Choice set options affect the valuation of risky prospects

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Abstract

A series of experiments is used to investigate the extent to which valuation of a risky prospect is affected by the values from which a participant selects a response. Three variables were considered: a smaller risk-free amount, a larger risky amount, and the probability of winning the larger amount. There were three conditions: in each, two of the three variables were held constant, and participants chose the value for the third variable that made the risky and risk-free options worth the same to them. This was done first by a free-choice valuation, and then, with different participants, by choosing one of four options that were either all below or all above the population free-choice median. The options presented had a strong effect on valuation of the missing variable. This effect remained even when the free-choice and multiple-choice conditions were presented within subjects. This demonstrates that people showing rational and consistent risk evaluation strategies could have their risk aversion manipulated by context. Overall, the experiments suggest that people's propensity for risk aversion is manipulable by context. This is problematic finding for traditional, context-independent, theories of decision under risk.

Introduction

From buying a new jacket to deciding whether to invest in shares or bonds, we have to come to decisions based on the merits of the different options available to us. One popular assumption about the decision-making process is that we examine each option in isolation, give each option some sort of value based on the pleasure it would give us, and then choose the one that scores the highest.

Nowhere is this thinking more apparent than in the domain of financial decision-making. One of the most enduring models used in financial decision-making research is expected utility (EU) theory. EU theory has been presented as the normative theory of rational choice in the domain of decision under risk (von Neumann & Morgenstern, 1947). According to EU theory, one should select, from a set of options, that which is associated with the outcome with the maximum utility. The utility of a probabilistic outcome is given by its expectation over events. A core assumption in EU is that the only information used to evaluate a risky prospect is its potential value and the probability of it occurring.

However, it is clear that other factors can affect people's valuation of a risky prospect. For example, people tend to be risk averse, that is, they prefer a smaller sure amount compared to the chance of a obtaining a larger amount when the expected values of the two are the same. But by reframing a choice, so that outcomes appeared to be losses rather than gains, Kahneman and Tversky (1979) were able to obtain preference reversals: Those who had been risk averse for gains became risk seeking for losses.

Several derivative theories have been developed to account for violations of this nature. The most notable, prospect theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992), assumes that the subjective expected utility of gains and losses, rather than absolute wealth levels, is maximized in reaching a decision. Other derivatives include rank-dependent utility theory (Quiggin, 1982; 1993) which was developed to account for demonstrations of non-linearities in the probability weighting function. Each of these theories can be viewed as a derivative of EU theory where one or more of the underlying axioms has been relaxed. Despite these relaxations, these theories all still have in common the key property outlined above: that a prospect's value or utility depends only on the attributes of that prospect.

However, these theories are at odds with findings in other areas of decision research, in which it is clear that contextual factors, like the values of other options in the choice set, affect evaluation of an option. Consider a binary choice between two options, A and B, that vary on two dimensions, where one option might be higher on one dimension and the other option higher on the other dimension. In the similarity effect (e.g., Tversky, 1972), the addition of a new competitive option that is highly similar to option A, but not option B, can reverse a preference for A in the binary case to a preference for B in the ternary case. The attraction effect (e.g., Huber, Payne, & Puto, 1982) describes the increase in preference for a dominating option, A, when an asymmetrically dominated option is added to the binary set. In the compromise effect (e.g., Simonson, 1989), an option that represents a compromise between two alternatives (A and B) may be preferred over the alternatives in the ternary choice, even though it was not preferred in either pairwise binary choice.

There is some evidence that effects of adding a third option to the choice set are found in trade-offs between risk and reward. In an unpublished study by Payne, Bettman, and Simonson (reported in Simonson & Tversky, 1992), participants were asked to make a choice between a pair of three-outcome prospects. Adding a third prospect that was dominated by one of the original prospects, but not the other, significantly increased the proportion of times the (original) dominating prospect was selected over the (original) non-dominating prospect.

