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The empirical research of risk preference based on prospect theory: A case study of China large state-owned enterprise managers

Zhang Yingyu[1*], Bo Xiaodong[2], Shao Wei[1], Luan Hui[1]

[1]School of management, Qufu Normal Universtiy, Rizhao, Shandong Province, (CHINA)

[2]National Academy of Economic Strategy, Chinese Academy of Social Science, Beijing, (CHINA)

E-mail: yingyu369@163.com

ABSTRACT

To test the applicability of prospect theory, 252 China large state-owned enterprises managers are surveyed. Results show that: Main assumptions and conclusions of prospect theory is generally applicable to China Large state-owned enterprise managers; There is little difference between our results and foreign countries in the parameter estimation of value function and weight function; There is different risk preference distribution among different types individual at different situation and different probability; 30% of individuals do not accord with the assumption that the individual data for probabilities of the risk attitude coefficients should be in the range between 0.05 and 0.95.

KEYWORDS

Prospect theory; Cumulative prospect theory; Value function; Weighting function; Parameter estimation; China large state-owned manager.

Behavioral Economics, represented by prospect theory is an interdisciplinary between psychology and economics, trying to modify the traditional economic theory assumes, bringing irrational and complex human behavior analysis into standard economic theory[1]. Because of the pioneering contribution of prospect theory, Kahneman won the 2002 Nobel Prize in economics, behavioral economics has gradually become mainstream economics. After thirty years of development, forms and conclusions of prospect theory are increasingly rich and perfect. 38 Zhongshan University graduate as the experimental samples, Chinese scholars Ceng (2007) verified the applicability of prospect theory, and obtained some conclusions inconsistent with prospect theory[2]. Similarly, whether the conclusions of prospect theory are also applicable to China large state-owned enterprise managers? There is no empirical data to test and answer this question.

PROSPECT THEORY AND CUMULATIVE PROSPECT THEORY

Prospect theory

Tversky & Kahneman (1979) published the pioneer article--*Prospect Theory: An Analysis of Decision under Risk.* Under prospect theory framework, human decision-making process is divided into two stages, namely, editing and evaluation[3]. Academic significance of value function is the fundamental reason of wining the 2002 Nobel Prize in Economics. Prospect theory uses value function to explain choice behavior under uncertainty[4]. Weighting function is not subjective probability, but a given probability of "twisted". Weighting function is not linear, inversing S-shaped curve, being concave in small probability conditions, being convex in large probability conditions[5]. Weighting function can be seen as contrary to common assumptions ratio of expected utility theory[6].

Cumulative prospect theory

After prospect theory, many scholars have proposed an expression called rank-dependent function or cumulative function[7-10]. Based on previous results and series of experiments, Teversky & Kahneman (1992) proposed cumulative prospect theory[11]. For convenience, prospect theory (PT) and cumulative prospect theory (CPT) will be collectively known as prospect theory, only when need to distinct the two theories, PT and CPT will be used. Compared with the PT, CPT majorly expand the following works: CPT can be applied to any finite prospects and continuous distributions; In the situation of gain and loss, allowing different decision weights, unlike the PT; Solving the question of PT that can not meet the first stochastic dominance issue, modeling the weight of cumulative distribution, developing the rank-dependent function.

Value function expression of CPT is:

$$v(x)=\begin{cases} x^{\alpha} & x\geq 0 \\ -\lambda\ (-x)^{\beta} & x\leq 0 \end{cases} \tag{1}$$

Where α, β is the coefficient of risk attitude, λ is the coefficient of loss aversion, and $\alpha<1, \beta<1,\ \lambda>1$.

Value function is concave in the case of gain, and convex in the case of loss. In other words, people will be risk aversion in the case of gain and risk seeking in the case of loss. In addition, the degree of risk aversion is stronger than risk seeking.

Weighting function expression of CPT is:

$$\begin{cases} w^{+}(p)=\dfrac{p^{\gamma}}{\left(p^{\gamma}+(1-P)^{\gamma}\right)^{1/\gamma}} \\ w^{-}(p)=\dfrac{p^{\delta}}{\left(p^{\delta}+(1-P)^{\delta}\right)^{1/\delta}} \end{cases} \tag{2}$$

Where γ, δ is the coefficient of weighting function, and $\gamma<1,\ \delta<1$.

