Aalto University
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Demand of Structured Products in a Prospect utility framework Utility increase from capital protected index linked products

Finance

Master's thesis

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2011

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Aalto University School of Economics | Abstract
Master’s Thesis | August 17, 2011
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DEMAND OF STRUCTURED PRODUCTS IN A PROSPECT UTILITY FRAMEWORK

Utility increase from using capital protected index linked products

PURPOSE OF THE STUDY

This study examines the behavioral factors driving the demand for structured products (SP) and the utility implications for investors using these products, assuming that preference are defined by Kahneman and Tversky’s prospect utility framework. Based on this framework I will test how the utility of an economic agent is affected by adding SPs in to his portfolio. This thesis has two main research questions; should there exist a demand for SPs and whether consumers are better off using these products.

A simple capital protected stock index linked note, the most common product category in Finland, is tested against an optimal two fund portfolio to determine the potential utility gain. I will also interview several professional engaged in the design and marketing of SPs to see whether the theoretical findings of my tests fit with the real world experience of the professionals.

DATA AND METHODOLOGY

To test for the utility implications of SPs I will simulate the expected return distribution of a capital protected SP and an optimal two fund portfolio using the monthly returns on the MSCI World index and US treasury bonds from 1970-2011. Due to the potential for non-representativeness I will also vary these distributions to make sure that the same conclusions would hold with other datasets.

To define revealed preferences I will use utility function parameters defined by Tversky and Kahneman (1992). The implications of expected utility being the true form of normative preference will also be tested using consumption based CAPM, with parameters defined by Mehra and Prescott (1985) and Mankiw & Zeldes’ (1991). I will also analyze the impact of different factors of the prospect utility framework by changing the function parameters to understand the precise factors driving the demand of SPs.

RESULTS

The results show that, in a prospect utility framework, there is a clear addition in utility in certainty equivalent return terms. This addition even after costs is large enough to explain the demand towards SPs. This utility addition is mainly driven by a combination of loss aversion and the use of subjective probabilities, which are both components of the prospect utility framework. On the other hand Expected utility and prospect utility with true probabilities is only slightly increased compared to an optimal two-fund portfolio, this increase is not enough to outweigh the structuring costs of SPs. This leads us to believe that these products can have a utility decreasing effect for economic agents with low cost optimal portfolios as the alternative investment asset.

KEYWORDS

Structured products, prospect theory, cumulative prospect theory, behavioral finance, optimal portfolio

Aalto-yliopiston Kauppakorkeakoulu Tiivistelmä
Pro-gradu Tutkielma 17.8.2011
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STRUKTUROITUJEN TUOTTEIDEN KYSYNTÄ PROSPEKTITEORIA HYÖTYKEHIKOSSA

Hyödyn lisäys pääomaturvatuista osakeindeksilinkitetyistä tuotteista

TUTKIELMAN TAVOITTEET

Tämän tutkimuksen tarkoituksena on tarkastella käyttäytymistekijöitä, jotka ajavat strukturoitujen tuotteiden (ST) kysyntää, olettaen että preferenssit määräytyvät Kahnemanin ja Tverskyn kehittämän prospektiteorian hyötykehikon mukaisesti. Tähän kehikkoon perustuen testaan kuinka yksilön hyötyyn vaikuttaa strukturoitujen tuotteiden lisäys portfolioon. Tämän tutkimuksen kaksi pääkysymystä ovat pitäisikö kysyntää esiintyä strukturoidulle tuotteille ja lisääntyykö sijoittajan hyöty näiden tuotteiden käytöstä.

Vertaan pääomaturvattua osakeindeksisidonnaista tuotetta, joka on yleisin strukturoitujen tuotteiden tyyppi Suomessa, optimoituun osake-velkakirja portfolioon määrittääkseni potentiaalisen hyödyn lisäyksen. Haastattelen myös näiden tuotteiden rakentamisesta ja markkinoinnista vastuussa olevia henkilöitä useista suomalaisista pankeista vertaillakseni omia teoreettisia tuloksiani ammattilaisten kokemuksiin tuotteiden myynnistä.

LÄHDEAINEISTO JA MENETELMÄT

Testaan strukturoitujen tuotteiden hyötyvaikutuksia simuloimalla odotetun tuottojakauman pääomaturvatulle tuotteelle ja optimaaliselle portfoliolle, perustuen MSCI Maailmaindeksin ja USA:n valtion velkakirjojen kuukausittaisiin tuottoihin vuosilta 1970–2011. Johtuen mahdollisista lähdeaineiston edustavuus ongelmasta muokkaan aineiston parametreja varmistaakseni, että samat päätelmät pätevät myös muilla aineistoilla.

Sijoittajien toimintaa määrittävät preferenssit perustuvat tutkimuksessani Tverskyn ja Kahnemanin (1992) määrittämiin parametreihin. Arvioin myös hyöty vaikutuksia odotetun hyödyn määrittäessä ihmisten todellisen hyödyn käyttäen kulutukseen perustuvaa CAP-mallia. Parametrit tähän malliin perustuvat Mehran ja Prescottin (1985) ja Mankiwin ja Zeldesin (1991) tutkimuksiin. Arvioin myös malleihin sisältyvien eri tekijöiden vaikutuksia muuttamalla näitä, nähdäkseni mitkä ovat tärkeimpiä ajureita strukturoitujen tuotteiden kysynnän kannalta.

TULOKSET

Testitulokset osoittavat, että prospektihyötykehikossa hyöty lisääntyy selkeästi varmaa tuottoa vastaavan tuoton lisääntymisen muodossa. Tämä lisäys on selkeästi suurempi kuin strukturointi kustannukset, selittäen kysynnän näitä tuotteita kohtaan. Tämä hyödyn lisäys johtuu pääasiassa subjektiivisesta todennäköisyyksien painottamisesta ja vahvasta tappioiden välttämisestä, jotka molemmat ovat prospektihyötykehikon olennaisia osia. Kuitenkin odotettu hyöty ja prospektihyöty ilman subjektiivista todennäköisyyksien painottamista lisääntyvät hyvin vähän, jolloin kustannukset ovat suuremmat kuin hyödyn lisäys. Tähän perustuen sijoittajat, joille halpa optimaalinen osake-velkakirja sijoitus on vaihtoehtoinen kohde, saatavat kärsiä strukturoitujen tuotteiden lisäyksestä portfolioonsa.

AVAINSANAT

Strukturoitu tuote, indeksi laina, prospektiteoria, kumulatiivinen prospektiteoria, behavioristinen taloustiede, optimaalinen portfolio

Contents

1 Introduction

1.1 Background

Structured products, SPs, also known as equity- or index-linked notes, combine classical assets (stocks, bonds, indices) with at least one derivative into a package that offers a payment structure not otherwise accessible to retail investors, like capital protection or increased upside participation. In Finland most SPs are capital protected (~90%) stock index linked (~75%) five year products, which at maturity return the invested capital plus a certain percentage of the positive return on the underlying index.

Structured products are highly popular in Europe: for instance in 2007 the German market capitalization of structured products was more than 200 billion euros, representing around 7% of all invested assets. Yet based on a several studies there exists a pricing premium of 3-6% (Ofir & Wiener 2010, Wallmeier & Diethelm 2008, et al.) in most commonly marketed SPs compared to the prices of the underlying components of the instrument. Still there is very little research into explaining the demand for these products.

In a classical utility framework, with a constantly concave utility of wealth curve, there should be no added utility from using SPs. This Expected utility framework has been generally accepted as a normative model of rational choice, it has been widely applied as a descriptive model of economic behavior. In 1953 Maurice Allais presented one of the most famous counter examples to the expected utility theory. He studied whether empirical findings would support the transitivity assumption in the expected utility theory. It showed that the domination principle; if option A is better than B and B is better than C, then A must be better than C does not necessarily always apply and that the pattern was predictable. Later clear evidence was also found contradicting the state independence principle (Kahneman & Tversky 1979, et al.) by showing that people respond to changes rather than absolute levels of wealth. This implied that the expected utility hypothesis might not fully describe preferences in choices involving risk.

Based on these findings Kahneman & Tversky (1979, 1992) formulated a new framework for revealed preferences called prospect theory. This framework has three basic principles; First individuals are highly averse toward reductions in wealth (loss aversion). Secondly diminishing sensitivity is assumed for both the magnitude of losses and gains. Finally probabilities assigned to outcomes are overweighed for small probability “tail events” in the both ends of the outcome distribution, while large probabilities are underweighted (decision weighing). When preferences are defined by the reference point dependent prospect utility framework, the mean-variance tradeoff relationship of optimal portfolios no longer holds and the structure of returns matters, thus providing a potential explanation for the demand of SPs.

1.2 Motivation and definition of the research problem

The question of explaining demand for structured products has received fairly little academic attention. Previous research has mainly explained SP demand through behavioral biases that explain why investors are willing to pay a premium for structuring these products, even though they "rationally" provide no added value. Ofir & Wiener (2010) noted through a laboratory experiment that products that cater to "biases" such as: loss aversion, the disposition effect, herd behavior, the ostrich effect, and hindsight bias were clearly preferable to their test subjects.

Rieger (2010) on the other hand tried explaining SP demand through consumers having consistently biased estimates on the probability distribution of stock returns. He noted that probability misestimation is likely to play a significant role in explaining the demand for products with return barriers (e.g. capital guarantee), due to investors' subjective overestimation of the likelihood of breaching the barrier levels.

There is also recent research by Hens and Rieger (2009), into explaining different kinds of payment structures through testing which utility frameworks could explain them. What they found was that for individuals with reference-point dependent utility could benefit from non-linear payment structures, specifically products with a capital guarantee. Even though this study shows that if preferences are defined by the prospect utility framework (without decision weighing), there can exist a significant utility increase from SPs. My thesis will expand on this idea by rigorously determining the variety of factors under which this is true, providing a generalized evaluation of the drivers of demand for structured products from both a theoretical and practical standpoint. My thesis will primarily ask three questions:

1. Under what conditions can the Prospect utility framework explain the demand for structured products
2. How big is the potential utility gain from using SPs
3. What is the optimal payment structure for an SP

1.3 Contribution to existing literature

The aim of this study is to evaluate the behavioral factors driving the demand for SPs. My thesis will concentrate on thoroughly estimating how big the potential utility gains are and whether they are big enough to explain the observed pricing premiums. Secondly I will pinpoint the individual factors that determine the preference towards SPs, mainly loss aversion, subjective probability weighing and upside & downside risk preferences. To test for this I will compare the utility values of a nominally capital protected index linked product and an optimized structured product against the optimal stock-bond portfolio. The nominally capital protected index linked was selected for study because these kind of products are the norm in the Finnish market.

Utility implications will be tested by assuming that Kahneman & Tversky's prospect theory (1979) defines revealed preferences, using function parameters estimated by Tversky and Kahneman (1992). I will also test the "true" implications in a setting where either expected utility or true probability weighed prospect utility defines true preferences, with decision weighed prospect utility as a biased revealed preference. The expected utility will be tested by using a consumption CAPM model with parameters estimated by Mankiw & Zeldes (1991) and Mehra & Prescott (1985).

I ran the utility calculations based on a simulated sample of 10 000 stock returns based on the monthly returns on the MSCI World Index from 1970 to 2011. This return distribution will define both stock returns and work as the underlying instrument for the options in the structured products. US-treasury bonds from the same period will act as the risk free component in the optimal two-fund portfolio and be used to create the capital protection component in the SP. The test will be conducted for time series from one to five years.

I have also conducted interviews with three professionals from prominent issuers and distributors in Finland involved in the structuring and marketing of SPs to understand "the real world" of structured products. Based on the interviews I will compare the anecdotal real world experience with SPs with the theoretical results of my simulations.

The main contribution compared to Hens and Rieger's (2009) similar study is that I will systematically define the instances when SP should be preferred and what are the key factors driving their demand. Furthermore I will also use realized data rather than depending solely on a normal distributed returns with mean and variance corresponding to realized data. The following factors were tested to determine the credibility of the findings:

- Applying decision weighing
- Changing return distributions – varying mean index & bond returns and variance
- Using realized data
- Changing evaluation periods

Many of these factors in the end proved to have a significant impact on the investors' subjective realization of utility and thus the explanation power of prospect theory as the driver of demand for SPs.

1.4 Limitations of the study

There are some important limitations to the scope of this study. Firstly some of the psychological factors potentially impacting the demand of structured products studied by e.g. Ofir and Wiener (2010) cannot be integrated in to simulated test on the utility implications of SPs. We have a pretty good understanding of the direction of these effects but the magnitude remains unclear.

Secondly the test instruments do not perfectly match those offered by SP issuers in Finland in terms of underlying asset or upside payment structure. Even though there isn't a clear numerical evaluation of the impact of the difference, I have tried to analytically evaluate the relevance of these differences.

Thirdly the differences in the regulation and ease of purchase between SPs and other more traditional products is also likely to have a significant effect that will not be captured by the utility simulations.

Some concerns may also arise from the representativeness of the dataset used. These concerns should be addressed by tests on the impact of changing the parameters of the dataset, mainly volatility, expected return and risk free rate.

Finally the "optimal structured product" is only designed to illustrate the magnitude of potential utility increase and the pattern of optimal payment structure suggested by the decision weighed utility framework, rather than being a perfectly optimal payment structure. The designing of a perfectly optimal product is limited by the use of a return distribution which isn't fully normally distributed; this can cause the B&S valuation of out of the money options used to construct the product to be biased.

1.5 Main findings

In the Base case scenario, with an evaluation period of one year, bond returns based on 1y US-Treasury bond returns and stock returns matching the simulated stock returns[1]. Using structured products can significantly increase the decision weighted prospect utility (+2,4%) of an investor. At the same time we notice that the utility increase is almost entirely dependent on decision weighing being part of the investors true preferences. In a situation where using true probabilities represents true preference (experienced utility), the existence of SPs only has a small utility increasing effect on investors in either prospect utility or expected terms (+0,2%). The results mostly persist after controlling for several factors like: varying volatility, expected return, risk free rate, different utility function parameters and using actual returns instead of simulations.

In any case the increase in Decision weighed utility in terms of certainty equivalent returns (+2-3% on annual basis) suggests that these products should be clearly preferred over stock and bond investments, yet they "only" represent less than 10% of all invested assets in any major markets. This could be due to differences between the SP offered to consumers compared with the theoretical instruments used in my tests. Buying SPs is also much more complicated than e.g. investing in a mutual fund.

1.6 Structure of the study

The structure of this thesis is as follows; first chapter 2 Explains the thesis' theoretical background of utility of outcomes involving risk in both expected utility and prospect theory framework. I will also cover previous research into the utility implications of structured products. In Chapter 3 I will show my hypothesis on SPs utility effects. Chapter 4 will cover my research methods. Chapter 5 will present the results of the test and discussions with the professionals involved in creation and marketing of SPs. Chapter 7 will present a summary of my findings.

[1] Bond return: 6,2%, Stock return: 10,9%, Stock index volatility 16,7%

2 Literature review

2.1 Structured products

This section defines what is meant by Structured Products. I will also describe the structured products' market's characteristics and talk about the pricing of SP's.

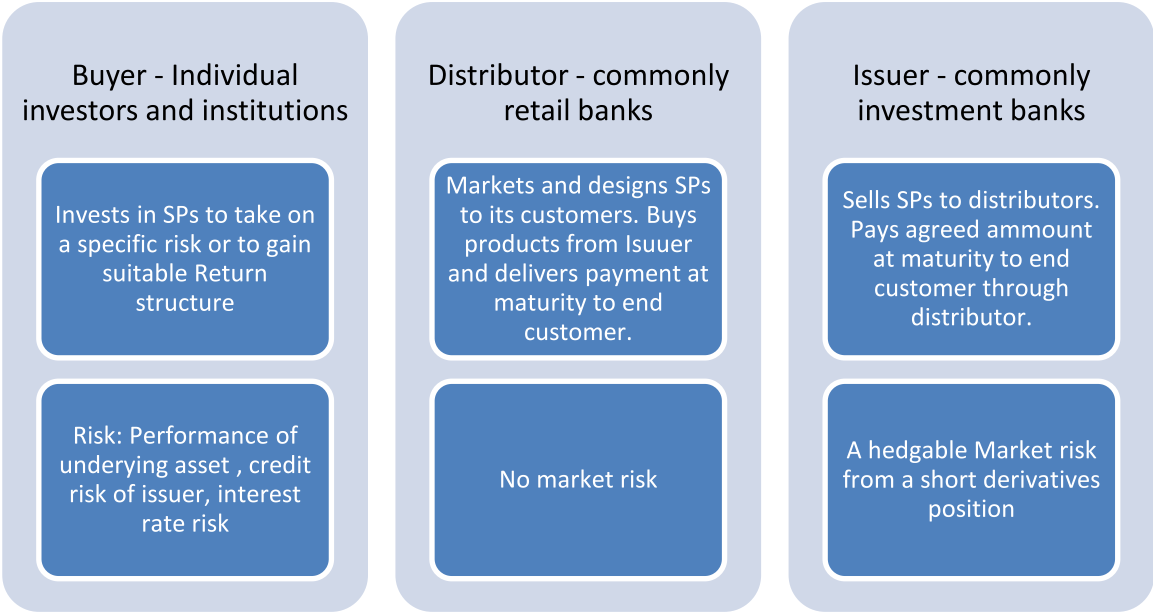
Structured products description

Structured products are basically newly packaged bundles of underlying financial assets. Hens & Rieger (2009) define SPs as: "a combination of classical assets such as stocks, bonds, and indices with at least one derivative, into a bundle that shall have specific interesting features for investors, like capital protection or increased participation".

The most basic structure is a nominally capital guaranteed product, conditional on the solvency of the issuer, that offers an extra return based on the return of an *underlying asset*(s) or index that the option part is connected to. This structure is created by a combination of a zero coupon bond, with a face value equal to the nominal value of the SP, and a bundle of derivatives which are linked to the underlying asset. There are also a wide variety of other more exotic payment structures, of which most common are: discount certificates, bonus certificates and reverse convertibles (Hens & Rieger 2009).

Structured products' Market

There are basically three participants in the SPs' market; the buyer, distributor and issuer. The distributor and issuer are most often financial institutions like investment banks, also in many cases they are the same institution. The issuer is the party liable for the SP. They sell the product and are responsible for paying the customer (usually through the distributor) at maturity the agreed amount conditional on the performance of the underlying index or asset. The issuer is in effect issuing options and debt to the end customer, so for them the sold structured products are a liability. This means that the credit risk of the issuer is a factor in pricing the instrument in a similar fashion as with bonds. The issuer on the other hand can mostly hedge the risk of this derivatives position so they are left with a relatively risk profit after the hedging costs and normal borrowing cost are deducted from the price of the SP.