More recently, Stewart, Chater, Stott and Reimers (2003) have shown effects of immediate context in a simple evaluation of a risky prospect. In one experimental procedure, participants gave a certainty equivalent (CE) for a risky prospect. A CE is the amount they could receive for certain that was worth the same to them as the risky prospect. Participants had to choose a CE from a set of four options, manipulated to be all higher or all lower than the population's free choice CE. The results demonstrated that people's CEs were, on average, shifted downwards when all the options were below the free-choice median, and shifted upwards when the options were above the free-choice median. Thus, even in a simple evaluation of risky prospect, the immediate context in which the evaluation is made affects the value given to a prospect.

The experiments reported here do three things. First they replicate the original work of Stewart et al. (2003), showing the effects of context on CE judgements. Second, they extend the work from CEs to the other two variables needed to value a risky prospect relative to a safe amount. Thus in these experiments we also set the values for risk-free and risky prospects and have participants give the probability of winning the risky prospect that makes the two worth the same. And, in addition, we set the value for the risk-free reward and the probability of gaining the risky reward, and have participants give the value of the risky reward to make the two options worth the same. Third, using the original CE paradigm, we demonstrate that the results were not just an artifact of people failing to understand the task, or the options being too extreme for one to be detectably better than the others. We do this by using a within subjects approach, using an individual participant's CE to set the values for the high and low options, also gaining a measure of whether a participant's free-choice responses were rational.

Experiment 1A

Experiment 1A used the same procedure as employed by Stewart et al.'s (2003) Experiment 1. The value and probability of a risky outcome was given and participants gave the risk-free amount that was worth the same to them as the risky prospect. In other words they gave the CE for the risky prospect.

Method

Participants Free-choice CEs were given by 24 undergraduates from the University of Warwick. A further 24 participants took part in the multiple-choice component of the experiment, where they chose a CE from among a set of four options.

Design Twenty prospects were generated by crossing the amounts £200, £400, £600, £800, and £1,000 with the probabilities .2, .4, .6, and .8. Free-choice CEs were obtained from the pretest phase. Multiple-choice options were generated to be all above or all below the free choice median, such that the overall range of the options, from the lowest low option to the highest high option, was approximately one interquartile range. Options were rounded to have familiar, easy-to-deal-with values and were evenly spaced across the inter-quartile range.

Twenty-four new participants were presented with the prospects and options as generated above, and chose their CEs from the options. For each participant, a random ten trials used the values from the high condition, and ten used those from the low condition. Presentation order of the high and low trials was randomized for each participant.

Procedure Participants were tested in a quiet room, individually or in small groups. They were given written instructions introducing the idea of choosing between a smaller risk-free amount and a larger risky amount, and that the response required in the experiment was the risk-free amount that was worth the same to them as the risky prospect. Participants completed a worked example on the instructions sheet, and an experimenter went through their response to ensure they understood the requirements of the task.

Each prospect was presented on a separate page of a 20-page booklet. Probabilities were presented as percentages, and options were presented in ascending numerical order, as below:

How much is the gamble
"60% chance of £400"
worth to you?
Is it: £60 £80 £100 £120

Results

The task, including instructions, took approximately ten minutes to complete. The proportion of times each options was chosen is given in Figure 1. The labels L1-L4 refer to the four below-median options presented in the low condition, with L1 the lowest. The labels H1-H4 refer to the four above-median options presented in the high condition, with H4 the highest. The analysis was performed using the following rationale. In the high condition, choosing H1 means that the CE is, for that trial, lower than H2. In the low condition, choosing L1, L2, or L3 means that the CE is, for that trial, lower

than L4. Given that L4 is numerically substantially lower than H2, in the absence of context effects, one would expect H1 to be chosen substantially more often than L1, L2, or L3, or at the very least, equally often. If, on the other hand, L1, L2, or L3 were chosen more often than H1, this would demonstrate the existence of a context effect.

