EUT CE is 0.25% higher than for the preferable MCPT product while the MCPT CE is only 0.1% lower.

If loss aversion is higher (1.25 or 1.75), the favorable compromise remains a cliquet product with $\theta = 100$, but the guaranteed rate increases to -16.4% or -9.4%, respectively. The MCPT-CE values of the favorable products exceed the MCPT-CE values of the EUT optimal product by a large amount of 1.78% respectively 4.66% while the EUT CE is reduced only by a moderate 0.66% respectively 1.03%. On the other hand, when the compromise-products are compared to the MCPT-preferred products, MCPT CE's are only reduced by 0.23% respectively 0.47% whereas EUT CE increases by 0.37% respectively 0.97%. In a nutshell, the favorable compromise has a significantly higher EUT CE than the subjectively most attractive product, but remains attractive for MCPT-investors.

For a high loss aversion of 2.25, the favorable compromise coincides with the MCPT preferable product and hence is not a compromise in a strict sense. It is a cliquet product with a positive guarantee (0.14%) and a stock ratio of 50% and comes with an EUT CE of 3.46% and an MCPT CE of 4.79%.

In this application, we again observe the advantages (and limitations) of the approach. The advantages can be seen particularly in the case $\lambda = 1.75$, where the favorable compromise combining a stock ratio of 100% (as for the optimal EUT product) and a guarantee (as for the preferable MCPT product) is almost as attractive as the most attractive product, but provides a significantly higher EUT CE. However, it is evident also in this application that a heavy loss aversion can cause the favorable compromise to be the most attractive product under MCPT. This shows the limitations of the approach and strengthens the suggestion, that it should be used in combination with approaches that help consumers overcome their loss aversion at least to a small extent (as already small reductions in loss aversion can lead to a favorable compromise with a significantly higher EUT CE, cf., e.g., Figure 2 (c) and 2 (d)).

	EUT optimal	favorable compromise / preferable MCPT					
$a = \gamma$		λ	1	1.25	1.75	2.25	2.75
0.6	∘(100, 82.5, −, 4.25, [1.47, −1.71])	K	∗(60, 40, 1.43, 3.26, 3.65)	∗(60, 40, 1.43, 3.26, 3.65)	∗(60, 40, 1.43, 3.26, 3.65)	∗(60, 40, 1.43, 3.26, 3.65)	∗(60, 40, 1.43, 3.26, 3.65)
		MCPT	∗(60, 37.5, 1.7, 3.22, 3.67)	∗(60, 37.5, 1.7, 3.22, 3.67)	∗(60, 37.5, 1.7, 3.22, 3.67)	∗(60, 37.5, 1.7, 3.22, 3.67)	∗(60, 37.5, 1.7, 3.22, 3.67)
0.65	∘(100, 95, −, 4.43, [2.29, −2.61])	K	◊(75, 100, −5.54, 4.08, 3.19)	∗(60, 42.5, 1.14, 3.3, 3.75)	∗(60, 42.5, 1.14, 3.3, 3.75)	∗(60, 42.5, 1.14, 3.3, 3.75)	∗(60, 42.5, 1.14, 3.3, 3.75)
		MCPT	∗(60, 40, 1.43, 3.26, 3.77)	∗(60, 40, 1.43, 3.26, 3.77)	∗(60, 40, 1.43, 3.26, 3.77)	∗(60, 40, 1.43, 3.26, 3.77)	∗(60, 40, 1.43, 3.26, 3.77)
0.7	∘(100, 100, −, 4.65, [3.26, −3.33])	K	◊(75, 100, −5.54, 4.21, 4.04)	∗(60, 45, 0.82, 3.34, 3.88)	∗(60, 45, 0.82, 3.34, 3.88)	∗(60, 45, 0.82, 3.34, 3.88)	∗(60, 45, 0.82, 3.34, 3.88)
		MCPT	◊(75, 100, −5.54, 4.21, 4.04)	∗(60, 42.5, 1.14, 3.3, 3.91)	∗(60, 42.5, 1.14, 3.3, 3.91)	∗(60, 42.5, 1.14, 3.3, 3.91)	∗(60, 42.5, 1.14, 3.3, 3.91)
0.75	∘(100, 100, −, 4.88, [4.23, −3.82])	K	∗(90, 100, −29.15, 4.71, 4.65)	◊(75, 100, −5.54, 4.35, 3.78)	∗(60, 47.5, 0.49, 3.39, 4.05)	∗(60, 47.5, 0.49, 3.39, 4.05)	∗(60, 47.5, 0.49, 3.39, 4.05)
		MCPT	◊(75, 100, −5.54, 4.35, 4.94)	∗(60, 45, 0.82, 3.35, 4.08)	∗(60, 45, 0.82, 3.35, 4.08)	∗(60, 45, 0.82, 3.35, 4.08)	∗(60, 45, 0.82, 3.35, 4.08)
0.8	∘(100, 100, −, 5.1, [5.28, −4.31])	K	∗(90, 100, −29.15, 4.88, 5.78)	◊(75, 100, −5.54, 4.48, 4.71)	∗(60, 50, 0.14, 3.44, 4.28)	∗(60, 50, 0.14, 3.44, 4.28)	∗(60, 50, 0.14, 3.44, 4.28)
		MCPT	∗(75, 100, −16.36, 4.59, 5.89)	◊(75, 100, −5.54, 4.48, 4.71)	∗(60, 47.5, 0.49, 3.4, 4.31)	∗(60, 47.5, 0.49, 3.4, 4.31)	∗(60, 47.5, 0.49, 3.4, 4.31)
0.85	∘(100, 100, −, 5.33, [6.37, −4.79])	K	∗(90, 100, −29.15, 5.06, 6.95)	◊(75, 100, −5.54, 4.62, 5.68)	∗(60, 50, 0.14, 3.45, 4.6)	∗(60, 50, 0.14, 3.45, 4.6)	∗(60, 50, 0.14, 3.45, 4.6)
		MCPT	∗(80, 100, −19.58, 4.83, 7.06)	∗(60, 100, −9.38, 4.37, 5.79)	∗(60, 50, 0.14, 3.45, 4.6)	∗(60, 50, 0.14, 3.45, 4.6)	∗(60, 50, 0.14, 3.45, 4.6)
0.88	∘(100, 100, −, 5.46, [7.05, −5.06])	K	∗(90, 100, −29.15, 5.17, 7.66)	∗(75, 100, −16.36, 4.8, 6.26)	∗(60, 100, −9.38, 4.43, 4.32)	∗(60, 50, 0.14, 3.46, 4.79)	∗(60, 50, 0.14, 3.46, 4.79)
		MCPT	∗(80, 100, −19.58, 4.92, 7.76)	∗(60, 100, −9.38, 4.43, 6.49)	∗(60, 50, 0.14, 3.46, 4.79)	∗(60, 50, 0.14, 3.46, 4.79)	∗(60, 50, 0.14, 3.46, 4.79)
0.9	∘(100, 100, −, 5.55, [7.5, −5.24])	K	∗(95, 100, −38.05, 5.39, 7.96)	∗(80, 100, −19.58, 4.98, 6.6)	∗(60, 100, −9.38, 4.47, 4.84)	∗(60, 50, 0.14, 3.46, 4.91)	∗(60, 50, 0.14, 3.46, 4.91)
		MCPT	∗(80, 100, −19.58, 4.98, 8.23)	∗(60, 100, −9.38, 4.47, 6.95)	∗(60, 50, 0.14, 3.46, 4.91)	∗(60, 50, 0.14, 3.46, 4.91)	∗(60, 50, 0.14, 3.46, 4.91)
0.95	∘(100, 100, −, 5.78, [8.64, −5.66])	K	∗(95, 100, −38.05, 5.59, 9.13)	∗(80, 100, −19.58, 5.12, 7.84)	∗(60, 100, −9.38, 4.56, 6.12)	∗(60, 72.5, −3.64, 3.95, 4.91)	∗(60, 52.5, −0.22, 3.52, 5.23)
		MCPT	∗(80, 100, −19.58, 5.12, 9.38)	∗(60, 100, −9.38, 4.56, 8.08)	∗(60, 100, −9.38, 4.56, 6.12)	∗(60, 52.5, −0.22, 3.52, 5.27)	∗(60, 52.5, −0.22, 3.52, 5.23)
1	∘(100, 100, −, 6, [9.76, −6.04])	K	∗(95, 100, −38.05, 5.79, 10.28)	∗(85, 100, −23.64, 5.44, 8.89)	∗(60, 100, −9.38, 4.66, 7.39)	∗(60, 100, −9.38, 4.66, 5.43)	∗(60, 57.5, −1, 3.64, 5.54)
		MCPT	∗(85, 100, −23.64, 5.44, 10.51)	∗(65, 100, −11.39, 4.81, 9.21)	∗(60, 100, −9.38, 4.66, 7.39)	∗(60, 70, −3.17, 3.93, 5.8)	∗(60, 52.5, −0.22, 3.54, 5.64)