The distributor is often the party who designs the products and then asks an issuer to quote a preliminary price for the desired SP. When they have the price for a certain amount of SPs they start marketing the product to the end customers during a period of couple of weeks. If the required amount of SPs is subscribed and conditions in the market haven't changed too much during to offering period to significantly affect the price quoted by the issuer, the order is filled and the distributor buys the product from the issuer and sells it to the end customer. The distributor makes its profit from the spread between the issuer's and the customer's price. Even though the distributor markets and often designs SPs, it is not liable for them in case the issuer defaults and thus takes on no market risk.

The buyers in structured products include both individual investors and institutions, but often individual products are targeted separately to these groups. SPs are highly popular in Europe: for instance in 2007 the German market capitalization of SPs was more than 200 billion euros, representing around 7% of total invested assets. In Switzerland SP assets were valued at 340 billion CHF which corresponds to 7-8% of all invested assets. At same time some European countries like Norway have instituted high regulatory barriers on SPs that limit their sales to most individual investors.

Pricing Premiums

Based on a several studies there exists a pricing premium of 3-6% (Ofir & Wiener 2010, Wallmeier & Diethelm 2008, et al.) in most commonly marketed structured products compared to the prices of the underlying components of the instrument. As most of these products are sold with 5y maturity, the annual premium is around 0,6-1,2%.This premium reflects a transfer of risk free profit from customer to issuer. Whether the riskless return premium produces returns over the work costs of structuring these products could still be debated. In theory competition should eliminate the arbitrage potential. In reality, due to the non-standard nature of the products and investors' "laziness" in comparing products from competing issuers, there might be a low level of pricing competition. Furthermore the price premium on these products is not often explicitly told to the customer, which combined with the complex nature of SPs makes it very hard for individual customers to compare the products and their pricing.

Finnish market description

According to information provided by the Finnish structured products association the value of all new structured products issued in Finland in 2009 was 3.11 billion euros. Around 66% of these were offered for a period of over 12 months, mostly for 5 years. Most of these products (~75% in 2010) were linked to stocks or stock indices. Most of these products also have a capital guarantee component (92% in 2006). Based on information from the websites of companies providing SPs; the structuring cost of most SPs offered in Finland is uniform at around 4% (0,8% p.a.) in addition to which most issuers charge a negotiable subscription fee of 1-2% (0,2-0,4 p.a). Due to new regulation (2011), in Finland all of these costs have to be explicitly stated in the SPs prospectus. As a comparison mutual fund fees for a holding period of five years would amount to around 1,4-1,7% p.a. for a portfolio with stock-bond weights comparable with the standard capital protected SP (see appendix 3 for more information).

2.2 Theoretical framework - Utility of outcomes involving risk

This chapter will describe the two most common frameworks for utility of outcomes involving risk. First I will describe the classical expected utility theory framework which is the basis for the "rational agent's" decision making. Secondly I will explain an alternative state dependent prospect utility framework that has risen from empirical findings contradicting classical utility theory.

There is a lot of debate about the utility of choices involving risks. The classical Von Neumann – Morgenstern (1944) expected utility theory states that the expected value of a risky choice is a linear combination of the utilities of the possible ***outcomes*** as shown in figure 1 . This simple form of the expected utility hypothesis has been challenged by among others Kahneman and Tversky's (1979)[2] prospect theory, which shows that ***changes*** are more relevant than final states of wealth or consumption.

Normative preferences vs. revealed preferences

I will conduct the study of the utility of structured products assuming that the prospect utility model defines revealed preferences. Whether or not prospect theory or expected utility represent the true normative preferences is not in the scope of this paper, but I will discuss the implications of both models as true preferences with the results later.[3]

2.2.1 Expected utility theory

In classical theory the utility of risky choices is a linear combination of the expected utilities of the possible outcomes weighed with their probabilities. The hypothesis also assumes that an individual has well defined preferences and can always decide between two alternatives. These preferences are also transitory as equation 2 shows. Furthermore rational individuals are also expected to be able to integrate their choices over the relevant economic investment period, which is often assumed to be over their entire lifetime. $E_t(U)$ In equation 1 is the expected utility of a combination of possible outcomes, p_i is the probability of outcome x_i and U(x_i) is the utility derived from outcome x_i.

$$E_t(U) = \sum p_i U(x_i), \sum p = 1 \qquad U(x_a) > U(x_b) > U(x_c) < U(x_a)$$

Equation 1 Expected utility **Equation 2 Transitivity principle**

Risk aversion based on marginal utility of wealth

In the expected utility framework risk aversion rises from the constantly decreasing marginal utility of wealth. This form is based on deriving the utility of wealth from the utility of consumption, which is a constantly concave function. The rational agent always consumes products in order of produced utility so as consumption increases the utility that can be gained for a given amount of wealth logically decreases.

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[2] A reference point dependent model had actually already been suggested by Markowitz (1952) with a modified version of Friedman and Savage's (1948) utility model. The difference is that Markowitz model had a reverse utility curve compared with Kahneman and Tversky's (1979) .
[3] Revealed preference = How people actually behave (defines actions), True preferences = How people should behave to maximize their own welfare (defines how consequences of actions are experienced)

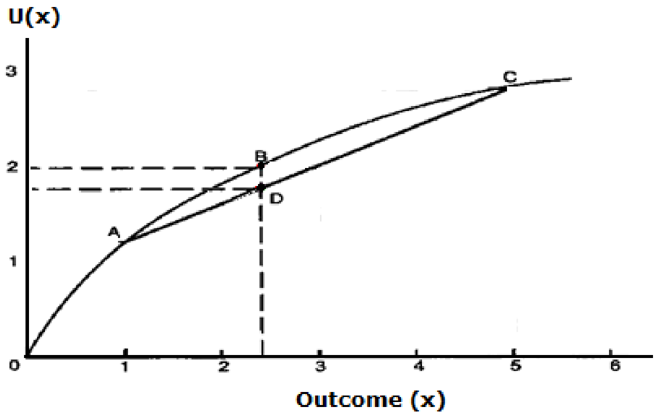

Figure 1 Expected Utility function. Utility as a function of wealth.

Figure 1 shows the diminishing marginal utility of wealth means that any probability weighed linear combination of any two outcomes (in figure: wealth A and C) produces a smaller utility than certain outcome (point B) equal to the expected value (point D) of the gamble. As we can also see from the figure the loss of utility from a gamble compared to a certain outcome also increases with size of difference between potential outcomes (risk). So expected utility is a function of risk and return with constant risk aversion dependent on the speed of diminishing of the marginal utility of wealth: $\frac{\partial U}{\partial w \partial w}$.

Asset valuation under expected utility framework

We already know that utility is a function of expected value and the distribution of outcomes, but investing in risky (stock) assets produces an infinite set of potential wealth outcomes, so there is a need to make different outcome sets comparable. In 1952 Markowitz showed that using the variance metric (σ^2) and expected value (E(w)) you can reduce any set of potential outcomes to two comparable figures[4]. This means that any two sets of outcomes with the same expected variance and value are equal in expected utility.

$$E(U) = F(E(w), \sigma^2)$$

Equation 3 Expected utility Function

With this knowledge we can construct a set of risky portfolios that dominate all others in terms of variance and expected return; this is called the efficient frontier. This representation was furthered by Tobin's (1958) two-fund-separation theory which shows that when we combine a risk free

[4] Only fully applies when the utility function is continuously differentiable power function

asset (e.g. government bonds), with an efficient stock portfolio we can select a level of risk (volatility) and return by adjusting weights of these two asset classes.

$$E(r) = b\sigma + r_f$$

Equation 4 Risk and return – expected return as a function of risk free rate and volatility

Structured products in an expected utility framework

Based on classical preferences, defined by a constantly concave reference point independent utility function, there shouldn't exist potential for a premium from structuring financial assets to produce non-linear payment structures. This holds even if the structures for these products would be impossible to simulate for the potential investors (Hens & Rieger 2008). This is due to the fact that these products can't improve the mean return – variance relation in a portfolio, which is an obvious consequence of zero arbitrage condition in pricing the derivatives used in constructing SPs. So as explained before portfolio selection depends on only on variance and mean return, so no added value can be created by non-standard payment structures. Rationally there should be no incentive to create these products.

Expected utility and price formation in the financial market

Between the years 1889 and 2000 the S&P returned an average of 6.9% p.a. in excess to the 90 day's U.S. Treasury bills' yield. In a ground breaking seminal paper Mehra and Prescott (1985) tested the expected size of the risk premium on equity with a model based on expected utility of wealth derived from realized consumption. Mehra and Prescott's model assumed that differences in average returns are explained by attributing them to differences in the degree to which a security's return co-varies with the typical investor's consumption. The higher the covariance the higher is the premium that investors demand to carry the extra risk to consumption. With this assumption they tried to find the coefficient of risk aversion that would justify the equity premium.

What they found was that stock returns' covariance with consumption was so small that the risks posed by equity investments only justified a premium of about 0.4%, which is far from the realized premium or any rational expectation of future risk premium. Even when adjusted for taxation, transaction costs, borrowing constraints and non-ownership of stock the projected premium is only a fraction of prevailing premiums.

This leads us to question whether the expected utility framework truly directs our behavior and the formation of prices in the financial market.

Expected utility theory critique

Expected utility theory has been generally accepted as a normative model of rational choice, it has been widely applied as a descriptive model of economic behavior. In 1953 Maurice Allais presented one of the most famous counter example to the expected utility theory. He studied whether empirical findings would support the transitivity assumption in the expected utility theory. It showed that the domination principle; if option A is better than B and B is better than C, then A must be better than C does not necessarily always apply and that the pattern was predictable. Later clear evidence was also found contradicting the state independence principle (Kahneman & Tversky 1979, et al.) by showing that people respond to changes rather than absolute levels of wealth. This implies that the expected utility hypothesis might not fully describe preferences in choices involving risk.

2.2.2 Reference point dependent utility - Prospect theory

Kahneman and Tversky (1979) found in their classic study Prospect Theory: An analysis of decisions under risk that rather than caring about end states of wealth, people care about changes in wealth relative to a reference level. They used a questioner study to test individuals' choices between alternatives involving risk. They presented people with two gambles with the same end states. The difference with the groups is that one group would reach the end state by losing money and the other by winning money compared to the their reference wealth, which was assumed to be the money given to the groups in the beginning. Even though the possible end states are the same, the groups made the opposite choices. This to Kahneman and Tversky was proof of the importance of a reference point in evaluating risky choices.

State dependent utility function

Several studies have shown that people assign higher values to objects already in their possession compared with those that are not, this is called the ***endowment effect***. Kahneman, Khnetz and Thaler (1990) empirically tested this hypothesis with a group of students. The First group was given coffee mugs and then asked how much they would sell them for. The second group didn't own any mugs and was asked how much they would be willing to pay for the mugs. The third was asked how much would they want for not receiving a mug. The results were that the group who owned the mugs valued the mugs more than twice as high as the two other groups, even though group three had the exact same possible end states. This result has also been confirmed by Knetsch (1989) with a similar test with pens and Knetsch and Sinden (1984) with a problem involving a choice between lottery tickets and money. What then is the relevance of the endowment effect? It proves that utility cannot be a stationary function; it has to move with the reference level.

From endowment effect we can derive an effect which Kahneman and Tversky coined ***loss aversion***. The logic is very straightforward: The loss of the owned coffee mug or a pen produced a much higher disutility than gaining of a mug or a pen produced utility. This is represented by the fact that people were willing to pay a lot less for the new pen than they would have sold an already owned pen. This means that the utility function's coefficient below the reference point is greater than above it. So first attaining a certain level of wealth or consumption and then falling back to your original level will leave you worse off than when you started. Also with data obtained from the housing market Genesove and Mayer (2001) prove the existence of loss aversion. Same result was also reached by Bateman, Munroe, Rhodes, Starmer and Sugden (1997).

Upside and downside risks preferences

Kahneman and Tversky (1979) also found that individuals surprisingly are more willing to take moderate downside risks compared with upside risks. This can be illustrated by the fact that in their questioner study people preferred sure bets to risky ones when they could only gain from the gamble. When the same test was conducted with negative numbers people now preferred the risky bet. This was tested several times and all the tests showed the same results with a big margin. These same results had already been reached by Swalm (1966) and Maurice Allais (1953). This behavior suggests that the utility function is convex below the reference point and concave above it as seen in figure 2.

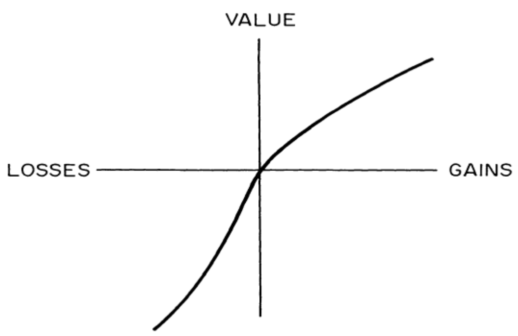

Figure 2 Value function, source: Kahneman and Tversky (1979). Prospect utility as a function of change in wealth

Outcome weights not equal to outcome probabilities

Considering the risk preferences presented in the previous section, we are presented with a problem; how can we explain lottery and insurance (downside risk aversion and upside risk seeking)? The answer lies in the weighing of outcomes. People in Kahneman and Tversky's test overweighed unlikely events, which lead them to both choose to gamble with positive unlikely outcomes and take the small certain loss in the negative ones. This is exactly the behavior people exhibit with gambling and insuring. From overweighing unlikely events we can also deduct that certain outcomes are also overweighed compared to the almost certain outcomes. This is obvious because the gamble with the almost certain outcome would also have an unlikely outcome which would be overweighed leading to the other components underweighting, as the weights add up to one. The resulting weighing function is depicted in figures 3 and 4.

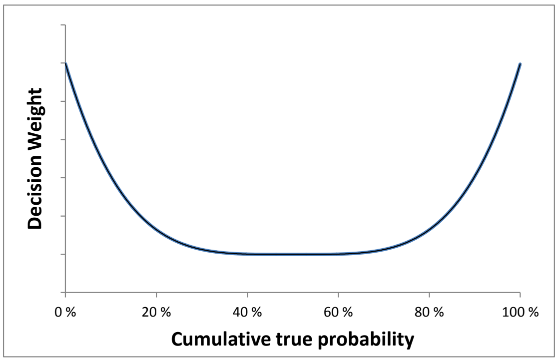

Figure 4 Decision weight as a function of cumulative true probability

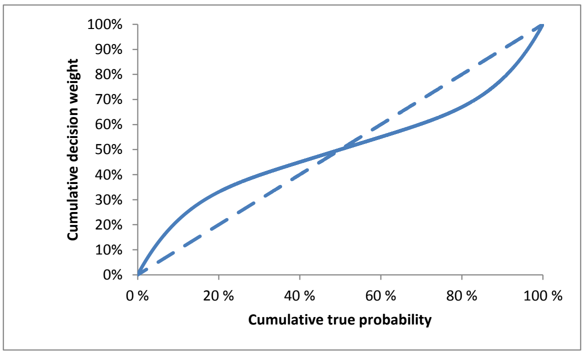

Figure 3 Cumulative decision weight as a function of cumulative true probability

The same results were also found by Kachelmeier and Shehata (1991) using a group of Chinese students. Due to the economic conditions in China, the investigators were able to offer subjects very large rewards. In the high payoff condition, subjects earned about three times their normal monthly income. Their main finding was massive risk seeking for small

(5%) probabilities, the median cash equivalent offered for unlikely bets was about three times the expected value. For gambles with likely small winnings the reverse applied.

This theory has been further developed in to the cumulative version (Tversky and Kahneman 1992, Quiggin 1982, Schmeidler 1989, Yaari 1987 and Weymark 1981), where one transforms cumulative rather than individual probabilities. The decision weight π depends on the cumulative distribution of a gamble, not only on the likelihood of the outcome in question. This means that only the (extreme) events in the tails of a distribution are overweighed, e.g. when rolling a dice the probability of getting a six or a one would be overweighed.

Prospect utility model

The utility model based on prospect theory and the later form; cumulative prospect theory differs from the expected utility model in four important ways explained in the previous sections: The utility curve isn't a stationary function; it is dependent on a reference point. The loss of wealth produces a higher disutility than a similar gain provides utility. Risk aversion is assumed in the positive and risk seeking in the negative domain. And last, decision weights differ from the expected probabilities of the possible outcomes. Equation 5 depicts the utility function estimated by Tversky and Kahneman (1992).

$$U = \sum_{i=1}^{k} \pi_i(p)\lambda v(x_i) + \sum_{j=k+1}^{n} \pi_j(p) v(x_j)$$

Equation 5 Prospect utility

In equation 5, λ is a loss-aversion parameter, π_i is the decision weight based on cumulative probabilities associated with the distribution of possible outcomes and x_i is the change in state (wealth).

Prospect Utility and structured products

Loss-aversion can induce a non-convex payoff function for optimal financial assets with a plateau at zero (Hens & Rieger 2009). The capital guaranteed payoff pattern which is a common feature in most Finnish structured products caters to this demand. Due to the high aversion towards losses a payoff pattern that gives an outcome distribution with only positive outcomes is preferred over a distribution with also negative outcomes that still has the same mean expected return and variance. So creating special payment patterns can clearly create added value to a customer who is highly loss averse.

2.2.3 Myopic loss aversion

The word Myopia comes from Greek and means short sightedness. To study the effects loss aversion one needs to define a period during which investments are evaluated, because this defines the possible outcomes and their probabilities. Next I will show that in the presence of loss aversion and investor short sightedness the projected equity premium matches empiric observations and thus gives credibility to the argument that the prospect utility model is a base for actual consumer choice in the financial market.

Myopia – failure to aggregate

The potential failure to aggregate expected returns over the investor's entire investment horizon is especially relevant in the presence of loss aversion. Consider two people with two period *investment* horizon, the other has a one and the other two period *evaluation* horizon[5]. They both own an asset which returns R during the first year and – R during the second year. The utility of the person with a two period evaluation period stays the same, as he experience no change in his wealth, while the person with a one period evaluation period is actually worse off, because based on prospect theory the gain doesn't produce as much utility as the loss produces disutility. More generally from the cumulative prospect theory utility equation; because $\lambda \neq 1$ it matters how you aggregate the results.[6]

The fact that individuals' behavior exhibits myopia was proved by Benartzi and Thaler (1996). They showed university employees two hypothetical retirement fund's return distributions, one derived from bond and one from stock distributions. Group A was shown a distribution of annual returns, while group B was shown a simulated 30 year return derived from the annual data. When asked how much would they invest in bonds and how much in equities group A only invested about 40%, while group B invested about 90% in stocks, although both groups in principle had the exact same information. Apparently group A failed to aggregate a distribution for a longer period from the one year distribution. Thaler, Tversky, Kahneman, and Schwartz's (1997) and Gneezy and Potters (1997) produced similar results in a lab test where they noticed that the allocation to stocks increased remarkably when the possible returns were aggregated over longer periods. Benartzi & Thaler (1995) also found proof that institutional investors and traders (Haigh and List 2005) also exhibit myopia.

