Preferences over Risky Aid

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Abstract

Understanding decisions in situations involving multiple risks is important in many contexts, including the provision of aid to developing countries. Aid typically involves trade-offs over multiple, desirable, but risky outcomes. We partner with an aid organisation and design a laboratory experiment to investigate multi-attribute risk preferences in the context of donations to risky aid projects. We find significant differences between attitudes over single risk outcomes in monetary and non-monetary domains. We find that individuals are generally multi-attribute risk averse and that aid outcomes are seen as substitutes rather than complements. These preferences of private donors contrast sharply with the views of experts and aid agencies, who tend to emphasise the complementary nature of aid outcomes. Finally, the degree of risk aversion decreases markedly when individuals make risky donation decisions with their own money rather than someone else's money.

Keywords: Multi-attribute risk preferences, non-monetary risks, correlation aversion, experiment

JEL codes: DO1, C91

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1 Introduction

How do we make decisions when outcomes are subject to risk? Economists have produced a rich theoretical and empirical literature on attitudes towards single risks. To date comparatively little empirical attention has been given to situations that involve multiple, risky outcomes. Yet such situations are commonplace. For example, physicians decide about health care, which consists of multiple outcomes, all of which are associated with inherently different levels of clinical risk. Similarly, development interventions are frequently designed to achieve the dual objectives of poverty reduction and natural resource protection, both of which are subject to risk. We examine decision making in the important context of aid where individuals face risks on single and multiple outcomes and in different domains.

Global spending on foreign aid is around USD 500 billion annually. In 2013 official development assistance made up just one third of the total aid budget in the OECD, and only around five percent was spent on budget support and on other non-specific objectives (OECD, 2015). These statistics highlight two important characteristics of foreign aid. First, the vast majority of foreign aid targets specific sectors, projects or outcomes. Second, peoples' preferences over aid matter because significant amounts of aid are raised and controlled by the private sector.

Preference heterogeneity may arise due to the risky and multidimensional nature of aid. Aid is inherently risky, in the sense that the final outcomes of aid projects depend on many factors that are outside the control of donors. Risk may or may not be explicitly acknowledged to donors, and can have a variety of causes ranging from corruption and geographical or technological challenges to adverse weather and natural disasters. Brock, Lange and Ozbay (2013) investigate the preferences of individuals for giving in risky settings where perceptions of fairness behavior are related to *ex ante* comparisons of opportunities or, as in our study, *ex post* comparisons of outcomes. Similarly, Exley (2015) investigates the effect on contributions when the charitable outcome is subject to risk and finds significant reductions in donations even when the risk is small. In addition to investigating risk attitudes over single outcomes, we investigate preferences and behavior when more than one outcome is subject to risk.

Aid projects commonly target numerous related outcomes simultaneously. For example, aid agencies often promote the multipronged approach of improving water, sanitation and hygiene to combat waterborne diseases. It is not clear, however, how private donors trade-off these different outcomes or if they are seen as being complements or substitutes. The charitable giving literature has investigated the relationship of an individual's giving to multiple organizations. For example, de Oliveira, Croson and Eckel (2011) find that there are "giving types" - people who give in many instances and across many charities (such as charities targeted towards education, health and job training) as opposed to people who seldom or never give. In contrast, we keep the aid organization the same, but have multiple outcomes that serve the purpose of improving the health and well-being of disadvantaged people. In addition, in our setting these outcomes are subject to risk.

We partner with a well-established aid organisation to accurately describe individual preferences with respect to risky aid. In particular, the problem of insufficient control in the field, needed to allow one to investigate these subtle conceptual issues, is circumvented by conducting laboratory experiments that use simple treatments over well-defined risks and aid outcomes.

We first analyze the extent to which preferences, in particular risk attitudes, differ across monetary and non-monetary outcomes, contributing to the extensive analysis of single attribute risk. Second, we investigate the nature of attitudes to the presence of multiple risks. Is the type of aid project chosen one that is likely to achieve one good outcome with near certainty at the cost of almost surely failing all others, one that might achieve just passable outcomes across all objectives, or one that either succeeds or fails in all domains? Are these risks traded off in an additive manner? Finally, the issue of the degree of detachment by the decision-maker and its effect on observed risk attitudes is examined by comparing donation decisions made by the participant with their own money with decisions that are made knowing that someone else is responsible for making the donation.[2]

Our results indicate that there are significant differences in single attribute risk attitudes between *monetary* and *non-monetary* (aid) outcomes. *Across* the different *non-monetary outcomes*, average risk attitudes are indistinguishable. However, individuals clearly prefer one aid outcome over the other. We find that individuals are on average averse to multi-attribute risk in non-monetary settings, and that this multi-attribute risk aversion is less pronounced when subjects make risky donation decisions with their own rather than someone else's money.

Section 2 provides a brief exposition of the theoretical framework tested. The experimental design and procedures are described in Section 3. The results of the data analysis are presented in Section 4, followed by a discussion of limitations and extensions in Section 5. Section 6 concludes.

2 Theoretical Framework

Modelling an individual's choices over risky aid projects requires a theoretical framework that is able to handle multiple outcomes that are subject to potentially correlated risks. A utility function that is non-additively separable in its multiple attributes has been shown to be

[2] This question differs from the one investigated by Chakravarty, Harrison, Haruvy and Rutström (2011), who studied differences in risk attitudes of individuals over risky outcomes to themselves versus risky outcomes to others.

sufficiently rich to allow for context-dependent risk preferences over single risks as well as aversion to multiple risks (Richard, 1975; Keeney and Raiffa, 1976; Bommier, 2007; Andersen, Harrison, Lau and Rutström, 2011). To avoid the added complexity of estimating a more general utility functional form, we assume the special case of Expected Utility Theory (EUT).

In our setting we have both monetary and non-monetary outcomes that are subject to risk. The risk to the monetary outcome is borne by the individual. The same individual then makes donation decisions over aid projects where the non-monetary outcomes for the recipients are subject to risk. We focus on two kinds of non-monetary outcomes, access to safe water and sanitation.

We define a multi-attribute utility function over the utilities derived from the aid outcomes in terms of water access, x, and sanitation, y, as well as experimental income, m:[3]

$$U(X,Y,M) = (1-\beta)\left(\frac{\left((1-\alpha)u(x)+\alpha u(y)\right)^{(1-\eta)}}{1-\eta}\right) + \beta u(m), \qquad (1)$$

where $x \in X$, $y \in Y$ and $m \in M$. The expressions $u(x) = x^{(1-r_w)}/(1-r_w)$ and $u(y) = y^{(1-r_s)}/(1-r_s)$ are, respectively, the utilities derived from the stochastic water access and sanitation outcomes as a result of donations to aid projects. The utility derived from the subject's earnings in the experiment is given by $u(m) = m^{(1-r_m)}/(1-r_m)$. The parameters r_w, r_s and r_m may be interpreted as attribute-specific or good-specific risk aversion parameters. Given the distinctive nature of the outcomes we consider, we allow for $r_w \neq r_s \neq r_m$. We assume that the non-monetary outcomes, water access and sanitation, enter the utility function in a separable but non-additive manner, whereas experimental income is a purely additive term. The weights α and β, respectively, describe the relative preferences across non-

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[3] Experimental income is defined as total experimental earnings minus total donations.

monetary attributes and between monetary and non-monetary attributes, and are not the major focus here.

