

## Testing Prospect Theory Parameters<sup>1</sup>

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### Abstract

*This research study used the original Tversky and Kahneman (1992) methodology to establish values of the key prospect theory parameters in samples of Slovakian construction managers and tertiary students. Median sample values for choice tasks with gains elicited in both samples were fairly similar to those established by the Tversky and Kahneman work (1992). When the same estimation techniques and data types are used, the prospect theory parameter values in Slovakian samples seem fairly similar for standard student populations in developed countries. Based on our results we assume that estimation techniques and data types may be more important for determining parameter values than testing environments and gender or experience of participants.*

**Keywords:** *prospect theory, prospect theory parameters, decisions under risk and uncertainty, behavioural economics*

**JEL Classification:** D01, D03, D81

### 1. Parameters of Decision Making in the Expected Utility Theory and the Prospect Theory

This research study deals with detection and computation of prospects in Tversky and Kahneman descriptive theory of decision making. To characterize the expected utility theory and the prospect theory we first compare similarities

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and differences between them. Then we present calculations and formulas of parameter values in the prospect theory and psychological properties of the weighting function. Eliciting parameters of the prospect theory is described in the next part. Finally we present the numerical results of prospect theory parameters of decision making as we determined them in our study with the discussion and implications of our findings.

When Daniel Kahneman and Amos Tversky published their first version of the prospect theory in 1979, the theory immediately attracted attention by researchers in behavioural science.<sup>2</sup> The prospect theory can be viewed as an extension of the expected utility theory which has dominated economic thought on decision-making on micro-level for over seven decades. According to the von Neumann and Morgenstern (1944) people frame their economic decisions in terms of gambles and construct their utility functions on (i) magnitudes of potential outcomes (whether pecuniary or non-pecuniary), (ii) probabilities of potential outcomes, and (iii) risk preferences.

The prospect theory overlaps with the expected utility theory in many areas but differs in being concerned with bounded rationality. There are key similarities between these two theories. Both theories consider expected utility to be a product of utility and probability of the outcome and accept neoclassical assumption on equilibriums. The expected utility theory and prospect theory also agree about assumptions on non-linear valuating (potential) outcomes.

The prospect theory does not dispute maximization effort of rational economic agents (the very basic assumption by neoclassical economy), which underlie decision processes. However, despite this fact computation of potential outcomes (prospects instead of utilities) is defined in rather different way in the prospect theory compared to the expected utility theory. The prospect theory is adding more parameters to computation processes.

As for the above mentioned assumptions the prospect theory is part of the mainstream economic thought. However, there are a certain number of assumptions where the prospect theory departs from the expected utility theory. The most important differences between two theories refer to (i) different weights assigned to positive and negative outcomes by the decision makers; (ii) non-linear weights assigned to small, and medium and large probabilities; (iii) assumption on reference points (people consider changes in utility rather than absolute total of utility), and (iv) concept of rank-dependent utility models. The major differences between the two theories can be formulated as follows:

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<sup>2</sup> In 2002 Daniel Kahneman was awarded the Nobel Prize in economics for his work on the psychology of judgment, decision-making and behavioural economics (Amos Tversky would have, no doubt, shared the prize with Kahneman, but died in 1996).

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- The expected utility theory actually uses just one parameter (curvature of the utility function) to compute value of the expected utility from probability and value of the bet. The prospect theory includes more parameters for computation of utilities of the potential outcomes (prospects): loss aversion and non-linear weighting objective probabilities. The prospect theory thus extends computation of the maximising processes to cases, which the classical expected utility fails to explain. The prospect theory therefore provides a more general framework for explaining decision-making processes. The expected utility theory, in fact, is a special case of the prospect theory, when (i) there is no difference between valuating losses and gains, and (ii) economic agents estimate objective probabilities smartly and assign decision weights identical to values of the probabilities.

- The expected utility theory assumes equal treating gains and losses by the decision makers. In other words, gain 1 000 euros and loss 1 000 euros generate utilities with the same magnitudes, but with different signs. The prospect theory assumes that psychological costs of losses are in average about 2.25 times higher (Tversky and Kahneman, 1992) than utility from the same amount of gains.

- The expected utility theory assumes that people consider objective probabilities when making their decisions. If the outcome A has probability 0.1 and the outcome B probability 0.9 then the outcome B is nine times more important for a decision maker than the outcome A. That seems a quite clear, but in fact behaviour in everyday life is different. Why so many people gamble with their money (in case of lotteries) or health (in case of smoking and drinking), if the probability plays against them? The prospect theory assumes decision weights that are assigned to objective probabilities in non-linear way. The people use to overweight low probabilities, and underweight moderate and large ones. Overweighting low probabilities explains widespread interest in lotteries, but also popularity of buying insurance against terrorist attacks in the air travel. Underweighting medium and large probabilities is behind low willingness to stop smoking and/or drive more safely. Like the expected utility theory, the prospect theory proposes that sure wins (risk-free gains) are considered more valuable than risky ones by decision makers. Once certainty is removed, non-linear weighting probabilities re-emerges.