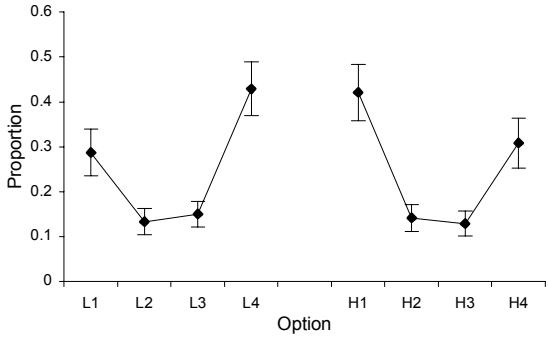

Figure 1: Proportion of times each option was chosen in Experiment 1A

Participants chose L1, L2, or L3 on 57% of low trials, and chose H1 on 42% of high trials. A paired-samples t-test showed the difference to be significant $t(23)=2.30$, $p=.03$, $\eta^2=0.19$. Thus the choice set affected participants' CE valuations. There were, however, also absolute effects present, as shown by participants choosing the options closest to the free choice median more often (43% of trials) than those furthest from the free-choice median (30% of trials) $t(23)=3.22$, $p=.003$, $\eta^2=0.31$.

Experiment 1B

Experiment 1B was designed to investigate whether the context effects of Experiment 1A were unique to CEs, or whether they were also seen when an alternative variable was used to equate risky and risk-free prospects. In this case participants were given a small risk-free amount and a larger risky amount and had to set the probability of the risky outcome to equate the two options for themselves.

Method

Participants Twenty-four participants provided free-choice estimates and a further 24 took part in the multiple-choice part of the experiment. Both groups were taken from the same population as in Experiment 1A. None had taken part in the previous experiment.

Design and procedure The design was the same as Experiment 1A, except the twenty trials were constructed by crossing the risky amounts £200, £400, £600, £800, and £1,000 with safe amounts that were 20%, 40% 60%, or 80% of the value of the risky amount. Participants were again given written and verbal instructions appropriate to the task, and the trials were of the following format:

What chance of winning £1000 would make a gamble worth £400 to you?

Results

The results of Experiment 1B are given in Figure 2. The same rationale was used in analyzing the results as was used in Experiment 1A. Participants chose L1, L2, or L3 on 53% of trials, and H1 on 30% of trials. The difference was significant $t(23)=3.03$, $p=.006$, $\eta^2=0.29$. Again, there was also an absolute effect, with the option closest to the free choice median being chosen more (39% of trials) than that furthest from the free-choice median (17% of trials) $t(23)=4.62$ $p=.0001$, $\eta^2=0.48$.

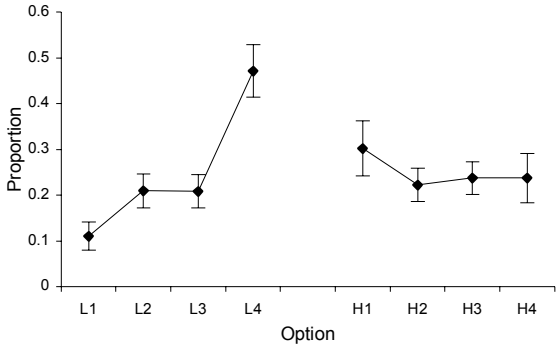

Figure 2: Proportion of times each option was chosen in Experiment 1B

Experiment 1C

Finally for Experiment 1C, the third variable was manipulated. This time risk-free amount and probability of risky success were given and a participant set the value of the risky outcome to equate it with the risk-free outcome.

Method

Participants As in previous experiments, 24 participants took part in the free-choice stage and a further 24 took part in the multiple-choice condition. None had taken part in Experiments 1A or 1B, but were drawn from the same population.

Design and procedure The design was the same as Experiment 1A, except the twenty trials were constructed by crossing the risk-free amounts £200, £400, £600, £800, and £1,000 with the probabilities of risky success of .2, .4, .6, and .8. Participants were again given written and verbal instructions appropriate to the task, and the trials were of the following format:

What amount that could be won with a 40% chance makes a gamble worth £200 to you?