Table 2: The favorable compromise based on the combined preference function K for different combination of risk aversion, risk attitude and loss aversion. The investment premium, the stock ratio, the guarantee, the EUT CE and the MCPT CE are given in the parenthesis, (α in %, θ in %, g in %, EUT CE in %, MCPT CE in %). For the optimal EUT product the MCPT CE is given as a range due to different loss aversions. The diamond ($\Diamond$) corresponds to ratch-up, the star ($*$) to cliquet and the circle ($\circ$) to constant mix products. In the green area the favorable compromise has a annual guarantee above 1%. In the red area the favorable compromise has a stock ratio of 100% and a low annual guarantee. In the blue area the favorable compromise is has a stock ratio of 50% and a annual guarantee slightly above 0.

Again, we analyze the favorable compromise for different values of risk aversion (and attitude) as well as loss aversion. Table 2 displays the optimal product under EUT, the preferred product under MCPT and the favorable compromise for different levels of risk aversion and attitude as well as loss aversion.

We observe that the favorable compromise is always a cliquet or ratch-up product, since these products protect annual gains, which is important under MCPT, cf., also Figure 2. When risk aversion or loss aversion (or both) are rather low (red cells in Table 2) the favorable compromise has a stock ratio of 100% (like the EUT optimal product) and a low annual guarantee (similar to the preferable MCPT product).

For a higher loss aversion and a medium risk aversion (blue cells in Table 2) the favorable compromise is a cliquet product with a guaranteed rate slightly above 0 and a stock ratio of 50%. If risk aversion becomes lower the guaranteed rate becomes negative and the stock ratio increases. This is mainly driven by the fact that also for the MCPT preferable product the guaranteed rate decreases and the stock ratio increases as the upside potential is valued higher. On the other hand, if risk aversion becomes higher, the stock ratio decreases and guarantees increase until for very high risk aversion (green cells in Table 2) the favorable compromise is a cliquet product with a guaranteed rate above 1% (1.43% and 1.14%) and a stock ratio of roughly 40%, independent of loss aversion. The compromise has a slightly higher EUT CE than the preferable MCPT product, since the guarantee is lower.

All in all, we observe similar patterns as in the case of CPT: The stock ratio (guarantee) of the favorable compromise is decreasing (increasing) for an increasing loss aversion or increasing risk aversion. Further, for a high loss aversion the compromise is very similar or equal to the preferable product of the subjective preference function (CPT/MCPT), because objectively more attractive products have no or only weak guarantees, which is heavily penalized by a high loss aversion.

5 Sensitivity Analysis

In this section, we present results of various sensitivity analyses.

5.1 Sensitivity Analysis of Application 1

We have analyzed the effect of different combinations of risk aversion (γ) and risk attitude (a) on the favorable compromise by varying a and γ independently. We have performed the analysis for different levels of loss aversion, however, in the remainder we focus on the case of $\lambda = 1.75$ where the results are most interesting. The results are shown in Table 3.