- The expected utility theory assumes that people frame their decisions in terms of gambles and the total wealth of an individual is starting point for valuation of the outcomes. The prospect theory assumes that gambles are framed only in terms of gains and losses. This assumption is based on fact that the brain relatively quickly adapts to certain level of utility. This level is considered *reference point* and changes are considered carriers of the value, rather than total wealth. According to Kahneman and Tversky (1979, p. 277) 'value should be

treated as a function with two arguments: the asset position that serves as reference point and the magnitude of the change (positive or negative) from that reference point’.

## 2. Computation of Prospects: Formulas and Parameter Values

The expected utility theory replaced expected values with the expected utilities. The prospect theory further refined assumptions on reference points and probability weighting and replaced utilities with prospects:

- The expected value is product of probability and value:  $E(V) = p * v$ ; where  $p$  – probability and  $v$  – value.
- The expected utility is product of probability and utility:  $E(U) = p * u(x)$ ; where  $p$  – probability and  $u(x)$  – utility.
- The prospect is product of decision weights and value of the potential outcome: prospect:  $P = w(p) * v(x)$ , where  $w(p)$  = weighted probability = decision weight, and  $v(x)$  = value of the potential outcome  $x$ . The value of the potential outcome is set as  $v(x) = x^\alpha$ , for  $x \geq 1$ , and  $v(x) = -\lambda(-x)^\alpha$ , for  $x < 1$ , where average  $\lambda = 2.25$ . Transformation of probabilities to decision weights is given by formula:

$$w(p) = \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}}$$

Comparison of expected value, expected utility and prospect concepts points to evolution of the economic thought in the microeconomics. The expected value concept considers a fully rational individual who evaluates potential outcomes according to their objective values and probabilities. The expected utility theory is more realistic as it accepts existence of the risk attitudes in human beings. These are expressed in curvature of the utility function. Individual curvatures of the utility functions are expressed via additional parameter (e.g.  $\alpha$ ), which reflects diverse risk attitudes by decision makers. The prospect considers two more psychological traits: loss aversion (expressed via the  $\lambda$  parameter) and non-linear transformation of objective probabilities to decision weights (expressed via the  $\gamma$  parameter).

The prospect theory had evolved over time. The original prospect theory was based on transformation of individual probabilities to decision weights. The *cumulative prospect theory* assumes that people most consider extreme outcomes of the choices. Cumulative probabilities (which take into account extreme outcomes) are transformed to decision weights instead of individual ones. There were many attempts to refine several proposition of the prospect theory. The

third generation of the prospect theory (Schmidt, Starmer and Sugden, 2008), for example, extends the cumulative prospect theory by allowing reference points to be uncertain (instead of equal to 0), while decision weights are specified in a rank-dependent way.

### 3. Psychological Properties of the Weighting Function

Further research in weighting probabilities (Gonzales and Wu, 1999) pointed to some interesting properties of the weighting function. Weighting may code two independent, yet intertwined psychological traits: (a) discriminability, and (b) attractiveness.

- *Discriminability* reflects subject's knowledge about the likely outcomes of the decisions and ability to discriminate probabilities of the likely outcomes. The more an individual knows about certain issue, the more precise discrimination of decision weights. An expert on horse races, for example, may give more realistic estimates on probability by a specific horse winning the race, than an amateur visitor. The discriminability is reflected in curvature of the weighting function. The more closely the curve resembles the straight line, the higher ability to discriminate probabilities. The step-like function signals low expertise in estimating probabilities and is typical, for example, for children (the probability is either high or low, but no precise estimate can be provided). A migrant can estimate the probability of getting a job in his field; a meteorologist can estimate chances of good weather in next three days.

- *Attractiveness* refers to interpersonal (and also intra-personal) differences in assigning decision weights to certain probabilities and is expressed in elevation of the weighting function. If one chance domain seems more attractive than another one, the first domain receives higher decision weights. The more an individual wishes certain outcome, the higher weights are assigned and the higher elevation of the weighting function. For example the more I wish to get an employment with a foreign company, the more I would overestimate probabilities of getting such job.

