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Prospect Theory and Expect Utility Theory: Application to Conditions of the Czech Republic

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Abstract:
Purpose of the article: Classical and neo-classical economic theories consider a human as a rational individual making logical decisions and maximizing his profit. But what if it is not the case? People making decisions in the real world will never be perfectly informed about product or service they want to purchase. The economic theories propose that people make their decisions rationally, practically avoiding the risk. Nevertheless, where could be then ranked gamblers, bookmakers and similar people? They are not just a negligible statistical deviation. On the contrary, there are many of them among us. This paper presents some of demonstrations that are different view on making decisions.
Methodology/methods: In this paper was applied primary and secondary research. The secondary research was based on analysis of papers and literature published about prospect theory and expected utility theory. This research was used to support a critical analyse of how individuals choose among risky alternatives. The primary research was conducted using the questionnaire.
Scientific aim: The aim of this paper is critically describe differences between expected utility theory and prospect theory a differences between decision making in original research applied by Kahneman and Tversky and research applied in this paper.
Findings: This survey discovered, that decisions of people making decision under risk, don't respond expected utility theory but prospect theory is valid. There are no differences when we compared original Kahmenam and Tversky survey with this paper
Conclusions: In situations where people making decision under risk, it is better to apply prospect theory then expected utility theory.

Keywords: prospect theory, framing effect, expected utility theory, decision under risk, probability, risk

JEL Classification: D01, D12

Introduction

Classical and neo-classical economic theories consider a human as a rational individual making logical decisions and maximizing his profit. But what if it is not the case? People making decisions in the real world will never be perfectly informed about product or service they want to purchase.

Human beings are irrational in the real world. They are influenced by their emotions, feelings, method of presentation of particular information. I.e., variety of factors, influencing the individual, should be taken into account. Definitely, not a single one results in the maximization of profit on the basis of rational decision. On the contrary, people are trying to eliminate the risk, which they face.

Each decision that we make carries along a certain risk. We try to eliminate it especially with information that we acquire. Whether you decide if you will go on a trip or which notebook you will buy, it always depends on information you work with and the method of presentation of information.

One of economic theories that deal with human decision making in terms of risk is the Prospect theory. Amos Tversky and Daniel Kahneman are the authors of this theory. They have presented the Prospect theory for the first time in their article Prospect theory: An Analysis of Decision Under Risk (1979).

1. Prospect theory

The theory is developed for simple prospects with monetary outcomes and stated probabilities, but it can be extended to more involved choices. (Kahneman and Tversky, 1979)

Prospect theory distinguishes two phases in the choice process: framing and valuation. In the framing phase, the decision maker constructs a representation of the acts, contingencies, and outcomes that are relevant to the decision. In the valuation phase, the decision maker assesses the value of each prospect and chooses accordingly. (Tversky and Kahneman, 1992)

People overweight outcomes that are considered certain, relative to outcomes which are merely probable. This is called the certainty effect. (Kahneman and Tversky, 1979)

This situation is also described by the way of probability determination. Authors divide probability into objective and subjective. Subjective probability is determined by Weight (w), which is attributed individually by each human for each situation. It is determined:

$$w(p): p \rightarrow w(p). \tag{1}$$

Weight then indicates the subjective perception of each human individual. Not only it takes the distribution of probability into account, but also the way how is the situation judged by human.

Total utility function which is known from „classical“ economic theories is in this case replaced by the so-called Value function (Figure 1).

Value function is:

- defined on deviations from the reference point,
- generally concave for gains and commonly convex for losses,
- steeper for losses than for gains.

The Prospect theory offers a nontraditional view upon decision making of human individuals. It defies other economic theories and it also contradicts that human behave rationally and try to maximize their profit.

The goal of this article is to verify if Prospect theory is applicable for conditions in Czech Republic. In order to verify this statement, a research realized by Kahneman and Tversky published in their article Rational Choice and the Framing of Decision (1986), was utilized.

