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Domain-specific risk preference and cognitive ability

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ABSTRACT

Kahneman and Tversky's works on Prospect Theory compellingly demonstrate that people tend to show varying risk-attitudes for gains versus losses as well as high versus low probabilities associated with the outcomes. Although some studies have found that individuals with lower cognitive skills tend to be risk averse, the literature has not addressed yet a comprehensive understanding of domain-specific risk preference variation by cognitive ability and by gains versus losses as well as high versus low probabilities associated with the outcomes. Thus, this paper attempts to provide a comprehensive picture of domain-specific risk preference variations. The results of this paper show the following: individuals with low cognitive skills tend to be risk-averse (and more risk-averse compared to people with high cognitive ability) when facing high probability of gain or low probability of loss, however risk-seeking (although less risk-seeking compared to people with high cognitive ability) when facing low probability of gain or high probability of loss. My results are consistent with the implications of Kahneman and Tversky's prospect theory.

1. Introduction

Kahneman and Tversky (1979, 1992) compellingly demonstrate that people's decision-making under risk violates the predictions of the expected utility theory. One of their key arguments is that people do not weight outcomes by their objective probabilities but rather by subjectively transformed probabilities. In particular, Kahneman and Tversky's work implies domain-specific risk-attitude.

On the other hand, there is a small literature examining the relation between economic decision-making and cognitive skills. In particular, some studies have found individuals with lower cognitive skills tend to be risk averse.[1] These studies have made very important and vital contributions in understanding the relation between economic decision-making and cognitive skills and my study also in part supports their results, however, the literature has not addressed yet a comprehensive understanding of domain-specific risk preference variation by cognitive ability and by gains versus losses as well as high versus low probabilities associated with the outcomes.[2] Thus, building on previous related studies, this paper attempts to provide a comprehensive picture of domain-specific risk preference variations.

This paper is related to a strand of literature on non-traditional determinants of financial decisions. For example, there exist some path-breaking studies on important effects of commitment, informal communication, soft factors, bargaining, moral hazard, implicit barriers on financial decisions.[3] The paper is organized as follows: Section 2 addresses theoretical predictions, Section 3 addresses the details of the experiment and the results, and Section 4 concludes.

2. Theoretical prediction

Kahneman and Tversky (1979, 1992) compellingly demonstrate that people's actual decision-making under risk systematically violates the decisions predicted by expected utility theory.

Consider a gamble

$$(x_{-m},\ p_{-m}; x_{-m+1},\ p_{-m+1}; \ldots; x_{n-1},\ p_{n-1};\ x_n, p_n)\,.$$

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[1] (e.g. Frederick, 2005; Shamosh and Gray, 2008; Oechssler et al., 2009; Dohmen et al., 2010; Benjamin et al., Unpublished) Also, there exists a study relating math skills and risk preferences (i.e. Brañas-Garza et al., 2008), however, I believe my study examines a related but different aspect since math skills are not exactly the same as cognitive abilities.

[2] Please note that variations in risk attitudes reflect preferences rather than degrees of irrationality.

[3] (i.e. Xue et al. (2015), Martinez et al. (forthcoming), Errunza et al. (2013), Martinez (2011), Banerji et al. (2008), Xue (2008), Banerji and Errunza (2005)).

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According to expected utility theory, an individual evaluates the aforementioned gamble as

$$\sum_{i=-m}^{n} p_i U(W + x_i), \tag{1}$$

where W is current wealth, and U is the utility function which is increasing and concave in $(W + x_i)$.

In contrast, according to Kahneman and Tversky's cumulative prospect theory (1992), an individual evaluates the above gamble as

$$\sum_{i=-m}^{n} \pi_i v(x_i), \tag{2}$$

where π_i are 'decision weights', and v is the value function which is increasing in x_i. That is, people do not weight outcomes by objective probabilities, p_i, but by subjectively transformed probability weights or decision weights, π_i.[4]

The inverse S-shaped probability weighting function can be depicted in the following form, where P is an objective probability and δ is the parameter determining the curvature of the function.[5]

$$\pi\,(P) = \frac{P^{\delta}}{(P^{\delta} + (1-P)^{\delta})^{\frac{1}{\delta}}}. \tag{3}$$

Furthermore, it can further be extended as follows, where P_c is the inflection point of the probability weighting function, and the subscripts d and u refer to low (down) and high (upper) probabilities respectively. Also, I introduce a parameter, γ, which refers to cognitive ability which can be either high or low. Now note that δ, the parameter of the curvature of the probability function, can be expressed as a function of γ. Furthermore, since the probability weighting under gain may not be equal to the probability weighting under loss, I introduce λ, a parameter referring to the sensitivity of the curvature of the probability function under loss compared to under gain. Then the probability weighting function becomes,

$$\pi\,(P) = \begin{cases} \dfrac{P^{\delta_d(\lambda(\gamma),\gamma)}}{(P^{\delta_d(\lambda(\gamma),\gamma)} + (1-P)^{\delta_d(\lambda(\gamma),\gamma)})^{\frac{1}{\delta_d(\lambda(\gamma),\gamma)}}}, & \text{if } P < P_c \\ P, & \text{if } P = P_c \\ \dfrac{P^{\delta_u(\lambda(\gamma),\gamma)}}{(P^{\delta_u(\lambda(\gamma),\gamma)} + (1-P)^{\delta_u(\lambda(\gamma),\gamma)})^{\frac{1}{\delta_u(\lambda(\gamma),\gamma)}}}, & \text{if } P > P_c. \end{cases} \tag{4}$$

Then, predictions can be made as follows. It is important to note that these variations reflect preferences rather than degrees of irrationality, thus I avoid using terms such as rational, irrational, etc.