Gonzales and Wu (1999) used the two-parameter weighting function to capture effects of the discriminability and attractiveness. Discriminability is expressed by the  $\gamma$  parameter, while the attractiveness by the  $\delta$  parameter of the weighting function:

$$w(p) = \frac{\delta p^\gamma}{\delta p + (1-p)^\gamma}$$

The  $\gamma$  essentially controls the degree of curvature, while the  $\delta$  essentially controls the elevation of the curve. The two traits, however, are inter-related. The less attractive the outcome, the less likely is to generate interest by the decision maker. A bookmaker may successfully estimate probabilities for horse races, but find himself disinterested and/or unable estimating likely winner of the Eurosong contest. As noted by Gonzales and Wu (1999, p. 161) 'we like what we know and we know what we like'.

#### 4. Eliciting Parameters of the Prospect Theory

Prospect theory generated a lot of discussions and controversies for its new enhanced view of the decision-making processes. Since 1992, when the cumulative prospect theory was published, the theory was subject to many tests and examinations. Most research studies aimed at additional measurement of parameters in the value and weighting functions. Table 1 summarises findings by several key studies in this field. How the parameters are measured and estimated? Comparison of the certainty equivalents and actual values of the outcomes in experimental tasks is the most common method for establishing parameters of the value and weighting functions. Imagine a person enters a fair game (chance 50 : 50). The option (A) gives 50% chance to win 50 euros and 50% chance to lose 50 euros; the option (B) provides for declining game and accepting some sure reward instead (= certainty equivalent), say 25 euros. Amount of the certainty equivalent indicates, whether the person is fully rational and risk-neutral (if yes, s/he demands certainty equivalent 50 euros for declining the game), or risk-seeking (in this case certainty equivalent is higher than 50 euros), or risk-averse (which implies certainty equivalent lower than 50 euros). The median certainty equivalent for the abovementioned game is 36 euros (Tversky and Kahneman, 1992). Parameters of the value and weighting functions are estimated from a set of games with different probabilities ( $p = 0.01; 0.05; 0.10; \dots 0.95; 0.99$ ), and values of potential outcomes and respective certainty equivalents. Selected studies (Table 1) in the prospect theory indicate that:

- a) most estimates of the value function parameter  $\alpha$  (curvature of the utility function) lie in interval 0.52 – 1.00 i.e. that most people are risk averse;
- b) most estimates of the weighting function parameter  $\gamma$  lie in interval 0.60 – 0.71 for gains and 0.51 – 0.76 for losses. It means that the decision weights tend to significantly differ from the subjective probabilities for most people.

Most research on the prospect theory took place in developed countries. Students in high-quality universities are typical sample members in this field of research. Majority of research studies use laboratory experiments with student

populations to elicit the risk aversion, loss aversion and the weighting function parameters. Experimental tasks have been administrated in controlled environment and undergraduates and postgraduates in economic, management and psychology have dominated most samples in prospect theory testing (Table 1). Numbers of participants varied from 10 (Gonzales and Wu, 1999) to 420 (Wu and Gonzales, 1996). The choice of controlled environment (laboratory) and student populations is often criticised as distant from common people behaviour in everyday life. Homogeneity of the sample is important for avoiding potential bias resulting from diverse socio-economic and socio-demographic backgrounds of participants however, in reality individual decisions are significantly impacted by a set of socio-economic and socio-demographic factors (age, education, income, employment status, etc.).

**Table 1**  
**Selected Studies Estimating Parameters of the Prospect Theory**

Source	Value Function ( $\alpha$ )	Weighting Function ( $\gamma$ )	Loss Aversion ( $\lambda$ )	Sample Character and Size
Tversky and Kahneman (1992)	0.88	0.61	2.25	25 students
Tversky and Fox (1995)	0.88	(0.69)	x	141 students
Wu and Gonzales (1996)	0.52	0.71 (0.68)	x	420 students
Wu and Gonzales (1999)	0.49	0.68	x	10 students of psychology
Abdellaoui (2000)	0.89	0.60 (0.60)	x	64 students
Bleichrodt and Pinto (2000)	0.77	0.67 (0.55)	x	51 students of economics
Kilka and Weber (2001)	0.76 – 1.00	(0.30 – 0.51)	x	55 students of finance
Abdellaoui et al. (2005)	0.91	(0.76)	x	52 students
Stott (2006)	0.19	0.96	x	96 students
Abdellaoui et al. (2008)	0.86	0.60	2.61	48 students of mathematics and psychology
Abdellaoui et al. (2011)	0.79	0.73	2.47	48 students of management
Authors (2013)	1.02	0.58	2.50	19 construction managers
Authors (2013)	1.00	0.62	2.10	96 students of economic and psychology

*Notes:* Value of the parameter of the weighting function for losses in parenthesis.

*Sources:* Authors' review of the literature and own data.

Overuse of the student population also raises questions about transferability of the prospect theory findings to other groups of people. Would the prospect theory parameter estimates be similar across diverse cultural environments and particular population groups? Are these parameters for example sensitive to gender and effects of perceived competence and/or life experience?