2. Expected utility theory

According to (Škapa and Vémola 2012) Daniel Bernoulli put basics of Expected utility theory in 1738. Bernoullis' followers were John von Neumann and Oscar Morgenstern in 1949. Both of them proposed some axioms and basics conditions which are important for this theory. Expected utility theory is one of basic theories in modern economic theory.

Expected utility can be measured. Equation for calculating expected utility is:

$$EU(X) = \sum_{i=1}^{n} U(X_i)\pi_i \,. \tag{2}$$

Expected utility of random results is mean value of individual results utility weight with their probabilities. Expected utility equation is *e* pressed by action X with *n* consequences X_j and its probability π_j.

Expected utility and its amount depend on probability of each results and utility of this results. We expected that people are able to evaluate each result with some number. We can say, that people perceive utility like cardinal utility function (Škapa and Vémola, 2012).

There are 3 groups of people in relation to the risk. First group is risk averse. Expected utility function

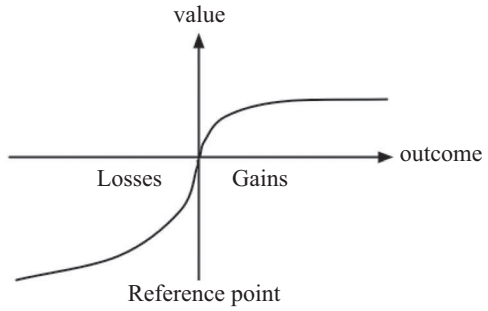

Figure 1. Value function. Source: Kagneman & Tversky 1979.

is concave. On the other side, expected utility function is convex, when people are risk seeking. This is the second group of relation to the risk. In hard group belong people which are neutral to the risk. Their expected utility function is linear. According classical economy theory people are risk averse. (Hořejší and Soukupová, 2010)

3. Research results

The research was realized in form of a survey. The questionnaire was published at website www.vyplnto.cz. In total 114 respondents participated in the survey. More precisely, it was 78 women and 36 men in range from 15 to 77 years. The respondents stated their highest achieved education as follows: primary education – 2 respondents, apprenticeships – 2 respondents, apprenticeships with GCE – 4 respondents, secondary education – 35 respondents, higher professional education – 5 respondents, university education (Bachelor's degree) – 33 respondents, university education (Master's degree) – 28 respondents, Higher University Education – 5 respondents. The survey was realized in May 2012.

The part of the survey included 14 questions which were taken from the article of authors (Kahneman and Tversky, 1986). Authors divided questions into several groups, where they have studied specific phenomenon.

3.1 Failures of invariance

In this group of questions, there was observed, how do respondents react to questions, that are the same, but differently formulated. This contains questions from no. 1 to no. 4. They are divided into two groups.

Question no.1 was formulated in a way, that the respondent would know how many patients will survive if they choose surgery as a treatment method and concurrently how many patients will survive if radiation therapy would be applied. This particular style of formulation questions is called mortality frame.

QUESTION NO. 1 (Survival frame) – Which of the following treatment would you choose if you had this information:

1. Surgery – Of 100 people having surgery 90 live through the post-operative period, 63 are alive at the end of the first year and 27 are alive at the end of five years. (45.61%)
2. Radiation Therapy: Of 100 people having radiation therapy all live through the treatment, 77 are alive at the end of one year and 23 are alive at the end of five years. (54.39%)

QUESTION NO. 2 (Mortality frame) – Which of the following treatment would you choose if you had this information:

1. Surgery – Of 100 people having surgery 10 die during surgery or the post-operative period, 27 die by the end of the first year and 63 die by the end of five years. (50%)
2. Radiation Therapy – Of 100 people having radiation therapy, none die during treatment, 23 die by the end of one year and 77 die by the end of five years. (50%)

At question no. 1. 52 respondents (45.61%) decided that they would choose surgery, while at question no. 2 the same decision was made by 57 respondents (50%). At question no. 1. 62 respondents (54.39%) decided that they would choose radiation therapy and at question no. 2 57 respondents (50%) decided the same way. The difference between these questions is not too striking. However, it is quite clear, that certain respondents are very sensitive to different forms of presenting questions.