	favorable compromise / preferable CPT / EUT optimal				
a	γ	0.65	0.75	0.88	0.95
0.65	K	$+(65, 100, 1.04, 3.65, 4.64)$	$+(65, 100, 1.04, 3.74, 4.64)$	$+(65, 100, 1.04, 3.87, 4.64)$	$+(65, 100, 1.04, 3.95, 4.64)$
	CPT	$+(60, 100, 1.07, 3.54, 4.67)$	$+(60, 100, 1.07, 3.61, 4.67)$	$+(60, 100, 1.07, 3.71, 4.67)$	$+(60, 100, 1.07, 3.76, 4.67)$
	EUT	$\circ(100, 95, -, 4.43, 1.2)$	$\circ(100, 100, -, 4.88, 1.24)$	$\circ(100, 100, -, 5.46, 1.24)$	$\circ(100, 100, -, 5.78, 1.24)$
0.75	K	$+(70, 100, 1.01, 3.76, 5.22)$	$+(70, 100, 1.01, 3.88, 5.22)$	$+(70, 100, 1.01, 4.05, 5.22)$	$+(70, 100, 1.01, 4.14, 5.22)$
	CPT	$+(65, 100, 1.04, 3.65, 5.3)$	$+(65, 100, 1.04, 3.74, 5.3)$	$+(65, 100, 1.04, 3.87, 5.3)$	$+(65, 100, 1.04, 3.95, 5.3)$
	EUT	$\circ(100, 95, -, 4.43, 2.71)$	$\circ(100, 100, -, 4.88, 2.85)$	$\circ(100, 100, -, 5.46, 2.85)$	$\circ(100, 100, -, 5.78, 2.85)$
0.88	K	$+(90, 100, 0.75, 4.23, 6.23)$	$+(95, 100, 0.62, 4.69, 6.06)$	$+(95, 100, 0.62, 5.16, 6.06)$	$+(95, 100, 0.62, 5.42, 6.06)$
	CPT	$+(70, 100, 1.01, 3.76, 6.43)$	$+(70, 100, 1.01, 3.88, 6.43)$	$+(70, 100, 1.01, 4.05, 6.43)$	$+(70, 100, 1.01, 4.14, 6.43)$
	EUT	$\circ(100, 95, -, 4.43, 5.09)$	$\circ(100, 100, -, 4.88, 5.42)$	$\circ(100, 100, -, 5.46, 5.42)$	$\circ(100, 100, -, 5.78, 5.42)$
0.95	K	$+(95, 100, 0.62, 4.34, 7.41)$	$+(95, 100, 0.62, 4.69, 7.41)$	$+(95, 100, 0.62, 5.16, 7.41)$	$+(95, 100, 0.62, 5.42, 7.41)$
	CPT	$+(90, 100, 0.75, 4.23, 7.49)$	$+(90, 100, 0.75, 4.52, 7.49)$	$+(90, 100, 0.75, 4.9, 7.49)$	$+(90, 100, 0.75, 5.12, 7.49)$
	EUT	$\circ(100, 95, -, 4.43, 6.41)$	$\circ(100, 100, -, 4.88, 6.84)$	$\circ(100, 100, -, 5.46, 6.84)$	$\circ(100, 100, -, 5.78, 6.84)$

Table 3: The favorable compromise based on the combined preference function K for different combination of risk aversion and risk attitude and for $\lambda = 1.75$. The investment premium, the stock ratio, the terminal guarantee, the EUT CE and the CPT CE of the products are given in the parenthesis, i.e., (α in %, θ in %, $\exp(gT)$, EUT CE in %, CPT CE in %). The plus (+) corresponds to roll-up and the circle ($\circ$) to constant mix products.

As a consequence of the relative high loss aversion, roll-up products with a stock ratio of 100% constitute the favorable compromises. The terminal guarantee decreases from 1.04 to 0.62 if the risk attitude is decreasing.[26] In contrast, we observe that a change in risk aversion has almost no impact on the favorable compromise, since it influences the EUT CE of the considered products only slightly and hence K suggests the same compromise. While for a high risk

[26]One main reason is that the probability for large gains is overweighted in CPT and hence products with lower guaranteed benefit are more attractive if the risk attitude is decreasing (ceteris paribus).

attitude the favorable compromise is very close to the preferable CPT product, for a medium and low risk attitude, the compromises have CE values which are very close to the respective maxima.[27] Interestingly, for medium and low risk aversion ($\gamma \geq 0.75$) and rather low risk attitude ($a \geq 0.88$) the favorable compromise is always a product with a stock ratio of 100% and the lowest considered guarantee (0.62).

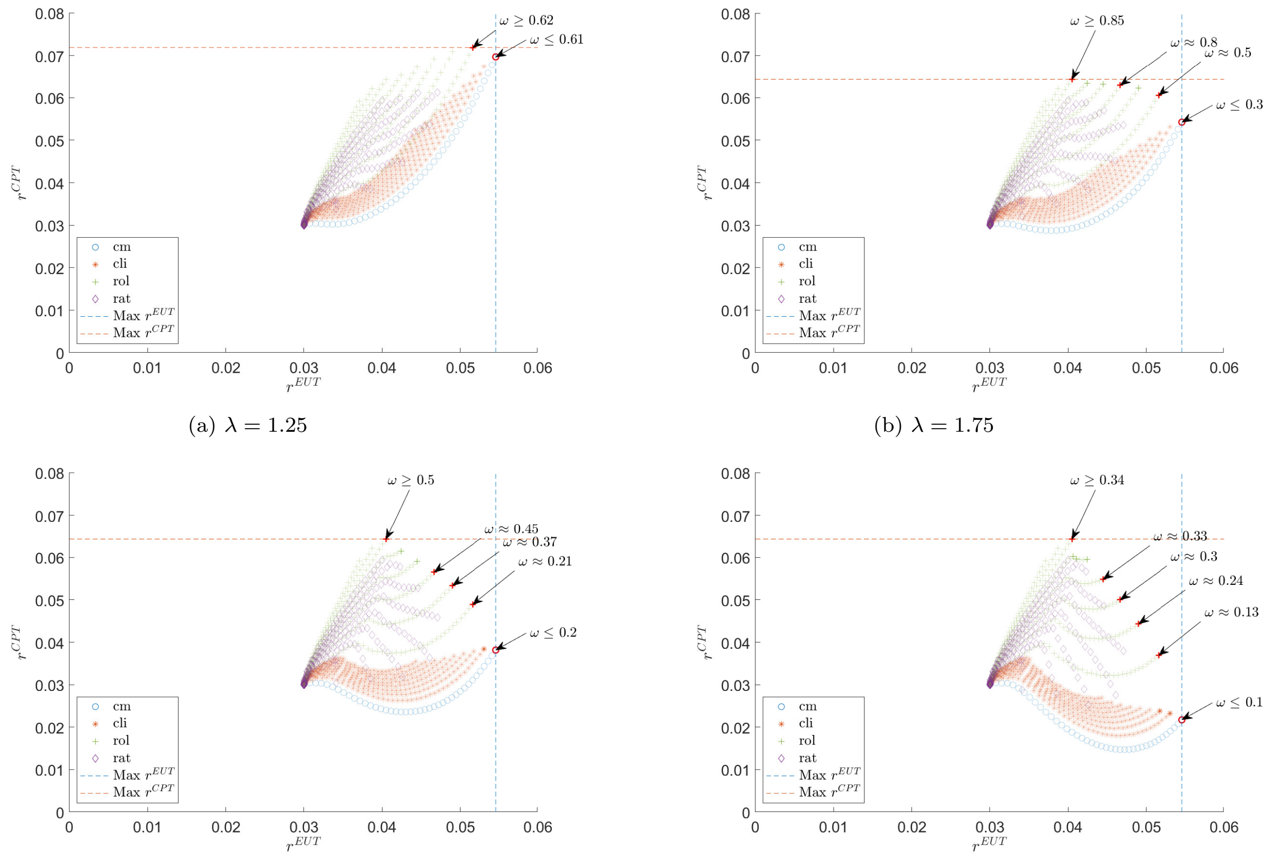
Next, we have analyzed the effect of preference weighting (ω) on the favorable compromise. We fix $a = \gamma = 0.88$ and vary λ between 1.25 and 2.75 as well as ω from 0 (pure EUT) to 1 (pure CPT) for each level of loss aversion. In Figure 3 we see the favorable compromises for different weights.

