



**From Ideal to Reality:
Understanding Decision-making Theories in Finance**

July 2023

Sven Peter Kooi

Thomas van den Berg

Summary

This article provides an overview of two prominent psychological theories in the field of finance: the Expected Utility Theory (EUT) and the Prospect Theory (PT). The EUT is a normative theory and states how individuals should make decisions. The EUT has 4 core principles: completeness, transitivity, continuity, and independence. However, empirical evidence from various tests reveals that people do not always adhere to the EUT. On the other hand, the PT, developed by Daniel Kahneman and Amos Tversky, describes how individuals actually make decisions under uncertain circumstances. It acknowledges that utility is defined in terms of gains and losses, rather than over wealth. The PT incorporates three key findings: risk aversion over gains, risk-seeking behaviour over losses, and loss aversion. These tendencies are graphically represented, demonstrating the concave risk aversion over gains and convex risk-seeking behaviour over losses. The PT also considers the overweighting of low probabilities and underweighting of high probabilities. Overall, the PT provides a more realistic view for understanding how people make decisions compared to the EUT.

How can Amsshare support

The information provided in this article is rather theoretical than practical. However, the information is well-known by Amsshare. Hence, Amsshare can support firms with projects within this area.

Introduction

This article elaborates on two psychological theories that are well-known in the field of Finance. The first theory is the Expected Utility Theory (EUT). It describes how people *should* make decisions based on rational calculations, without accounting for cognitive limits or emotions. The second theory is the Prospect Theory (PT). This theory describes how people actually make decisions instead of how they should make decisions.

Expected Utility Theory (EUT)

The EUT, introduced by Von Neumann & Morgenstern, describes how people should make decisions. However, this does not mean that people actually make decisions based on the EUT. The EUT is rather a homo economicus theory about decision making. Since it is a homo economicus theory, the EUT is like a normative theory. A normative theory is concerned with establishing standards, ideals, or norms that guide actions.

The EUT has 4 axioms. These axioms are the fundamental principles of the theory:

1. Completeness
2. Transitivity
3. Continuity
4. Independence

Axiom 1: Completeness

‘Completeness’ means that investors always have an opinion. For example, there are two stocks: NVIDIA and Tesla. ‘Completeness’ means that the investor always has an opinion about the comparison of these stocks. The investor prefers (1) NVIDIA over Tesla, or (2) Tesla over NVIDIA, or (3) the investor does not prefer one stock above the other. This must hold according to EUT.

Axiom 2: Transitivity

‘Transitivity’ means that investors are always consistent in their preferences. For example, there are three stocks: NVIDIA, Tesla and Apple. If the investor prefers NVIDIA over Tesla and Tesla over Apple, then the investor automatically prefers NVIDIA over Apple. This must hold according to the EUT.

Axiom 3: Continuity

‘Continuity’ means that one can come up with a combination of two stocks that give you equal utility as just for one stock. For example, the investor prefers NVIDIA over Tesla and Tesla over Apple. ‘Continuity’ states that the investor can achieve the same utility for a Tesla stock by combining the NVIDIA and Apple stocks in a particular division. This must hold according to EUT.

Axiom 4: Independence

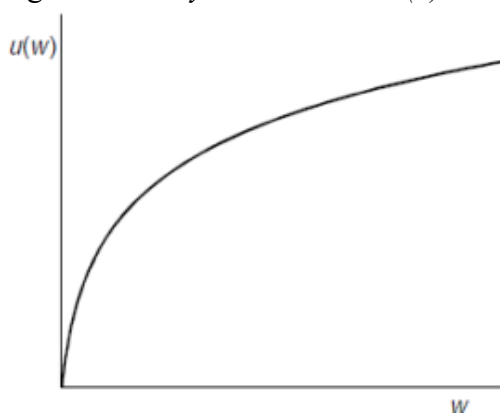
‘Independence’ means that the preferences of an investor are independent. For example, the investor prefers NVIDIA over Tesla. Then the investor should also prefer NVIDIA + Apple above Tesla + Apple. So, the preference of NVIDIA over Tesla should not be affected when the Apple stock is added. In this way, the preferences of an investor is independent according to EUT.

The 4 axioms are the core of the EUT. The EUT is also called a mean-variance utility theory. This means that investors are happy with more wealth, but they are less happy when they face potential risks (variation in wealth). So, the mean-variance utility in the Von Neumann & Morgenstern EUT has two properties:

1. Utility is conditional on wealth
2. Investors are risk averse

The relationship between utility and wealth can be expressed in a graph (Figure 1). Figure 1 shows that there is a concave relationship between utility and wealth. The concaveness represents the risk aversion of investors: when the investor goes from 0 to 10 wealth, the marginal utility increases more than when the investor goes from 10 to 20 wealth. This is also called a ‘diminishing marginal utility’.