Multi-attribute risk aversion, η > 0, incorporates the special case of correlation aversion, a term coined by Epstein and Tanny (1980). A necessary condition for aversion to correlated outcome risks is that water access and sanitation are substitutes and not complements. Formally, the Edgeworth-Pareto condition of substitutability between *x* and *y* requires that $\frac{\partial^2 u}{\partial u_x \partial u_y} < 0$, which holds for η > 0. On the other hand, if it is found that η < 0, the interpretation becomes ambiguous since this could arise due to multi-attribute risk loving preferences or from the complementarity between *x* and *y*, defined as $\frac{\partial^2 u}{\partial u_x \partial u_y} > 0$ and requiring η < 0. Setting η = 0 implies additively separable preferences in *x* and *y*, which is appropriate if one assumes multi-attribute risk neutrality.

We disentangle substitutability from multi-attribute risk by exploiting two broad strands of the theoretical literature on multi-attribute risk aversion in our experimental design.[4] Building on early works by de Finetti (1952) and Richard (1975) [FR], one strand of this literature defines multi-attribute risk aversion in the sense of correlation aversion and over decisions between binary lotteries with identical, but arbitrary, marginal probabilities. Let $x_0, x_1 \in X$ denote, respectively, low and high water security outcomes, $x_0 < x_1$. Similarly, $y_0, y_1 \in Y$ are low and high sanitation outcomes, $y_0 < y_1$.[5] Given the two lotteries options

$$Option\ A = \begin{cases} x_1, y_0 & w.p. \quad p \\ x_0, y_1 & w.p. \quad 1-p \end{cases} \qquad \text{and} \qquad Option\ B = \begin{cases} x_1, y_1 & w.p. \quad p \\ x_0, y_0 & w.p. \quad 1-p \end{cases},$$

[4] See Finkelshtain, Kella and Scarsini (1999) and Dorfleitner and Krapp (2007) for helpful discussions of this literature.

[5] Assuming non-satiation in each attribute, we assume $U(x_0) < U(x_1)$ and $U(y_0) < U(y_1)$.

an agent is averse to correlated outcome risk if Option A is preferred to Option B for *p=0.5*. Our experiment extends the probability space to $0 \le p \le 1$ so as to provide a richer experimental test of the extent of correlation aversion. The ambiguity arises in this setting if Option B is preferred, since this could imply correlated risk loving preferences or that *x* and y are seen as complements, therefore resulting in any Option that yields asymmetric payoff across the two attributes being rejected.

To parse out this distinction, we also present subjects with a modified set of bivariate lotteries, which exemplify the natural extension of single attribute risk aversion into the multi-variate domain proposed by Kihlstrom and Mirman (1974) (KM).[6] Given a vector of random outcomes $(X, Y, ..., Z)$, a multi-attribute risk averse agent is said to prefer the expected value vector over the utility of the corresponding random outcome vector, for any $(X, Y, ..., Z)$

$$\mathrm{U}\left[\left(\mathrm{E}(\mathrm{X}), \mathrm{E}(Y), \ldots, \mathrm{E}(Z)\right)\right] \ge \mathrm{U}(\mathrm{X}, Y, \ldots, \mathrm{Z}).$$

We adapt this notion of multi-attribute risk aversion to our experimental setting by modifying the "safe" lottery Option A from FR to yield medium level outcomes, $0.5(x_0 + x_1)$ and $0.5(y_0 + y_1)$, for each attribute with probability *p* as well as *(1-p)*

$$Option\ A = \begin{cases} 0.5(x_0 + x_1), 0.5(y_0 + y_1) & w.p. \quad p \\ 0.5(x_0 + x_1), 0.5(y_0 + y_1) & w.p. \quad 1-p \end{cases} \quad \text{and} \quad Option\ B = \begin{cases} x_1, y_1 & w.p. \quad p \\ x_0, y_0 & w.p. \quad 1-p \end{cases}.$$

Hence, both lottery options are equally acceptable if the complementarity between *x* and *y* is considered to be a sufficiently important characteristic. However, a clear choice prediction can be made on the grounds of risk: a multi-attribute risk *loving* individual prefers Option B

[6] This definition has the advantage of spanning *n* attributes, but its validity in terms of comparing risk aversion across multi-attribute utility functions is restricted to those utility functions that maintain the same preference ordering over non-stochastic outcomes. This restriction is appropriate for comparisons defined over a single decision-maker or, as in our case, a "representative agent."

over Option A. In contrast, someone who prefers Option A over Option B exhibits multi-attribute risk *aversion* in the sense of KM: it is better to donate to a project that achieves medium level outcomes in both attributes for sure over one that may achieve good outcomes in both attributes or in neither.

The structural framework outlined above enables the investigation of the following three research questions. Do individuals exhibit different levels of risk aversion when choosing over risky monetary versus risky aid outcomes? Is there evidence of multi-attribute risk aversion when multiple attributes are subject to risk? And finally, do individuals perceive risk differently if they make decisions with someone else's money instead of their own money?

3 Experimental Design

Overview

The experiment involves donations to WaterAid, an international aid organisation that provides water, sanitation and hygiene (WASH) related services to combat waterborne diseases in developing countries. Donations to WaterAid can be made easily and verifiably online, and it is possible to specify whether the donor is an individual or a group. The contribution is designated to the overall cause or to a specific objective, such as improving water security, sanitation or hygiene education. For the purpose of the experiment we focus on two outcomes of WASH projects: water security and sanitation.

In accordance with WaterAid's definition, water security is explained to our subjects as the "reliable access to water of sufficient quantity and quality for basic human needs, small-scale livelihoods and local ecosystem services, coupled with a well-managed risk of water-related disasters." In terms of sanitation outcomes, WaterAid estimates that providing 1000 people with improved sanitation will prevent on average one death that is attributable to the lack of hygiene and sanitation. In the experiment, water security outcomes from aid projects are measured in terms of the average number of people gaining water security, while sanitation outcomes are quantified in terms of disability-adjusted life months (DALMS) gained for each member of a poor family of four.[7]

The outcomes from any aid project are subject to risks. In the case of WASH services the risks are often technology, weather and location specific. With respect to providing water security a number of different technology options exist to provide clean water to individuals and communities in rural areas of developing countries. Examples of technologies are hand-dug wells, boreholes and gravity flow schemes. These technologies not only differ in their costs and the level of water security they offer, but some technologies may not be feasible in some settings. Similarly for sanitation outcomes, the cost/benefactor ratio is determined by the type of technology installed and how many people have convenient access to it.[8] Thus, from a donor's perspective, both the water security and sanitation outcomes that result from a given donation to water security or sanitation and hygiene are subject to risk. This risk was described to the subjects and a draw from the bingo cage mimics this randomness for subjects in the experiment.