Varying the preference weighting changes the indifference curves which results in different favorable compromises. By increasing ω, the favorable compromise changes along the efficient frontier starting on the vertical line for $\omega = 0$. Overall, we observe that for all levels of loss aversion, the favorable compromise is a constant mix in case of rather low values of ω and a roll-up product otherwise. However, with increasing loss aversion, the maximal value of ω for which a constant mix product is the favorable compromise, becomes smaller. Moreover, the guaranteed benefit of the favorable compromise increases with increasing ω, but the stock ratio remains at 100%.

We have also analyzed the effect of different exponents β in the combined preference function K, which also influences the shape of the indifference curves. We find that reasonable choices of β do not significantly influence the favorable compromise.

Moreover, we find that for reasonable choices of the minimum constraint b the favorable compromises do not or only slightly change, i.e., the stock ratio or the guarantee of the favorable compromise can only be slightly higher or lower.

[27]E.g., for $a = 0.88$ and $\gamma = 0.75$, the EUT CE (CPT CE) is only 0.19% (0.37%) lower compared to the optimal EUT (preferable CPT) product while the CPT CE (EUT CE) is 0.64% (0.81%) higher.



(a) $\lambda = 1.25$

(b) $\lambda = 1.75$

(c) $\lambda = 2.25$

(d) $\lambda = 2.75$

Figure 3: The certainty equivalent values of CPT and EUT for different levels of loss aversion. The diamond ($\Diamond$) corresponds to ratch-up, the star ($*$) to cliquet, the plus ($+$) to roll-up and the circle ($\circ$) to constant mix products, where the symbols are bold if the corresponding product lies on the efficient frontier. The red symbol is the favorable compromise for different values of ω. The dashed vertical line represents the highest EUT CE, while the dashed horizontal line represents the highest CPT CE.

Next, we have analyzed the impact of probability weighting. If the probabilities are more ($\zeta = 0.5$) or less distorted ($\zeta = 0.8$), the favorable compromises are very similar compared to the base case ($\zeta = 0.65$). The favorable compromises have slightly lower (higher) guaranteed benefits and the terminal guarantees start at a lower (higher) loss aversion in case of more (less) distorted probabilities. The reason is that the probability of large losses is more (less) overweighted and the probability of small losses is more (less) underweighted. Further, as in the base case, for both cases nearly all favorable compromises have a lower guaranteed benefit than the preferable CPT product.

If there is no probability weighting ($\zeta = 1$), we find that in case of a medium or low risk aversion and attitude as well as low loss aversion, the favorable compromise is a pure stock investment (coinciding with the EUT optimal product). For a high loss aversion the favorable compromise comes with a terminal guarantee close to 1 and a stock ratio of 100% for medium and low risk aversion. If risk aversion and attitude and loss aversion are high, the favorable compromise has a medium stock ratio (30-55%) and a terminal guarantee above one. Moreover, the stock ratio of the favorable compromise is significantly higher than the stock ratio of the preferable CPT product (with θ between 10-30%). However, we observe that for some combinations of λ and $a = \gamma$ the favorable compromise is a ratch-up product (but closely followed by a roll-up), cf., Table B. This can be explained by the comparatively high CPT CEs of ratch-up products (that come with a rather low volatility) when the probabilities of large gains of the more volatile roll-up products are not overweighted. Combined with the relative high EUT CE, ratch-up products are good candidates if risk aversion and attitude are high.

Finally, we have investigated the impact of the underlying financial market parameters. If the volatility of the stock market is lower (10%) the favorable compromise is a pure stock investment (coinciding with the optimal EUT product) for consumers with low or medium loss aversion and low or medium risk aversion and attitude, since the probability of a loss is significantly lower than in the base case. For other combinations of loss aversion and risk aversion and attitude, a roll-up product with the lowest considered guaranteed benefit ($\alpha = 0.95$) and a stock ratio of 100% is favorable as the terminal guarantees are cheaper. Further, it has a lower guaranteed benefit than the preferable CPT product, in this setting.

If the expected return and the risk-free interest rate are lower (4% and 1%, respectively), the favorable compromises in case of no or a low loss aversion is a pure stock investment (which is also the EUT optimal product in most cases), since the probabilities of large gains are overweighted, terminal guarantees are expensive and losses are not or only slightly penalized. For a medium and high loss aversion and high risk aversion and attitude the favorable product has a terminal guarantee slightly above 1 and a stock ratio of roughly 80%. This is lower than in the base case, because guarantees are more expensive, due to the lower expected return of the stock market. If risk aversion and attitude are moderate or low and loss aversion is high, the favorable compromise has a stock ratio of 100% as in the base case but the terminal guarantee is lower then in the base case, because guarantees are more expensive. Moreover, these compromises have significantly higher CE values compared to the CPT CE (EUT CE) of the optimal EUT (preferable CPT) product.