We tried to address the abovementioned research questions in the two research studies aimed at eliciting prospect theory parameters in Slovakian samples. As far as we know the prospect theory assumption has never been examined in

Slovakia neither in any of the East and Central European country so far. We carried out the studies with the two population groups and two different research environments: (i) the study with sample of 19 construction managers was performed in the field, while (ii) the study with sample of 96 University students was done in controlled laboratory environment (computer rooms).

The prospect theory tests risk attitudes under 'pure risk' gambles. Distributions of the 'general risk' trait seem fairly stable across population (Weber, Blais and Betz, 2002; Zuckerman and Kuhlman, 2000) for developed countries at least. Therefore we assumed that the prospect theory parameters elicited with the same methodology should be similar across various countries, so the parameter values found in Slovakia would not differ from the results obtained so far.

Similarly risk taking attitudes examined via the prospect theory are presumably not impacted by gender and previous experiences with longer stay abroad (with the risk involved). Therefore we expected that there would not be substantial difference in the prospect theory parameters for men/women and migrants/non-migrants. We also did not expect any difference between the two different samples of participants (construction managers and students).

## **5. Method**

### **5.1. Participants**

Data were collected in the two samples. The Sample 1 consisted of 19 construction managers (university graduates) aged 27 – 32. The sample was dominated by young and relatively well paid men with above-average income (there were just four women in the sample). Seven out of total construction managers had migration history and previously worked in the United Kingdom, USA, Austria and the Netherlands. The sample 1 participants were not paid for their participation. Testing procedure was performed in the field.

The Sample 2 consisted of 96 undergraduate and postgraduate students (76 women and 20 men aged 20 – 26) of the economics (the University of Economics), and psychology and pedagogics (Comenius University in Bratislava). Nineteen participants had a migration history – they mostly participated in the ERASMUS exchange and/or had at least 6 months working experience in the United Kingdom, Austria, Germany, USA and other countries. Some seminal works in prospect theory used flat payments to students (USD 25 in Tversky and Kahneman, 1992; USD 3 – 5 in Wu and Gonzales, 1996). Slovak students were paid 10 euros for their participation. Reimbursement for participants corresponded with about median net daily income of Slovak students. The construction managers had much higher income than the students and would not consider participation



in the study for 10 euros. Testing procedure used the same online-based software tools as in sample 1, but took place in the computer rooms of the abovementioned Universities.

The method of participant selection in both samples was convenient-based, the participants were recruited via networks of authors and their friends. They voluntarily agreed to participate in the study.

## **5.2. Measures**

### ***Research Instrument***

We have developed an online-based software which replicated Tversky and Kahneman (1992) procedures for eliciting prospect theory parameters and subjected it to verification (program beta testing). Our effort was to create a compute application that would follow the Tversky and Kahneman procedure as it was described in the 1992 study (pp. 305 – 306). The differences from the original design Kahneman and Tversky were twofold: (1) examining only positive prospects; (2) smaller amount of winnings.

The first part of the software instrument consists of 28 games in seven rounds. A participant can hypothetically win amount from euros 20 to euros 200 in particular tasks. Participant's task is to choose between two alternatives: either a risky game (for example, with the possibility of winning some amount of money with 50% probability or not winning anything) or sure amount of money (instead of playing game). The basic question in the first part of the instrument is: At what amount participant prefers to get the money for certain and at what amount does s/he prefer to play the risky game?

The second part of the software consists of 8 tasks. The games are based on a toss of coin, i.e. constant probability of 50% for one of the alternatives. The role of a participant is to compare two games and then determine how much winning the second game has to offer so that both games appeared equally attractive to him/her. The basic question in the second part of the instrument is: At what amount are the games equally attractive for participant?

Participants were connected to the online-based software and performed their tasks on the notebooks individually. All data were automatically recorded to the central database as a software component. The initial training was provided for participants to familiarize them with the tasks.

### ***Methods of Parameter Estimates***

In the prospect theory estimates of parameters vary with the type of data used, estimation techniques, and number and experience of subjects. Original research on the weighting function estimated the one-parameter ( $\gamma$ ) form of the function

and used the cash equivalent data to fit the function  $w(p) = p^\gamma / [p^\gamma + (1 - p^\gamma)]^{1/\gamma}$  (Tversky and Kahneman, 1992). Other researchers also considered one-parameter function, but differed in terms of estimation techniques (nonlinear regression of cash equivalents versus fitting stochastic choice functionals) and data uses (choice versus cash equivalent) (Abdellaoui, 2000; Tversky and Fox, 1995; Wu and Gonzalez, 1996). Gonzales and Wu (1999) used the median data and the individual subject data to estimate two-parameter weighting function:  $w(p) = \delta p^\gamma / [\delta p^\gamma + (1 - p^\gamma)]^\gamma$ . All studies found broadly similar parameter estimates (Table 1), but also considerable diversity at the level of individual subjects. Diversity at the individual data translates to differences in parameter estimates computed from median and individual data. The same finding applies to the value function parameter ( $\alpha$ ). While most studies found median estimates of the  $\alpha$  parameter of the power function in interval 0.77 – 1.00, individual-level data use to account for standard deviations over 45% means and 55% medians (Abdellaoui, Bleichrodt and Paraschiv, 2007).