The experiment comprises three parts.[9] Throughout the experiment, subjects make 70 consecutive choices over pairwise lotteries yielding monetary payoffs to themselves, water

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[7] The units of measurements are based on information that WaterAid publishes on its website about the costs of providing particular services and the number of benefactors of these services in different countries (http://www.wateraid.org/au, 2012). The cost and outcome information from ten developing countries in Africa and South East Asia where WaterAid is currently operating indicates that giving access to safe water costs on average $2.50 (AUD) per person. A unit of the sanitation outcome is scaled to match the average cost of providing a unit of of the water security outcome: the average cost of providing one DALM to each member of a poor family of four is also $2.50. At the time of the experiment the exchange rate was approximately 1 Australian Dollar (AUD) = 1.02 U.S. Dollars (USD).

[8] Technologies that are used to provide water security in developing countries range in cost from AUD 250 to AUD 17,000 and in terms of benefit from providing water to 100 to 1,000 people. Similarly, the statistics on sanitation and hygiene education services show a large variation in costs from AUD 10 to AUD 14000 and number of benefactors ranging from one family to 50,000 people.

[9] We provide a condensed description of the experiment here. Additional detail and a full set of experimental instructions can be found in Appendices A and B.

security or sanitation outcomes for the aid recipients, or a combination of these. The complexity of the pairwise lottery choices increases throughout the experiment and culminates in decision tasks of the type shown in Figure 1, which specifies pairwise lotteries over multiple non-monetary attributes, connecting a price to each lottery. This risk experiment therefore builds on the multiple price list approach of Holt and Laury (2002). We describe the experiment by starting from Part 3 for ease of explanation, even though the instructions indicate subjects participated sequentially from Part 1 to Part 3.

Joint outcome lotteries with subject donation

The choice task shown in Figure 1 embeds all arguments of equation (1) in the sense that subjects are asked to choose over two aid projects with multiple, risky outcomes, each associated with a unique donation amount to be made by the subject.[10] The aid projects are described as Options A and B and yield different water security and sanitation outcomes to recipients in developing countries. Subjects are also given an opt-out Option C that carries no donation and no water security or sanitation benefits.[11]

The water security and sanitation outcomes for each Option are subject to risk. In the example shown in Figure 1, there is a 50-50 chance that donating AUD 9.51 to Option A provides either 4 people with access to safe water and prolongs the life of each member of a family of four by 3 healthy life month <u>or</u> provides 3 people with access to water and prolongs

[10] The donation amounts presented are calculated for each participant and lottery, using two willingness-to-donate elicitation questions (an example is shown in Figure 2). The first elicitation question asks subjects to nominate an amount out of their experimental earnings that they would be willing to donate to an Aid project that provides a single outcome (water security or sanitation). In a second elicitation question subjects are asked to nominate an amount they would like to donate to an aid project that has both water security and sanitation benefits. These stated willingness to donate are used to infer the amounts that a subject would be willing to donate per unit of outcome from which unique donation amounts for each lottery for each subject are calculated. Appendix A provides a detailed explanation and some examples.

[11] The opt-out Option C was added to ensure that no one would be forced to donate if they did not want to. There is some evidence from stated-choice experiments, reviewed by Harrison (2014), that providing this “opt-out” Option mitigates hypothetical bias (e.g. List, Sinha and Taylor (2006)). Of course, our experiments were not hypothetical.

the life of each member of a family of four by 4 healthy life months. In contrast, donating AUD 10.29 to Option B yields a 50-50 chance that either seven people are given access to safe water and the life of each member of a family of four is prolonged by seven healthy life months <u>or</u> provides only 1 person with access to safe water and prolongs the life of each member of a family of four by one healthy life month. Hence, Option A may be considered the safer choice since it guarantees at least a medium level of water security and sanitation provision. In this decision block, subjects were shown 10 pairwise lotteries with identical payoffs and an opt-out option and only the payoff probabilities and donation amounts varied.

Joint lotteries such as the one described above are necessary to determine the curvature of the joint utility function $U(X,Y)$ and hence help infer the value for η. In order to distinguish Option B choices that are due to a multi-attribute risk loving preferences from Option B choices that are motivated by aid outcomes being seen as complements, each subject is presented with two different versions of lotteries over joint outcomes in water security and sanitation. Only the aid outcomes from Option A differs between the KM and FR versions, as explained earlier. The FR version of Option A yields one high and one low payoff with probability p and one low and one high payoff with probability $(1-p)$. In contrast, and as shown in Figure 1, the KM version of Option A guarantees medium payoffs for both attributes. Subjects made a total of 20 decisions in the context of these joint lotteries.

Three-part experimental design

The remaining 50 decisions in the experiment are variants of the lotteries shown in Figure 1 and are designed to help with the identification of all parameters in equation (1). In addition to the joint lotteries described above, Part 3 comprised a set of 10 decisions over single attribute lottery pairs involving either water security or sanitation outcomes. The purpose of having choices over single-attribute lotteries is to determine the curvature of the single-attribute utility function with respect to water security or sanitation, i.e. r_w and r_s in

$u(x)$ and $u(y)$, respectively, in equation (1). Figure 3 gives an example of such a single-attribute lottery decision task over water security.

Part 2 closely replicates Part 3 in the sense that it comprises decisions over single and joint lottery pairs. But in Part 2 subjects make decisions over risky aid projects *on behalf of the experimenter:* it is the experimenter and not the subject who makes the donation that corresponds to the subject's choice. This design feature allows us to test whether risk attitudes vary when aid projects are being supported by the subject's rather than the experimenter's money. Figure 4 gives an example of a joint outcome lottery of the FR type from Part 2.

Part 1 consists of one set of 10 binary monetary lotteries using the payoffs of Holt and Laury (2002), shown in Figure 5. The objective of this task is to determine the curvature of $u(\tilde{m})$, the degree of risk aversion with respect to money, r_m.

Common design features

Several experimental design features are common throughout the experiment. Each lottery type is presented in a series of 10 decisions in which payoffs remain the same, while payoff probabilities vary in increments of 0.1.

The payoffs for all pairwise lotteries (single and joint outcomes and with and without donation by the subject) are constructed such that an individual with a neutral attitude towards all single and multiple risks is expected to choose the safe Option A for payoff probabilities 0.1-0.9, 0.2-0.8, 0.3-0.7 and 0.4-0.6 and the riskier lottery in the remaining six cases. This choice pattern corresponds to a Constant Relative Risk Aversion (CRRA) parameter range $-0.15 < r_m < 0.14$ for the monetary attribute. The payoffs in the single non-monetary lotteries of either 5 or 4 persons or DALMS in Option A, and either 9 or 1 persons or DALMS in Option B, yields the CRRA range $-0.11 < r_w, r_s < 0.26$ for the risk neutral choice pattern (see 4th line in Table 1).[12] Similarly, for all other lotteries the payoffs are constructed such that four choices of Option A are optimal for a single and multi-attribute risk neutral subject (see Tables 2 and 3 as examples of the single and joint lottery games with subject donation).