Meaning of the weighting function is that people generally overestimate small probability and underestimate high probability. With the probability close to 1, it returns to the "true" state. Expected utility theory simply uses utility function to judge individual risk preference, while prospect theory joints value function and weighting function to judge risk preference. Under the framework of prospect theory, the mode of risk preference is a quartile mode, which proposes that risk taking is asymmetric about a reference point, and that people will be risk aversion when they perceive themselves to be in the domain of gain, and risk seeking in the domain of loss. Prospect theory has stimulated numerous research studies into risk preferences and risk taking. A key premise of the theory is that individual level risk taking is relatively inconsistent across situations--a person will take risk in some circumstances, and avoid risk in other circumstances. The prompt for behavioral change could be as simple as the semantic presentation of data, for example whether a choice outcome is presented as a loss or a gain.

THE DEVELOPMENT OF PROSPECT THEORY

Other forms of value function

Wakker & Zank (2002) proposed a two-stage power function value function[12]:

$$u(x_i)=\begin{cases} ax_i^{\alpha} & x_i \geq 0 \\ -b|x_i|^{\beta} & x_i \leq 0 \end{cases} \quad (3)$$

Where x_i is the degree of income away from the reference point, $u(x_i)$ measures the relative gain or loss of value judgment.

Rieger (2007) considered that the value function of CPT can not describe the issue of very risk-averse. Therefore, he proposed a new expression of value function[13]:

$$v(x)=\begin{cases} 1-e^{-\alpha x} & x \geq 0 \\ -\lambda+\lambda e^{\beta x} & x \leq 0 \end{cases} \quad (4)$$

Where $\alpha, \beta \in (0,\infty)$.

In addition, Rieger (2007) proposed another expression of value function:

$$v(x)=\begin{cases} \lambda(x+\frac{\alpha^{-}}{2}x^2) & x<0 \\ x-\frac{\alpha^{+}}{2}x^2 & x \geq 0 \end{cases} \quad (5)$$

Other forms of weighting function

Before the study of Tversky & Kahneman's CPT, scholars improved a number of modification of expected utility theory to overcome "birth defects" such as "linear". Among them, the greatest impact is the weighting function of Quiggin (1982):

$$h_i(p)=f\left(\sum_{j=1}^{i} p_j\right)-f\left(\sum_{j=1}^{i-1} p_j\right) \quad (6)$$

Significance of the formula (6) is to consider $h_i(p)$ depends on all probability $p_1=p_2=\cdots=p_n$, not just the new weighting function expression p_i, which is a correction of expected utility theory. In addition, the relationship between probability and its weighting function depends on the position of the preference rating of all kinds of outcomes.

Another alternative weight function expression is proposed by Prelec (1998)[14]:

$$g(p)=e^{-(-\ln p)^{\gamma}} \quad (7)$$

The curve intersects the 45° line at point $p=1/e\approx 0.37$. As γ decreases, the weighting function is more concave on the left of $1/e$, on the right is more convex.

Gonzalez & Wu (1999) used discriminability to characterize curvature, with attractiveness to depict the elevation, proposed the following expression[15]:

$$w(p)=\frac{\delta p^{\gamma}}{\delta p^{\gamma}+(1-p)^{\gamma}} \quad (8)$$

Where $\delta=\exp\tau$, δ is used to control the curvature, γ is used to control the elevation.

Enrico, et al. (2007) proposed the following switch-power weighting function:

$$w(p)=\begin{cases} cp^{a} & p \leq \hat{p} \\ 1-d(1-p)^{b} & p>\hat{p} \end{cases} \quad (9)$$

Where $\hat{p}$ is the probability of intersection of weighting function and 45° line.

Compared with the weighting function of CPT, the switch-power weighting function is more "accurate", because formula (9) is a two-stage function, the shape of left and right sides are different, and it is described by multiple parameters.

SURVEY DESIGN AND STATISTICAL ANALYSIS BASED ON PROSPECT THEORY

Methods

In CPT paper, CE (certain equality) used by Teversky & Kahneman can analyze qualitatively and quantitatively the risk preference, and return a specific value function and weighting function parameters. Therefore, this paper also uses CE paradigm. Along Teversky & Kahneman's research ideas, two types of questions are designed in the questionnaire:

A: Gain or loss a_1 yuan with the probability of p_1, gain or loss a_2 yuan with the probability of p_2.