Results

The results of Experiment 1C are given in Figure 3. In this experiment it seems clear that the multiple-choice group have a higher risky amount for a given probability and risk-free amount than the free-choice group. However, this does not affect the method of data analysis. The same rationale was used in analyzing the results as was used in Experiments 1A and 1B. Participants chose L1, L2, or L3 on 44% of trials, and H1 on 20% of trials. The difference was significant $t(23)=4.95$, $p<.0001$, $\eta^2=0.52$. Again, there was also an absolute effect, with the option closest to the free choice median being chosen more (38% of trials) than that furthest from the free-choice median (21% of trials) $t(23)=4.24$ $p=.0003$, $\eta^2=0.44$.

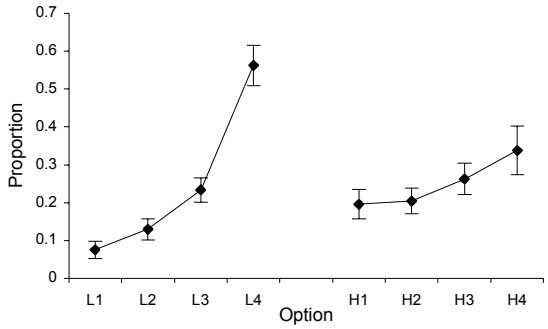

Figure 3: Proportion of times each option was chosen in Experiment 1C

Discussion

Experiments 1A, 1B, and 1C have demonstrated that the choice set affects people's relative valuations of a risk-free and a risky outcome, a phenomenon described by Stewart et al. (2003) as *prospect relativity*. This replicates the findings of Stewart et al. and demonstrates that the original work extends to conditions in which a measure other than CE is used. These findings are problematic for theories like expected utility, which assume that people are not affected by context in evaluating risky prospects.

Although these experiments show a fairly convincing effect of context on risky prospect valuation, it might be worth exploring two alternative explanations of the data. If a subset of participants responded randomly, a context effect like that observed would be found. The two most obvious reasons for responding randomly would be that a participant did not understand the task, or that he or she felt that all the options were inappropriate, so there was no point in thinking about which to choose. It is unlikely, although possible, that the former is a contributing factor. Participants were given an example which was explained by the experimenter. All seemed to understand the task, or if they gave an irrational response, they seemed to understand once it was explained.

The latter concern, that all the options seem inappropriate to the participant, is also unlikely to be a strong contributor to random responding. The options were not widely spaced from the free-choice median, and there was not a large variation in individual participants' CE judgements. However, there may have been some subjects, with extreme risk aversion or risk proneness, for whom the options were so inappropriate for them that they gave up trying to perform the task accurately.

Thus the logical next step would be to attempt the same type of experiment, but using a within-participants design, getting a measure of risk aversion from the participant, then using it to generate options for the participant that are all above or all below that individual participant's free-choice response. This would allow one to check that a participant was responding rationally from the free-choice phase, thus demonstrating they understood the task, and to ensure the options presented in the multiple-choice phase were relevant for the participant. To do this we switched to a computer-based experimental design.

Experiment 2

The design of Experiment 2 follows the same logic as that for Experiments 1A, 1B, and 1C, except that it was computer-based, and free-choice and multiple-choice conditions are within-subjects.

Method

Participants Thirty undergraduate and graduate students from the University of Warwick took part in the experiment. Participants were paid for taking part in a session that included other unrelated experiments.

Design The free-choice phase comprised 16 trials, generated by crossing the amounts £300, £500, £700 and £900 with the probabilities 0.2, 0.4, 0.6 and 0.8. For each trial response, a crude measure of risk aversion, R, was calculated by dividing the value of the participant's response by the expected value of the risky prospect. Thus sixteen measures of R were obtained from the free-choice phase, which were used to generate the multiple-choice options in the following way. The median (R_m) and upper and lower quartile values of R were taken from the free-choice data. Thus the median-upper quartile (R_{mu}) and median-lower quartile (R_{ml}) ranges could be easily calculated. For the low condition, options were generated using risk aversion values of R_m-¼R_{ml}, R_m-½R_{ml}, R_m-¾R_{ml}, and R_m-R_{ml} were used, and for the high condition, risk aversion values of R_m+¼R_{mu}, R_m+½R_{mu}, R_m+¾R_{mu}, and R_m+R_{mu} were used. This allowed the creation of option sets that were close to, but all above, or all below, the best estimate of what the participant's free-choice response would be.