The next group of questions contains question no. 3 and question no. 4. This pair of questions was focused on the outcomes that could have brought monetary gain or monetary loss to the respondent.

QUESTION NO. 3 (favorable prospect) – Imagine that you face the following decision. Choose between:

1. A sure gain of 4,800 CZK. (81.58%)
2. 25% chance to gain 20,000 CZK and 75% chance to grain nothing. (18.42%)

QUESTION NO. 4 (unfavorable prospect) – Imagine that you face the following decision. Choose between:

1. A sure loss of 15,000 CZK, (9.65%)
2. or 75% chance to lose 20,000 CZK and 25% chance to lose nothing. (90.35%)

At question no. 3, which was focused on sure gain, 93 respondents (81.58%) would rather choose

a sure gain of 4,800 CZK than 25% chance to gain 20,000 CZK. In this case, 18.42% of respondents would have risked (21).

Question no. 4 had the exact opposite result. 103 respondents (90.35%) would rather choose a 75% chance to lose 20,000 CZK than a sure loss of 15,000 CZK.

This option was chosen by 11 respondents (9.65%). By this pair of questions, it is certain that people risk more when they know they will lose money instead of cases, in which they know that they will gain money.

If the expected utility theory is applied, than the utility from first choice in question no. 3 is 4,800 CZK, utility from second choice is 0.25 × 20 000 + 0.75× × 0 = 5,000 CZK. People should choose the second choice. The prospect theory has been confirmed.

At question no. 4 the utility of first and second choice was 15,000 CZK. It doesn't matter which answer respondent chose. This result confirmed prospect theory, respondents are risk averse. They preferred choice where there was an option to loose nothing before the choice where a sure loss was the only option.

3.2 Framing outcomes

Human decision making is affected by information that can be formulated differently. At question no. 5 and question no. 6 the respondent has to decide between a sure gain or loss. The answers from respondents are then affected by the fact, if the information upon which the result of the decision depends, are presented as gain or loss. Question no. 5 is conceived in a way, that the respondent has a chance of a sure gain while on the opposite side, the question no. 6 considers a certain loss.

QUESTION NO. 5 – Assume yourself richer by 6,000 CZK than you are today. You have to choose between:

1. Sure gain 2,000 CZK, (67.54%)
2. or 50% chance to gain 4,000 CZK and 50% chance to gain nothing. (32.46%)

QUESTION NO. 6 – Assume yourself richer by 10,000 CZK than you are today. You have to choose between:

1. A sure loss of 2,000 CZK, (34.21%)
2. or 50% chance to lose nothing and 50% chance to lose 4 000 CZK. (65.79%)

At question no. 5 as well as at question no. 3, there was confirmed that if the respondent has a certainty of gain then he rather chooses certainty than risk. It is a risk aversion. 77 respondents (67.54%) would choose a sure gain of 2,000 CZK, 37 respondents (32.46%) would choose the possibility of a higher profit. The majority of respondents is then averse to risk. At question no.6 the tendency is exactly opposite. Respondents rather risk even if the assumed loss could be higher than 2,000 CZK. In this particular case, 39 respondents (34.21%) would choose a sure loss and 75 respondents (65.79%) would choose the risky option with a 50% chance of no loss at all.

In this particular decision making, the amount of gain and the stated size of amount to be decided, play an important part.

Preferences are quite insensitive to small changes of wealth but highly sensitive to corresponding changes of wealth.

If the expected utility theory is applied to both questions the utility for each answer is the same – 2,000 CZK. If people should choose between sure and probable gain, they will choose sure gain. But if they have to choose between sure and probable loss, they will choose probable loss. Because there is some chance, that they lose nothing. People are able to risk when they can something loose but they are averse to risk, when there is sure gain. Prospect theory was confirmed in this case.