The parameters  $\alpha$  and  $\gamma$  were elicited from the median cash equivalents for the gains only (as we did not consider gambles with negative outcomes). An overwhelming majority of studies used median fitted parameters (and student samples) to establish parameter estimates (see Fox and Poldrack, 2008, for an excellent review of the prospect theory parameters). Medians of the cash equivalents were entered into a non-linear regression assuming a power value function ( $v(x) = x^\alpha$ ), and either (i) single-parameter weighting function  $w(p) = p^\gamma / [p^\gamma + (1 - p^\gamma)]^{1/\gamma}$  or (ii) two-parameter weighting function:  $w(p) = \delta p^\gamma / [\delta p^\gamma + (1 - p^\gamma)]^\gamma$ .

The ‘Nonlinear Regression’ command (based on the Levenberg-Marquardt algorithm) in the SPSS programme was used for model expression and parameter estimates. The algorithm provides a numerical solution to the problem of minimising a non-linear function over a space of parameters of the function and is frequently used in the least squares curve fitting (Levenberg, 1944). The parameter values were estimated from the median sample values, individual-level medians and individual means (Table 2).

### 5.3. Results

Sample 1 generated values  $\alpha = 1.02$ ,  $\gamma = 0.58$  and  $\lambda = 2.50$ . Median value of the  $\gamma$  and  $\lambda$  parameters were quite close to that by Tversky and Kahneman (1992), while the  $\alpha$  value was somewhat higher. Men seemed more risk seeking than women (respective values of the  $\alpha$  parameter were 1.021 and 1.018), and also were doing better in discriminating probabilities (respective values of the  $\gamma$  parameter were 0.578 and 0.529). Migrants accounted for somewhat lower levels of the risk-aversion. Median sample value of the power function ( $\alpha$  parameter)

was 1.018 for migrants and 1.015 for non-migrants. The migrants, however, accounted for slightly lower levels of the loss aversion. The median value of the  $\lambda$  parameter was 2.23 for migrants and 2.50 for the non-migrants. The highest differences between the two groups were in median values of the  $\gamma$  parameter: 0.660 for migrants and 0.529 for non-migrants. Migrants seemed to do better in setting decision weights closer to objective probabilities when transforming probabilities to decision weights. This observation was taken from everyday life, and is not directly comparable with samples of students examined in controlled environments. The sample size also was too small to claim representative results. It however, is interesting that median values of the key parameters in the total sample of construction managers ( $\alpha = 1.00$ ,  $\lambda = 2.50$ , and  $\gamma = 0.58$ ) were not far from values established by the Tversky and Kahneman ( $\alpha = 0.88$ ,  $\lambda = 2.25$ , and  $\gamma = 0.61$ ). High standard deviations for the individual means of  $\alpha$ ,  $\gamma$ ,  $\lambda$  parameters indicated very diverse attitudes to risk-taking, loss-aversion and probability weighting in sample 1 as well. However, all studies on the prospect theory parameters found considerable variation at individual level (see Fox and Poldrack, 2008, for discussion).

Most findings from the Sample 1 were replicated in the Sample 2. The Sample 2 generated values  $\alpha = 1.00$ ,  $\gamma = 0.62$ , and  $\lambda = 2.10$ . These values also were quite close to those estimated by the Tversky and Kahneman (1992). Median sample values for particular population group indicated that men were rather more risk seeking than women (respective values of the  $\alpha$  parameter were 1.007 and 1.002) and also accounted for better discriminating probabilities (respective values of the  $\gamma$  parameter were 0.656 and 0.596). Migrants accounted for somewhat higher levels of the loss-aversion. The median value of the  $\lambda$  parameter was 2.30 for migrants and 2.10 for the non-migrants. High heterogeneity in individual values of  $\alpha$ ,  $\gamma$ ,  $\lambda$  parameters (attested by high standard deviations) was confirmed for the Sample 2.

High heterogeneity in individual values of  $\gamma$  parameter was reflected in very diverse shapes of the weighting function (Figures 1 – 4). Figure 1 compares shapes of weighting functions for gains established via median cash equivalents by Tversky and Kahneman (1992) ( $\gamma = 0.61$ ) and authors ( $\gamma = 0.62$ ). The functions have typical shapes of inverse S.