5.2 Sensitivity Analysis of Application 2

Again, we have analyzed the effect of different levels of risk aversion and risk attitudes independently for a fixed loss aversion of 1.75. The results are shown in Table 4.

	favorable compromise / preferable MCPT / EUT optimal				
a	γ	0.65	0.75	0.88	0.95
0.65	K	$\ast(60, 42.5, 1.14, 3.3, 3.75)$	$\ast(60, 42.5, 1.14, 3.31, 3.75)$	$\ast(60, 42.5, 1.14, 3.33, 3.75)$	$\ast(60, 42.5, 1.14, 3.33, 3.75)$
	MCPT	$\ast(60, 40, 1.43, 3.26, 3.77)$	$\ast(60, 40, 1.43, 3.27, 3.77)$	$\ast(60, 40, 1.43, 3.28, 3.77)$	$\ast(60, 40, 1.43, 3.29, 3.77)$
	EUT	$\circ(100, 95, -, 4.43, -0.49)$	$\circ(100, 100, -, 4.88, -0.55)$	$\circ(100, 100, -, 5.46, -0.55)$	$\circ(100, 100, -, 5.78, -0.55)$
0.75	K	$\ast(60, 47.5, 0.49, 3.37, 4.05)$	$\ast(60, 47.5, 0.49, 3.39, 4.05)$	$\ast(60, 47.5, 0.49, 3.41, 4.05)$	$\ast(60, 47.5, 0.49, 3.43, 4.05)$
	MCPT	$\ast(60, 45, 0.82, 3.33, 4.08)$	$\ast(60, 45, 0.82, 3.35, 4.08)$	$\ast(60, 45, 0.82, 3.37, 4.08)$	$\ast(60, 45, 0.82, 3.38, 4.08)$
	EUT	$\circ(100, 95, -, 4.43, -0.54)$	$\circ(100, 100, -, 4.88, -0.6)$	$\circ(100, 100, -, 5.46, -0.6)$	$\circ(100, 100, -, 5.78, -0.6)$
0.88	K	$\ast(60, 100, -9.38, 4.01, 4.32)$	$\ast(60, 100, -9.38, 4.19, 4.32)$	$\ast(60, 100, -9.38, 4.43, 4.32)$	$\ast(60, 100, -9.38, 4.56, 4.32)$
	MCPT	$\ast(60, 50, 0.14, 3.41, 4.79)$	$\ast(60, 50, 0.14, 3.43, 4.79)$	$\ast(60, 50, 0.14, 3.46, 4.79)$	$\ast(60, 50, 0.14, 3.48, 4.79)$
	EUT	$\circ(100, 95, -, 4.43, -0.31)$	$\circ(100, 100, -, 4.88, -0.34)$	$\circ(100, 100, -, 5.46, -0.34)$	$\circ(100, 100, -, 5.78, -0.34)$
0.95	K	$\ast(60, 100, -9.38, 4.01, 6.12)$	$\ast(60, 100, -9.38, 4.19, 6.12)$	$\ast(60, 100, -9.38, 4.43, 6.12)$	$\ast(60, 100, -9.38, 4.56, 6.12)$
	MCPT	$\ast(60, 100, -9.38, 4.01, 6.12)$	$\ast(60, 100, -9.38, 4.19, 6.12)$	$\ast(60, 100, -9.38, 4.43, 6.12)$	$\ast(60, 100, -9.38, 4.56, 6.12)$
	EUT	$\circ(100, 95, -, 4.43, 0.08)$	$\circ(100, 100, -, 4.88, 0.1)$	$\circ(100, 100, -, 5.46, 0.1)$	$\circ(100, 100, -, 5.78, 0.1)$

Table 4: The favorable compromise based on the combined preference function K for different combination of risk aversion and risk attitude and for $\lambda = 1.75$. The investment premium, the stock ratio, the guarantee, the EUT CE and the MCPT CE of the products are given in the parenthesis, i.e., (α in %, θ in %, g in %, EUT CE in %, MCPT CE in %). The star ($\ast$) corresponds to cliquet and the circle ($\circ$) to constant mix products.

We observe that the favorable compromise is always a cliquet product with $\alpha = 0.6$ but different stock ratios. Again, we find that the favorable compromise is (at least for $\gamma \geq 0.65$) independent of the risk aversion as it has only little impact on the EUT CE of the considered products. In contrast, a change in the risk attitude can strongly change the MCPT CE value. Moreover, we observe that K suggests the same product as in the base case ($a = \gamma = 0.88$) if risk attitude is lower ($a \geq 0.88$), that is, 100% stock and maximum possible guaranteed rate, which is also the MCPT preferable product for low risk attitude (e.g., $a = 0.95$). The reason is that products with a higher EUT CE have a significantly lower MCPT CE. Further, for a medium risk attitude ($a = 0.88$), the favorable compromise differs significantly from both the EUT optimal and the MCPT preferable product, but provides very well balanced CE values. E.g., for a risk aversion of 0.75, the compromise only has a lower MCPT (EUT) CE by 0.47% (0.69%) while the EUT (MCPT) CE is 0.76% (4.76%) higher, compared to the most preferable (optimal) product.

We have also analyzed the effect of preference weighting. We consider the base case with $a = \gamma = 0.88$ and vary λ between 1.25 and 2.75 as well as ω from 0 (pure EUT) to 1 (pure MCPT) for each level of loss aversion. Illustrations are given in Figure 4. As in the first application, the favorable compromise changes along the efficient frontier from the vertical line to the horizontal line. Note that with increasing loss aversion, the product with the highest MCPT CE is the favorable compromise for decreasing values of ω. Moreover, the favorable compromise comes with lock-in features in most cases (except for $\lambda = 1.25$ and $\omega \leq 0.15$), since loss aversion heavily reduces the attractiveness of products with terminal guarantees only (due to evaluation of annual changes in MCPT). In case of low loss aversion, the favorable compromise always has a stock ratio of 100%. If loss aversion is higher, the stock ratio decreases.

As in the first application, we find that for reasonable values of the exponent β, the influence on the favorable compromise is very minor. Also, for reasonable choices of the minimum constraint b, the favorable compromise changes only slightly if at all.