To ensure that our results are not affected by the specific sequence in which the lotteries are presented (Harrison, Johnson, McInnes and Rutström, 2005), subjects are shown the lottery pairs in a random order and each on a separate screen. To reduce the cognitive burden on the subjects, the payoffs and probabilities are presented visually, using color coded bar charts and pie charts, as well as explained in words, as shown in Figures 1, 3, 4 and 5.

Procedure

All sessions were conducted at the Monash Laboratory for Experimental Economics (MonLEE), using Z-tree (Fischbacher, 2007). Subjects were drawn from the undergraduate student population, broadly recruited across the university by email using ORSEE (Greiner, 2015). Although some had participated in other economics experiments, all were inexperienced in the sense that they had never participated in a similar experiment which had features of decision making relating to risk or charitable giving. Each session had about 20 subjects and we collected data from 154 subjects.

At the beginning of each session an experimenter read the instructions aloud while subjects followed along on their own copy. The instructions and computer decision screens used context specific terminology. In particular, the instructions provide information about WaterAid and about the attributes: water security and sanitation. The instructions for the experiment are given in Appendix B.

We used a within-subject design where all subjects made decisions in all three parts,

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[12] These minor differences in CRRA ranges arise because of the constraint to use integer payoff values for the number of people being given access to water or number of life months saved.

allowing for control over individual-specific effects. Participants were given explanations on each part just prior to starting it. We asked for a volunteer to come forward to be the monitor in each of the sessions. The monitor took part in the experiment just like everyone else, and in addition helped pick out balls from the bingo cage for random number determination and verified that the money was donated online to the aid organization at the end of the experiment. The procedure of using a monitor who verifies the amount donated helped ensure credibility of the decision tasks.

Each of the three parts in the experiment was incentivized by selecting one of the choices made in that part using a bingo cage. A second draw from the bingo cage determined the outcome of the randomly selected lottery. The outcomes of these draws were told to all participants. In Part 1 this process, conducted at the beginning of Part 3, determined each subject's earnings from the monetary lottery game to be added to the AUD 20 showup fee. In Part 2 the same process was used to determine which lottery outcome was converted into a donation made by the experimenter to WaterAid. Part 3 was incentivized in the same manner as Part 2, except that the donation amount associated with the subject's choice of Option was deducted from the subject's earning balance.[13] The random draws for Parts 2 and 3 were implemented at the end of Part 3. At the end of the experiment subjects were paid in cash and were shown the total amount of donations that were made in the session towards water, sanitation and the joint projects.

The average payout to subjects was approximately AUD 32. The total amount donated

[13] To control for order effects the parts were presented in two different sequences. In one sequence (as described here and presented in the Appendix) subjects made decisions over risky aid lotteries with donations from their own funds last. In the other sequence they made decisions in this game second. It is possible that after making decisions that lead to donations made from the funds of the experimenter, the subject may want to free ride on the experimenter's donation and not donate in Part 3. Changing the order of these two parts allows us to test for this effect. We do not find any order effects.

by participants was AUD 198.36 (an average of 2.54 per subject) and the total amount donated by the experimenters was AUD 1187.50 (an average of 15.22 per subject). Including the instruction and payment distribution time, sessions usually lasted between 90 and 120 minutes.

4 Results

The econometric results are organised around the three research questions outlined earlier. All risk parameters are estimated jointly for the theoretical model described by equation (1), which allows for the two aid outcomes to interact in a non-additive manner, while these two then interact with money in an additive manner. In effect, this is assuming a nested multi-attribute utility function, which is the natural choice, given that the amount that the subjects donate in Part 3 is not subject to risk.

The structural econometric model mimics the theoretical specification explained earlier. It is estimated using full-information maximum likelihood, following the general procedures outlined in Appendix C as well as in Harrison and Rutström (2008) and the specific procedures for estimating correlation aversion. The novelty is the use of a "hurdle" specification for the decision to contribute in Part 3: we separate the data-generating process explaining the decision to contribute a positive amount from the data-generating process explaining the decision on how much to contribute.[14] We exploit the recursive nature of the experimental design, and follow Andersen, Harrison, Lau and Rutström (2011), to allow identification of all parameters. From Part 1 we identify and estimate univariate risk attitudes towards money, from Part 2 we use those estimates to identify and estimate univariate and

[14] Hurdle specifications are widely used in health economics and other fields, and find natural application in many experiments in which there is a clear "spike" at some specific value. Botelho, Costa, Harrison and Rutström (2009) illustrate the application to experimental behavior, in the context of contributions to public goods, where there is typically a spike at zero due to free-riders.

multivariate risk attitudes towards the two aid outcomes, the two attributes, for donations made by the experimenter, and from Part 3 we undertake comparable estimates of risk attitudes towards own-contributions of aid.

Ignoring demographics, we use profile likelihood estimation[15] and find that subjects on average strongly prefer the monetary attribute $(\beta = 0.85)$ over the two non-monetary attributes. Preference weighting is also highly asymmetrical across the two non-monetary attributes, with subjects preferring water security to sanitation outcomes $(\alpha = 0.10)$. To aid the identification of the risk parameters of interest, we constrain $\alpha = 0.10$ and $\beta = 0.85$.

With respect to univariate risk we find that the coefficients for all three attributes reflect statistically significant single-attribute risk aversion. Table 4 shows that risk aversion is greatest with respect to money $(r_m = 0.920)$, followed by water $(r_w = 0.497)$ and sanitation $(r_s = 0.516)$. While we cannot reject the hypothesis that the two non-monetary attributes have the same degree of risk aversion $(r_w = r_s;$ *p*-value $= 0.320)$, they are significantly different from the monetary attribute $(r_m = (r_w = r_s);$ *p*-value $< 0.001)$.

Pooling the FR and KM lotteries in the multi-variate case, we find significant evidence of multi-attribute risk aversion shown in Table 4, where $\eta = 0.312$ (*p*-value < 0.001). When allowing for the different ways to test for multi-attribute risk aversion an intriguing result emerges. Table 5 shows that η is economically and statistically significantly greater with the FR lotteries than the KM lotteries: the multi-attribute risk aversion parameter increases by

[15] Profile likelihood estimation is a technique used to "concentrate" the likelihood and reduce the number of independent parameters that have to be estimated. It most often arises in the presence of "nuisance parameters" that are not the main focus of interest, and that might confound identification of the parameters of interest. In effect one assumes values for those parameters, and then optimizes the likelihood conditional on those assumed values. By tracing out these conditional likelihoods, one can identify the values of the nuisance parameters that maximize conditional likelihood of the overall structural model. In parametric settings, such as ours, it is possible to infer asymptotically valid confidence intervals for the non-nuisance parameters, conditional on these parameter values (e.g., Barndorff-Nielsen and Cox (1994, p.90ff.)).