Figure 2 exemplifies step-like shape of the weighting function with low values of  $\gamma$  parameter (participant no 5 in sample 1,  $\gamma = 0.262$ ). The step-like function indicates less sensitivity to changes in probability than the linear function, except near 0 and 1. Low values of  $\gamma$  associate with the poor ability to discriminate probabilities and “corresponds to the case in which an individual detects ‘certainly will’ and ‘certainly will not’, but all other probability levels are treated

equally” (Gonzales and Wu, 1999, p. 137). For values of the  $\gamma$  parameter higher than 1 the shape of the weighting function resembles S. Values of the  $\gamma$  parameter higher than 1 are rather scarce. We found five such participants in the Sample 2 (96 students) and none in the Sample 1 (19 construction managers).

Figure 3 displays shape of the weighting function for participant no 37 in the Sample 2 ( $\gamma = 1.579$ ). Finally weighting functions with  $\gamma$  parameters close to 1 indicate good ability to estimate probabilities and their shapes blend with straight lines assumed in linear weighting (Figure 4, participant no 2 in the Sample 2,  $\gamma = 0.898$ ). Linear or near-linear shapes of the weighting functions indicate high sensitivity to relatively small changes in odds and are sometimes found for certain professionals gambling in their domain of expertise (Thaler and Ziemba, 1988).

Next we used sample medians and applied the two-parameter weighting function:  $w(p) = \delta p^\gamma / [\delta p^\gamma + (1 - p^\gamma)]^\gamma$  to elicit values of the  $\delta$  parameter in the Samples 1 and 2. The  $\delta$  parameter of weighting function refers to elevation of the weighting function due assigning higher decision weights to certain probabilities which seem attractive to decision maker.

- In the Sample 1 the total sample median value of  $\delta$  parameter was 1.0. Values for the respective subpopulations were 0.797 for men, 0.870 for women, 0.943 for migrants, and 0.870 for non-migrants.

- In the Sample 2 the total sample median value of  $\delta$  parameter 0.753. As for the subpopulation median values, these were 0.876 for men, 0.701 for women, 0.762 for migrants, and 0.749 for non-migrants.

Most values of the  $\delta$  parameter fall into interval 0.6 – 1.00. Values of the  $\delta$  parameter found in our research corresponded with those established by Abdellaoui (2000) (0.65), Abdellaoui, Vosmann and Weber (2005) (0.77), Tversky and Fox (1995) (0.77) and Stout (2006) (1.00).

Higher values of  $\delta$  are reflected in higher elevation of the weighting function and associated with less risk aversion for gains and more risk aversion for losses. Sample median values of  $\alpha$  and  $\lambda$  parameters seem to confirm this pattern for men/women and migrants/non migrants in the Sample 2 in particular. Men and migrants found gambling more attractive.

Values of  $\delta$  lower than 1 indicate that the decision weights of complementary events sum to less than one  $\{w(p) + w(1 - p)\} < 1$  for a typical decision maker (Fox and Poldrack, 2008, p. 156). This property is known as subcertainty (Kahneman and Tversky, 1979) and is satisfied whenever  $\delta < 1$ .

Research studies with the Samples 1 and 2 indicated that the prospect theory parameters elicited with the same methodology in the Slovak samples as a whole did not differ from the results found in the other countries.