Further, we have considered different values for the probability distortion parameter ζ. If $\zeta = 0.5$, the favorable compromise is very similar to the base case, where for medium and low risk aversion and attitude, there is a tendency for higher stock ratios (due to the strong overweighting of high gains). As a consequence the favorable compromises have a higher EUT CE than in the base case. If the probability weighting parameter is 0.8, the favorable compromise is a pure stock investment in case of no loss aversion and a rather low risk aversion and attitude (which is also the optimal EUT product). For other loss aversion as well as combinations of risk aversion and attitude, the favorable compromise is similar as in the base case (only the stock

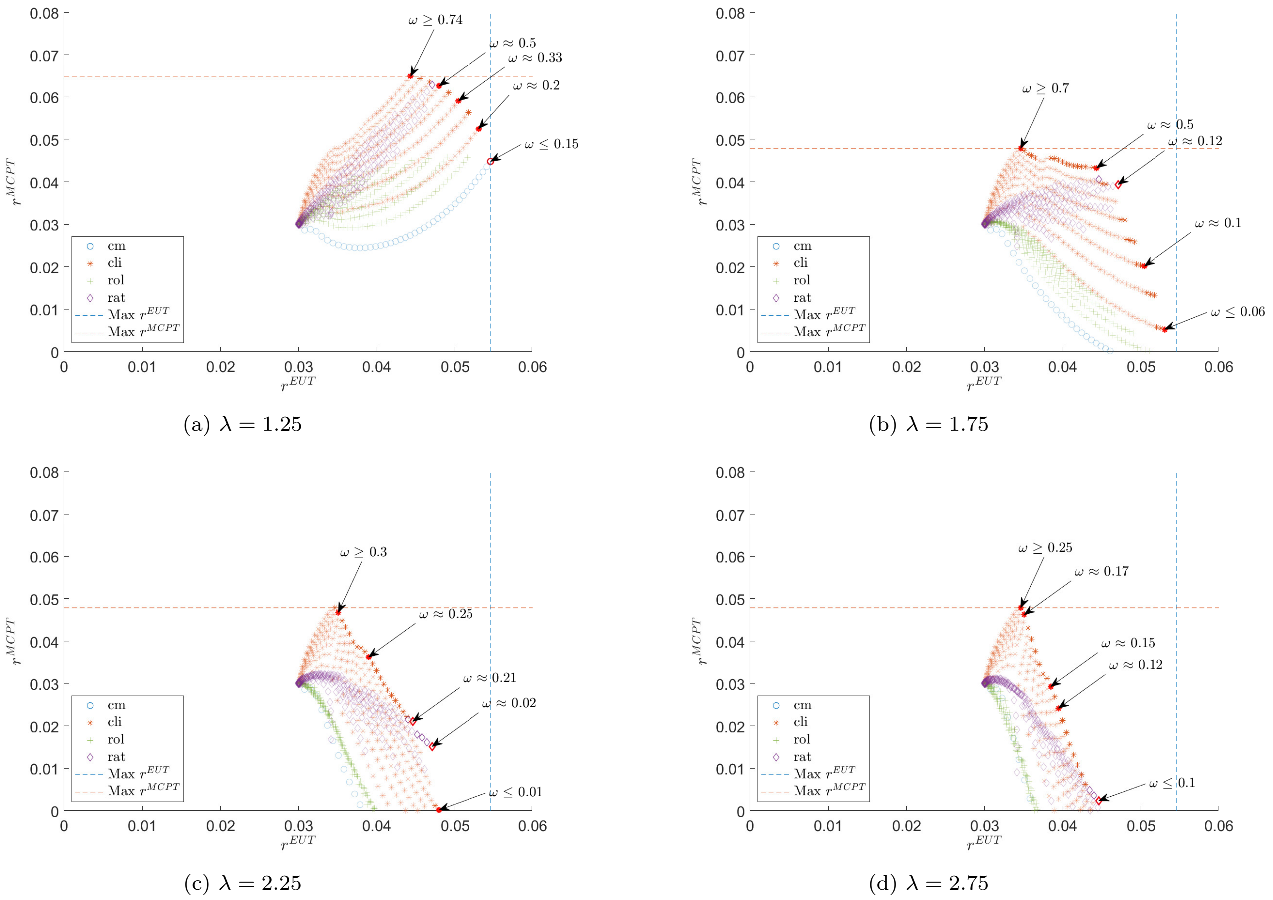


Figure 4: The certainty equivalent values of MCPT and EUT for different level of loss aversion. The diamond ($\Diamond$) corresponds to ratch-up, the star ($*$) to cliquet, the plus ($+$) to roll-up and the circle ($\circ$) to constant mix products, where the symbols are bold if the corresponding product lies on the efficient frontier. The red symbol denotes the favorable compromise for different values of ω. The dashed vertical line represents the highest EUT CE, while the dashed horizontal line represents the highest MCPT CE.

ratio is slightly lower and the guarantee is slightly higher). The reason is that the probability of large gains is less overweighted and the probability of medium losses is less underweighted, which makes higher guarantees and lower stock ratios more attractive.

If there is no probability distortion, the favorable compromise for very risk averse consumers is a product without guarantee and a very low stock ratio (5% or 7.5%) for all level of loss aversion, because the probability of a loss is close to zero. In this case, the favorable compromise comes with no guarantee (as the optimal EUT product) and a low stock ratio (as the preferable MCPT product). The favorable compromise is a pure stock investment in case of no or low loss aversion and rather low risk aversion and attitude (coinciding with the optimal EUT product). Otherwise, the favorable compromise is a cliquet product with similar guarantee rates (close to zero), but with a lower stock ratio, since the probabilities of large gains are not overweigthed. Again, the guarantees of the favorable compromises are lower than the guarantees of the preferable MCPT products.

Finally, we have performed sensitivity analyses with respect to the the financial market parameters μ, σ and r. If we change σ from 0.3 to 0.1, the favorable compromise is a cliquet product or a product without guarantee. For consumers with loss aversion, K suggests cliquet products with stock ratio of 100% and a guarantee between -6.6% and 0.5%, where the guarantee is increasing for an increasing loss aversion. The stock ratios of the favorable compromise are higher than in the base case, because guarantees are less expensive, since the volatility of the stock market is lower. Moreover, for high loss aversion, the favorable compromises are similar to the preferable MCPT product. For no loss aversion a pure stock investment, which is the optimal EUT product, is favorable, since the probability of large losses is rather low, because of the low stock market volatility.

If the risk-free rate and the expected return of the stock market are lower (1% and 4%, respectively), only cliquet and ratch-up products are favorable as in the base case. For a low loss aversion and a high risk aversion the favorable compromise is a ratch-up with a stock ratio close to 100% and a low guarantee. This means that only protection against high annual losses is bought when guarantees are more expensive. Similarly, if loss aversion remains low and risk aversion is only medium or low, the stock ratio increases up to 100% and guarantees are further reduced to levels between -40.05% and -21.58%. For a high loss aversion, K suggests a cliquet product with a stock ratio of roughly 30% and a guarantee close to 0. Here, the loss aversion results in guarantees close to zero which can now only be afforded for low stock ratios.