$\eta_{FR} = 0.122$ (p-value =*0.023*) from $\eta_{KM} = 0.234$ (p-value < *0.001*) when subjects are presented with KM lotteries.[16]

This difference in observed behavior under multi-variate risk is not explained by behavioral errors, which are very similar at $\mu = 0.461$ when FR and KM are not separately accounted for, as compared to $\mu = 0.454$ when they are distinguished separately.[17] The large and significant increase in η when presented with a FR lottery indicates strong aversion to correlated risk, which in turn suggests that the two non-monetary attributes are viewed as substitutes. This is an important behavioral distinction between private donors and experts in the provision of aid services to developing countries. The finding that donors are genuinely averse to multi-attribute risk is confirmed by the positive and significant value on η when presented with KM lotteries. However, the results show a greater incidence of risky Option B being chosen in the KM lottery as compared to the FR lottery. This suggests that subjects are more willing to risk near universal failure (outcomes of 1 in both attributes) in order to avoid mediocre outcomes across the board.

Finally, we investigate whether attitudes to single or multiple risks vary when subjects make risky aid decisions on behalf of the experimenter in Part 2 or with their own money in Part 3. We compare the results in the 3rd and 4th column of Table 6 with the estimation results that exclude observations from Part 2, which are shown in the 5th and 6th column. Reassuringly, we find no statistically significant difference in monetary risk aversion ($r_{m(all\ parts)} = r_{m(parts\ 1+3)}$, p-value = *0.86)*. We also find almost no difference in aversion to sanitation risk ($r_{s(all\ parts)} = r_{s(parts\ 1+3)}$, p-value = *0.90)*. However, we find that aversion to water security

[16] The total effects for the multi-attribute risk aversion parameters from FR and KM lotteries are, respectively, $\eta_{FR} = 0.356$ (p-value < *0.001*) and $\eta_{KM} = 0.234$ (p-value < *0.001*).

[17] The estimation includes all individuals, even those that might have switched multiple times from one Option to the other. See Wilcox (2008) for an examination of stochastic models of choices under risk.

risk decreases significantly when subjects make donations with their own money ($r_w = 0.46$, $r_{w(all\ parts)} = r_{w(parts\ 1+3)}$, p-value $= 0.003$). We also find subjects exhibit significantly less multi-attribute risk aversion ($\eta_{(all\ parts)} = \eta_{(parts\ 1+3)}$, p-value < 0.001) when they are making donation decisions to risky aid projects using their own earnings.

Overall we find that risk attitudes are jointly significantly different when subjects make risky aid decisions on behalf of the experimenter as compared to with their own money (p-value <0.001). A possible explanation for this result is that subjects focus primarily on the donation amount, which involves a premium for risk averse choices. Given the estimated value for the preference weight on money income, $\beta = 0.85$, it is perhaps not surprising that the premium on the donation amount is given greater consideration than are the outcomes for aid recipients and the riskiness of outcomes. This conjecture is also supported by the high correlation of the subjects' stated maximum willingness to donate to single and multiple outcomes of 0.91, shown in Figure 6.

Our findings in this aspect are consistent with results from other researchers, who show that subjects are influenced by the fixed total sacrifice effect. Subjects seem to use a two stage reasoning in which they first determine the amount they want to keep for themselves and then distribute the remaining amount (if any) among needy causes. Selten and Ockenfels (1998) for example, show that in their gift exchange game the total amount of gift given by subjects is independent of the number of recipients: it is the same for one or two recipients.

5 Limitations and Extensions

This research contributes to our understanding of how preferences over multiple monetary and non-monetary risks may be characterised. Given the additional complexity required to model multi-attribute risk attitudes, we deliberately kept other aspects of the utility framework simple by assuming EUT. Our analysis suggests that EUT is indeed suitable to model behaviour subject to multiple risks. However, this does not rule out other models of decision-making under risk, such as Rank Dependent Utility, which may reveal a richer behavioral picture in these settings.

Our experimental investigation has important implications for understanding behavior that is subject to multiple risks in the field. In particular, we find that the presence of multiple risks matters beyond the existence of individual risks. Two immediate opportunities to extend this research arise. The first relates to the nature of the risky goods under investigation. While our focus is on the provision of risky aid outcomes, similar issues arise with respect to private goods. Examples include choosing between competing job offers, when several aspects such as promotion opportunities and future salary increases are subject to risk, or choosing between different schools where learning outcomes and fees are subject to risk. There are only a few examples in the literature that investigate behaviour with respect to multiple risky private goods (see for example, von Winterfeld, 1980).

The second research avenue relates to the nature of risky aid. Our experimental design applies the same background risk to water security and sanitation lotteries. Investigating these in a less parsimonious model of risk would be interesting, especially in light of the diversity of risks that influence aid outcomes, ranging from poor administration, to corruption, poor implementation and to adverse environments.

Finally, our research has direct links to the literature on multi-dimensional poverty. When aid is given to reduce poverty, which dimensions do donors care most about? How are these influenced by the existence of risk, including the risk of poverty spells?

6 Conclusion

Questions about how people behave when facing decisions involving single and multiple risks are important in many public and private good contexts that involve trade-offs over multiple risky outcomes. We designed a laboratory experiment to investigate whether individuals exhibit different levels of risk aversion when choosing over risky monetary or aid outcomes; if there is evidence of multi-attribute risk aversion when several outcomes are subject to risk; and whether individuals perceive risk differently if they make decisions with someone else's money versus their own.

The experiment comprised three parts, and for each part participants were presented with choice pairs over single or joint payoff lotteries involving either monetary or non-monetary outcomes from a contribution to an aid organisation. Contributions had either water access or sanitation implications for poor people in developing countries, and subjects made donation decisions with the experimenter's money as well as their own money.

Our results show that risk attitudes are generally significantly different across single monetary and non-monetary risks. Individuals showed greater risk aversion when presented with lottery pairs over monetary outcomes compared with equivalent lottery pairs over aid outcomes. Moreover, while the average risk attitudes towards different aid outcomes are indistinguishable, individuals preferred to donate to projects that yielded access to safe water rather than sanitation outcomes.

The experiment was designed to test for multi-attribute risk aversion according to two popular definitions used in the literature. We find that individuals behave in accordance with being multi-attribute risk averse according to both definitions, and that choices between binary lottery pairs that are consistent with testing for correlation aversion induce significantly greater multi-attribute risk averse behaviour than binary lottery pairs that differ in the riskiness of the lotteries but not in the correlation of the risk. We take this as being indicative of subjects viewing water access and sanitation outcomes as being substitutes rather than complements. In contrast, aid agencies tend to emphasis the complementarity of different aid outcomes, which would find greatest appeal among donors that exhibit correlation loving preferences. This finding is significant as it can help in the design of fundraising campaigns that result in better matches between philanthropic donors and aid providers.

We also found that subjects were less risk averse when making risky donation decisions with their own money compared with the experimenter's money. In line with previous findings in the literature, we conjecture that subjects who make donation decisions with their own money are primarily concerned with the donation amount, while giving less consideration to higher-order effects such as the riskiness of the outcome.

Our findings suggest that decision making in the presence of one kind of risk is different to decision making when multiple risks are involved. Our research is a first step in understanding behavior in situations involving multiple risks, which are commonly observed in the field.