Twenty trials were generated by crossing the amounts £200, £400, £600, £800, and £1,000 with the

probabilities .2, .4, .6, and .8, with options generated for each trial using the risk aversion measure described above. As before, for each participant, a random half the trials were from the high condition and half from the low condition. This time, however, participants were yoked in pairs, both receiving the same trials in the same order, but where one had a trial on which the high options were presented, the other had low options presented.

Procedure The experiment was implemented in Java, and run using an IBM-compatible PC running Linux or Windows NT. Initially a box appeared on the screen instructing participants to read an instruction sheet next to the computer, and then press to start. The written instructions were similar to those from Experiments 1A, 1B, and 1C, except they had no worked example. Participants were instructed to ask the experimenter if there was anything they did not understand. There the followed sixteen free-choice trials in which the prospect was displayed as follows:

What certain amount of money is worth
the same to you as
a 40% chance of £600

Below was a text field and submit button. A submitted value was checked to see if it was an integer and whether it was smaller than or equal to the risky amount of money. If either was not the case an error message was displayed and the participant could try again. After sixteen trials, a box appeared informing the participant that they should read the second instruction sheet and press to continue. The second sheet informed participants that they would now be choosing from options rather than giving their free-choice response. Twenty trials followed, of the same format as the free-choice condition, except that the text field and submit button were replaced by four buttons each labeled with an amount of money, in ascending numerical order and the participant had to click on one of the buttons to continue.

Results

Participants generally took between ten and fifteen minutes to complete the experiment. The measure of free-choice rational behavior was whether CEs increased monotonically with value of risky prospect (collapsed across probability), and with probability of winning (collapsed across value). Only one participant failed to show this effect in both conditions, and was not excluded because the magnitude of the deviation was small (<5%) and only occurred in one of the conditions. The results are given in Figure 4. The analysis follows the same rationale as in previous experiments. Participants chose L1, L2, or L3 on 56% of trials, and H1 on 36% of trials. The difference was significant $t(29)=3.07$, $p=.005$, $\eta^2=0.25$. Again, there was also an absolute effect, with the option closest to the free choice median being chosen more (40% of trials) than that furthest from the free-choice median (21% of trials) $t(29)=4.22$ $p=.0002$, $\eta^2=0.38$.

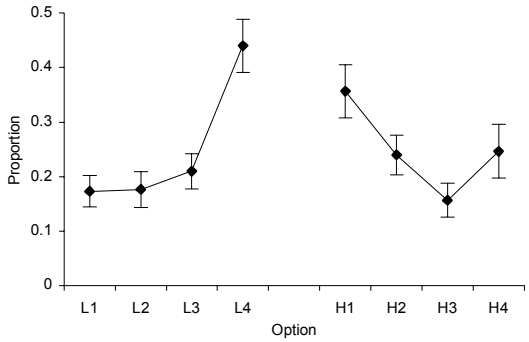

Figure 4: Proportion of times each option was chosen in Experiment 2.

Discussion

This experiment has shown that people's valuation of risky prospects is affected by the choice set even when they clearly understand the task, and the options generated for them are close to what they would have selected in a free-choice condition. It therefore shows Stewart et al.'s prospect relativity, even when they had previously been valuing risky prospects entirely consistently and rationally.

General discussion

The experiments presented here demonstrate that people's valuation of a risky prospect is affected by the choice set. In a series of experiments, participants had to equate a smaller risk-free sum of money and a larger, risky sum. They did this either by choosing the risky amount, given a safe amount and a probability of winning the risky amount; or by choosing the probability of winning the risky amount, given a safe amount and a risky amount; or by choosing the safe amount, given a risky amount and a probability of winning the risky amount. In all three conditions, the options from which participants chose the most appropriate option affected the value chosen. In addition, a further experiment was run in which participants chose a safe amount that best equated with a given risky amount and probability of winning (i.e. a CE). In this case the same context effect was found, even though the options were generated for the individual participant, and the participant showed rational behavior in a free-choice version of the task minutes before.