[5] Not to be mixed with investment period. Evaluation period (horizon) refers to how often people experience the utility implications of their investments, whereas investment period (horizon) refers to the time interval between making an investment and using the proceeds for consumption.
[6] Also since upside and downside risk preferences and decision weights differ

Effect of myopic loss aversion – Asset allocation under prospect utility

ALLOCATIONS TO BOND FUND

		Percent allocation to bond fund		
Feedback group	*n*	Mean	*SD*	*SE*
		A. Final decision		
Monthly	21	59.1	35.4	7.73
Yearly	22	30.4[b]	25.9	5.51
Five-yearly	22	33.8[b]	28.5	6.07
Inflated monthly	21	27.6[b]	23.2	5.07

Table 1 Allocation to bond fund. Source: Thaler, Tversky, Kahneman, and Schwartz's (1997) and Gneezy and Potters (1997). Test subjects had to make allocation decision between stocks and bonds after which they reseived feedback in the form of random simulated returns. The table shows the results of final allocations (after several rounds of allocation decisions and feedback) based on the aggregation of returns (feedback).

Shlomo Benartzi and Richard Thaler (1995) tested the possibility of explaining the equity risk premium puzzle with myopic loss aversion. They approached the problem by trying to maximize the representative agent's utility shown in equation 5. Their model tests the hypothesis with changes in wealth, so no assumptions are made about whether or not the utility of wealth is simply a derivative of the utility of consumption. As opposed to the coefficient of risk aversion tested by Mehra and Prescott (1985), Benartzi and Thaler test what is the length of the evaluation period needed to explain the premium. They assumed a form shown in equations 7 and 8 for the utility function. The return distribution used in their calculations was a simulated random sample from real historical returns (1926-1990). Their Findings are depicted in figure 4, from where it's possible to see that for an evaluation period of one year the expected premium was 6,5%[7] as the size of the premium. For a two year evaluation period the premium drops to 4,65%. An evaluation period of one year would be highly plausible as individuals receive most comprehensive reports from their funds and retirement accounts once a year, taxes are filed once a year, and for fund managers their performance is often appraised annually.

[7] These results were based on tests with nominal return's, using real returns actually made stocks more desirable and increased the evaluation period needed to explain the premium. This is most likely caused by money illusion, with high inflation the possibility of nominally negative returns is reduced, which in the presence of loss aversion increases the willingness to take risks.

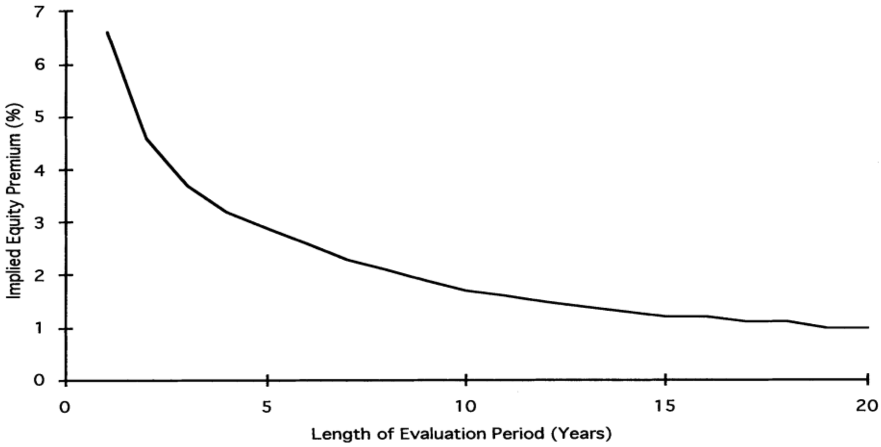

Figure 5: Equity premium as a function of evaluation period, source: Benartzi and Thaler (1995). Premium reflects the level when, based on prospect utility, individuals are indifferent between stocks and bonds.

These results were based on testing the size of the return that made investors indifferent between stocks and bonds. They then further tested what would be the division between stocks and bonds with a one year evaluation. They found that the optimum portfolios would have about 30-55% invested in stocks, which is approximately how portfolios in the real world are divided. For example based on Greenwich Associates' report pension funds and endowments invest on average 47% in stocks. Of course the fact that there also exists a bunch of other assets such as corporate bonds makes it hard to find the true optimum division between risk free bonds and stocks.

Robustness of results

When Benartzi and Thaler (1995) tested effect of model misspecification, they concluded that the loss aversion coefficient λ is the main determinant of their results. The effect of using actual probabilities instead of the weighing function actually reduced the equilibrium evaluation period where bonds had the same utility as stocks. Similarly using x instead of the value function V(x) reduced the required evaluation period by several months. As previously shown a wide range of research supports a relatively large coefficient for the loss aversion parameter λ, so we can be quite confident that a large premium will exist for short evaluation periods.

The explaining power of the prospect theory utility function for the large equity premium is then mostly dependent on the degree to which people exhibit myopia. But since the fact that investors exhibit myopia is also largely supported by several studies makes the myopic loss aversion explanation for the equity premium highly plausible. Also the predictions about asset allocation, equity premium and evaluation period that Benartzi and Thaler's model makes are in line with observed facts. All in all the prospect utility model seems to predict realized behavior relatively well.

Myopia and structured products – The ostrich effect

In comparison two assets which are otherwise identical with the exception of liquidity, the one with the better marketability should have a lower yield[8] as it includes the option to cash in the investment at any point in time without risking the locked in return, by having to wait for maturity (or perpetuity).

Galai and Sade (2006) found that investors prefer to hold illiquid assets and are even willing to pay a premium for them. This seems anomalous as liquidity provides the option to liquidate the position at any time and by definition an option cannot have a negative value. Galai and Sade attribute this seemingly anomalous behavior to an aversion to receiving information on potential interim losses. In other words the illiquidity seems to mediate myopic behavior. This behavior is called the ostrich effect defined as avoiding risky financial situations by, "sticking your head in the sand" and pretending they do not exist. In other words, certain individuals, when faced with uncertainty, prefer investments for which the risk is unrealized to similar investments for which the risks are reported frequently. Support for ostrich effect behavior can be found in various types of financial markets and countries (Ofir & Wiener 2010).

Most structured products are highly illiquid, there can be either direct costs or there is a wide spread between the quoted repurchase price and the components of the instrument. Investors can avoid apparently risky financial situations throughout the lifetime of an illiquid structure by assuming these situations do not exist, especially with capital guaranteed products where you know the lower limit of value at maturity. The only situation with which the investors are concerned is the one occurring at maturity.

As explained earlier, investors are less risk averse when they base their decisions on data aggregated over a longer time period (Benartzi & Thaler, 1996 and Gneezy and Potters 1997, et. al.). With structured products you receive information on a longer time horizon in the form of the lower bound of returns.

[8] Or at least the same yield. In present value terms liquidity of course has no impact, if we assume a holding period until maturity or perpetuity

All in all the low level of marketability of structured products can have reducing level effect on risk aversion duo to lengthening evaluation periods and thus reducing the impact of Myopia.

2.3 Previous research – utility implications of structured products

2.3.1 Maximal Utility gain from structured products

Thorsten Hens and Marc Rieger (2009) studied structured products utility implications from the customers' perspective using data from the Swiss and German markets. They studied whether different forms of utility could explain a willingness to pay a premium for non-standard payment structures. To do this they constructed optimal SPs matching the utility models in question and tested these against the optimal two-fund portfolio and risk free asset in a two period one year model where prices were defined by the Black & Scholes and Capital asset Pricing models. In addition they also constructed a multi touch computer model which they used to test individuals' preference towards different payment structures.

They first concluded that using classical expected utility power (constant relative risk aversion) and exponential (constant risk aversion) functions, one could not significantly increase utility. They concluded that the added certainty equivalent return (~0,06%) could definitely not explain the premiums paid for SPs (annually ~1%). Similar results have also been reached by Branger and Bauer (2007) studying the utility of retail derivatives.

They then tested whether adding an aspiration level (e.g. buying real estate) to the investors' utility function. With this utility framework an individual experiences a jump in utility at the level of the aspiration thus hedging returns to that level could potentially add utility. Hens and Rieger's utility model with an aspiration level produced a certainty equivalent return addition of 0,24%, which is already significant but still can't explain the paid premiums. There is still some support for aspiration levels playing a part in explaining SP investment. A study by AZEK training center for investment professionals (2006) found that individuals with plans to buy real-estate preferred capital protected products even when controlled for factors like loss aversion.

For loss aversion Hens and Rieger estimated the optimal payment structure to differ significantly from a linear two-fund portfolio (figure 6), which provided a significant potential for increasing value with structured payment patterns. At the commonly assumed loss aversion level of λ=2, the increase in utility was 1,5% in certainty equivalent terms, which is already significantly higher than the premiums paid for SPs. Hens and Rieger used actual probabilities rather that subjective decision weights. They also used a fully normally distributed return distribution. Due to these reasons my results could significantly differ from their conclusions.

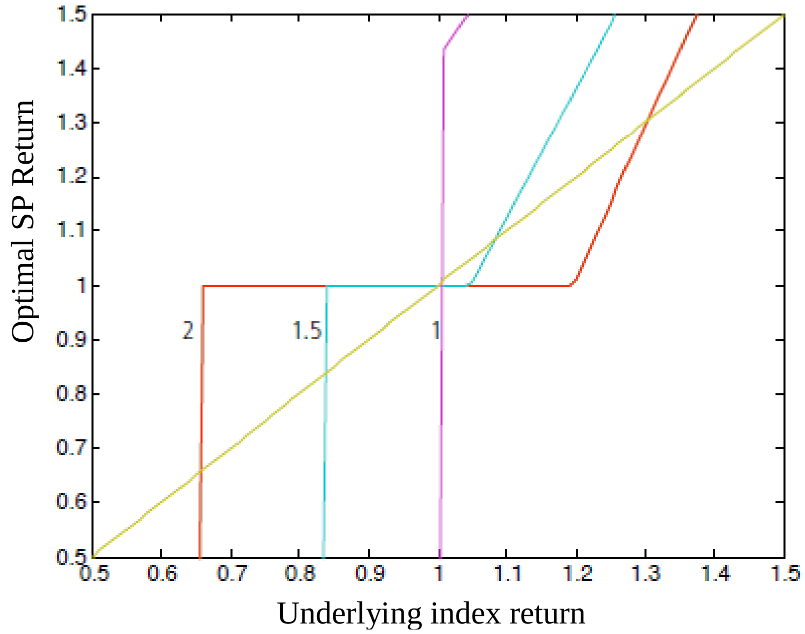

Figure 6 Optimal (utility maximizing) payment structure with different levels of loss aversion (source: Hens & Rieger 2009). The values 2, 1.5 and 1 reflect the levels of the loss aversion parameter λ in the prospect theory framework.

Hens and Rieger also tested what would the payoff patterns be like if investors could freely design them. Using a computer model that allowed the test subjects (visitors to the 175th anniversary exhibition of Zurich University) to select a payment profile in relation to an underlying asset, which was fixed as the SMI with one year maturity and pricing according to Black-Scholes. The test subjects were also allowed to use back testing, meaning they could see how well their products would have performed in the past. The Finding was that 49% selected full capital protection and a further 19% used partial protection. This suggests that people have a clear and predictable preference towards non-linear payment structures.

In the end they concluded that: Most popular structured products use behavioral factors, like loss-aversion or probability misestimation to be attractive in the eyes of potential investors. Thus they came to the conclusion that "by and large the market for structured products, which is a huge business for banks, provides little utility gain for investors".

2.3.2 Utility evaluation of structured products – Evidence from Norway

There is also a Norwegian master's thesis (Kjos 2010) regarding the utility implications of structured products under prospects' utility and whether Norway's "ban" on SPs was a sound decision. The following extract from the executive summary of the thesis summaries his findings well:

"The prospect theory analysis shows that an irrational investor can increase his utility by investing in structured products compared to the alternative investments. Contrarily, a rational investor will halve his utility by doing the same. The main conclusion is that investing in structured products is irrational, and that it was a sound decision to practically ban structured products from the Norwegian market. "[9]

Even though low in quality, the thesis does give some credibility to the argument that investors with preferences defined by prospect theory can significantly increase their utility by using SPs even after premiums. Unfortunately his data set was on individual products and is thus not applicable to the general case.

2.3.3 Structured products targeting behavioral biases

Moran Ofir and Zvi Wiener (2010) studied marketing materials and features of SPs' and based on these they posit that:"…the current supply of structured products is commonly designed to exploit some common behavioral biases in the area of decision making under uncertainty." They identified several features of structured products, associated with behavioral biases. They found that most SP marketing materials were designed to take advantage of[10]: loss aversion, the disposition effects, herd behavior, probability distortion, the ostrich effect and the hindsight bias. They also ran an experiment examining investor decision-making in relation to investments in SP trying to find out if the aforementioned biases actually impacted investors willingness to invest in SPs. Their experiment was conducted by offering test participants nine binary choices between investment alternatives

[9] This statement unfortunately well underlines the low academic quality of the paper. If rational investors gain no additional utility, they are only likely to invest in SPs by mistake, whereas irrational (prospect utility) investors are far likelier to invest since they experience a utility gain. All in all one would expect overall utility to increase. Relation of rational to irrational investors would ultimately define total utility gain or loss.

[10] The disposition effect: inclination to sell "winners" and hold on to "losers". Herd behavior: doing what everyone else is doing, here investing in trendy assets. The ostrich effect: inclination evaluate illiquid investments only on maturity. Hindsight bias: Overestimating future probabilities based on Past realized outcomes.

The difference between the alternatives was based on the behavioral bias tested in the specific investment decision.

- **Loss aversion** – Capital protection was preferred by most subjects
- **The disposition effects** – Some SPs require mandatory conversion to shares of the underlying, rather than cash, if the price falls under a certain threshold. Most people in the test preferred to take the shares rather than cash, letting them hold on to the “losers”
- **Herd behavior** – Most investors preferred SPs targeting trendy investments like developing markets or green energy over other investments with similar past performances
- **The ostrich effect** – Inferior illiquid investment opportunities were preferred by around 30%, even though there should have been no interest
- **The hindsight bias** –Investment opportunities that have in the past yielded good results were preferred over those with worse past records

They posit that their findings demonstrate that investors tend to be affected by these behavioral biases, favoring SP investments. They reason that since investors decision to invest in SPs doesn’t satisfy the Von Neumann & Morgenstern axioms that the premium paid for Structured products only represents a transfer of utility to the seller from the buyer. This viewpoint lead them to believe that: “regulation dealing specifically with SPs may be warranted to improve investor protection”.

Ofir and Wieners findings support the fact that due to “behavioral biases” there should exist a clear demand for structured products. But even putting aside the fact that expected utility is assumed to reflect true preferences, the writers seemingly fail to consider that if people act according to the aforementioned behavioral biases the selection they make between bonds and stocks could be even less optimal than SPs even in terms of expected utility. As an example if the ostrich effect induces longer evaluation periods it should benefit investors by protecting them from “exaggerated” risk avoiding behavior induced by loss aversion[11].

[11] With longer investment periods the chance of incurring losses is smaller and investors will benefit both in terms of prospect and expected utility (See Results, 7.6 impact of myopia).

2.3.4 Probability Misestimation and Preferences in Financial Investment Decision

Marc Rieger (2008) studied the influence of systematic probability misestimation on complex financial investment decisions on the context of structured financial products. He conducted a questioner study on economics students, who had to evaluate the probability of certain stock indexes hitting barrier levels (-10%, -20% and -25%). What they found was that the test subjects grossly overestimated the probability of the indexes hitting the barrier levels.

	Real prob.			Estimate		
DJIA below:	90%	80%	75%	90%	80%	75%
at some point:	29.6%	19.2%	13.8%	50.0%	32.5%	22.6%
at maturity:	7.5%	1.6%	0.4%	16.6%	12.0%	9.0%
Rel. difference:	3.97	11.95	36.21	3.01	2.71	2.51

Table 2 probability estimates for the DJIA index to fall below a threshold during a one year period. Source: Rieger 2008

These results suggest that capital protected products should be interesting to investors due to misestimation of the probability of the underlying index falling below the level of capital guarantee.

3 Hypotheses

Based on previous research, the prospect utility change from using a simple capital protected SP is likely to be positive, though this is still dependent on the distribution of the returns of the underlying and the risk free rate. An optimized structured product on the other hand by definition will increase utility. Based on Ofir & Wiener (2010) the potential for utility increase should be significant and likely to be higher than structuring costs.

An investor with prospect theory as revealed preferences and expected utility as true preferences can also benefit from SPs, if the optimal structured products has a higher stock allocation than an optimal two fund portfolio. This is due to the fact that the prevalent equity premium is far higher than the rational investor “should” demand.

3.1 Impact of value function

Loss aversion

Loss aversion has the impact of giving a large overweight for negative outcomes. This means that an optimal portfolio is likely to have a significant allocation in risk free bonds to avoid potential losses. The importance of loss aversion is defined by the return distribution, specifically the relative magnitude and frequency of negative returns. Based on previous research loss aversion is the main reason for the existence of capital protected products (Ofir & Wiener 2010).

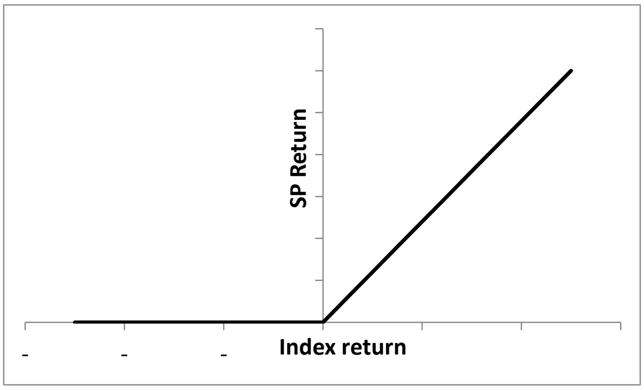

Figure 7 Estimated optimal payment structure based only on loss aversion. Individuals expected to avoid all losses while being risk neural for gains.

The above and the following "Optimal" structures point at the portions of the return distribution that should be under/overweighed (increased/reduced participation), rather than being a perfectly optimal structures.

Upside and downside risk preferences

With the risk aversion parameters estimated by Tversky and Kahneman (1992) and individual is risk averse in gains and risk seeking in losses. This would suggest an optimal portfolio with low upside and high downside volatility. As can be seen from figure 8 neither the two fund portfolio or a capital protected product seem to be very optimal in regards to upside/downside risk preferences. Previous studies have noted that the impact of upside and downside risk preferences is overshadowed by the loss aversion parameter (Thaler 1995).[12]

[12] As an illustration, if we disregard loss aversion, returns from three periods of +20€,- 9,1€ and -9,1€ would produce zero utility. This reflects a risk premium of around 2€ (10%). Whereas if we only consider loss aversion returns of -20€, +22,5€ and 22,5€ would combined produce zero utility This reflects a risk premium of around 25€ (125%).