B: Certainty gain or loss *x* yuan.

Numerical design of the outcome: The data used by Teversky & Kahneman (1992), Zeng (2007) and Gonzalez & Wu (1999) are combined, four pairs of data are selected, including four positive and four negative: (±100, 0), (±200, 0), (±75, ±50), (±150, ±100).

Probability design: In Teversky & Kahneman (1992) experiment, 0.01, 0.05, 0.10, 0.25, 0.50, 0.75, 0.90, 0.95, 0.99 are selected. Gonzalez & Wu (1999) added 0.40 and 0.60 based on the nine groups. This paper uses the former.

Combination rule of outcome and probability: eight outcome number and nine probability are combined, resulting 72 kinds of combinations. In order to reduce the overload of those surveyed, 72 kinds of combinations are divided into six groups, which includes 12 combinations. In addition, two repeated questions are designed in each questionnaire, to test the consistency of selection of those surveyed. It should be noted that the difference on the subject don't lead to difference in the nature of result of survey, because the validity of prospect theory obviously should not depend solely on the prospect of Teversky & Kahneman's experiment.

Design of CE options: we take "round selection method", namely, the interval range of prospect is given directly to four investigation object selection.

About the experimental sample, we believe that the sample number of previous researches is small, the number should be increased. 143 large state-owned enterprise managers as sample, a total of 400 questionnaires were distributed, 296 recovered, 74% recovery rate. Among them, 252 questionnaires is valid.

Results

Teversky & Kahneman (1992) took the median of CE of the prospects. We improve on the median and mean integration, let

$$MM = \frac{Median + Mean}{2} \quad \textbf{(10)}$$

Our purpose mainly include: First, average median and mean can minimize survey error; Second, mean is the most important statistical data of central tendency, its disadvantage is easily influenced by extreme values; Median is suitable for sequential data measure of central tendency, however, can not take advantage of all the data. Integrating of the mean and median can overcome their shortcomings, but also play their respective advantages.

The questionnaire contains 28 positive and 30 negative prospects (some questionnaire is invalid), TABLE 1 lists these prospects and its MM of certain equality.

By non-linear regression, we obtain the parameters of value function of CPT: $\alpha = \beta = 0.92,\ \lambda = 1.97$.

TABLE 1 : The MM of certain equality of prospects

	.01	.05	.10	.25	.50	.75	.90	.95	.99
(100, 0)	2.5	10.0	17.0	22.5	35.0	64.0	74.0	85.5	95.0
(-100, 0)	-6.0	-8.0	-12.0	-27.0	-48.5	-75.0	-80.0	-85.0	-92.5
(200, 0)	4.0		25.3		83.0	112.0	155.0	183.0	187.0
(-200, 0)	-4.5	-19.0	-24.5	-65.0	-97.0	-141.5	-157.5	-178.5	-192.5
(75, 50)	52.5	52.0		56.0	61.0		70.0	70.0	
(-75, -50)	-52.5	-52.5		-59.0	-66.0		-66.5	-69.0	
(150, 100)		103.0	107.5	111.0		134.5	141.5		146.5
(-150, -100)	-102.0		-106.0		-125.0	-133.0		-140.0	-143.0