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Figure 1: Example of a joint-attribute KM (Kihlstrom and Mirman) decision problem from Part 3

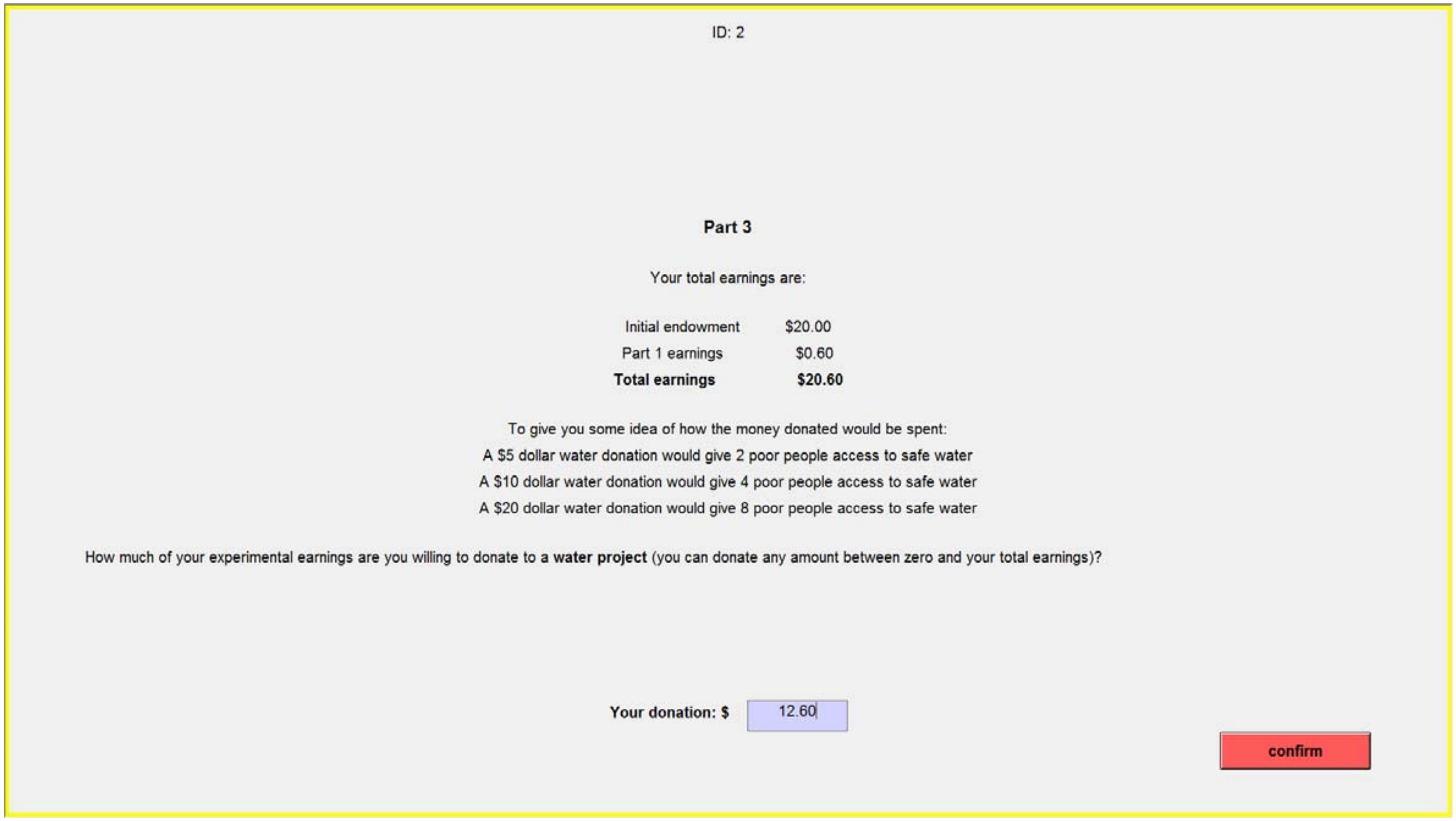

Figure 2: Example of elicitation of willingness to donate to a charitable project with water security benefits (Part 3)

Figure 3: Example of a single-attribute decision problem from Part 3

Figure 4: Example of a multi-attribute (de Finetti and Richard: FR) decision problem from Part 2