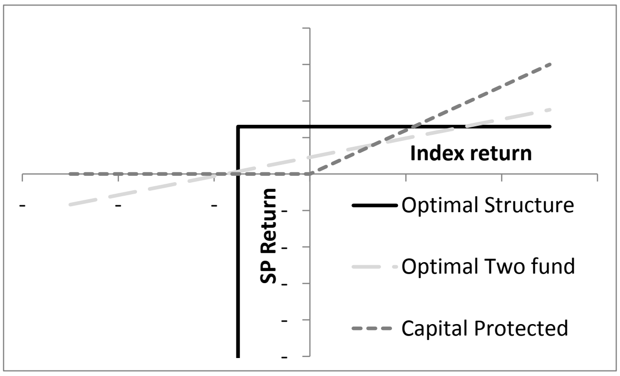

Figure 8 Estimated optimal payment structure based only on upside and downside risk preferences. Individuals assumed to avoid small losses and large gains as sensitivity to losses and gains diminishes with magnitude.

3.2 Impact of Probability weighing

Using decisions weights, with parameters defined by Kahneman and Tversky (1992), instead of true probabilities gives excess weight to unlikely extreme tails of the return distribution, furthermore losses also receive in general a slightly higher weight than gains. For losses the effect is also compounded with the loss aversion parameter giving them and even larger weight. Probability weighing thus has the effect of increasing the utility for payment structures with increased participation for extremely good returns and zero or negative participation (put options) for big losses. Capital protected products avoid entirely the large overweighing of negative outcomes at same time it is not clear whether the optimal two fund portfolio or the SP has a higher return for the extreme positive outcomes as this is defined by the composition of the optimal portfolio.

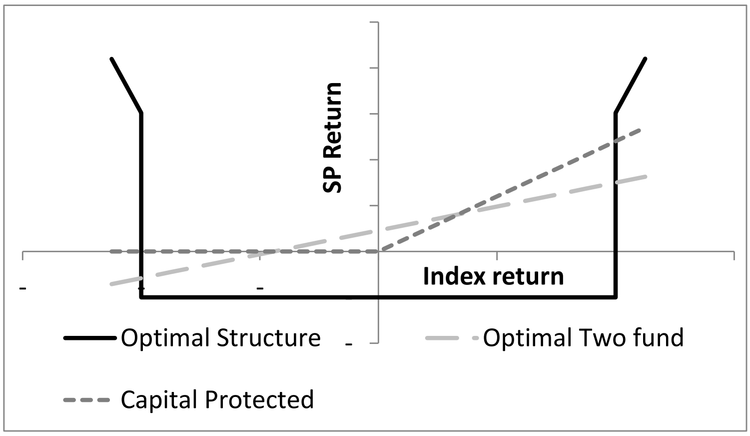

Figure 9 Estimated optimal payment structure based only on decicion weighing. Due to overweighing of tail outcomes, individuals expected to target these unlikely portions of the return distribution.

3.3 Combined utility impact

The combination of loss aversion and decision weighing should make Capital Protected SPs superior compared with the optimal two fund portfolio. This is supported by Ofir and Wiener's (2010) study on the prospect utility increase from using SPs, which noticed a significant increase in utility. This study did not take into account the impact of decision weighing, which is also likely to have a positive impact on the prospect utility of Capital protected SPs compared with the two fund portfolio.

Hypothesis 1: Capital protected SPs should increase prospect utility weighted with true probabilities

Hypothesis 2: Applying decision weighing will increase the utility impact of using SPs

3.4 Impact of myopia

The length of the evaluation period has a significant impact on prospect utility as it determines the return distribution. The longer the evaluation period the smaller the frequency of negative returns, the smaller the frequency of negative returns the smaller the risk aversion of an investor. This will constantly reduce the need for capital protection.

Hypothesis 3: Lengthening evaluation periods will strictly reduce the usefulness of Capital protected SPs

4 Methods

I will test whether using structured products (non-standard payment structures), can significantly increase investors' utility if his preferences match those estimated by Tversky and Kahneman (1992). I will compare the utility values of an optimal bond-stock portfolio, a standard structured product with a full capital guarantee and a utility optimized structured product. I will also test what would the utility implications be for an individual with expected utility or true probability weighed prospect utility as true preferences, with decision weighed prospect utility as a biased revealed preference.

The preferences of an individual investor will be defined by Tversky and Kahneman's (1992) parameters for prospect utility function. Using these parameters I will calculate utilities based on simulated and actual stock return distributions. The utilities are then transformed to certainty equivalent returns, which will define the monetary value of the payment structures and whether the added utility is enough to compensate for the high structuring costs.

4.1 Data set

The stock returns and underlying returns for the options in the structured products will be based on a sample that will consist of 100 000 simulated return series based on historical (1970-2011) returns on MSCI World (total return). The data on stock returns is taken from MSCI World index as it represents most of the markets accessible to investors during the time horizon in question. Any future reference to stock returns will refer to returns on the MSCI World.

The simulations are conducted by generating distributions for various time horizons by drawing 10 000n-month returns, with replacement, from the monthly MSCI World index returns data set. The 10 000 simulated stock return series are then ranked by total return from best to worst so that we can apply cumulative decision weights to the different outcomes.

This method removes any serial correlation, beyond one month time horizon, in asset prices. There is some research to suggest short term trending and long term mean reversion (Fama & French 1988). Because of this I will also run the test using actual returns for each time period rather than simulating returns based on monthly returns.

Risk free return will be estimated as the geometric mean return (between 1970 and 2011) of US treasury instruments, with maturity defined by the corresponding evaluation period (1-5 years). US treasury bonds were chosen due to two reasons; firstly during the time period in question they were regarded as the closest you can get to a zero risk investment. Secondly, the MSCI World index is denominated in dollars, which removes the need to adjust for exchange rate fluctuations.

4.2 Utility calculation

Even though there is a lot of evidence supporting prospect theory as a model for revealed preferences, we still can't say for sure that expected utility or some other model doesn't define true preferences. This is why I will also test the utility implication of SPs for an investor with true preferences defined by expected utility maximization, with risk aversion defined by a consumption based CAPM.[13]

4.2.1 Prospect utility calculation parameters

The following parametric forms estimated By Kahneman & Tversky (1992) will define revealed preference, based on which I will calculate the utilities of the structured product and the optimal two fund portfolio. The composition of the optimal two fund portfolio will also be defined by these preferences. These parameters are supported by several different experimental studies (Wu and Gonzalez 1996). Wu and Gonzales also noted that "Tversky-Kahneman functions are remarkably similar to those found by several others using very different estimation procedures and experimental methods". This parametric form is also supported by its ability to explain for example the realized equity premium and the allocation between stocks and bonds (Benartzi and Thaler 1995).

Value function parameters

Tversky and Kahneman (1992) estimated a parametric form, based on an experiment where test subjects were presented with a long series of gambles with different probabilities and sure outcomes. The subjects had to choose between the sure and the risky options and based on these choices Tversky and Kahneman estimated the following parametric form:

$$U(I) = \sum \pi(p_i) v(x_i)$$

Equation 6 Prospect Utility of a risky outcome

$$v(x) = \begin{matrix} x^{0,88} \\ -2,25(-x)^{0,88} \end{matrix} \; if \; \begin{matrix} x \geq 0 \\ x < 0 \end{matrix}$$

Equation 7 Value function

The utility (U) of a financial instrument (I) is defined as the sum of value (v) provided by the different potential financial outcomes (x_i), weighted by decision weights (π). The value function v(x) is defined piecewise around the reference point with a slope of 2,25 for losses representing the loss aversion parameter observed by Kahneman and Tversky. In equation 6 $\pi(p)$ represents the subjective probability (decision weight) and x_i is the outcome relative to the reference point, e.g. purchase value of equities.

[13] Appendix 2 shows an example of the utility calculations.

Decision weights

As explained earlier in prospect utility framework the weights assigned to outcomes are different from their actual probabilities. For the weighing function parameters will use those estimated by Kahneman and Tversky (1992). They suggested the following one parameter form for the **decision weight** parameter π, where the rank (position in a distribution ranked from worst to best) and probability of an outcome define its weight. Let W denote the nonlinear transform of the cumulative distribution of a gamble, let p_i be the probability of obtaining an outcome that is at least as good as x_i and let p_* be the probability of obtaining an outcome that is strictly better than x_i.[14] (Numerical example in Appendix 2)

$$\pi(p_i) = W(p_i) - W(p_*) \qquad W(p) = \left(\frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}} \right)$$

8a 8b

Equation 8 Weighing function.

Tversky and Kahneman estimated the parameter γ to be 0,61 in the domain of gains and 0,69 in the domain of losses. If the distribution only includes positive or negative values, the weights will add up to 100%. With both positive and negative outcomes the weights on the other hand do not add up to one, so we have to divide each decision weight with the sum of the weights to have the weights add up to one[15]. We can also note that in any sample where each individual outcome has an equal likelihood of occurrence, then $p_* = p_i - 1/N$, where N is the sample size. Since here each outcome has the same likelihood of occurrence (1/10 000) the implication is that the probability assigned to an outcome (decision weight) is dependent only on the position (rank) within the distribution[16]. More specifically the probability of gaining an outcome that is worse (for positive returns) or better (for negative returns) defines overweighing/underweighting. So if we for example think of a six sided dice defining potential returns, the probability of getting a 6 would be overweighed because the likelihood of getting an outcome that is worse would be high (5/6).

[14] For negative outcomes the reverse applies p(i) is the probability of obtaining an outcome that is at least as bad x(i) and $p_*(i)$ is the probability of getting and outcome that is strictly worse than x(i)

[15] The weights add up to around 108% for a one year sample and the adjustment doesn't have a noticeable effect on any of the tests

[16] The amount relation of positive and negative outcomes also has an impact as the function parameters differ for positive and negative outcomes. For distributions with uneven probabilities the rank of the outcome is still positively correlated with overweighing of outcomes

It has also been noted in empirical tests that the decision weighing function only works well when the cumulative probability p is over 5% and below 95% (Tversky & Kahneman 1992, Diecidue, Wakker & Zeelenberg 2007, et al.). For example for a 0,01% probability in the positive end of the distribution, the decision weight would be around 54 times the true probability. This would indicate a willingness to pay 20€ for a 0,01% probability to win 10 000€ (expected value: 1€)[17]. We can adjust for this by assigning average decision weights for the tail outcomes.

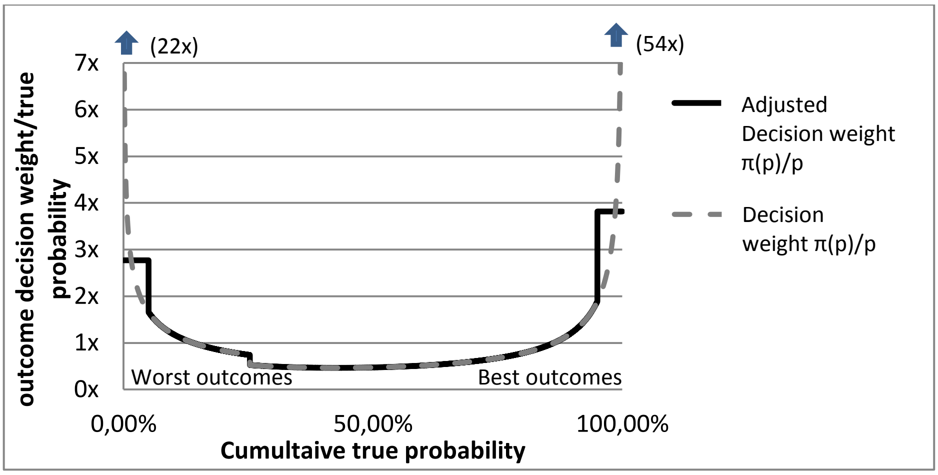

Figure 10 Over- and under weighing of outcome probability as a function of cumulative true probability[18]. The distribution of negative (~25%) and positive outcomes (75%) based on one year returns on MSCI World (Cumulative probability ≈ rank of outcomes from worst to best)

In the base case scenario I will adjust the decision weights for the tail outcomes (5%>p>95%) using equation 9. It assigns the average decision weight between 0 and 5% (and 95-100%) to each outcome in this interval. This method mediates the impacts of decision weighing by reducing the weight of the most extreme outcomes. Benartzi and Thaler (1995) in a similar test solved the same problem by grouping stock returns and thus eliminating the extremely small probabilities assigned to individual outcomes. This method is not perfect because the expected value of the prospect utility function v(x) is not equal to the utility of the expected outcome x: E(v(x))≠v(E(x)). The difference though is very small for any sample size that doesn't combine positive and negative outcomes.

$$\pi(p=0-5\%)=\frac{\pi(p=5\%)}{N(p=0-5\%)}=\frac{\sum_{i=0-1\%}\pi(p_i)}{N(p=0-5\%)}$$

Equation 9 Probability weighing of tail small probabilities

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[17] Individual with prospect utility preferences. For a risk neutral individual the value of the gamble would be 54€

[18] The non-symmetry and the jump at around 25% in the cumulative distribution is caused by the return distribution going from negative to positive

Reference point

As utility in prospect theory is defined over gains and losses, we need to define a comparable reference level. I have assumed that level to be the purchase price of an instrument. This is commonly the assumption when using prospect theory (Benartzi & Thaler 1995, et al.). Returns are also calculated in nominal dollars, rather than deflated returns. This assumption is based on stock, bond and mutual fund returns being mostly reported in nominal terms, secondly Benartzi and Thaler (1995) noted that if investors considered real returns most US treasury instruments would yield negative prospect utilities.

Certainty equivalent return

All results will be displayed as certainty equivalent returns, meaning a level of risk free return that would produce the same utility as the instrument in question. The calculation is fairly straightforward; it is basically the reverse of a utility calculation.

$$R_f = \begin{matrix} U(I)^{1/0,88} \\ -1/2,25(-U(I))^{1/0,88} \end{matrix} \; if \; \begin{matrix} U(I) \geq 0 \\ U(I) < 0 \end{matrix}$$

Equation 10 Certainty equivelant return as function of prospect utility

4.2.1 Excepted Utility calculation

To evaluate the expected utility implications of SPs I will use a consumption based model. As the constantly concave form of the utility of wealth is derived from the decreasing marginal utility of consumption, it is only reasonable to base the utility calculation on stock returns correlations with realized consumption.

The consumption correlation figures are based on Mehra and Prescott's (1985) research into the puzzling nature of the equity premium. This data is supplemented by Mankiw & Zeldes' (1991) study into the difference of consumption between stockholders and non-stockholders. They found that the correlation between consumption and stock returns is approximately 3 times higher with stockholders than with the entire population. Unfortunately the data they used in their opinion underestimated the overall level of correlation. They suggested using Mehra & Prescott's data (US consumption growth in non-durables and services and S&P 500 returns) and adjusting (Adj. term in the bellow equation) for difference in consumption patterns. This method was suggested to explain the large size of the equity premium, so it is likely the highest plausible figure to explain as much of the premium as possible.[19]

$$E(R_s) - E(R_f) = A \times corr(R_s - R_f, GC) \times \sigma(GC) \times \sigma(R_s - R_f) \times Adj.$$

Equation 11 Consumption CAPM

From the consumption CAPM we can derive the certainty equivalent return of any instrument. We can note that since in my simulation the correlation between risk free return (Rf) and stock return (Rs) is 0, we can reduce the model to the following form.

$$E(R_f) = E(R_s) - A \times corr(R_f, GC) \times \sigma(GC) \times \sigma(R_f) \times Adj.$$

Equation 12 Certainty equivalent return

Mehra and Prescott calculated the values for consumption (GC) and stock return correlation; 0,40 and standard deviation of consumption; 0,036. The risk aversion parameter A is usually assumed to be between 1 and 2 (Mankiw & Zeldes' 1991). I have used 1,5 for A in this study.

4.3 Test instruments

The structured products in my test are linked to the MSCI World index. They are priced using the Black-Scholes model, with volatility and risk free rate defined by US Treasury bond returns and the volatility on MSCI World. Since I will be partly using actual data, that isn't necessarily fully normally distributed, there is a risk that the Black & Scholes formula will not work properly[20]. To control for this I will compare the mean return and volatility of a bond-stock portfolio, with the same Stock-bond weight as the synthetic weights of the SP in question to make sure the SP doesn't dominate the two fund portfolio in terms mean return and variance.

4.3.1 Reference two-fund portfolios

The optimal two fund portfolio is constructed by combining shares in the MSCI World index with US treasury bonds with a maturity equal to the time period for which returns are calculated. The bond and stock weights are estimated by maximizing the decision weighted prospect utility score of the portfolio. The composition of the optimal portfolio constantly

[20] One could of course use actual option prices. This would likely present even bigger problems as options have to be priced based on some estimate of future volatility, whereas valuing them myself allows me to use realized volatility, which would provide perfectly correct prices if the assumptions on Black & Scholes hold.

changes with the parameters of the tests. The optimal portfolio is always maximizes the investors utility based on the preference structure and return distribution of the test in question. I will also compare the SP returns to a two-fund portfolio with stock and bond weights equal to a replicating portfolio. The portfolio is weighted using the Black and Scholes models implication that an option can be replicated using risk free instruments and the underlying asset.

4.3.2 Standard capital guaranteed SP

The vast majority of structured products sold to private investors in Finland are stock (index) linked capital guaranteed SPs. The structured product in my test will closely resemble these products. The SP is constructed by combining a single zero coupon US treasury bond with MSCI World index call options with a strike price equal to current price.