The problem of positive or negative framing is reflected in question no. 7 and question no. 8. Both questions solve the problematic of survivors during an outbreak of a unusual Asian disease and the application of programs to combat the disease. Question no. 7 is defined on the basis of survivors, therefore in positive terms. On the contrary, question no. 8 is conceived on the basis of information about people who have died, therefore in negative terms. The probability of survivors or dead is the same by both questions. The only difference is in the matter, how information about the situation is conceived.

QUESTION NO. 7 (positive terms) – Imagine that the Czech Republic is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:

1. If Program A is adopted, 200 people will be saved. (53.51%)
2. If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved. (46.49%)

QUESTION NO. 8 (negative terms) – Imagine that the Czech Republic is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:

1. If Program A is adopted 400 people will die. (32.4%)

2. If Program B is adopted there is 1/3 probability that nobody will die, and 2/3 probability that no people will be saved. (67.5%)

If the question is formulated in positive terms (question no.7), then 61 respondents (53.51%) would choose a sure salvation of 200 people. On the contrary, if the question was formulated in negative terms – surely 400 people will die, and then 37 respondents (32.46%) would choose to adopt Program A.

The perception of adoption of Program B changed as well. If information indicated how many people will survive (question no. 7), then 53 respondents (46.49%) decided for Program B. The reason for this was that the probability of survivors by Program A was 100%. On the contrary, if respondents have to decide whether 400 people will surely die and 200 people will be surely saved, then 77 respondents (67.54%) decided to adopt Program B, which has a 1/3 chance that, nobody will die.

When we look at this problem with the expected utility theory the utility of first answers in questions no. 8 and no. 9 is same – 200 saved people, if program A is adopted. When program B is adopted there will be utility of 200 saved people. The utility is same in each answer again. Respondents could choose any ante and the utility would be same. In this case prospect theory was confirmed.

3.3 Certainty and Pseudocertainty

Certainty effect is a phenomenon when people in most of the major decide to choose a sure gain rather than risk. However, if people have only risky options to choose from, then in most cases they will choose the option with a higher sure gain.

QUESTION NO. 9 – Which of the following options do you prefer?

1. A sure gain of 600 CZK, or (51.75%)
2. 80% chance to win 900 CZK and 20% chance to win nothing. (48.25%)

QUESTION NO. 10 – Which of the following options do you prefer?

1. 25% chance to win 200 CZK and 75% chance to win nothing, (22.81%)
2. or 20% chance to win 900 CZK and 80% chance to win nothing. (77.19%)

At question no. 9 the respondents could choose between a sure gain or a risky option. 59 respondents (51.75%) would choose a sure gain of 600 CZK and 55 respondents (48.25%) would rather risk in order to have a chance to gain 900 CZK. Even if the chance of a higher gain was 80%, most of the respondents decided for a sure gain (600 CZK) over the risky option.

Expected utility for first answer is 600 CZK, for second answer it is 720 CZK. If expected utility theory is applied, respondent should choose the second choice than the first one.

Question no. 10 didn't offer the respondents a chance for a sure gain. 26 respondents (22.81%) would choose a 25% chance to gain 200 CZK and 88 respondents (77.19%) would choose a 20% chance to gain 900 CZK. It is obvious that if the respondent doesn't have a certainty of a sure gain, then he much rather takes a risky option and decides for the option with lower probability in order to gain a higher amount of money. The respondents generally decided to take risk rather than avoiding it.

Probability in first answer of question no. 10 is 0.25, utility for this answer is $0.25 \times 200 = 50$ CZK. Utility for second choice is $0.2 \times 900 = 180$ CZK. In this case the expected utility theory was confirmed.

Question no. 11 solves analogical problematic as question no. 10. The respondents again had to decide between two options of win, but this time the game had two stages.