Table 2

## Estimates of the Prospect Theory Parameter Values in the Slovak Samples

Data type	Construction Managers in Slovakia			University Students in Bratislava		
	Median value	Individual-level median	Individual-level mean	Median value	Individual-level median	Individual-level mean
<b>All subjects</b>	N = 19			N = 96		
Value function ( $\alpha$ )	1.021 (0.008)	1.035	1.042 (0.059)	1.003 (0.005)	1.016	1.027 (0.046)
Weighting function ( $\gamma$ )	0.578 (0.040)	0.571	0.541 (0.202)	0.623 (0.033)	0.499	0.578 (0.423)
Loss aversion ( $\lambda$ )	2.500	2.300	2.584 (1.063)	2.100	2.300	2.404 (1.021)
<b>Men</b>	N = 15			N = 20		
Value function ( $\alpha$ )	1.021 (0.008)	1.035	1.049 (0.050)	1.007 (0.004)	1.013	1.032 (0.045)
Weighting function ( $\gamma$ )	0.578 (0.040)	0.571	0.532 (0.197)	0.656 (0.033)	0.626	0.642 (0.414)
Loss aversion ( $\lambda$ )	2.500	2.500	2.713 (1.010)	2.167	2.033	2.297 (1.217)
<b>Women</b>	N = 4			N = 76		
Value function ( $\alpha$ )	1.018 (0.011)	1.036	1.014 (0.090)	1.002 (0.005)	1.016	1.026 (0.047)
Weighting function ( $\gamma$ )	0.529 (0.041)	0.546	0.579 (0.247)	0.596 (0.034)	0.480	0.561 (0.426)
Loss aversion ( $\lambda$ )	1.767	1.800	2.100 (1.275)	2.100	2.300	2.433 (0.970)
<b>Migrants</b>	N = 7			N = 19		
Value function ( $\alpha$ )	1.015 (0.009)	1.015	1.045 (0.066)	1.002 (0.004)	1.016	1.033 (0.051)
Weighting function ( $\gamma$ )	0.660 (0.064)	0.621	0.594 (0.203)	0.681 (0.039)	0.597	0.605 (0.422)
Loss aversion ( $\lambda$ )	2.233	2.300	2.586 (1.275)	2.300	2.700	2.514 (1.253)
<b>Non-migrants</b>	N = 12			N = 77		
Value function ( $\alpha$ )	1.018 (0.011)	1.045	1.040 (0.579)	1.001 (0.005)	1.016	1.026 (0.045)
Weighting function ( $\gamma$ )	0.529 (0.041)	0.478	0.511 (0.204)	0.601 (0.038)	0.485	0.571 (0.426)
Loss aversion ( $\lambda$ )	2.500	2.400	2.583 (0.982)	2.100	2.300	2.377 (0.936)

Notes: Standard deviations in parenthesis. All values computed from the single-parameter weighting function.

Source: Authors' own research.

## 6. Testing Prospect Theory Parameters for Gender and Migration Experience

Parameter estimates computed both from the median sample data and individual-level data found that men accounted for the higher values of the  $\gamma$  parameter than women and migrants than non-migrants. As for the  $\alpha$  and  $\lambda$  parameters, no clear pattern was established.

The Sample 1 (construction managers) was too small for taking reasonable tests on differences in parameters stemming from gender and/or previous migration experience. In the Sample 2 (Slovak students) the abovementioned differences were examined via the Mann-Whitney U-test:

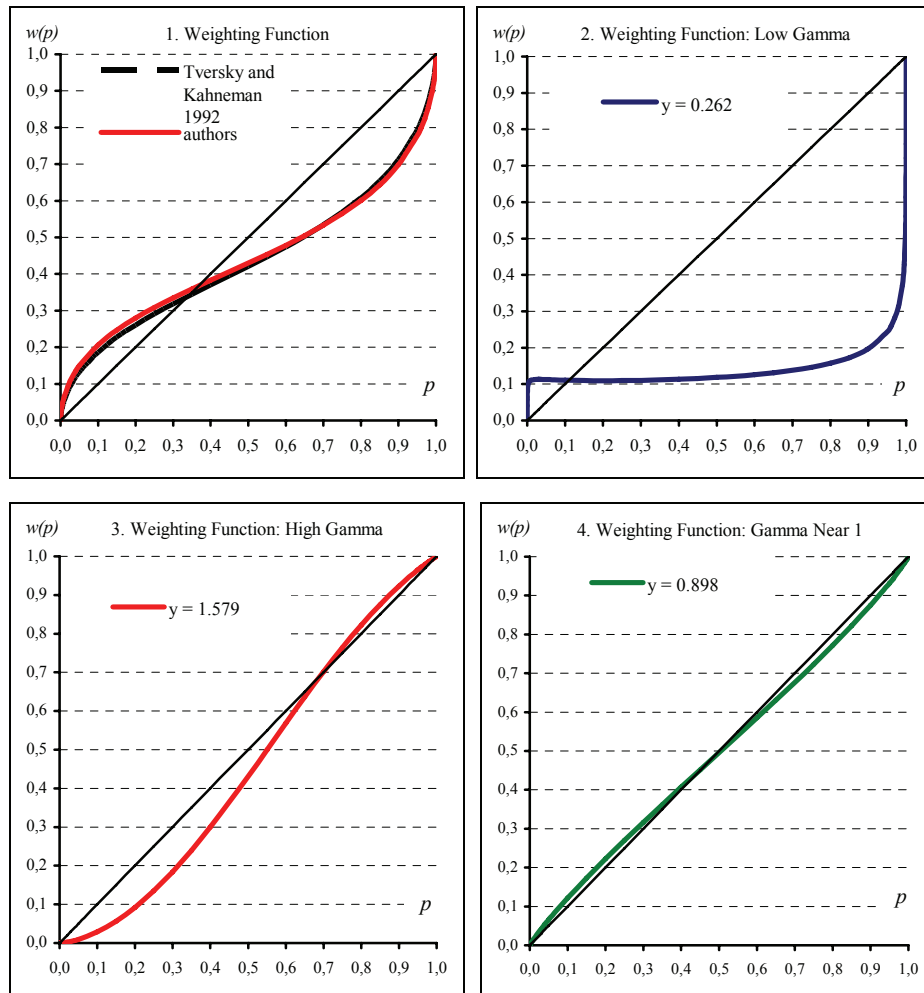
- As for the gender, the test values established for the parameters  $\alpha$  ( $Z = -0.140$ , sig. 0.889),  $\gamma$  ( $Z = -1.015$ , sig. 0.310), and  $\lambda$  ( $Z = -0.629$ , sig. 0.529) indicated no significant differences between men and women.