6 Conclusion and Outlook

In this paper, we have proposed an approach designed to identify choices that constitute a suitable compromise between a theoretically optimal choice (that might however be rejected by consumers due to behavioral biases) and the subjectively most attractive choice (which might come with a rather low objective utility). Ideally, such a compromise should be subjectively more attractive than the objectively optimal choice while providing a higher objective utility than the subjectively preferred choice.

Our proposed approach allows a simultaneous consideration of two different preference formulations. In our applications, we used EUT and (M)CPT. The approach is generally applicable and fulfills several desirable properties.

We have applied our approach by identifying "compromise products" for retirement savings in two different settings. The results of both applications show that the approach can in many cases identify suitable compromises which fit consumers needs while at the same time being subjectively attractive.

Our results under CPT as well as under MCPT indicate that the degree of loss aversion has a particularly high impact on the identified compromise product. For individuals with very low loss aversion, the suggested compromise is identical or very similar to the EUT optimal product. In such cases, no compromise might be required in the first place. For (reasonable) moderate values of loss aversion, the approach seems to work particularly well, identifying choices that combine characteristics of the objectively optimal product and the subjectively preferred product. As a consequence, the suggested compromise products are subjectively more attractive than the objectively optimal choice while providing a higher objective utility than the subjectively preferred choice – as desired. This is an important result as it shows that we can find suitable compromises for many individuals with reasonable degree of loss aversion. For high loss aversion, however, the "compromise" is given by the subjectively preferred product under CPT or MCPT, respectively. Here, our approach alone does not seem sufficient. We therefore propose that it should be combined with other measures suitable to reduce loss aversion at least to some extent.

Due to demographic change, private old-age provision will be increasingly important to maintain a desired standard of living in many countries. Consequently, many countries promote private old-age provision (including occupational old-age provision) e.g., by government subsidized schemes or tax advantages. In this context, the development of retirement savings products that are accepted by consumers and at the same time objectively fit their needs is of high relevance. Hence our findings should be of importance to legislators, product providers, as well as financial advisors.

The paper provides numerous suggestions for further research: Firstly, it is important to investigate under which assumptions (e.g., with respect to the underlying preference formulations) and to what extent people will actually accept such suitable compromises. In this context, it would also be interesting to investigate which additional actions can improve individuals' decision making. Also, it seems worthwhile to analyze whether the strong impact of loss aversion can be confirmed empirically. Secondly, future research should identify suitable compromises based on more realistic product designs (e.g., including products with collective savings elements that play an important role in many countries) and particularly including the decumulation period (i.e., the annuitization decision and the design of annuity products in the payout phase). Thirdly, the properties of the general approach to combine objective utility and subjective attractiveness presented in our paper should be subject to more theoretical analysis and other potential areas of application (beyond retirement savings) should be explored.

A Cumulative Prospect Theory[28]

In Cumulative Prospect Theory (CPT) an investment A with (random) final outcomes E is valued with an S-shaped value function v and with respect to a given reference point χ. The gains and losses are described by the random variable $X := E - \chi$. Then the CPT utility is

[28]This section closely follows Ruß & Schelling (2018) and Graf *et al.* (2019).

defined as

$$CPT(X) = \int_{-\infty}^{0} v(x) d\left(w\left(F(x)\right)\right) + \int_{0}^{\infty} v(x) d\left(-w\left(1 - F(x)\right)\right), \tag{1}$$

where $F(x) = \mathbb{P}(X \leq x)$ and v is the investor's value-function which is defined as $v(x) := x^a \mathbb{1}\{x \geq 0\} - \lambda |x|^a \mathbb{1}\{x < 0\}$ where $\lambda > 0$ is the loss aversion parameter and $a \in \mathbb{R}_+$ controls the risk appetite. The probability distortion function is given by $w(p) := \frac{p^\zeta}{\left(p^\zeta + (1-p)^\zeta\right)^{\frac{1}{\zeta}}}$ with $\zeta \in (0.28, 1]$, where the lower boundary for ζ is chosen such that w is strictly monotonically increasing for $p \in [0, 1]$.

In Multi Cumulative Prospect Theory (MCPT) the annual gains and losses (X_t) of an investment A are taken into account, i.e., $X_t := A_t - \chi_t$, where $t \in \{1, \ldots, T\}$, T is the maturity of the investment, A_t is the account value at time t and χ_t is the reference point at time t. The MCPT value of investment A is then defined by

$$MCPT(A) := \sum_{t=1}^{T} \eta^t CPT(X_t) \tag{2}$$

with a discounting parameter $\eta \in \mathbb{R}_+$ and with $CPT(X)$ as defined in (1).