Expected utility benchmark prediction: Since a risk-neutral individual weights objective probabilities correctly as shown in Eq. (1), δ_{RB}, the coefficient of curvature of her probability weighting function, should equal one. That is, $\delta_{RB} = 1,\ \forall\, P,\ \gamma,\ \delta_d,\ \delta_u$. And $\lambda = 0$. That is, one's risk preference does not depend on probability of an event.

Prospect theory benchmark prediction: According to the prospect theory,[6] an individual tends to overweight low probabilities and tends to underweight high probabilities as shown in Eq. (3). Therefore, δ_{PTB}, the coefficient of curvature of her probability weighting function, should be less than one. That is, $\delta_{PTB} < 1,\ \forall\, P,\ \gamma,\ \delta_d,\ \delta_u$. And $\lambda < 0$.[7] That is, there are 2 by 2 risk preferences: people are risk-averse for a gamble with high probability of gain, risk-seeking for a gamble with high probability of loss, risk-seeking for a gamble with low probability of gain, and risk-averse for a gamble with low probability of loss.

Domain-specific prediction: By definition of cognitive reflection, δ must be increasing in γ, and λ, loss sensitivity, is decreasing in γ, because low cognitive ability must mean more deviation from the expected utility prediction. That is, there are 2 by 2 by 2 domain-specific risk attitudes for different domains of high versus low probabilities, gains versus losses, and high versus low cognitive ability.

3. Experiment and results

3.1. Experiment

An experiment has been conducted with adult financial consumers in South Korea during winter 2014, with the help of one nation-wide commercial bank. Participants were randomly recruited in various branches of the bank. In total, 243 subjects have participated in the experiment. The experiment was a paper-based experiment. Subjects were asked to and have agreed to participate in financial experiments. Conducting the experiment with a Korean sample should not be problematic since cultural aspect should affect neither cognitive abilities themselves nor the relation between cognitive abilities and decision-makings.

3.1.1. Risk preference

The experiment includes questions that elicit risk preferences.[8] First, the questions used to measure risk preferences in the positive domain are in the following form:

(RP1) Please choose an option, (A) or (B), that you prefer.

(A) There are 100 balls in a box with 5 red balls and 95 white balls. If you pick a red ball, you *receive* KRW 1,000,000 (approx. USD 914). Otherwise, you *receive* nothing.

(B) You *receive* KRW X for sure, where X is KRW 30,000, 50,000, 80,000, 100,000, 130,000, 150,000, 180,000, 200,000 (approx. USD 27, 46, 73, 91, 119, 137, 165, 183). In other words, there are eight questions which are presented with X in ascending order. Such a presentation is to make the strategy of choosing the probabilistic gain, (A), for small X, and choosing the safe bet, (B), for large X, salient.

The questions used to measure risk preferences in the negative domain are the same as above but reworded to represent losses.[9]

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4 According to Kahneman and Tversky, the probability weighting function is a function increasing in p_i but tends to overweight low probabilities, that is, unlikely extreme outcomes, and tend to underweight high probabilities.

5 Note that low values of δ refer to higher degree of curvature of the probability function.

6 And Kahneman and Tversky (1992)'s experimental evidence.

7 Note that according to the experiment by Kahneman and Tversky (1992), the loss sensitivity of probability weighting function exists for regions of low probabilities only. Thus, to be more specific, I should write $\lambda > 0$ for $P < P_c$, $\lambda =$ (or even $<$) $0\ P > P_c$. For the purpose of the theoretical presentation, I do not impose such restrictions, however, I later show that my results are consistent with the finding of Kahneman and Tversky.

8 The questions follow the study by Frederick (2005), and building on his study, I attempt to make comparisons across different probabilities possible by keeping the amounts of certain outcomes the same across all prospects in the questionnaire, and to measure risk preferences separately in the positive and negative domains.

9 (RP2) Please choose an option that you prefer.

(A) There are 100 balls in a box with 5 red balls and 95 white balls. If you pick a red ball, you *lose (equivalently, pay)* KRW 1,000,000 (approx. USD 913). Otherwise, you *lose* nothing.

(B) You *lose* KRW X for sure, where X is KRW 30,000, 50,000, 80,000, 100,000, 130,000, 150,000, 180,000, 200,000 (approx. USD 27, 46, 73, 91, 119, 137, 164, 183) as the same as before. Again, all eight questions are presented with X in ascending order. Such a presentation is to make the strategy of choosing the certain loss, (B), for small X, and choosing the probabilistic loss, (A), for large X, salient.