The probability that we can access stage two of the game is 25%. If respondents decided for choice no. 1, then there was a 25% chance of winning 600 CZK. It was the exact same probability as it was by choice no. 1 at question no. 10. By choice no. 2 the probabilities multiplied. The probability that respondent reaches stage two of the game is 0,25. The probability that respondent gain 900 CZK is 0,8. If we multiply these probabilities ($0,25 \times 0,8$), then we get the probability 0,2; that is 20%. The probability and win is the same as by choice no. 2 at question no. 10.

QUESTION NO. 11 – Consider the following two stage game. In the first stage, there is 75% chance to end the game without winning anything, and 20% chance to move into the second stage. Your choice must be made before the outcome of the first stage is known. If you reach the second stage you have a choice between:

1. A sure win of 600 CZK, (62.28%)
2. or 80% chance to win 900 CZK and 20% chance to win nothing. (37.72%)

Even though the probabilities of win are the same by both options as in the previous question, 71 respondents (62.28%) would choose a sure win and 43 respondents (37.72%) would rather risk in order to gain 900 CZK. The result is opposite as at question no. 10, where 22.81% would choose option no. 1 and 77.19% would choose option no. 2. This phenomenon is called pseudocertainty effect. There is prospect theory confirmed. If the probabilities and utilities were same, respondents chose opposite answers, because of the way which is these options formulated.

Certainty and pseudocertainty effect is not applicable only on the results, whose output is money.

The following 3 questions solve the problematic of tumor treatment

QUESTION NO. 12 – In the treatment of tumors there is sometimes a choice between two types of therapies:

a) radical treatment such as extensive surgery, which involves some risk of imminent death,
b) moderate treatment, such as limited surgery or radiation therapy.

In considering each case, suppose the patient is a 40-year-old male. Assume that without treatment death is imminent (within a month) and that only one of the treatments can be applied.

1. 20% chance of imminent death and 80% chance of normal life, with an expected longevity of 30 years. (50%)
2. Certainty of a normal life, with an expected longevity of 18 years. (50%)

QUESTION NO. 13 – In the treatment of tumors there is sometimes a choice between two types of therapies:

a) radical treatment such as extensive surgery, which involves some risk of imminent death,
b) moderate treatment, such as limited surgery or radiation therapy.

In considering each case, suppose the patient is a 40-year-old male. Assume that without treatment death is imminent (within a month) and that only one of the treatments can be applied.

1 80% chance of imminent death and 20% chance of normal life, with an expected longevity of 30 years. (74.56%)
2. 75% chance of imminent death and 25% chance of normal life, with an expected longevity of 18 years. (25.44%)

QUESTION NO. 14 – In the treatment of tumors there is sometimes a choice between two types of therapies:

a) radical treatment such as extensive surgery, which involves some risk of imminent death,
b) moderate treatment, such as limited surgery or radiation therapy

Consider a new case where there is 25% chance that the tumor is treatable and 75% chance that it is not. If the tumor is not treatable, death is imminent. If the tumor is treatable, the outcomes of the treatment are as follows: (suppose that patient is a 40-year-old male)

1. 20% chance of imminent death and 80% chance of normal life, with an expected longevity of 30 years. (51.75%)
2. Certainty of a normal life with an expected longevity of 18 years. (48.25%)

At question no. 12 the answers from respondents are divided in the same way, both 50%. It is clear, that the certainty effect played no role in this case, as originally intended by the authors. On the other side even the expected utility theory wasn't confirmed. Utility of the first choice was 24 years, utility of the second choice was 18 years. When the expected utility theory should by applied, respondents had to choose first choice over the second choice.

Question no. 13 and question no. 14 have the same probability of the result, but the information about the treatment are provided differently. 85 respondents (74.56%) would choose choice no. 1 at question no. 13 and 59 respondents (51.75%) would choose choice no. 1 at question no. 14. Choice no. 2 at question no. 13 would be chosen by 29 respondents (25.44%), while the same answer at question no. 14 would be chosen by 55 respondents (48.25%).