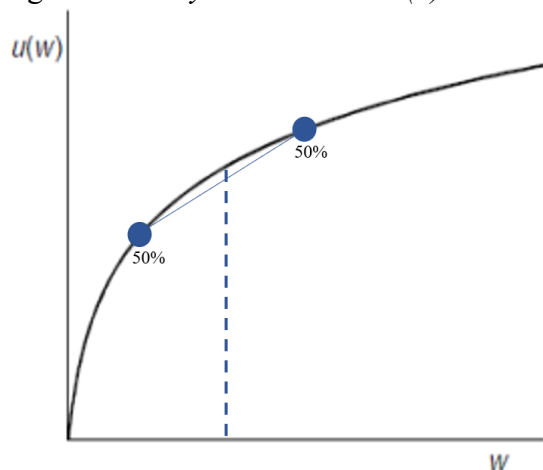
Figure 1. *Utility Function EUT (1)*



Source: *Zwinkels, 2022*

The risk aversion is also shown in Figure 2. When two points of wealth are chosen and an investor has 50% chance to end up in both points, one should draw a linear line between these points. However, this line shows that the investor never has the same utility in times of uncertainty as the initial line (the black line). Apparently, there is a risk premium that investors expect when they face uncertainty. So they want extra compensation for facing risks. Hence, investors are risk averse. The risk premium is the space between the linear line and concave line. The vertical dotted line shows the expected level of wealth when there is a 50% chance of ending up in the nodes on the black line. The difference between the intersection of the dotted line with the linear line and the dotted line with the concave line is the risk premium. The risk premium gets larger when the two points are further apart, because the risk increases when this happens.

Figure 2. *Utility Function EUT (2)*



Testing the EUT

The EUT describes how people should make decisions. A lot of research has been done on whether investors actually make the decisions according to EUT or not. To keep this paper concise, three questions/tests will be evaluated and the results come from the literature. You can also answer the questions yourself before looking at the results.

Test 1

In addition to whatever you own, you have been given €1.000. Now choose between:

- A. You have 50% chance of receiving another €1.000 and 50% chance of receiving €0.
- B. You have 100% chance (no uncertainty) of receiving €500.

The expected value of option A is $€1.000 + 0.5 * €1.000 = €1.500$. The expected value of option B is $€1.000 + €500 = €1.500$. So, the expected values are equal. However, research has shown that most people choose B over A because B is certain and A is uncertain. This shows that people are risk averse over gains. This is consistent with EUT, except for the fact that we are talking about gains (delta of wealth) instead of wealth itself.

Test 2

In addition to whatever you own, you have been given €2.000. Now choose between:

- C. You have 50% chance of losing €1.000 and 50% chance of losing nothing.
- D. You have 100% chance (no uncertainty) of losing €500.

Again, the expected values of option C and D are €1.500. However, research has shown that most people choose C over D while C is the uncertain option here. According to EUT it should not matter whether an investor chooses C or D, but people tend to choose C. This shows that people are risk-seeking over losses. This is not incorporated in the EUT.

Test 3

In this test the game heads or tails will be played where there is a 50% chance of heads and 50% chance of tails. The question is which games you are willing to play and when you don't want to play anymore.

1. If it's heads, you lose €2. If it's tails, you win €6.
2. If it's heads, you lose €3. If it's tails, you win €6.
3. If it's heads, you lose €4. If it's tails, you win €6.
4. If it's heads, you lose €5. If it's tails, you win €6.
5. If it's heads, you lose €6. If it's tails, you win €6.
6. If it's heads, you lose €7. If it's tails, you win €6.

Most people stop playing the game around game 3. This means that there is an asymmetric relationship between gains and losses. Apparently, the loss has a bigger impact than the gain. When you stop playing from game 3, we can state that the loss of €4 has more impact than a gain of €6. This is also called: loss aversion. People weigh losses heavier than gains. The loss aversion is not incorporated in the EUT.

These 3 little tests show in what way people actually behave instead of how they should behave. Hence, this proves that the EUT is not a realistic model for showing how people make decisions. The Prospect Theory is an alternative theory for the EUT that tries to incorporate the results of the tests.