Firstly we standardize the MSCI world index values to start from 1 and the price of the SP (P_{PS}) to 1. We need to define the price of the zero coupon bond required to provide the capital guarantee at maturity (t). The price of the call option (P_C) on the MSCI world index with an exercise price (Ex) of 1 is set using Black & Scholes. Then we can define the amount of call options (C) that can be included in the SP. The amount of the options will then define the participation rate on the positive index returns.

$$P_{PS} = P_B + P_O \times \mathrm{C} = 1 \qquad P_B = \frac{1}{(1+\mathrm{R_B})^{\mathrm{t}}} \qquad C = \frac{P_{PS} - P_B}{\mathrm{P_C}(\mathrm{Ex}=1)}$$

Equation 13 SP pricing, Equation 14 Price of Zero coupon component, Equation 15 amount of call options in a SP

The return (R_{SP}), relative to purchase price, on the structured product is then calculated as the participation rate times the Index return (R_S) over gains and as zero for negative returns on the MSCI World.

$$R_{SP} = \begin{matrix} R_S \times C \\ 0 \end{matrix} \; if \; \begin{matrix} R_S \geq 0 \\ R_S < 0 \end{matrix}$$

Equation 16 Return on SP

4.3.3 Optimal structured product

I will also test what is the utility maximizing payment structure for an investor with prospect utility preferences. This test will be conducted to find out whether more exotic payment structures can significantly increase an investors utility. The optimal structured product will be constructed by buying and selling call options (C), put options (PO) and zero coupon bonds (B) that as a portfolio maximize the utility of the investor, considering the underlying index return distributions and a budget constraint.

$$MAX(U(I)) = \sum \pi(p_i)v(x_i)$$

Equation 17 Utility Maximization target

$$P_{PS} = \sum (P_{C_i} \times \mathrm{C}_i) + \sum (P_{PO_i} \times \mathrm{PO}_i) + B * P_B = 1$$

Equation 18 Budget constraint

The optimization will be conducted by solving for 20 different call option and put option amounts and exercise prices, with a budget constraint of 1 and a utility maximization as target. The structure is not fully optimal as the amount of options would need to be equal to sample size, which would at the same time make the option valuation biased as I am using a discreet return distribution, which would allow targeting specific outcomes, while providing zero return for discontinuous parts of the distributions (between returns). But this won't be problem as the aim is to find a general form for the optimal product and see if there is significant utility addition potential and not to create the perfect product.

4.4 Test parameters

Impact of volatility, mean stock and bond returns

We cannot know for certain whether the past 40 years returns are a true representation of future returns and risk level. The MSCI World might not be a true representation of the potential stock portfolio available to investors. This is supported by for example a strong bias towards stocks in the home market (Tesar & Werner 1995, Coval & Moskowitz 1999 et al). There is also speculation that future risk premiums are likely to smaller than in the past (Fama & French 2002 & Blanchard 1993). Due to these concerns I will vary the return level and volatility while holding the other constant. Modifying volatility with holding mean return constant is done by multiplying every return outcome (x_i) in the sample with a volatility multiplier (v) and adding a constant $\bar{x}$(1-v). Mean return is varied by simply adding a constant to every value in the sample.

$$v\sigma = \sqrt{1/(n-1)\sum (x_i \times v + \bar{x}(1-v) - \bar{x})^2}$$

Equation 19 Volatility transformation

$$\bar{x} = 1/n \sum (x_i v + \bar{x}(1-v)) = 1/n \sum x_i$$

Equation 20 Expected return

Impact on myopia

As previously explained, there are some indications pointing to SPs increasing investors' evaluation periods. I will test what impact this will have on certainty equivalent returns by lengthening the SPs investment period while holding the comparable bond-stock portfolios horizon constant. Furthermore I will also test how changing the evaluation periods for both SPs and conventional portfolios will have on utility scores. The time intervals tested will range from 1 to 5 years.

Decision weighing

As previously explained subjective probability weighing (using decision weights instead of true probability) is a well-documented fact in research. It is still debatable whether this only represents revealed rather than true preferences. Because of this I will apply subjective decision weights to portfolio selection and optimization, but I will also test the impact of real probabilities defining true preferences by only applying the value function V(x) to utility calculations.

Loss aversion

Like probability weighing, investor loss aversion is also supported by volumes of research. The degree to which people exhibit loss aversion is still likely to vary, so I will also test the impact of changing the loss aversion parameter λ.

5 Test and Results

In the Base case scenario, with an evaluation period of one year, bond returns based on 1y US-Treasury bond returns and stock returns matching the simulated stock returns[21]. Using structured products can significantly increase the decision weighted prospect utility of an investor. At the same time we notice that the utility increase is almost entirely dependent on decision weighing being part of the investors true preferences. In a situation where decision weighing only represents revealed preferences (actions), the existence of SPs will not significantly add utility to either investors with prospect utility or expected utility as true preferences. In the following sections I will present the factors driving these results and test the impact of changing the assumptions underlying these results.

[21] Bond return: 6,2%, Stock return: 10,9%, Stock volatility 16,7%

	Capital Protected SP	Synthetic SP	Optimal Two fund
Decision weighted utility	9,9 %	7,3 %	7,5 %
Value function only	7,3 %	7,2 %	7,2 %
Expected utility	7,4 %	7,7 %	7,2 %
Stock allocation		40 %	26 %
Portfolio Return	7,9 %	8,1 %	7,4 %
Standard deviation	8,1 %	6,7 %	4,3 %
Sharpe ratio	20,1 %	27,2 %	27,2 %

Table 3 Utility in certainty equivalent terms. Synthetic SP refers to a stock-bond portfolio with weights equal to the synthetic weights' of the capital protected SP

5.1 Utility curve

In the MSCI World stock return sample the decision weighing function rather than the prospect utility function defines risk aversion. As can be seen from figure 11 the S shape of the value function, v(x), is reversed when subjective decision weights are applied producing risk aversion in the domain of losses and risk seeking in gains. This implies that if the individual is protected from losses he will try to maximize both return and volatility, thus preferring to maximize upside risks.

The following figure (11) depicts the form of utility function with the parameters estimated by Tversky and Kahneman combined with a distribution of returns based on a simulated set of 10 000 one year returns (simulations based on MSCI World monthly returns). As the figure shows, the impact of decision weighing is so strong as transform the utility function to produce risk aversion in losses an risk seeking in gains. Due to decision weighing the utility curve for any distribution is unique, but the general form is likely to be very similar for any expected stock return series.

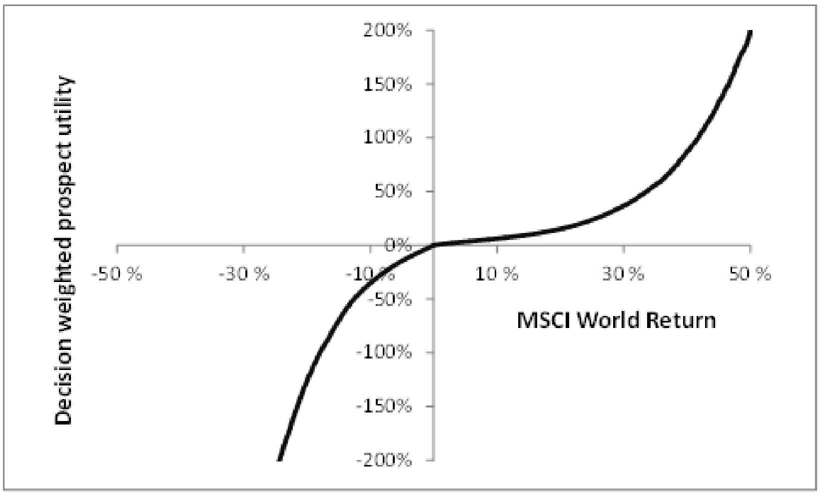

Figure 11 Decision weighted prospect utility as a function of portfolio return U=π(p)v(x). Distribution of returns (x) based on a simulated sample of 10 000 one year returns drawn from monthly MSCI World returns

This form has in some previous research been suggested as the general form of the utility function. Levy and Levy (2002) argue that since the tests of prospect theory are mostly based on a possibility of only one sided outcomes and since this isn't how most problems in real life exist, it should be tested whether this had any effect on the results. Based on their data they concluded that the prospect theory was "much ado about nothing". Based on their findings one was to assume that the true form of the utility curve was a reverse S shape (like the one above) proposed by Markowitz in 1952.

Wakker (2003) showed that the error in Levy and Levy's analysis is that they neglect to disentangle the weighting function from the prospect value function. When Wakker accounted for the decision weights being different than the actual probabilities of the outcomes he found that Levy and Levy's data actually supported the prospect theory. The reverse-S shape curve only applied to the specific sample. As explained earlier the decision weight depends on the rank of the outcome whereas the impact of the value function depends on the magnitude of the outcome as a consequence the shape of the curve depends on the distribution of the returns.

5.2 Impact of varying prospect utility parameters

5.2.1 Value function

When we vary the parameters in the prospect utility function we can see that there is an impact on expected preference towards SPs. When we use a linear value function, with 1 as exponents instead of 0,88, we notice that risk aversion decreases and the optimal share allocated in stocks increases, for maturities longer than one year the preference towards SPs decreases significantly. Less loss averse individuals (π=1,5) are also unlikely to gain any utility from products with a maturity beyond 1 year, the utility decreases is so great that even the one year products might not be preferred after costs. We can also notice that even before costs SPs for all maturities would be utility decreasing in terms of true probability weighted prospect value. One the other hand a higher loss aversion level could explain preference towards SPs even for five year maturities.

Maturity	1y	2y	3y	4y	5y	1y	2y	3y	4y	5y
Prospect utility parameters	Standard					Linear utility of wealth. Loss aversion: 2,25				
Prospect utility addition (decision weighted)	2,4 %	1,9 %	0,9 %	0,4 %	0,1 %	2,5 %	0,8 %	0,1 %	-0,2 %	-0,3 %
Prospect utility addition (true probabilities)	0,2 %	-0,1 %	-0,5 %	-0,6 %	-0,6 %	0,1 %	-0,8 %	-0,8 %	-0,8 %	-0,7 %
Expected utility addition	0,2 %	-0,9 %	-1,4 %	-1,1 %	-0,9 %	-0,7 %	-1,8 %	-1,4 %	-1,1 %	-0,9 %
Stock allocation in optimal Portfolio	26 %	75 %	100 %	100 %	100 %	51 %	100 %	100 %	100 %	100 %
Prospect utility parameters	Loss aversion: 1,5					Loss aversion: 3				
Prospect utility addition (decision weighted)	0,8 %	0,1 %	-0,2 %	-0,3 %	-0,4 %	2,5 %	2,2 %	1,8 %	1,1 %	0,6 %
Prospect utility addition (true probabilities)	-0,9 %	-1,1 %	-1,0 %	-0,8 %	-0,7 %	0,2 %	0,4 %	0,2 %	-0,3 %	-0,4 %
Expected utility addition	-2,4 %	-1,8 %	-1,4 %	-1,1 %	-0,9 %	0,3 %	0,4 %	0,0 %	-1,1 %	-0,9 %
Stock allocation in optimal portfolio	100 %	100 %	100 %	100 %	100 %	23 %	40 %	61 %	100 %	100 %

Table 4 Utility addition from using SPs compared to optimal portfolio. (Linear utility of wealth refers to value function outcomes having an exponent of 1 instead of 0,88. “Standard” refers to the function parameters estimated by Kahneman and Tversky.)

5.2.2 Probability weighing

To test the impact of the probability weight adjustment for small and large cumulative probabilities (5%>P>95%) I also ran the simulation using the unadjusted weights. Table 5 shows that the unadjusted decision weighted prospect utility increase from using SPs is higher than the increase with the adjusted form. So we can conclude that the preference for SPs for shorter maturities should exist regardless of the adjustment. If we on the other hand use true probabilities we notice that the standard capital protected product is after costs in all cases utility decreasing. So we can note that the usefulness of SPs is largely dependent on decision weighing.

Time frame	1y	2y	3y	4y	5y
	Decision weighted				
Optimal stock allocation	26 %	75 %	100 %	100 %	100 %
Prospect utility addition (decision weighted)	2,4 %	1,9 %	0,9 %	0,4 %	0,1 %
Prospect utility addition (true probability weighted)	0,2 %	-0,1 %	-0,5 %	-0,6 %	-0,6 %
Expected utility addition	0,2 %	-0,9 %	-1,4 %	-1,1 %	-0,9 %
	Decision weights (unadjusted)				
Optimal stock allocation	26 %	100 %	100 %	100 %	100 %
Prospect utility addition (decision weighted)	3,0 %	2,2 %	1,2 %	0,6 %	0,3 %
Prospect utility addition (true probability weighted)	0,2 %	-0,2 %	-0,5 %	-0,6 %	-0,6 %
Expected utility addition	0,2 %	-1,8 %	-1,4 %	-1,1 %	-0,9 %
	True probability				
Optimal stock allocation	35 %	100 %	100 %	100 %	100 %
Prospect utility addition	0,1 %	-0,2 %	-0,5 %	-0,6 %	-0,6 %
Expected utility addition	-0,1 %	-1,8 %	-1,4 %	-1,1 %	-0,9 %

Table 5 Impact of probability weighing. Certainty equivalent utility scores with preferences based on different probability estimates. Unadjusted decision weights refer to the adjustment in weights for outcomes >5% and <95%. (the adjusted form is used elsewhere in the paper).

Time frame	1Y	2Y	3Y	4Y	5Y
Stock allocation (Optimal Portfolio)	26 %	75 %	100 %	100 %	100 %
Stock allocation (SP)	40 %	55 %	65 %	72 %	77 %
Anualized return (two fund p.)	7,4 %	9,8 %	10,9 %	10,9 %	10,9 %
Difference expected return	0,4 %	-1,0 %	-1,5 %	-1,2 %	-0,9 %
Difference in prospect value	0,2 %	-0,1 %	-0,5 %	-0,6 %	-0,6 %
-"- in Decision weighted utility	2,4 %	1,9 %	0,9 %	0,4 %	0,1 %
Impact of expected return difference	0,4 %	-1,0 %	-1,5 %	-1,2 %	-0,9 %
Impact of aplying value function	-0,3 %	0,9 %	1,0 %	0,6 %	0,4 %
Impact of uplying decision weights	2,2 %	2,0 %	1,4 %	0,9 %	0,6 %

Table 6 Sources of utility addition from using the capital protect SP compared to optimal two fund portfolio (For illustrative purposes, the three factors contribution is interconnected so that when we remove one factor it will impact the others). Impact of expected return = return differential between optimal portfolio and SP, Impact of value function= difference between the expected return difference and prospective value difference, Impact of decision weight = difference between the prospect value difference and decision weighted utility difference

The previous table (6) illustrates the impact of different factors on the utility increase form SPs. We can notice that there is significant difference in the impact of the different factor between two and three years due to the optimal portfolio having 100% stock weight. For maturities longer than two years we see that the factors start converging due to the increasing synthetic stock weight of the SP and the decreasing portion of negative stock returns for the longer maturities. The decrease from utility based on the value function for the one year period is due to the fact that the optimal stock portfolio almost never produces negative returns (~3%) and the average negative return is very small (~1,5%) at the same time it has less upside volatility. Overall for longer maturities with larger optimal stock allocations return difference is the main factor decreasing the utility increase from SPs, with the prospect value assigning function and decision weighing countering this effect (decision weighing being the dominant factor of utility increase).

5.3 Optimal Two fund portfolio

In the Base case scenario the optimal portfolio consists of 26% in stocks and 74% in Bonds. With most feasible interest rate, stock volatility and return scenarios, stock allocation should settle at around 5-30%. Still if we significantly decrease interest rates or volatility or increase stock returns or maturity, the optimal stock allocation will jump to 100%. The graph 13 shows how increasing the equity premium makes the certainty equivalent return curve strictly increasing between allocations of 0-100% and thus the optimal allocation will jump to the upper limit of 100%. These results are well in line with Arjan Berkelaar and Roy Kouwenberg's (2002) results in their study of stock allocation of loss averse investors.

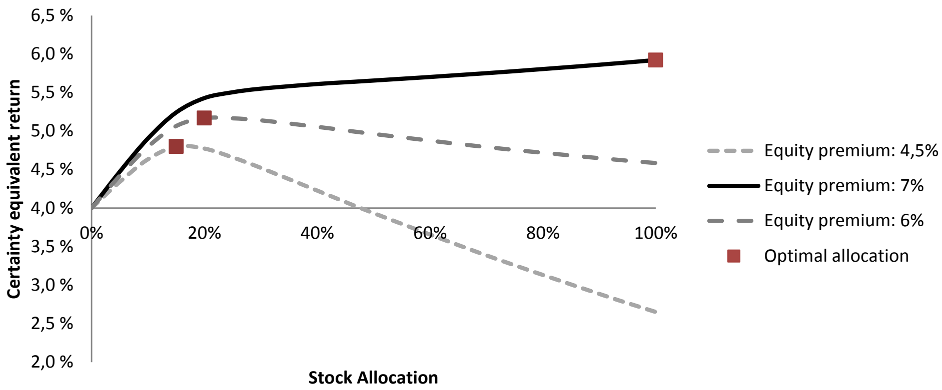

Figure 12 Certainty equivalent returns (utility) with different stock allocations (at 4% risk free rate)[22]

Increasing interest rates while at the same time increasing stock returns (~high inflation) induces prospect utility investors to increase their allocation in the risky asset as the likelihood of getting negative returns drops. The same effect was noticed by Thaler, Tversky, Kahneman, and Schwartz's (1997) empirically. They noticed that the test subjects increased allocation in the risky asset when both the risk free rate and the risky return were increased due to high inflation. Increasing only stock returns strictly increases allocation in stocks, whereas higher bond yields can both increase or decrease allocation in stocks. This is due to

[22] The reason why the certainty equivalent return curves at around 20% is due to the amount of negative portfolio returns increasing significantly around that level. At the same time the magnitude of negative returns increases somewhat linearly in relation to stock allocation.

higher interest rates increasing the appeal of bonds, while at the same time making them a better hedge against negative stock returns, so that less are needed to keep portfolio returns positive. We can also note that the synthetic stock allocation for the SP changes faster than the stock allocation for the optimal portfolio when interest rates are varied.[23]

Optimal portfolio Stock allocation							Capital protected SP synthetic stock allocation
	Stock return						
Interest rate		6,0 %	7,0 %	8,0 %	9,0 %	10,0 %	11,0 %	
	1,5 %	6,3 %	7,2 %					11,5 %
	2,5 %	9,2 %	10,5 %	12,1 %				18,5 %
	3,5 %		11,3 %	14,6 %	16,8 %			24,9 %
	4,5 %			16,4 %	18,8 %	21,7 %		30,9 %
	5,5 %				20,1 %	23,0 %	26,5 %	36,4 %
	6,5 %					23,8 %	27,2 %	41,5 %

Table 7 Stock allocation at different interest rate and stock return levels. The average stock return is varied by subtracting (adding) a constant from each sample return.

5.4 Impact of interest rates, mean stock returns and volatility

Interest rates and mean stock returns

To test the impact of different levels of expected stock and bond return I varied the return distribution by increasing a constant to every return and also varied the level of the risk free rate. As we deflated the bond and stock returns from the historical (high) levels the capital protected product becomes less appealing. Both bond and stock returns have a positive correlation with utility addition from using a capital protected SP.[24]

With increased interest rates it becomes cheaper and cheaper to produce the capital protection, thus allowing a larger stock position without the possibility of incurring losses. The capital protected products synthetic stock weight increases faster than the stock weight for the optimal two-fund portfolio. Due to risk seeking in the positive domain, caused by decision weighing, the increase in volatility for a capital protected product is strictly utility increasing.