- As for the previous migration experience, the test values established for the parameters  $\alpha$  ( $Z = -0.372$ , sig. 0.710),  $\gamma$  ( $Z = -0.352$ , sig. 0.730), and  $\lambda$  ( $Z = -0.369$ , sig. 0.712) indicated no significant differences between migrants and non-migrants.

We found no substantial difference in the prospect theory parameters for men and women, and migrants/non-migrants.

Figures 1–4

#### Examples of Shapes of the Weighting Function



Source: Tversky and Kahneman (1992) and examples from authors' own research.

## 7. Discussion and Conclusions

This research study used the original Tversky and Kahneman (1992) methodology to establish values of the key prospect theory parameters in the Samples of Slovak construction managers and tertiary students. We found that median sample values for the gains (based on cash equivalents) elicited in both samples were fairly similar to those established by the Tversky and Kahneman findings (1992), but also those by Abdellaoui, L'Haridon and Bleichrodt (2008). Parameter values are sensitive to methods of estimation technique and data use. When the same estimation techniques and data types are used, parameter values seem fairly similar for the standard student population. Interestingly, similar values of  $\alpha$ ,  $\gamma$ ,  $\lambda$  and  $\delta$  parameters were found in our samples 1 and 2, which differed in terms of (i) age, occupation, gender and income structure, and (ii) testing environments (field work versus laboratories). We assume that estimation techniques and data types may be more important for determining parameter values than testing environments and gender/occupation/income structure of sample. This assumption, however, must be verified on larger samples.

There is an extensive literature on gender differences in the broader field of research on risk. A meta-analysis of 150 studies (Byrnes, Miller, and Schaffer, 1999), for example, found that men were more risk tolerant in 14 out of 16 observed types of risk behaviour. Individual willingness to take risks may be related to optimism and overconfidence (Lovallo and Kahneman, 2003). Individuals may account for positive beliefs about their personal knowledge and capabilities when dealing with risks. Most research on individual risk-taking focuses on financial decisions, reflecting the prominence of the topic and the availability of data from financial markets and institutions. Almost all research studies on financial risk-taking indicate higher risk aversion in women (e.g., Bernasek and Shwiff, 2001; Schubert et al., 1999). Studies of financial risk-taking, however, are made in a competence-informed context, where prior knowledge is brought to play. Studies of financial risk-taking cannot explain gender differences in a 'pure chance' risk context, such as gambling. Studies examining gender attitudes to risks in laboratory environments (Daruvala, 2007; Ronay and Kim, 2006) found no significant differences in risk-taking by men and women. The procedure used to derive parameters of the prospect theory is free of the competence effects and simulates 'pure risk' environment. Parameter values should not be impacted by perceived competence and/or previous experience and account for similar levels across selected socio-demographic groups. We tested this assumption for gender and previous migration experience. In our research study (the Sample 2) we found the median sample values and median of individual values of the  $\alpha$  parameter higher for men than women. The difference, however, was insignificant.

The  $\gamma$  parameter essentially measures ability to estimate probabilities of events. This parameter could be affected by previous experience with various events with uncertain outcomes (such as weather forecasting, horse race betting or investing on financial markets). There is some evidence that shape of the probability weighting function is source dependent (Kilka and Weber, 2001) and determined by a subject's ability to discriminate probabilities (Fox, Rogers and Tversky, 1996; Thaler and Ziemba, 1988). Migrants had opportunities to live/study in foreign countries. Any migration is a risky undertaking with uncertain outcomes. It could be assumed that migrants may have better training and ability for estimating probabilities, but this ability may be related to migration risks only. In our research men and migrants seemed to account for higher values of the  $\gamma$  parameter, but this difference also was found insignificant on level 0.05.

Our research have had several important limitations. The Sample 1 was too small to examine differences related to particular socio-demographic group. The Sample 2 accounted an adequate size, but was dominated by women (76 out of total 96) and non-migrants (77 of total 96). Further research studies may consider samples of higher size and better structure in terms of gender and migration experience.

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