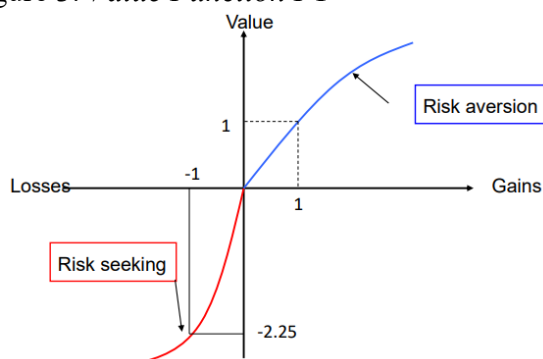
Prospect Theory (PT)

The Prospect Theory (PT) is a psychological theory that explains how individuals make decisions under uncertain circumstances. It is a theory that is particularly applied in the field of Finance. The PT was developed by Daniel Kahneman and Amos Tversky. Instead of the EUT being a normative theory, the PT is a descriptive theory. The PT states that utility is defined over gains and losses while the EUT stated that utility was defined over wealth. The PT incorporates the three main results of the literature:

1. Investors are risk averse over gains
2. Investors are risk-seeking over losses
3. Investors are loss averse: losses weigh heavier than gains

These three main results can be shown in the graph of the PT. This is presented in Figure 3.

Figure 3. *Value Function PT*



Source: *Zwinkels, 2022*

The blue line in Figure 3 shows the risk aversion of investors over gains. This concave line was also shown in Figure 1 and 2, but the axes are different. The concave line proves the diminishing marginal utility and, therefore, the risk aversion of investors. The red line in Figure 3 shows that investors are risk-seeking over losses. This line is a convex line. The same principle that was used in Figure 2 can be applied to the red line in Figure 3, but then the result is the other way around. Investors feel that uncertainty (for example, 50% chance of two points on the red line) about a loss gives them greater value than a certain loss. Also, the loss aversion is shown in Figure 3: a gain of 1 results in a value of +1, while a loss of 1 results in a value of -2.25.

Another property of the PT is that low probabilities are overweighted and high probabilities are underweighted. This means that an actual low chance is perceived as a higher chance than it is and that an actual high chance is perceived as a lower chance than it is. For example, you need to choose between A and B:

- A. You have 0.1% chance for receiving €10.000.
- B. You have 100% chance (no uncertainty) for receiving €10.

According to EUT, it should not matter which option you choose because both options have an expected value of €10. According to the PT, you may choose option B on the first sight, because people tend to choose the certain option when we are talking about gains (risk aversion over gains). However, most people choose option A here. The chance of option A (a low chance) is overweighted. This is also called: probability transformation. This property is incorporated in the PT.

Comparison of EUT and PT

The EUT is based on how investors should make decisions. In this theory, it is stated that investors are risk averse over wealth. The PT states something similar, but then that investors are risk averse over gains rather than over wealth. Besides, the EUT does not incorporate the risk-seeking behaviour of investors over losses and the loss aversion that investors have. The PT does account for this. Moreover, the PT states that low probabilities are overweighted and that high probabilities are underweighted by people. The EUT does not account for this.

To make a deeper comparison of the EUT and PT, the 4 core principles of the EUT are applied to the PT:

1. Completeness: 'completeness' still holds in the PT, because people still have an opinion about the options they have.
2. Transitivity: 'transitivity' does not necessarily hold in the PT. In the explanation of the EUT it was said that investors are always consistent in their preferences. If an investor prefers NVIDIA over Tesla and Tesla over Apple, then the investor automatically prefers NVIDIA over Apple. However, under PT this is not necessarily true. When you already have the Tesla stock and you are asked to exchange Tesla for NVIDIA, the loss of the Tesla stock weighs 2.25 heavier than the gain of the NVIDIA stock. This means that the 'transitivity' argument only holds when the NVIDIA stock makes you 2.25 times happier than the Tesla stock does.
3. Continuity: 'continuity' still holds in the PT because this is a mathematical property. In the PT it is also possible to come up with a combination of two stocks that create the same utility as you would get from just one stock.
4. Independence: 'independence' does not necessarily hold in the PT. This has to do with the fact that some options feel as a gain or a loss, and thus don't have an equal weight. For example, you can choose between an (1) online subscription on FD (Dutch financial newspaper) for €49, (2) print subscription on FD for €99 and (3) online and print subscription on FD for €99. When all three options are shown, most people tend to choose option 3 because this feels as a gain. However, when only the first two options are shown, most people select option 1.