[23] Synthetic stock allocation is not dependent on expected mean return, only on the risk free rate, volatility and exercise price of the option component.
[24] The same pattern continues when stock and bond returns are increased from the levels in table 7

Prospect utility (decision weighted)

Interest rate	Stock return: 6,0%	7,0%	8,0%	9,0%	10,0%	11,0%
1,5%	2,7%	2,9%				
2,5%	4,2%	4,4%	4,6%			
3,5%		5,5%	6,0%	6,2%		
4,5%			7,1%	7,5%	7,8%	
5,5%				8,5%	8,9%	9,3%
6,5%					9,8%	10,2%

Prospect utility addition (decision weighted)

Interest rate	Stock return: 6,0%	7,0%	8,0%	9,0%	10,0%	11,0%
1,5%	0,9%	1,0%				
2,5%	1,3%	1,4%	1,5%			
3,5%		1,6%	1,8%	1,8%		
4,5%			1,9%	2,1%	2,1%	
5,5%				2,1%	2,3%	2,3%
6,5%					2,3%	2,4%

Table 8 Capital protected SP Prospect utility and utility increase compared with optimal two fund portfolio (utility addition=Difference in certainty equivalent returns between the SP and the optimal portfolio)

Based on the increase in decision weighted utility being between 1% to 2% in certainty equivalent return terms, there should be a preference towards these products even after costs. On the other hand the capital protected SP is only preferable over the optimal portfolio if the individual has decision weighing as part of his true preferences. Table (9) shows that while the using the SP would increase utility in prospect utility terms, weighted with true probabilities the increase is too small to cover costs. At any feasible combination of expected interest rates and stock returns (table 9) the utility increase (0,1-0,3%) would be much smaller than the costs of buying a SP (0,6-1,2% annually).

Prospect utility addition (true probability weighted)

Interest rate \ Stock return: 0,0%	6,0%	7,0%	8,0%	9,0%	10,0%	11,0%
1,5%	0,1%	0,1%				
2,5%	0,1%	0,2%	0,2%			
3,5%		0,0%	0,2%	0,2%		
4,5%			0,1%	0,2%	0,3%	
5,5%				0,0%	0,2%	0,2%
6,5%					0,0%	0,1%

Expected utility addition

Interest rate	Stock return: 6,0%	7,0%	8,0%	9,0%	10,0%	11,0%
1,5%	0,1%	0,2%				
2,5%	0,1%	0,2%	0,2%			
3,5%		0,1%	0,2%	0,3%		
4,5%			0,2%	0,2%	0,3%	
5,5%				0,2%	0,2%	0,2%
6,5%					0,1%	0,2%

Table 9 True probability weighted prospect utility and expected utility increase from using SPs (utility addition=Difference in certainty equivalent returns between the SP and the optimal portfolio)

Volatility

Increasing or decreasing volatility has very little impact on the capital protected SP in terms of prospect utility, whereas increasing volatility increases the amount of negative outcomes, which has a more marked impact on the optimal portfolio. All in all volatility should not have a large impact on the preference towards SPs, as the SPs decision weighted certainty equivalent return stays clearly above the optimal portfolio (figure 13). Neither can increasing volatility make SPs utility increasing when true probabilities are applied.

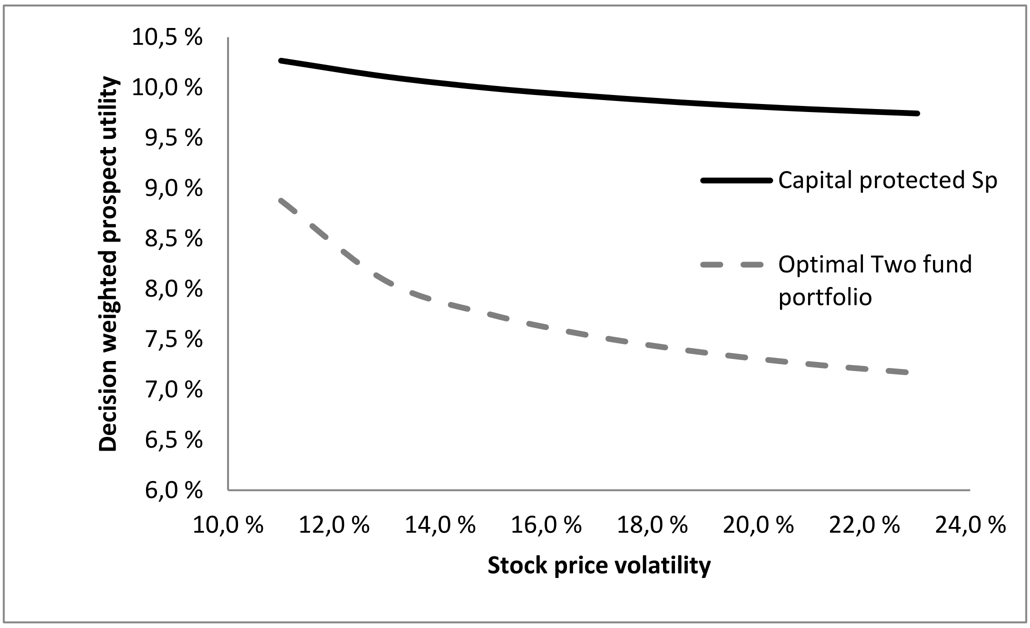

Figure 13 Prospect utility as a function of volatility

STDV	11 %	13 %	15 %	17 %	19 %	21 %	23 %
Stock allocation in optimal portfolio	100 %	43 %	32 %	26 %	21 %	18 %	16 %
Optimal portfolio prospect utility	8,9 %	8,1 %	7,7 %	7,5 %	7,4 %	7,3 %	7,2 %
Capital protected prospect utility	10,3 %	10,1 %	10,0 %	9,9 %	9,8 %	9,8 %	9,7 %
Difference in prospect utility	1,4 %	2,0 %	2,3 %	2,4 %	2,5 %	2,5 %	2,6 %
Difference in prospect utility (true probabilities)	-1,9 %	0,0 %	0,2 %	0,2 %	0,2 %	0,2 %	0,2 %
Expected utility	-0,6 %	0,1 %	0,2 %	0,1 %	0,1 %	0,0 %	0,0 %

Table 10 Stock price volatility's impact on utility differences between the optimal portfolio and a capital protected product

5.5 Simulated data vs. realized returns

There are major differences in the simulated data sets compared to the realized MSCI world returns over the past 40 years. Figure 14 shows the how the realized returns differ from the simulated, normally distributed returns. The realized returns have the highest frequency between average (~11%) and +20%, the negative tail is also clearly “fat”, which could have serious consequences in a prospect utility environment. Table 11 shows how there is a huge difference in especially the lowest 5% of returns, which are weighted more heavily due to decision weighing and loss aversion.

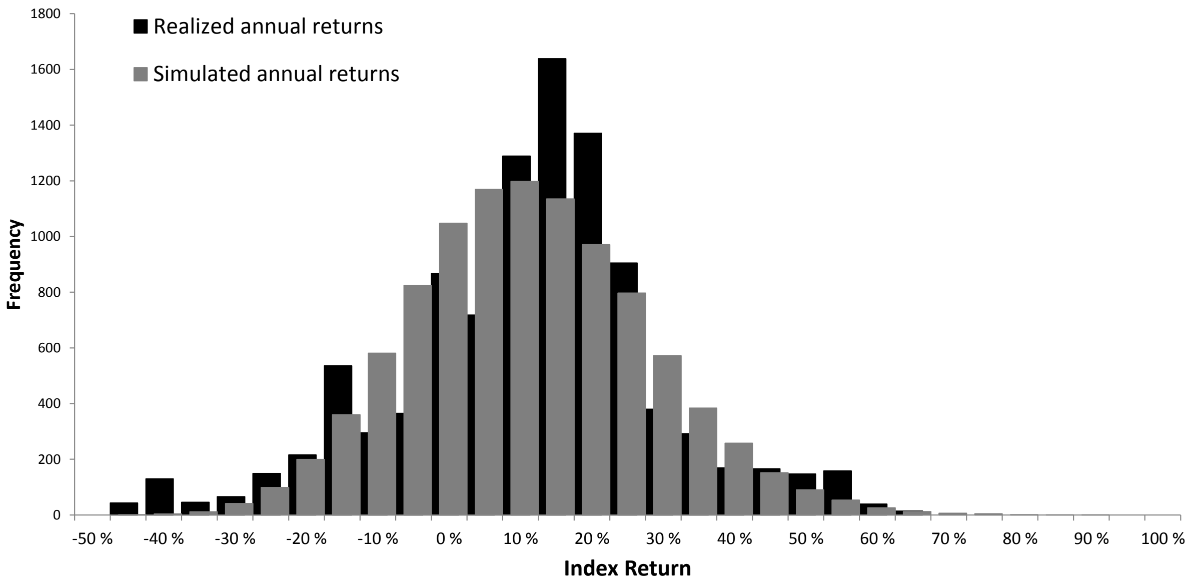

Figure 14 One year index return distribution (grouping: +/-2,5%)

The large difference in total returns with the 5 year evaluation period is due to the lower weight given to the first and last five years in the time horizon. With the nested returns, the last and first 60 months appear less frequently in realized returns. in the five year returns the first (and last) 59 months appear 1-59 times (first return appears ones and the 59th 59 times)

		1Y	2Y	3Y	4Y	5Y
Realized	Total Return	11 %	24 %	38 %	55 %	56 %
	STDV	18 %	30 %	42 %	55 %	54 %
	Average return in lowest 5%	-31 %	-36 %	-33 %	-23 %	-23 %
	Average return in highest 5%	51 %	104 %	147 %	197 %	195 %
Simulated	Total Return	11 %	23 %	36 %	51 %	68 %
	STDV	17 %	26 %	36 %	46 %	58 %
	Average return in lowest 5%	-21 %	-24 %	-25 %	-24 %	-23 %
	Average return in highest 5%	48 %	83 %	122 %	164 %	214 %
Difference	Total Return	6 %	4 %	4 %	8 %	-17 %
	STDV	10 %	17 %	16 %	21 %	-6 %
	Average return in lowest 5%	49 %	48 %	30 %	-6 %	-2 %
	Average return in highest 5%	6 %	25 %	20 %	20 %	-9 %

Table 11 Comparison of the realized and simulated MSCI index return distributions (difference = Realized/simulated-1)

	1y	2y	3y	4y	5y
			Realized data		
Optimal stock allocation	16 %	31 %	100 %	100 %	100 %
Prospect utility addition (decision weighted)	3,1 %	2,7 %	1,9 %	1,2 %	0,6 %
Prospect utility addition (true probability weighted)	0,8 %	0,8 %	-0,1 %	-0,3 %	-0,4 %
Expected utility addition	0,8 %	0,8 %	-1,5 %	-1,2 %	-1,0 %
			Simulated data		
Optimal stock allocation	26 %	75 %	100 %	100 %	100 %
Prospect utility addition (decision weighted)	2,4 %	1,9 %	0,9 %	0,4 %	0,1 %
Prospect utility addition (true probability weighted)	0,2 %	-0,1 %	-0,5 %	-0,6 %	-0,6 %
Expected utility addition	0,2 %	-0,9 %	-1,4 %	-1,1 %	-0,9 %
			Difference		
Prospect utility addition (decision weighted)	0,7 %	0,8 %	1,0 %	0,8 %	0,5 %
Prospect utility addition (true probability weighted)	0,6 %	0,9 %	0,4 %	0,3 %	0,2 %
Expected utility addition	0,6 %	1,7 %	-0,1 %	-0,1 %	-0,1 %

Table 12 differences in certainty equivalent utility scores between simulated and realized data (difference = Realized– simulated, utility addition=increase of utility from using SPs compared to optimal portfolio)

From table 12 we can see that there are significant differences in utility scores. The biggest difference is in the two year evaluation period, where we can see that the allocation in the risky asset differs by ~44%. This difference is likely due to the fat tail in negative returns combined with "over" estimated probability of tail events and loss aversion, producing a high disutility, making the actual distribution more risky in a prospect utility framework. Furthermore for 1 and 2 year evaluation periods the expected and true probability weighted prospect utilities increase enough to possibly cover the structuring costs. For the longer maturities comparison between the simulated and realized data sets is harder as due to lesser frequency of appearance of recent returns.

5.6 Impact of myopia – Varying maturity

Most structured products offered to individual investors in Finland mature in five years, yet at five year maturity/evaluation period there seems to be no utility addition from using SPs. Furthermore evaluation periods are usually assumed to be around one to two years (Benartzi and Thaler 1995), which would make using five year SPs even less rational as the product is not capital guaranteed before maturity and usually there is a significant premium for cashing in SPs before maturity.

	1y	2y	3y	4y	5y
	Capital Protected SP				
Prospect utility (decision weighted)	9,4 %	10,3 %	10,9 %	11,2 %	11,6 %
Prospect utility (true probability weighted)	6,9 %	8,0 %	8,6 %	9,1 %	9,4 %
Expected utility	7,0 %	8,0 %	8,6 %	9,0 %	9,3 %
	Optimal Two fund portfolio				
Prospect utility (decision weighted)	7,3 %	8,9 %	10,3 %	11,1 %	11,7 %
Prospect utility (true probability weighted)	6,9 %	8,6 %	9,4 %	9,9 %	10,2 %
Expected utility	6,8 %	10,2 %	10,3 %	10,3 %	10,4 %
	Difference				
Prospect utility (decision weighted)	2,1 %	1,4 %	0,6 %	0,1 %	-0,1 %
Prospect utility (true probability weighted)	0,0 %	-0,6 %	-0,8 %	-0,8 %	-0,7 %
Expected utility	0,1 %	-2,2 %	-1,7 %	-1,3 %	-1,1 %

Table 13 SP and optimal two fund portfolio utilities in certainty equivalent return terms (difference= SP utility – Two fund utility)

There is some evidence showing that using SPs could in fact lengthen the investment horizon of an investor. Table 14 shows that if using SPs can significantly increase the evaluation period beyond one year, there could be a significant utility increase based on either expected or prospect utility. A significant difference in evaluation periods between SPs and the optimal two fund portfolio should create a preference towards SPs based on decision weighted prospect utility (table 14).

Prospect utility (decision weighted)

Optimal portfolio	Capital Protected SP: 1y	2y	3y	4y	5y
1y	2,1 %	3,0 %	3,6 %	3,9 %	4,3 %
2y		1,4 %	2,0 %	2,3 %	2,7 %
3y			0,6 %	0,9 %	1,3 %
4y				0,1 %	0,4 %
5y					-0,1 %

Prospect utility (true probability weighted)

Optimal portfolio	Capital Protected SP: 1y	2y	3y	4y	5y
1y	0,0 %	1,1 %	1,7 %	2,2 %	2,5 %
2y		-0,6 %	0,0 %	0,5 %	0,8 %
3y			-0,8 %	-0,3 %	0,0 %
4y				-0,8 %	-0,5 %
5y					-0,7 %

Expected Utility

Optimal portfolio	Capital Protected SP: 1y	2y	3y	4y	5y
1y	0,1 %	1,2 %	1,8 %	2,2 %	2,5 %
2y		-2,2 %	-1,6 %	-1,2 %	-0,8 %
3y			-1,7 %	-1,3 %	-0,9 %
4y				-1,3 %	-1,0 %
5y					-1,1 %

Table 14 Utility addition from SPs lengthening evaluation period. The vales are the certainty equivalent return differences between the SP and the optimal two fund portfolio, when different evaluation periods are applied to the products. The years are the evaluation periods applied to the product in question.

On the other hand even if SPs do not lengthen investors' evaluation periods, a 5 year product could still be optimal for an investor who retains a one year evaluation period. The theoretical expected minimal annualized utility increase from an **optimal** 5 year product for an investor with one year evaluation period would still be at least the same as the gain from an **optimal** one year product. The product would simply have to have an annual return lock feature, meaning that once a year the return would be calculated and set to the level that an investment in a one year product would have offered and the capital guarantee level for the next year is set at this level. This kind of product would be exactly the same as making a contract to buy/sell five consecutive SPs. There actually is a similar class of SPs that is somewhat common, they are called return lock products, but rather than locking in any positive returns annually, they usually lock returns at certain thresholds (e.g. +20%, 30% and +50%).

5.7 Structured products as part of a larger portfolio

This far I have made the assumption that SPs make up potential investors entire portfolio. In reality most SP investors have a wide portfolio of products in various assets. Figure 15 shows how adding SPs to an optimal portfolio impacts the utility of an investor in terms of certainty equivalent returns. We can see that utility increases in a linear fashion relative to the portfolio weight of the SP. This leads us to conclude that the relative usefulness compared to portfolio weight is somewhat constant, or at least positive in the case of true probability weighted prospect utility. So the share of SPs in one's portfolio is not a big factor in determining their usefulness, meaning that the previous conclusions hold even if investors have other instruments in their portfolio.

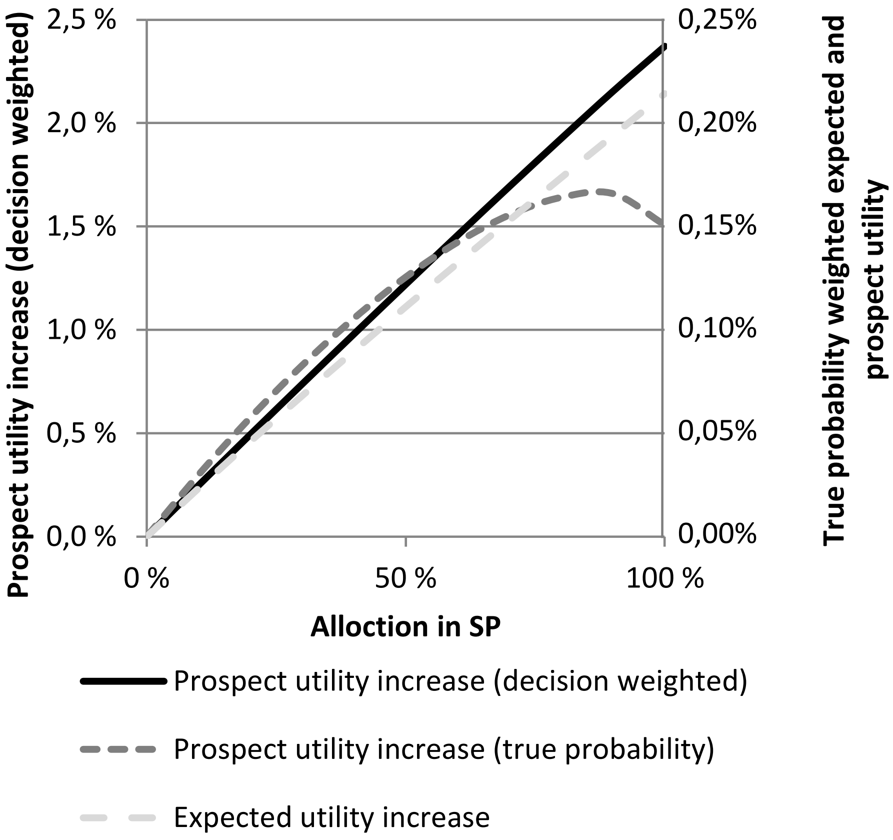

Figure 15 Utility increase from adding a Capital protected SP to an optimal bond-stock portfolio.