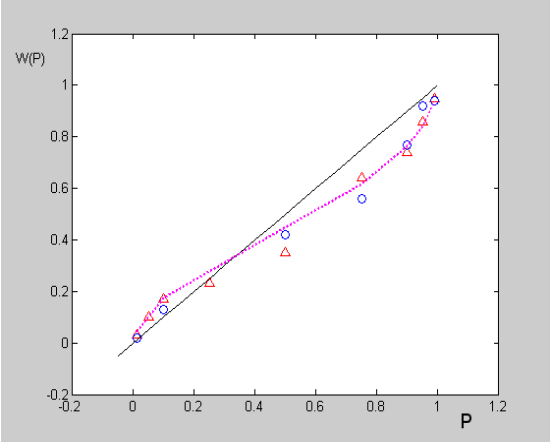

Figure 1 : Weighting function under gain situation

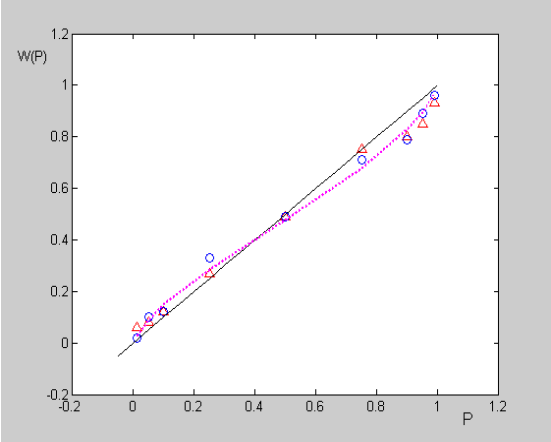

Figure 2 Weighting function under loss situation

For the prospect $(x, p; 0, 1-p)$, if the result is not equal to zero, let c/x represents the ratio of CE of the prospect. Comparing with the c/x and probability of the prospect under gain and loss situation, we can obtain the distribution of probability of weighting function. By non-linear regression, we obtain the parameters of weighting function: $\gamma = 0.68$, $\delta = 0.77$. Curves in Figure 1 and Figure 2 are the curve of weighting function under gain and loss situation respectively, the triangle represents the c/x median of $|x| = 100$ under gain situation, the circle represents the c/x median of $|x| = 200$ under loss situation.

Through Figure 1 and Figure 2, it seems to be correct that weight function through the 45 ° line at the point $p = 1/e \approx 0.37$. However, parameters are different under gain and loss situation, implicit premise of the weighting function proposed by Prelec is that parameters are the same, inconsistent with this research. The weighting function proposed by Enrico, et al. (2007) is more accurate, but it requires multiple parameters to describe the function. The significance of this paper is to test the applicability of cumulative prospect theory, so we don't give the specific parameters estimation of that weighting function.

Parameters comparison of value function and weighting function

The parameter estimation of risk attitude ($\alpha = \beta = 0.92$) of this paper is consistent with the assume $\alpha, \beta < 1$, but the number is bigger than $\alpha = \beta = 0.88$, which is proposed by Teversky & Kahneman (1992). This shows that the utility function is in line with the law of diminishing utility on the one hand, but on the other hand the diminishing strength is small. The parameter estimation of loss aversion is $\lambda = 1.97$, which is smaller than $\lambda = 2.25$. This shows that our results are consistent with the universal law that the pain caused by the loss of a amount of money is bigger than the happiness caused by the gain of the same amount of money, the ratio of the pain and happiness is smaller (see Figure 3). Of course, this is normal, because Teversky & Kahneman (1991) believe that this ratio is approximately 2[16]. Compared with other estimations of Camerer & Ho ($\alpha = 0.32$)[17], Wu & Gonzalez ($\alpha = 0.52$)[18], and Gonzalez & Wu ($\alpha = 0.49$)[19], our result is bigger.