Figure 5: Example of monetary lottery decision problem from Part 1

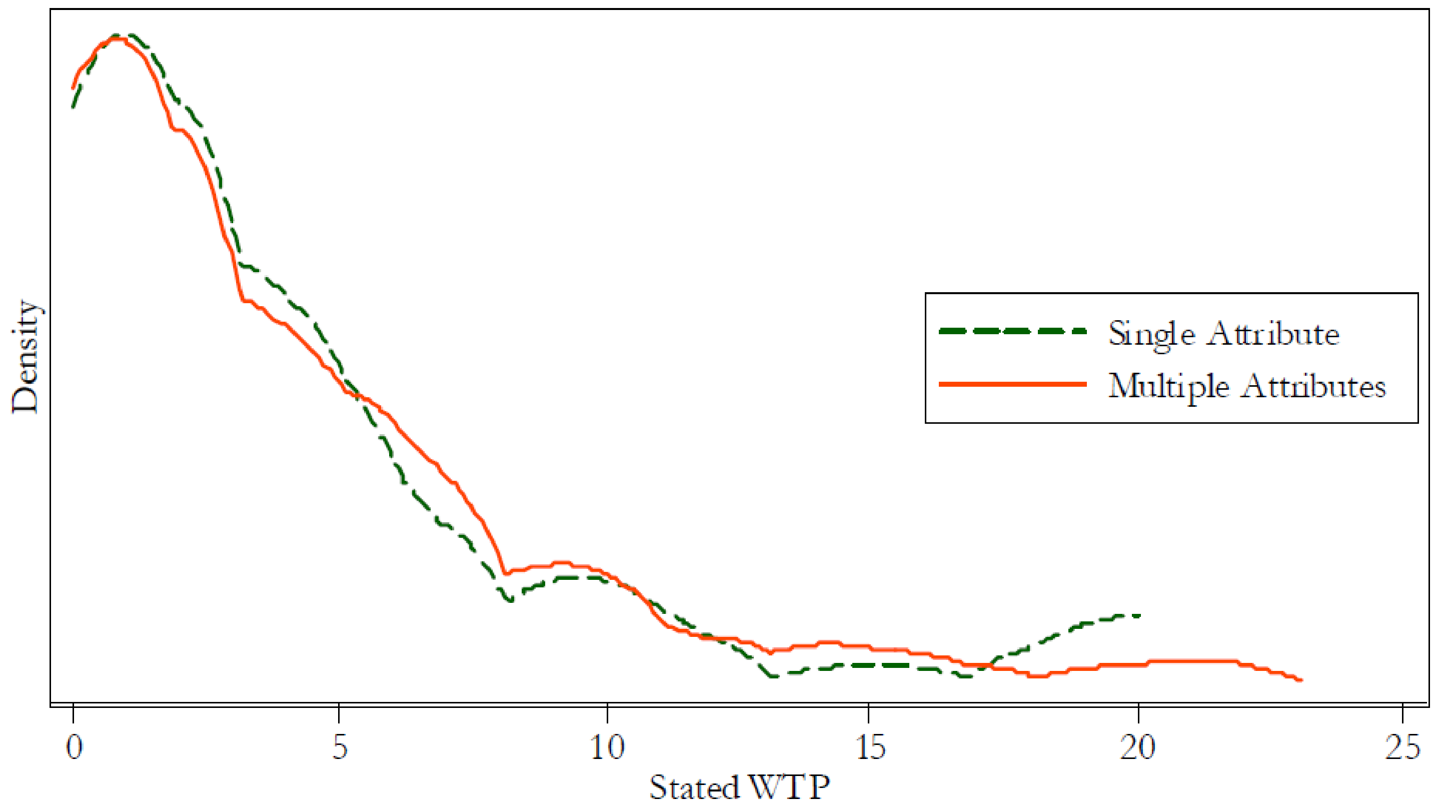

Figure 6: Maximum Willingness to Donate to WaterAid in AUD

Table 1: Payoffs and implied risk attitudes for a charitable lottery game over a single risky outcome: water security outcomes as measured in the number of people gaining access to safe water.

	Option A		Option B		EV(A) – EV(B)[(a)]	Risk Aversion		
	Left	Right	Left	Right	$		r_w	
Outcome (x)	5	4	9	1				
Probabilities	0.1	0.9	0.1	0.9	5.75	-1.94	$< r_w \leq$	-1.08
	0.2	0.8	0.2	0.8	4.00	-1.08	$< r_w \leq$	-0.54
	0.3	0.7	0.3	0.7	2.25	-0.54	$< r_w \leq$	-0.11
	0.4	0.6	0.4	0.6	0.50	-0.11	$< r_w \leq$	0.26
	0.5	0.5	0.5	0.5	-1.25	0.26	$< r_w \leq$	0.61
	0.6	0.4	0.6	0.4	-3.00	0.61	$< r_w \leq$	0.99
	0.7	0.3	0.7	0.3	-4.75	0.99	$< r_w \leq$	1.42
	0.8	0.2	0.8	0.2	-6.50	1.42	$< r_w \leq$	2.04
	0.9	0.1	0.9	0.1	-8.25	2.04	$< r_w \leq$	460.16
	1.0	0.0	1.0	0.0	-10.00	460.16	$< r_w$	

(a) The expected values for options *A* and *B* are based on an exchange rate of $2.50 per person being given access to safe water.

Table 2: Illustrative payoffs for a charitable lottery game over a single risky outcome (water security outcomes as measured in the number of people gaining access to safe water) with donations based on an elicited willingness to pay of $12.60.

	Option A		Option B		Donation ($)[(a)]		EP(A) – EP(B)
	Left	Right	Left	Right	Option A	Option B	$
Outcome (x)	5	4	9	1			
Probabilities	0.1	0.9	0.1	0.9	5.74	3.81	1.29
	0.2	0.8	0.2	0.8	5.88	4.54	0.90
	0.3	0.7	0.3	0.7	6.06	5.26	0.50
	0.4	0.6	0.4	0.6	6.16	5.99	0.11
	0.5	0.5	0.5	0.5	6.58	7.00	-0.28
	0.6	0.4	0.6	0.4	7.11	8.12	-0.67
	0.7	0.3	0.7	0.3	7.64	9.24	-1.06
	0.8	0.2	0.8	0.2	8.18	10.36	-1.46
	0.9	0.1	0.9	0.1	8.71	11.48	-1.85
	1.0	0.0	1.0	0.0	9.24	12.60	-2.24

(a) The donation amounts for Options *A* and *B* are calculated based on the participants stated willingness to donate to a charitable water security project, assumed to be $12.60 in this example. Opting for the risk neutral choice pattern (Option A for lines 1-4 and Option B for lines 5-10) will result in paying the expected value of the choice, whereas deviations from this choice pattern come at a cost premium equal to the absolute value of entries in last column.

Table 3: Illustrative payoffs for a KM lottery game over joint risky outcomes, water security (*x*, outcome in number of people gaining access to safe water) and sanitation (*y*, outcome in number of life months saved per family), with donations based on an elicited willingness to pay of $19.60.

	Option A		Option B		Donation ($)[a]		EP(A) – EP(B)
	Left	Right	Left	Right	Option A	Option B	$
Payoff (x,y)	4,3	3,4	7,7	1,1			
Probabilities	0.1	0.9	0.1	0.9	9.80	6.61	2.13
	0.2	0.8	0.2	0.8	9.80	7.62	1.46
	0.3	0.7	0.3	0.7	9.80	8.62	0.78
	0.4	0.6	0.4	0.6	9.80	9.63	0.11
	0.5	0.5	0.5	0.5	10.36	11.20	-0.56
	0.6	0.4	0.6	0.4	11.03	12.88	-1.23
	0.7	0.3	0.7	0.3	11.70	14.56	-1.90
	0.8	0.2	0.8	0.2	12.38	16.24	-2.58
	0.9	0.1	0.9	0.1	13.05	17.92	-3.25
	1.0	0.0	1.0	0.0	13.72	19.60	-3.92

(a) The donation amounts for Options A and B are calculated based on the participants stated willingness to donate to a charitable single attribute project ($12.60 for this example) as well as the stated amount for a project resulting in water and sanitation benefits ($19.60 in this example). Opting for the risk neutral choice pattern (Option A for lines 1-4 and Option B for lines 5-10) will result in paying the expected value of the choice, whereas deviations from this choice pattern come at a cost premium equal to the absolute value of entries in last column.

Table 4: Joint estimation of the non-additive EUT specification for all single and joint lotteries

Variable	Description	Estimate	Robust Standard Error	*p*-value	Lower 95% Confidence Interval	Upper 95% Confidence Interval
r_m	CRRA (money)	0.9201	0.0782	<0.001	0.7669	1.0734
r_w	CRRA (water security)	0.4967	0.0203	<0.001	0.4568	0.5365
r_s	CRRA (sanitation)	0.5155	0.0252	<0.001	0.4661	0.5649
η	MARA (FR&KM)	0.3121	0.0302	<0.001	0.2529	0.3713
α	Weight on sanitation	0.1000	(constrained)			
β	Weight on money	0.8500	(constrained)			
γ	P(contribution > 0)	0.5281	0.1508	<0.001	0.2326	0.8237
μ	Behavioral error	0.4612	0.0653	<0.001	0.3333	0.5891

Pseudo Loglikelihood	Observations	Subjects
-8752.7091	10,780	154

Notes: Standard errors are clustered by subject.