5.8 Robustness of simulation results

The simulated dataset is not fully normally distributed, which could imply that the Black & Scholes formula used to price options might produce biased estimates. To study whether the utility addition from using SPs is caused by mispricing of the SPs option component I compared the expected return of the SP with a replicating two fund portfolio. As table 15 shows the difference is either insignificantly small or negative. So we can conclude that option mispricing plays no part in making Capital protected SPs preferable.

	SP return difference with replicating portfolio				
Realized data	0,03 %	0,09 %	0,07 %	0,06 %	0,01 %
Simulated data	-0,20 %	-0,12 %	-0,08 %	-0,08 %	-0,09 %

Table 15 Difference in expected returns between the capital protected standard SP and a replicating two fund portfolio with synthetic stock and bonds weights equal to the SP (difference = annual SP return less replicating portfolio return)

To determine the expected stock return distribution I simulated 10 000 years of returns. To see whether this sample was big enough not to cause any bias in expected certainty equivalent returns, I also tried rerunning the expected stock return simulations to see if there would be a significant impact. The difference in terms of expected returns was around +/-0,15% between the highest and lowest returns. But since the difference in stock weight between the Capital protected SP and the optimal two fund portfolio was around 14 percentage points the utility impact of rerunning the simulations was insignificant (+/-0,02%).

5.9 Optimal structured product

These results for the “optimal structured products are only indicative of the general form the optimal payment structure. This is due to the possibility of the B&S formula producing biased estimates for the out of the money options used to construct the SP.

Due to decision weighing an individual with prospect theory preferences with future expectations matching the past 40 year data set, will be risk seeking in the positive domain (as shown in Figure 11). *This means that with a full capital protection an option component that maximizes return and volatility will maximize utility*. Increasing the synthetic stock weight of a portfolio should, with a normally distributed returns, strictly increase expected return and volatility. Thus in theory, increasing the synthetic stock weight by buying call options that are as out of the money as possible, will strictly increase utility without any upper limit.[25] [26]

$$\begin{matrix} \lim_{w \to \infty} w r_s + (1-w) r_f = \infty \\ \lim_{w \to \infty} w \sigma_s + (1-w) \times 0 = \infty \end{matrix} \longrightarrow \lim_{w \to \infty} V(x)\pi(p) = \infty$$

Equation 21 Utility impact of increasing synthetic stock weight (w) for a capital guaranteed product

With the simulated dataset, increasing the 1 year maturity option component's strike price to +34% from +/-0%[27], will approximately double prospect utility in terms of certainty equivalent return. This again does not transfer to expected utility or prospect utility weighted with true probabilities, actually the reverse applies.

It is somewhat unclear whether using this simulated dataset biases the black & Scholes valuation of out of the money options[28]. What we can see from table 17 is that the "optimal capital protected product is inferior in terms of expected returns and volatility compared to the standard capital protected SP. The expected return should be higher, since it has a higher synthetic stock weight, but it is considerable lower. The replicating portfolio for the optimal capital protected product has around 3% points higher returns, which indicates that the options may be overpriced, which would indicate that the preference towards out of the money call options should be even stronger. If the price of the option component was set at a level that would offer the same expected return as the replicating portfolio, the certainty equivalent returns in all frameworks would significantly increase, but expected utility and true probability weighted prospect utility would still be below the optimal two fund portfolio levels.

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[25] With the obvious expectation that expected stock returns are higher than the risk free rate

[26] The goal being to increase the standard deviation of the product returns and not those of the underlying asset

[27] I also tested adding more options, including put options. The optimal product had a weight of zero in other options, including put options. The only restriction was that the participation rate (amount of options) had to increase with strike prices of call options (decreased for puts). This condition was in place to limit the targeting of small segments of the distribution that by chance had more outcomes.

[28] For at the money call options the replicating portfolio has almost identical total returns

Maturity	1y	2y	3y	4y	5y	1y	2y	3y	4y	5y
Product	Optimal Capital protected SP					Capital Protected				
Prospect utility (decision weighted)	18,6 %	21,3 %	24,2 %	25,1 %	26,6 %	9,9 %	10,7 %	11,2 %	11,5 %	11,8 %
Prospect utility (true probabilities)	4,5 %	5,6 %	6,3 %	7,2 %	8,3 %	7,3 %	8,4 %	8,9 %	9,3 %	9,6 %
Expected utility	4,7 %	5,9 %	6,4 %	7,4 %	8,5 %	7,4 %	8,4 %	8,9 %	9,3 %	9,5 %
Stike price	134	157	192	220	259	100	100	100	100	100
Product	Call option only					Optimal Two fund portfolio				
Prospect utility (decision weighted)	87,4 %	61,6 %	54,1 %	47,0 %	44,2 %	7,3 %	8,9 %	10,3 %	11,1 %	11,7 %
Prospect utility (true probabilities)	-55,1 %	-26,3 %	-16,1 %	-8,8 %	-4,3 %	6,9 %	8,6 %	9,4 %	9,9 %	10,2 %
Expected utility	-19,2 %	1,2 %	4,8 %	9,3 %	11,8 %	6,8 %	10,2 %	10,3 %	10,3 %	10,4 %
Stike price	134	157	192	220	259	-	-	-	-	-

Table 16 Utility of optimal SP and a call option only portolio

Maturity	1y	2y	3y	4y	5y	1y	2y	3y	4y	5y
Product	Optimal Capital protected SP					Capital Protected				
Total return	6,5 %	16,5 %	30,4 %	47,9 %	73,5 %	7,9 %	18,5 %	30,8 %	44,8 %	60,7 %
Annual return	6,5 %	8,0 %	9,3 %	10,3 %	11,6 %	7,9 %	8,9 %	9,4 %	9,7 %	10,0 %
Standard deviation	29,0 %	69,7 %	162,5 %	237,3 %	378,7 %	8,1 %	16,9 %	26,6 %	36,9 %	48,9 %
Sharpe	1,0 %	4,3 %	5,5 %	7,4 %	8,8 %	20,1 %	29,2 %	34,8 %	39,1 %	42,2 %
Product	Call option only					Optimal Two fund portfolio				
Total return	11,3 %	38,6 %	71,7 %	105,8 %	156,6 %	7,0 %	23,0 %	36,3 %	51,1 %	67,8 %
Annual return	11,3 %	17,7 %	19,7 %	19,8 %	20,7 %	7,0 %	10,9 %	10,9 %	10,9 %	10,9 %
Standard deviation	493,9 %	583,8 %	917,0 %	1019,4 %	1322,6 %	2,7 %	26,0 %	35,7 %	45,7 %	57,6 %
Sharpe	1,0 %	4,3 %	5,5 %	7,4 %	8,8 %	27,2 %	36,3 %	41,3 %	45,3 %	48,0 %

Table 17 Portfolio return and standard deviation

So for a capital protected product it is clearly utility maximizing to increase the synthetic stock weight, but is the capital protection itself always utility increasing? It doesn't seem like it. For a portfolio of only call options the decision weighted utility score is around 9 times higher than for the standard capital protected product. What makes this even more unrealistic is the fact that the certainty equivalent return for the call option only portfolio (prospect utility), is around 8 times higher than, its expected return. In other words you would be indifferent between a certain return of 87% and the extremely risky return of 11%.[29] This utility increase is due to out of the money options targeting the tail outcomes which have the highest decision weights. If we apply the decision weights directly to the returns we gain a subjectively weighted return of 294% as opposed to the expected return of 11%.[30] This kind of lottery behavior has been noticed in e.g. the pricing of close to bankruptcy stocks (Kumar 2009, et al.), which have very low returns in absolute terms, yet it is obviously not how portfolios are generally allocated.

[29] With a strike price of 100 (current index level) the simple call option provides 3-5% higher certainty equivalent returns in terms of decision weighted prospect utility. For longer (4-5 years) evaluation periods the call option only (strike price 100) also provides significantly higher expected utility and true probability weighted prospect utilities.

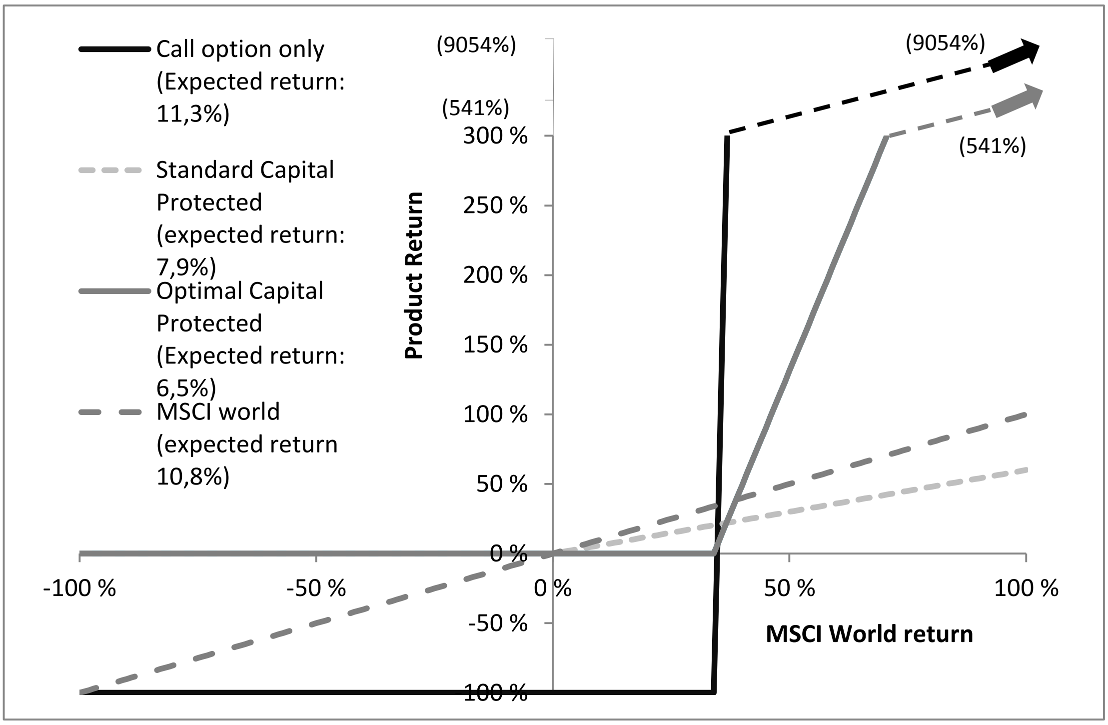

Figure 16 Optimal SP returns as a function of index return

5.10 Practitioner interviews

In the previous chapters I have studied the theoretical implications of nonlinear payment structures in terms of utility addition from using SPs. This chapter will try to broaden the perspective to understand whether the various behavioral biases and alternative preferences, discussed earlier, are visible in customer contact situations and in the planning and marketing of Structured Products. The aim is to understand the customers' underlying rational for investing in SPs and to evaluate how real customer behavior matches with the findings from the theoretical simulations.

To gain an insight in to the "real world" of structured products I interviewed three professionals involved in the design and marketing of SPs from FIM, United Bankers and Sampo Bank, all of which design and distribute SPs. To preserve the anonymity of interviewees, their standpoints on various topics are combined together. Next, we present the insights gained from the interviews.

5.10.1 Rationale for existence & origination process

Based on the interviews the rationale for origination of new structured products as agreed by all interviewees was firstly based on providing return profiles that would not be otherwise accessible. Almost all SPs sold by the institutions represented by the interviewees had a capital guarantee component. As agreed by all there, there exist two distinct groups of customers in terms of risk taking and rational for investing in capital protected SPs.The larger group invested in SPs based on the "Guarantee to get your investment back with a significant upside potential from participation in the stock market". *This is well in line with the theoretical findings showing that loss averse investors, who apply decision weights on potential outcomes, seek to minimize downside risks and while still seeking upside risks*[31].

The Second smaller, but significant, group used capital protected SPs to take large downside risks by using leverage to purchase SPs. Due to the capital guarantee component SPs receive a high collateral value allowing the use of significant leverage. The amount of leverage can amount to the same level as the zero coupon bond component of the SP, in a way they cancel each other out as you are loaning money to buy the bonds of the lender combined with options. So in the end you are actually only buying the option component. *This kind of behavior was actually predicted by the optimal structured product which due to the high impact of decision weighing was basically call option with a high strike price. For long evaluation periods (4-5 years) the call option with 100 strike price is also clearly superior in all utility frameworks compared with a two fund portfolio and a standard capital protected product. The issue with this type of investment is the "double" fee from the combination of structuring costs and the premium on the leverage used to buy the SP.*

The interviewees also agreed that providing access to markets and asset classes, like commodities, not accessible to retail investors in general or not covered by the existing portfolio offered by the distributor, was sometimes an important reason for the creation of SPs.

What the interviewees somewhat disagreed on was the use of structured products to access new profit opportunities for customers. One of the interviewees felt that since creating new SPs is relatively fast, they are a good vehicles to realize "good" investment opportunities (you can't start a new mutual fund every time you have a new investment idea).

5.10.2 Customer understanding of SP pricing

Our interviewees had somewhat differing interpretations on customers' understanding of structured products and their pricing. In Finland the structuring costs and the subscription fee must be explicitly shown in the prospectus for SPs. This means that comparing SPs investing

[31] *Italic text notes writers analysis and doesn't necessarily reflect the interviewees' opinions*

in similar underlying markets is relatively easy, yet the interviewees felt that most customers were more interested in the participation rate[32], which two of the interviewees thought was not very reasonable as it wasn't really a comparable measure across different issuers and products due to differences in underlying assets and different payment structures. As an example some products' underlying index closing and starting values were averaged over longer periods and some used risk adjusted indexes. Both of these measures reduce the underlying volatility of the option component, thus reducing its value and allowing for higher participation rates.

The interviewees themselves felt that SPs weren't especially expensive. This view was mostly shared by customers in the sense that the price of the SPs was rarely the main sticking point for unwillingness to buy them. *With a subscription fee of 1-2%[33] and a structuring fee of 4% (0,8% p.a.)[34], SPs might seem like extremely expensive but when this is compared with e.g. fees for mutual funds, this level of fees doesn't seem so high. The costs for a mutual fund, with portfolio weights comparable to those of the 5 year capital protected SP used in the my tests, would amount to around 10% for FIM and 9% for Sampo Bank.[35],[36]. (See appendix 3 for more information) As these costly mutual funds, rather than direct stocks or bonds, are often the alternative to investing in SPs, it could even be argued that the utility increase from the payment structure of SPs doesn't even have to offset the costs as the cost relative to the alternative option might even be negative.*

5.10.3 SPs and evaluation periods

Structured products seem to offer some protection against myopia as the interviewees told that customers weren't checking on their investments very actively during the holding period as they were confident on getting at least the principal at maturity. Capital protected SPs were, in most cases, sold only when they were significantly up in value to "lock" the floor

[32] Participation rate defines how much the product returns compared to the underlying asset. E.g. a participation rate of 50% would mean that if the underlying index returned +50%, the SP would return +25%.
[33] Subscription fees are negotiable and might not fully apply. Big customers can are likely to pay only a fraction of the list fee
[34] Based on most recent emissions from the banks in question the structuring cost was 4% (0,8% p.a.) and the subscription fee for FIM and UB was 2% and 1% for Sampo for investments under 50 000€.
[35] UB did not offer mutual funds that could be used as a comparison.
[36] Costs based on information from company web pages. Mutual funds for FIM were A global stock fund (77%) and European government bond fund (23%). For Sampo Bank the fund costs were based on a Europe stock fund (38,5%), US stock fund (38,5%) and a EU government bond fund (23%). The costs included the management fee subscription and the redemption fee.

value to a new level by investing in a new issue of SPs and this was often done from the suggestion of the sales staff of the bank in question.

5.10.4 Customer attitude towards counterparty risk

In terms of marketing, these products often rely on transforming complex judgment calls to more simple choice tasks by asking questions like “Do you believe Nokia’s stock will not fall any further? You’ll receive an annual 15% coupon”. The same kind of binary belief in something either happening or not happening, rather than viewing each possible outcome as having a certain probability of happening, was also visible in customers understanding of counterparty risk. The interviewees agreed that the issue of counterparty risk doesn't receive almost any attention as long as the customer “can’t imagine the issuer defaulting”, which according to them is the case with “reliable” domestic issuers. *This kind of thinking could have a big impact as the overweighting of the (small) probability of default of the issuer, if considered, could make the marketing of these products very hard. This kind of small probability ignorance has been recorded for example by Jessup, Bishara and Busemeyer (2008) in studying the subjective probability assigned to unlikely binary (either happens or doesn’t happen) events based on feedback rather than descriptive information.*

5.10.5 Reasons for not buying SPs

Firstly structured products are only suggested to customers who do not intend to spend the money during the running period (normally 5 years). Secondly investing in SPs is much more complicated than an investment in mutual funds. You can purchase shares in a mutual fund through your internet banking service platform or over the phone. On the other hand if a customer wishes to purchase SPs he has to fill out an evaluation form designed to assess the products suitability to the needs of the customer[37] and each product is offered only for a short period (couple of weeks). The interviewees also felt that many customers did not wish to invest in SPs because they didn’t fully understand or trust them. These factors could be a major deterrent against purchasing SPs as it has been noticed that in many situations economic agents chose the default or the “easiest” option (Choi et al 2006c). Furthermore this phenomenon is strengthened when the choice involves a large degree of complexity (Shafir & Tversky 1993 et al.), large number of choices (Iyengar & Kamenica 2006 et al) or limited personal understanding (Choi et al 2005a).

[37] Required by the EU ”markets for financial instruments” directive

All in all based on the interviews it seems that customers are not necessarily fully capable of evaluating the usefulness of SPs, which could suggest that the impact of behavioral biases and risk preferences might be overshadowed by the lack of understanding. Yet the interviews positions on customers (and their own) rational for offering these products are in line with the theoretical findings of my study. Furthermore it still needs to be noted that all of the interviewees told that personnel and especially the people structuring these products tend to invest heavily into most new issues, so they at least can't be seen to view these instruments as simply a way to exact high premiums from uninformed customers through confusing marketing tactics.

5.11 Test limitations and conflicts with reality

The test simulations had only one form of capital protected product linked to one underlying market index, when in reality products cover a large variation of underlying assets.