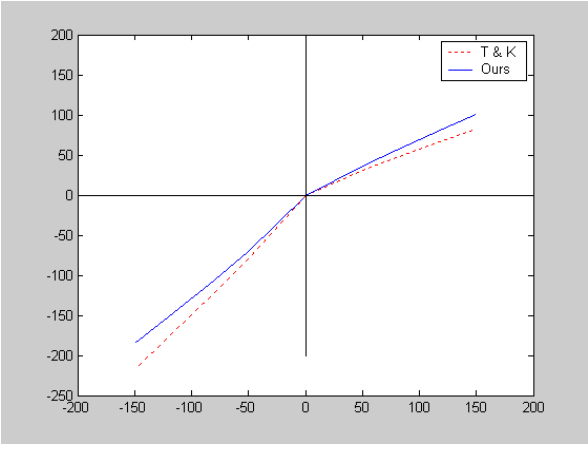

Figure 3: Curve comparison of value function

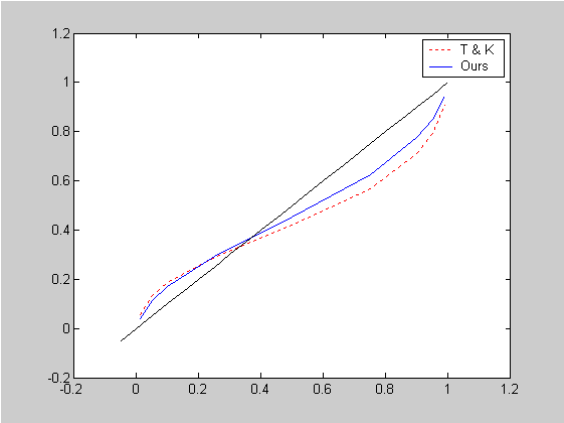

Figure 4: Curve comparison of weighting function under gain situation

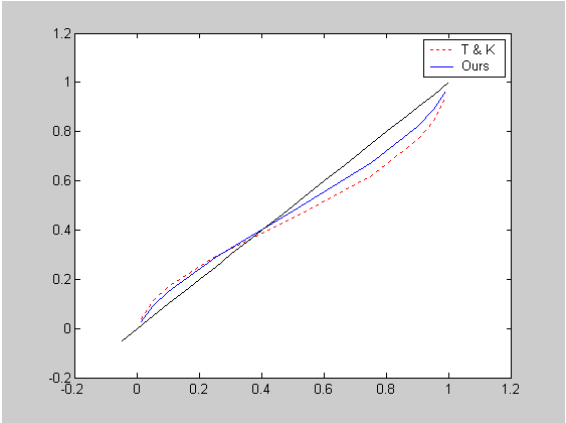

Figure 5: Curve comparison of weighting function under loss situation

Compared with Figure 4 and Figure 5, we can find that the curve of Teversky & Kahneman (1992) is steeper than the curve of ours, either in the gain situation or in the loss situation, especially in the loss situation. This shows that the extent of the overestimate to small probability and the underestimate to large probability to China large state-owned managers is much minor. Our empirical result is larger than Camerer & Ho ($\gamma = \delta = 0.56$), is roughly equal with the result ($\gamma = \delta = 0.74$) of Wu & Gonzalez (1996). Compared with the result ($\gamma = 0.44, \delta = 0.77$) of Gonzalez & Wu (2003), our result is consistent in the loss situation, but different in the gain situation.

Analysis

As mentioned previously, the parameters estimation of value function and weighting function is different with the previous experimental results, and some difference is much bigger. We believe that the reason for this difference may include:

First, different experimental subjects. Students are as experimental subjects in previous studies, but enterprise managers are as those survey in our study. Due to managers with many years of work experience, probability estimation is more consistent with reality, they will neither too highly overestimate the small probability, nor will underestimate the large probability. With a certain economic base, the sensitivity to the results is much smaller.

Second, Cross-cultural differences. There is a huge culture differences between China and abroad, and the difference will lead to the difference of analyzing an handling specific issues for individual. In general, compared with foreigners, Chinese people are more cautious, taking things more fully, the estimation of probability and outcome will be more conservative.

Third, The number of experimental subjects. Number of previous investigations is generally small, whether the experimental results could be applied to general features worth discussing. Through large-scale survey, our conclusion might be more suitable for a certain general characteristics.

FURTHER RESEARCH ISSUES

In addition to the statistical analysis of the results, we also find some results are inconsistent with the assumptions and conclusions of prospect theory. First, under the framework of prospect theory, Teversky & Kahneman think that quartile mode of risk preference is a common empirical results in conditions of risk selection, there is no significant correlation between different individuals. Our statistical analysis does not support this view, instead, there are significant differences between different types of individuals in different conditions of the probability distribution of risk preference. Second, Teversky & Kahneman believe that the individual risk attitudes coefficient of value function is between 0.05 to 0.95, although there is a little difference between the result of Teversky & Kahneman ($\alpha = \beta = 0.88$)and ours ($\alpha = \beta = 0.92$), further analysis, 30% of individuals do not meet this assumption. These issues deserve further exploration in the next research.

CONCLUSIONS

By analysis, the below conclusions can be drawn: The main assumptions and conclusions of prospect theory is generally applicable for China large state-owned enterprise managers; About the parameter estimates of the value function and weighting function, there are some empirical data differences between China and abroad; There are significant different distribution between different type personnel under different situation and different condition of probability; 30%of the individual does not meet the assumption that the value of risk attitude coefficient of value function between 0.05 and 0.95[20].

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