Implications for existing models

The findings reported here replicate, extend, and strengthen the work of Stewart et al. (2003), and illustrate that context affects decision making under

risk. This finding is problematic for theories that assume people evaluate each option from a choice set independently of other options and not taking in to account contextual factors. It is clear that even having to choose a CE from a set of options rather than generate it in free-choice situation affects valuation of a risky prospect – although the selection of a CE from options has been used in the past (e.g. Tversky & Fox, 1995; Tversky & Kahneman, 1992). Thus traditional models of decision making under risk, like EU theory and its derivatives, fail to capture the data presented here.

There is, however, a class of model that can cope with the findings. Rather than assume people bring a preference set to a decision-making situation and use it to choose the best option, the likes of Slovic (1995) and Loewenstein (2001) have suggested that people's preferences are constructed during the consideration leading to a decision. Thus their theories of decision making allow for all factors present in the decision context to affect the final choice. The data here support a model of this kind more than they do a traditional, context-independent model.

Whilst our data and those of Stewart et al. (2003) demonstrate that prospects are valued, to some extent, relative to the option set available they do not rule out the possibility that there some absolute valuation process, perhaps like EU theory, that also contributes (indeed we presented some evidence consistent with this possibility). At this stage it is an open question as to whether theories where prospects are judged in purely relative terms can be extended to cover the range of empirical evidence in the literature currently accounted for by the existing models.

A more general effect?

These replications and extensions of the basic prospect relativity finding extend the generality of the result. In recent work, from our own laboratory, we have found very similar effects for the valuation of delayed rewards. In this domain, the normative standard has been that people discount exponentially. In competition as a descriptive theory is hyperbolic discounting. Neither theory can account for the context effects observed. Thus it appears that the context effects demonstrated here with risky prospects may just be illustrating a more general effect of context in decision making at large. If this proves to be the case, then this research may make it possible to formulate a more general model of context effects in decision making by providing a common psychological framework for understanding these decisions in more than one domain.

Acknowledgements

We would like to thank Simon Moore and Henry P. Stott for their comments and input, and Rod Freeman and Petko Kusev for their help running the experiments.

This work was supported by Economic and Social Research Council Grants R000239351 and L328253039.

References

Huber, J., Payne, J. W., & Puto, C. (1982). Adding asymmetrically dominated alternatives: Violations of regularity and the similarity hypothesis. *Journal of Consumer Research, 9,* 90-98.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*, 263-291.

Loewenstein, G. (2001). The creative destruction of decision research. *Journal of Consumer Research, 28*, 499-505.

Loomes, G., & Sugden, R. (1982). Regret theory: An alternative theory of rational choice under uncertainty. *Economic Journal, 92*, 805-824.

Quiggin, J. (1982). A theory of anticipated utility. *Journal of Economic Behavior and Organisation, 3*, 323-343.

Quiggin, J. (1993). *Generalized expected utility theory: The rank-dependent model.* Norwell, MA: Kluwer Academic Publishers.

Simonson, I. (1989). Choice based on reasons: The case of attraction and compromise effects. *Journal of Consumer Research, 16,* 158-174.

Simonson, I., & Tversky, A. (1992). Choice in context: Tradeoff contrast and extremeness aversion. *Journal of Marketing Research, 29*, 281-295.

Slovic, P. (1995). The construction of preference. *American Psychologist, 50*, 364-371.

Stewart, N., Chater, N., Stott, H. P., & Reimers, S. (2003). Prospect relativity: How choice options influence decision under risk. *Journal of Experimental Psychology: General, 132,* 23-46.

Tversky, A. (1972). Elimination by aspects: A theory of choice. *Psychological Review, 102,* 269-283.

Tversky, A., & Fox, C. R. (1995). Weighting risk and uncertainty. *Psychological Review, 102,* 269-283.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty, 5,* 297-323.

von Neumann, M., & Morgenstern, O. (1947*). Theory of games and economic behavior (2 ed.).* Princeton, NJ: Princeton University Press.