Timeframe – Most SPs offered to consumers in Finland have a running period of one year, yet the investors' evaluation periods are often assumed to be around one to two years and most of the my tests are run for an evaluation period of one year. Furthermore if investors actually had evaluation periods of five years SPs would produce little or no utility increase.[38] This discrepancy could be explained by the fact that investors evaluation periods could be lengthened by these products, which is supported by some empirical proof (Galai and Sade 2006) as well as anecdotal evidence from the interviews. It is also possible to create e.g. 5 year capital protected products with annual capital protection, so investors with shorter evaluation periods could make longer investments. Of course issuers could also offer more one year products, but these would likely be very costly in annualized terms.

Counterparty risk – In the tests the capital protection was created by using risk free zero coupon bonds, which return was based on US government bonds. In reality these products use the issuers own debt adding a default risk to the products, not considered in the tests. The use of own debt rather than hedging by buying e.g. government debt instead is likely done to give investors higher upside potential, while investors, based on the interviews, seem to disregard the counterparty risk in most cases. This could have a significant effect on the expected value of utility experienced by investors after the purchase.

[38] Notable utility increase for five year products produced by the realized dataset and high loss aversion

Underlying asset – SPs are often not linked to indexes that encompass fewer markets than the MSCI World index. This means that the volatility, expected return and risk free rate might be clearly different from those used in the tests. But since the change in any of these parameters didn't produce a significant difference in the utility addition of SPs, Structured products should still be useful regardless of the underlying market. The underlying indexes are often also not simple total return indexes, but rather averaged index returns or growth indices. This is often done for marketing reasons to decrease volatility so the apparent "participation rate" would be higher. This is also likely to only cause a small difference in terms of utility as most of the utility addition is created by hedging against negative returns.

6 Conclusions

6.1 Summary of results

The main findings of this paper are summarized in the Table below. All in all, I will present evidence on the usefulness of SPs in framework where revealed preferences are defined by the prospect utility framework.

Structured products are often seen as a kind of an anomaly and product of investors' behavioral biases. Yet these products represent around 7% of invested assets in many European countries. Based on recent studies most SPs have a structuring cost of around 3-6% (around 0,5-1,2% p.a), this transfer of risk free premium from investor to issuer has raised questions whether these products are simply designed to con consumers. Yet we have to remember that many of the alternatives, like mutual funds and private wealth management, offered to consumers by financial institutions are at least as costly and produce no significant excess return.

In the Base case scenario, with an evaluation period of one year, bond returns based on 1y US-Treasury bond returns and stock returns matching the simulated stock returns. Using structured products can significantly increase the decision weighted prospect utility of an investor. At the same time we notice that the utility increase is almost entirely dependent on decision weighing being part of the investors true preferences. In a situation where using true probabilities represents true preference (experienced utility), the existence of SPs only has a small utility increasing effect on investors in either prospect utility or expected terms (+0,2%). The results mostly persist after controlling for several factors like: varying volatility, expected return and expected return, different utility function parameters, using actual returns instead of simulations and changing evaluation periods.

Impact of decision weighing

	Revealed preferences		
	DW (A)	DW	TP
PU addition	2,4 %	3,0 %	-
PU addition (TP)	0,2 %	0,2 %	0,1 %
EU addition	0,2 %	0,2 %	-0,1 %

The true probability weighted PU increase is close to zero, so the usefulness of standard capital protected SPs is highly dependent on Decision weighing being part of revealed preferences.

Utility function parameters

	Revealed preferences		
	Linear Utility function	Loss aversion: 1,5	Loss aversion: 3
PU addition	2,5 %	0,8 %	2,5 %
PU addition (TP)	0,1 %	-0,9 %	0,2 %
EU addition	-0,7 %	-2,4 %	0,3 %

For capital protected SPs to be preferable an individual has to be loss averse to a certain degree, yet even a loss aversion parameter of 1,5 seems to be enough. The curvature of risk aversion on the other hand does not seem to have a significant impact on SP demand

Longer evaluation periods

Evaluation period	2y	3y	5y
PU addition	1,9 %	0,9 %	0,1 %
PU addition (TP)	-0,1 %	-0,5 %	-0,6 %
EU addition	-0,9 %	-1,4 %	-0,9 %

For Investors who are less shortsighted (longer evaluation periods), SPs will not be preferable, as the Bond-stock portfolio is less likely to produce negative returns over longer periods

Evaluation period increase for SP only

Evaluation period increase	+1y	+2y	+4y
PU addition	3,0 %	3,6 %	4,3 %
PU addition (TP)	1,1 %	1,7 %	2,5 %
EU addition	1,2 %	1,8 %	2,5 %

If SPs can have the effect of lengthening evaluation periods, the utility increase in every framework is very significant.

CP= Capital Protected, PU=Prospect utility, EU=expected utility, DW=Decision weighted, TP=true probability, A=adjusted (tail outcome weights averaged - used in base case scenarios). Utility addition of SP compared with optimal portfolio

Index Volatility

Volatility	15 %	17 %	19 %
PU addition	2,3 %	2,4 %	2,5 %
PU addition (TP)	0,2 %	0,1 %	0,1 %
EU addition	0,2 %	0,2 %	0,2 %

It seems that even if the MSCI world index did not represent true future volatility expectations the results would not significantly change.

Expected MSCI World return

Expected return	8 %	9 %	10 %
PU addition	1,8 %	2,1 %	2,1 %
PU addition (TP)	0,2 %	0,2 %	0,0 %
EU addition	0,3 %	0,2 %	0,2 %

Risk free rate = 4,5%

The same applies for expected return. The impact of different expected returns do not have significant impact.

Risk free rate

	3,5 %	4,5 %	5,5 %
PU addition	1,9 %	2,1 %	2,1 %
PU addition (TP)	0,1 %	0,2 %	0,3 %
EU addition	0,2 %	0,2 %	0,3 %

Stock Return = 9%

The decrease in risk free rate does have an impact on the usefulness of SPs, but even at a very low level (1,5%) the positive impact of using SPs persists in all utility frameworks.

Using realized data

Evaluation period	1y	3y	5y
PU addition	3,1 %	1,9 %	0,6 %
PU addition (TP)	0,8 %	-0,1 %	-0,4 %
EU addition	0,8 %	-1,5 %	-1,0 %

Using realized data instead of simulations actually increases the utility addition from using SPs and could explain demand even for 5 y maturity products

Robustness check SP return vs. replicating portfolio

Evaluation period	1y	3y	5y
Simulated data	-0,2 %	-0,1 %	-0,1 %
realized data	0,0 %	0,1 %	0,0 %

SP return - replicating portfolio return

The return on the replicating portfolio is almost identical to that of the SP, so mispricing of the option component should not be a source of utility increase

Optimal SP

	Standard SP	Optimal CP	Call option
PU addition	2,4 %	11,0 %	79,9 %
PU addition (TP)	0,2 %	-2,7 %	-62,2 %
EU addition	0,2 %	-2,4 %	-26,4 %
Expected return	7,9 %	6,5 %	7,8 %
Strike price	100	134	134

Due to decision weighing the optimal SP targets the extreme tail outcomes by having a very high strike price. The most optimal structure would actually be a pure call option.

CP= Capital Protected, PU=Prospect utility, EU=expected utility, DW=Decision weighted, TP=true probability, A=adjusted (tail outcome weights averaged - used in base case scenarios). Utility addition of SP compared with optimal portfolio

Impact on standard capital protected SP utility addition

	Prospect utility (DW)	Prospect U. (TP)	Expected utility
Index Volatility	+	+/-	+/-
Index average return	+	-	+/-
Interest rates	+	+	+/-
Using realized data	+++	++	++
Increasing evaluation period	---	--	--
Increased evaluation period for SP only	+++	+++	+++
Loss aversion	+++	++	+++
Downside risk seeking	--	-	-
Upside risk aversion	+	+	+
Using unadjusted decision weights	++	+/-	+/-
Using true probabilities		-	-

Utility impact = increase/decrease of spread between the certainty equivalent returns of a capital protected SP and the optimal two fund portfolio

+++/---	impact more than 1,5%
++/--	Impact 0,5-1,5%
+/-	Impact 0,1-0,5%
+/-	impact less than 0,1%

6.2 Conclusions and suggestions for further research

My results contribute to the literature on structured products in three ways; first the results add to evidence on behavioral factors explaining the demand for SPs. Second, providing evidence on the impact of SPs on consumers experienced utility. Thirdly, fitting together the practical anecdotal evidence from the interviews with theoretical results of the simulations.

Based on my tests we can draw two main conclusions:

1. Structure products clearly increase decision weighted prospect utility, making them clearly preferable over traditional asset combinations

The increase in Decision weighed (+2-3% on annual basis) suggests that these products should be clearly preferred over stock and bond investments, yet they "only" represent less than 10% of all invested assets in any major markets. This discrepancy could be caused by the purchase of SPs being much more complicated than e.g. investing in a mutual funds or making a deposit at a bank. Based on previous research the complexity of products and the ease of making a choice are major determinants in portfolio allocation decisions. There are also some differences between the SPs offered to consumers compared with the theoretical instruments used in my tests. In Finland most SPs are five year products, yet the evaluation period is usually assumed to be around one year. Issuers may avoid offering one year products due to high annualized costs. This problem could be avoided by offering products with annual capital protection, but the options in such a product are highly complex and would likely be sold at a higher premium. The issue of mismatch between evaluation period and maturity could still be mitigated by the lengthening of evaluation periods for products like capital protected SPs.

2. Utility increase without using true probabilities (+0,2%) is much smaller than the annualized cost of SPs (1,2-0,8%)

If using decision weights is seen as a bias, rather than as part of true preferences, the utility increase is too small to cover costs making SPs utility decreasing. Still this is only true if the other investment option is an optimal two fund portfolio with very low costs. If on the other hand an investor holds a portfolio that has high costs (e.g. mutual funds) this might not be true.

Lastly the payment structure of the "optimal SP", which is basically a call option with a high strike price, raises some questions about the direct applicability of the decision weighing function on preferences towards investment alternatives. Even though this kind of lottery behavior has been recorded even for gambles with negative expected return, it still seems questionable whether this is the behavior expected from an average individual.

Future research could test traditional investment options against structured products in a lab setting where the customer's preferences could be tested by providing a choice between a risk free option and a structured products with different attributes.

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FIM: https://www.fim.com/suomi/structured

Finnish structured products association: http://sijoitustuotteet.fi

Appendix 1: Interview questions

I conducted a total of 3 interviews with banking professionals involved in the creation and marketing of SPs. Two of the interviews were directly involved with both creating and marketing side, while one interviewee was mainly involved in the selling of the products. The interviewees worked at Sampo Bank, FIM and United bankers. In each bank a single professional was interviewed. To gain answers that would be as honest as possible, the interviews were told beforehand that their specific answers would not be reported. For the same reason the interviews were not recorded. I felt that these measures were necessary to gain also answers that might not fully reflect positively on the institutions the interviewees represented. All of the interviewees were asked the same "headline" questions, but depending on the answers the interviewees received different follow-up questions to get them to address the main issues at hand in a consistent fashion. All in all the interviews lasted from 30 minutes to one hour.

The questions asked from the bankers can be found bellow:

1. How would you compare the marketing of structured products with other more traditional products like mutual funds?
    a. In terms of risk and return
    b. In terms of pricing?
2. What are the main selling arguments for the average structured product?
    a. Payment structure?
    b. Investment opportunity in the underlying asset?
3. What kinds of payment structures do you mostly offer? Why?
    a. How important is capital protection to customers?
4. What are the main underlying assets for the structured products you offer?
5. What do you perceive to be the customers main rational for buying these instruments?
6. What kind of customers invest in these products?
7. For customers what are the most common counterarguments or sticking points in buying structured products?
    a. For customers how big is the issue of being at least partly "stuck" with the products for a period of 5 years?
    b. How do customers perceive products with return caps?
8. How capable are customers at comparing structured products and their pricing?

a. What are the main factors when customers compare products between issuers?
b. How concerned are customers about the price of a structured product?
c. How worried are customers about the risk of the issuer?
   i. Has this changed post Lehman Brothers?

9. How do you evaluate structured products suitability to a customer?
10. How big is the portion invested in SPs for a customer that has them in his portfolio?
11. How active are customers with their SP investments?
    a. Do they check on them often?
    b. How often do they sell these products before maturity?

Appendix 2: Simplified example of utility calculations

1	2	3	4	5	6		7	
MSCI W. Retrurn distribution: X(s)	Probaility of a better outcome (p)	Outcome decision weight π(p)	SP return: X(sp)	Optimal portfolio return: X(op)	Value function v(x)		Decision weighed prospect utility π(p)*v(x)	
					Structured product	Optimal portfolio	Stuctured product	Optimal portfolio
-21 %	95 %	14 %	0 %	-1 %	0 %	-3 %	0,0 %	-0,5 %
-12 %	90 %	7 %	0 %	1 %	0 %	2 %	0,0 %	0,2 %
-8 %	85 %	5 %	0 %	3 %	0 %	4 %	0,0 %	0,2 %
-5 %	80 %	4 %	0 %	3 %	0 %	5 %	0,0 %	0,2 %
-2 %	75 %	4 %	0 %	4 %	0 %	6 %	0,0 %	0,2 %
0 %	70 %	3 %	0 %	5 %	0 %	7 %	0,0 %	0,2 %
3 %	65 %	2 %	2 %	5 %	3 %	8 %	0,1 %	0,2 %
5 %	60 %	2 %	3 %	6 %	4 %	8 %	0,1 %	0,2 %
7 %	55 %	2 %	4 %	6 %	6 %	9 %	0,1 %	0,2 %
9 %	50 %	2 %	5 %	7 %	8 %	10 %	0,2 %	0,2 %
11 %	45 %	2 %	7 %	7 %	9 %	10 %	0,2 %	0,2 %
13 %	40 %	2 %	8 %	8 %	11 %	11 %	0,3 %	0,3 %
15 %	35 %	3 %	9 %	9 %	12 %	12 %	0,3 %	0,3 %
18 %	30 %	3 %	11 %	9 %	14 %	12 %	0,4 %	0,4 %
20 %	25 %	3 %	12 %	10 %	16 %	13 %	0,5 %	0,4 %
23 %	20 %	4 %	14 %	11 %	17 %	14 %	0,6 %	0,5 %
26 %	15 %	4 %	16 %	11 %	19 %	15 %	0,8 %	0,6 %
30 %	10 %	5 %	18 %	12 %	22 %	16 %	1,2 %	0,9 %
36 %	5 %	7 %	21 %	14 %	26 %	18 %	1,9 %	1,3 %
48 %	0 %	19 %	29 %	17 %	33 %	21 %	6,3 %	4,0 %
Expected return		Sum π(x)	Expected return		Average: v(x)		Sum: π(p)*v(x)	
11 %		100 %	7,9 %	7,4 %	10,0 %	9,8 %	13,1 %	10,3 %

					SP
Optimal portfolio stock weight (a)	26 %	**8**	Propect utility	9,9 %
Ammount of call options in SP (C)	0,6	**9**	True probability weighed Prospect U.	7,3 %
Risk free rate	6,2 %	**10**	Expected Utility	7,4 %

SP	Optimal two fund	Utility addition
9,9 %	7,5 %	2,4 %
7,3 %	7,2 %	0,2 %
7,4 %	7,2 %	0,2 %

1 Distribution of 20 returns based 5% percentiles of the simulation returns

2&3 $$W(p) = \left(\frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}} \right)$$ *y=0,61, x>0; *y=0,69, x<0

1 $$X_{SP} = \begin{cases} X_S \times C & \text{if } X_S \geq 0 \\ 0 & X_S < 0 \end{cases} \qquad \pi(p_i) = w(p_i) - w(p_i - 5\%)$$

5 $$X_{OP} = a(1+X_S) + (1-a)(1+6{,}2\%) - 1$$

6 $$v(x) = \begin{cases} x^{0,88} & \text{if } x \geq 0 \\ -2{,}25(-x)^{0,88} & x < 0 \end{cases}$$

7 $$U(I) = \sum \pi(p_i) v(x_i)$$

8 $$R_f = \begin{cases} U(I)^{1/0,88} & \text{if } U(I) \geq 0 \\ -1/2{,}25(-U(I))^{1/0,88} & U(I) < 0 \end{cases}$$

9 $$R_f = \begin{cases} v(x_i)^{1/0,88} & \text{if } v(x_i) \geq 0 \\ -1/2{,}25(-v(x_i))^{1/0,88} & v(x_i) < 0 \end{cases}$$

$$E(R_f) = E(R_s) - A \times corr(R_f, GC) \times \sigma(GC) \times \sigma(R_f) \times Adj.$$

10 $$E(R_f) = E(X_s) - 1{,}5 \times 0{,}4 \times 0{,}36 \times \sigma(X_s) \times 2{,}86$$

Example of decision weighing parameter: The decision weight for a 48% return (based on the return distribution in the above table is calculated as follows. The likelihood p_i of getting and outcome that is equal or worse than 48% is 100% as it is the best possible outcome in the distribution. The probability p_* of getting an outcome that is strictly worse than +48% is 95% (all the other outcomes).

$$W(p_*) = \left(\frac{0{,}95^{0{,}61}}{(0{,}95^{,061} + (1-0{,}95)^{0{,}61})^{1/0{,}61}} \right) = 0{,}7932 \qquad W(p_i) = \left(\frac{1^{0{,}61}}{(1^{,061} + (1-1)^{0{,}61})^{1/0{,}61}} \right) = 1$$

$$\pi(p_i) = W(p_i) - W(p_*) = 1 - 0{,}7932 = 20\%$$

One can note that decision weight $\pi(p_i)$ differs from the one in the above table (17%). This is caused by the figure in the table being divided by the sum of probability weights (117%). The decision weights in the table do not add up to one because the distribution includes both negative and positive outcomes, which due to the different exponents for negative and positive outcomes (0,61 for positive and 0,69 for negative), causes the weights to not add up to one.

Appendix 3: Cost of mutual funds in Finland

The following table summarizes the costs of mutual funds with similar composition compared to the Capital protected index linked SP. Nordea, Sampopankki and OP-Pohjola were chosen as they represent a very large part of the market in both SPs (~60%) and banking services in general. The costs were calculated based as a combination of costs of a government bond fund and a global stock fund (or a 50/50 combination of EU and US funds). The weights were defined by the SPs synthetic stock weight, so the cost depends on the SPs maturity. in addition to the supervisory fees I also added the subscription fee to the costs, with the assumption of a 5 year holding period (0,2-0,3%).

SP Maturity	1y	2y	3y	4y	5y
SP synthetic stock weight	40,2 %	55,2 %	64,7 %	71,7 %	77,1 %
		Comparable annualized cost			
Nordea	1,3 %	1,5 %	1,6 %	1,7 %	1,7 %
Sampo	1,2 %	1,3 %	1,3 %	1,4 %	1,4 %
OP-Pohjola	1,0 %	1,3 %	1,5 %	1,6 %	1,7 %

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