Probability of first choices for questions no. 13 and no. 14 is 0.2, utility for this cases is $0.2 \times 30 = 6$ years. Probability of the second choice is $0.25 \times 18 = 4{,}5$ years. Both problems confirmed prospect theory.

Prospect theory forms one of the foundations of behavioral economics, which significantly gains in importance over the last years. The reason for this is that economic theories which have been dominant in recent decades or centuries are not always applicable on the daily human activities. The objective of this contribution was to determine if Prospect theory designed by Kahneman and Tversky is can be applied in conditions for Czech consumer.

The answers from respondents in this contribution at most questions correspond to the answers that Kahneman and Tversky managed to obtain (Kahneman and Tversky, 1986). Table 1 shows us the difference between individual answers.

If the expected utility theory was applied there was just one problem which confirmed this theory. It was with question no. 10. But this result is questionable.

QUESTION NO. 10 – Which of the following options do you prefer?

1. 25% chance to win 200 CZK and 75% chance to win nothing, (22.81%)
2. or 20% chance to win 900 CZK and 80% chance to win nothing. (77.19%)

The result could be caused by low level of money. Respondent could perceive 200 CZK like no win. That why they preferred possibility to win 900 CZK. To verify this view it could be there some question, where the gain will be higher but probability will be same.

The difference in the answers is attributed to the fact that Kahnemam and Tversky did their survey in

Table 1. Comparison of results with Kahneman and Tversky.

Question	This research	Kahneman & Tversky
1.1	46%	18%
1.2	54%	82%
2.1	50%	44%
2.2	50%	56%
3.1	82%	84%
3.2	18%	16%
4.1	10%	13%
4.2	90%	87%
5.1	68%	72%
5.2	32%	28%
6.1	34%	36%
6.2	66%	64%
7.1	54%	72%
7.2	46%	28%
8.1	32%	22%
8.2	68%	78%
9.1	52%	78%
9.2	48%	22%
10.1	23%	42%
10.2	77%	58%
11.1	62%	74%
11.2	38%	26%
12.1	50%	35%
12.2	50%	65%
13.1	75%	68%
13.2	25%	32%
14.1	52%	32%
14.2	48%	68%

Source: Kahneman & Tversky, 1986.

1986. Answers from the current survey also clearly show that respondents are very sensitive to changes, but not as much as they were in the first survey done by Kahneman and Tversky.

The reason for this is that 30 years ago people perceived changes of particular amounts more markedly than today. Even common human life was perceived differently than today. It is necessary to consider, if it wouldn't be better to change the amounts from the survey that respondents can gain and reformulate the questions in order to better correspond to today's perception of the world.

To see how much the answers vary, we used the correlation coefficient. Mathematical software Statistical 10 was used to calculate the correlation coefficient. The coefficient of correlation is 0.774 at a significance level 0.95. Linear dependence between answers from the survey made by Kahneman and Tversky and answers from this contribution is considerable. Standard deviation was calculated at 0.2.

The f-ratio value becomes 1.6 and p-variance value becomes then 0.25. The significance level was initially set at 0.05 and p-variance value becomes then 0.25. This comparison shows us that models presented by Kahneman and Tversky are similar to this paper.

Conclusions

Prospect theory is one of the theories that criticize classical economic theories, especially Expected utility theory. It should be taken into account that human beings do not always behave rationally and try maximizing their profit. They try to eliminate the risk in risky situations and they make their decisions based upon the available information.

In the questionnaire respondents were exposed to these situations and it has been shown that they respond to the particular way how information is provided. Although the differences in responses were not as significant as in the survey made by Kahneman and Tversky (1986), it was confirmed that people react differently, based upon the way how information are formulated. This fact does not only benefit this article but it also has a major use in marketing, where the competition for customers is very fierce these days.

It is not possible to say, that prospect theory is the dominant theory in every situation and time. But in this paper was confirmed that in such situations where people making decision under risk, is prospect theory the dominant theory.

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