B Additional numerical results

	EUT optimal	favorable compromise/ preferable CPT					
$a=\gamma$		λ	1	1.25	1.75	2.25	2.75
0.6	$\circ(100, 82.5, -, 4.25, [1.95, -0.05])$	K	$+(95, 30, 1.04, 3.51, 3.09)$	$+(95, 30, 1.04, 3.51, 3.09)$	$+(95, 30, 1.04, 3.51, 3.09)$	$+(95, 30, 1.04, 3.51, 3.09)$	$+(95, 30, 1.04, 3.51, 3.09)$
		CPT	$+(95, 22.5, 1.09, 3.35, 3.17)$	$+(95, 22.5, 1.09, 3.35, 3.17)$	$+(95, 22.5, 1.09, 3.35, 3.17)$	$+(95, 22.5, 1.09, 3.35, 3.17)$	$+(95, 22.5, 1.09, 3.35, 3.17)$
0.65	$\circ(100, 95, -, 4.43, [2.29, -0.15])$	K	$\circ(100, 55, -, 4.17, 2.65)$	$+(90, 42.5, 1.04, 3.58, 3.1)$	$+(90, 42.5, 1.04, 3.58, 3.1)$	$+(90, 42.5, 1.04, 3.58, 3.1)$	$+(90, 42.5, 1.04, 3.58, 3.1)$
		CPT	$+(95, 22.5, 1.09, 3.36, 3.2)$	$+(95, 22.5, 1.09, 3.36, 3.2)$	$+(95, 22.5, 1.09, 3.36, 3.2)$	$+(95, 22.5, 1.09, 3.36, 3.2)$	$+(95, 22.5, 1.09, 3.36, 3.2)$
0.7	$\circ(100, 100, -, 4.65, [2.77, -0.19])$	K	$\circ(100, 87.5, -, 4.59, 2.84)$	$\Diamond(80, 55, 0.82, 3.68, 3.12)$	$\Diamond(80, 55, 0.82, 3.68, 3.12)$	$\Diamond(80, 55, 0.82, 3.68, 3.12)$	$\Diamond(80, 55, 0.82, 3.68, 3.12)$
		CPT	$+(95, 25, 1.07, 3.42, 3.24)$	$+(95, 25, 1.07, 3.42, 3.24)$	$+(95, 25, 1.07, 3.42, 3.24)$	$+(95, 25, 1.07, 3.42, 3.24)$	$+(95, 25, 1.07, 3.42, 3.24)$
0.75	$\circ(100, 100, -, 4.88, [3.32, -0.17])$	K	$\circ(100, 100, -, 4.88, 3.32)$	$\circ(100, 87.5, -, 4.76, 2.71)$	$+(85, 57.5, 1.03, 3.73, 3.22)$	$+(85, 57.5, 1.03, 3.73, 3.22)$	$+(85, 57.5, 1.03, 3.73, 3.22)$
		CPT	$\circ(100, 87.5, -, 4.76, 3.33)$	$+(95, 27.5, 1.06, 3.48, 3.29)$	$+(95, 27.5, 1.06, 3.48, 3.29)$	$+(95, 27.5, 1.06, 3.48, 3.29)$	$+(95, 27.5, 1.06, 3.48, 3.29)$
0.8	$\circ(100, 100, -, 5.1, [3.89, -0.12])$	K	$\circ(100, 100, -, 5.1, 3.89)$	$\circ(100, 100, -, 5.1, 3.16)$	$\Diamond(65, 92.5, 0.3, 3.97, 3.2)$	$\Diamond(65, 92.5, 0.3, 3.97, 3.2)$	$\Diamond(65, 92.5, 0.3, 3.97, 3.2)$
		CPT	$\circ(100, 100, -, 5.1, 3.89)$	$+(90, 42.5, 1.04, 3.63, 3.37)$	$+(90, 42.5, 1.04, 3.63, 3.37)$	$+(90, 42.5, 1.04, 3.63, 3.37)$	$+(90, 42.5, 1.04, 3.63, 3.37)$
0.85	$\circ(100, 100, -, 5.33, [4.45, -0.05])$	K	$\circ(100, 100, -, 5.33, 4.45)$	$\circ(100, 100, -, 5.33, 3.74)$	$+(70, 100, 1.01, 4.01, 3.46)$	$+(70, 100, 1.01, 4.01, 3.46)$	$+(70, 100, 1.01, 4.01, 3.46)$
		CPT	$\circ(100, 100, -, 5.33, 4.45)$	$\circ(100, 100, -, 5.33, 3.74)$	$+(80, 70, 1.02, 3.85, 3.5)$	$+(80, 70, 1.02, 3.85, 3.5)$	$+(80, 70, 1.02, 3.85, 3.5)$
0.88	$\circ(100, 100, -, 5.46, [4.79, 0.01])$	K	$\circ(100, 100, -, 5.46, 4.79)$	$\circ(100, 100, -, 5.46, 4.1)$	$\circ(100, 100, -, 5.46, 2.69)$	$+(70, 100, 1.01, 4.05, 3.62)$	$+(70, 100, 1.01, 4.05, 3.62)$
		CPT	$\circ(100, 100, -, 5.46, 4.79)$	$\circ(100, 100, -, 5.46, 4.1)$	$+(70, 97.5, 1.02, 4.01, 3.62)$	$+(70, 97.5, 1.02, 4.01, 3.62)$	$+(70, 97.5, 1.02, 4.01, 3.62)$
0.9	$\circ(100, 100, -, 5.55, [5.01, 0.16])$	K	$\circ(100, 100, -, 5.55, 5.01)$	$\circ(100, 100, -, 5.55, 4.33)$	$\circ(100, 100, -, 5.55, 2.93)$	$+(70, 100, 1.01, 4.08, 3.73)$	$+(70, 100, 1.01, 4.08, 3.73)$
		CPT	$\circ(100, 100, -, 5.55, 5.01)$	$\circ(100, 100, -, 5.55, 4.33)$	$+(70, 100, 1.01, 4.08, 3.73)$	$+(70, 100, 1.01, 4.08, 3.73)$	$+(70, 100, 1.01, 4.08, 3.73)$
0.95	$\circ(100, 100, -, 5.78, [5.56, 0.7])$	K	$\circ(100, 100, -, 5.78, 5.56)$	$\circ(100, 100, -, 5.78, 4.92)$	$\circ(100, 100, -, 5.78, 3.57)$	$+(70, 100, 1.01, 4.14, 4)$	$+(70, 100, 1.01, 4.14, 4)$
		CPT	$\circ(100, 100, -, 5.78, 5.56)$	$\circ(100, 100, -, 5.78, 4.92)$	$+(70, 100, 1.01, 4.14, 4)$	$+(70, 100, 1.01, 4.14, 4)$	$+(70, 100, 1.01, 4.14, 4)$
1	$\circ(100, 100, -, 6, [6.1, 1.38])$	K	$\circ(100, 100, -, 6, 6.1)$	$\circ(100, 100, -, 6, 5.49)$	$\circ(100, 100, -, 6, 4.21)$	$\circ(100, 100, -, 6, 2.85)$	$+(70, 100, 1.01, 4.21, 4.27)$
		CPT	$\circ(100, 100, -, 6, 6.1)$	$\circ(100, 100, -, 6, 5.49)$	$+(70, 100, 1.01, 4.21, 4.27)$	$+(70, 100, 1.01, 4.21, 4.27)$	$+(70, 100, 1.01, 4.21, 4.27)$

Table 5: The favorable compromise based on the combined preference function K for different combination of risk aversion, risk attitude and loss aversion. The investment premium, the stock ratio, the guaranteed terminal value or the annual guarantee in case of a ratch-up, the EUT CE and the CPT CE are given in the parenthesis, i.e., (α in %, θ in %, $\exp(gT)$ or g in %, EUT CE in %, CPT CE in %). For the optimal EUT product the CPT CE is given as a range due to different loss aversions. The diamond ($\Diamond$) corresponds to ratch-up, the plus ($+$) to roll-up and the circle ($\circ$) to constant mix products and $\zeta = 1$.

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