Table 5: Joint estimation of the non-additive EUT specification with separate FR and KM effects

Variable	Description	Estimate	Standard Error	*p*-value	Lower 95% Confidence Interval	Upper 95% Confidence Interval
r_m	CRRA (money)	0.9200	0.0777	<0.001	0.7677	1.0723
r_W	CRRA (water security)	0.4960	0.0204	<0.001	0.4560	0.5360
r_S	CRRA (sanitation)	0.5183	0.0249	<0.001	0.4694	0.5672
η_{FR}	MARA (FR)	0.1223	0.0540	0.023	0.0166	0.2281
η_{KM}	MARA (KM)	0.2338	0.0444	<0.001	0.1468	0.3208
γ	P(contribution > 0)	0.5281	0.1508	<0.001	0.2326	0.8237
μ	Behavioral error	0.4540	0.0647	<0.001	0.3271	0.5808

Pseudo Loglikelihood	Observations	Subjects
-8748.015	10,780	154

Notes: Standard errors are clustered by subject. η_{FR} is the marginal effect on multi-attribute risk aversion when presented with a de Finetti and Richard (FR) lottery.

Table 6: Comparison of risk preferences over all lotteries (Parts 1, 2 and 3) compared with lotteries with donations by the subject (Parts 1 and 3)

		Parts 1&2&3		**Parts 1&3**	
Variable	Description	Estimate	*p*-value	Estimate	*p*-value
r_m	CRRA (money)	0.9201 (0.0782)	<0.001	0.9350 (0.0834)	<0.001
r_w	CRRA (water security)	0.4967 (0.0203)	<0.001	0.4583 (0.0130)	<0.001
r_s	CRRA (sanitation)	0.5155 (0.0252)	<0.001	0.5130 (0.0192)	<0.001
η	MARA (FR&KM)	0.3121 (0.0302)	<0.001	0.1707 (0.0255)	<0.001
μ	Behavioral error	0.4612 (0.0653)	<0.001	0.5650 (0.0562)	<0.001
Pseudo Loglikelihood		-8752.7091		-5907.0793	
Subjects		154		154	
Observations		10,780		6,160	

Notes: Estimation results are copied from Table 4 with robust standard errors, clustered by subject, given in brackets.

Appendix A: Calculation of Subject and Option Specific Donation Amounts (Part 3)

The experiment is divided into 3 Parts. Part 1 is a monetary lottery. Part 2 consists of 20 pairwise single and 10 pairwise joint lottery decisions, where the subject chooses amongst risky aid projects on the experimenter's behalf. Part 3 involves 10 single outcome lottery decisions and 20 joint outcome lottery decisions. Each of these Part 3 lottery decision is associated with an option and subject specific donation amount to be made by the subject.

Single outcome

These option specific donation amounts are calculated for each participant, using two elicitation questions. The first elicitation at the beginning of Part 3 asks subjects to nominate an amount that they would be willing to donate to a single type of outcome (water security for half the subjects and sanitation for the other half of the subjects) by entering their willingness to donate in a decision box as shown for an illustrative amount of AUD 12.60 in Figure 2. We do not present any explicit risk associated with this outcome. This stated willingness to donate is followed by 10 single attribute lottery choices. Each of the lottery Options has a monetary donation associated with it that is constructed such that it never exceeds the subject's initial nominated donation amount and such that a univariate risk neutral choice pattern is given by 4 Options A and 6 Options B.

Table 2 shows the subject-specific donation amounts for the case of water security for a stated willingness to donate (AUD 12.60 in this example). The subject's nominated amount is taken as the maximum willingness to donate and is set equal to the required donation of selecting Option B when probabilities are 1/0, i.e. the high payoff of 9 people being given access to safe water is achieved with certainty. Accordingly, the largest donation amount shown in Table 3 is AUD 12.60, which corresponds to Option B in the last line of the Table and allows the calculation of an individual specific exchange rate for water security of ER_w = AUD 12.60/9 = AUD 1.40 per person being given access to safe water. This exchange rate is used to calculate the expected value of each Option A and B. The donation amounts associated with each of the lottery choices within the risk neutral choice pattern of 4 Option A and 6 Option B represent their expected value to the participant, while deviations from the risk neutral choice pattern incur a donation premium.[18] Hence, selecting Option B for probabilities, 0.1-0.9, 0.2-0.8, 0.3-0.7 and 0.4-0.6 requires a donation amount in excess of the expected value, whereas selecting Option A attracts a donation premium in the remaining lottery pairs. In the experiment, the subjects were not presented with information about expected values of lotteries, nor about differences in expected payoffs.

Using the subjects' initial willingness to pay for charitable outcomes to calculate their donation amounts in different lotteries helps isolate differences in risk attitudes from differences in valuations of charitable outcomes that exist regardless of the riskiness of outcomes. The initial elicitation is not affected by risk and that can help guide the true valuation of individuals for these charitable outcomes.

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[18] This was done for two reasons. First we wanted to avoid indifferent choices for the risk neutral decision maker. Secondly, by adding the donation premium to the options consistent with risk averse or risk loving attitudes, we made these relatively less attractive as compared with the risk neutral choice and therefore avoided introducing a bias. For example, the donation amount for Option A for probabilities 0.1/0.9 in the first line of Table 2 is equal to its expected outcome value, EV(A) = (0.1×5+0.9×4)×AUD1.40 = AUD5.74 and a risk neutral person would be indifferent between donating AUD5.72 or not to Option A. The expected outcome value of Option B for probabilities 0.1-0.9 is EV(B) = (0.1×9+0.9×1)×AUD1.40 = AUD2.52. Being classified as a risk loving choice, Option B attracts a donation premium, which is based on the expected values for Options A and B and equal to |(EV(A) – EV(B))/2.5| = |(AUD5.74 – AUD2.52)/2.5| = AUD1.29. The donation amount associated with Option B is then Donation (B) = AUD2.52 + AUD1.29 = AUD 3.81 and the expected payoff for Option B is EP(B) =AUD2.52 – AUD3.81 = –AUD1.29. The difference in expected payoffs is EP(A) – EP(B) = AUD1.29*,* which is reported in the last column of Table 2.

Joint outcomes

Subjects are then asked to nominate an amount they would like to donate to a risky aid project that has *both* sanitation and water security benefits. Again, this amount is not paid directly to WaterAid. Instead, this stated willingness to pay is used to calculate donation amounts associated with lotteries in subsequent decision problems. Using their single attribute donation in addition to the multiple attribute donation, an exchange rate for the remaining attribute, for example, the exchange rate per life month saved for a family of 4, is calculated as follows:

$$ER_s = \frac{D_j - ER_w W_{Bh}}{S_{Bh}},$$

where D_j is the subject's nominated donation amount for a project with sanitation and water security benefits, ER_w is the exchange rate for water security based on the single attribute donation, W_{Bh} is the high water security payoff, and S_{Bh} is the high sanitation payoff in Option B. Based on this exchange rate, and using the same adjustment mechanism described above for the single attribute lotteries, donation amounts were calculated for each option in the joint outcome lotteries that generated the 4-6 choice pattern for single-attribute and multiple-attribute risk neutral individuals and never exceeded the nominated donation amount. This was done for the elicited donation amount, which in the example shown in Table 4 is AUD 19.60 for a project that has both water security and sanitation benefits. Figure 5 shows how the second-last line of Table 4 was presented to subjects.

Appendix B: Instructions to the Participant

Original formatting has been preserved

INSTRUCTIONS

General Information

Thank you for participating in this experiment. This is a study of decision-making. You will receive compensation for your participation, which will be paid to you in cash at the end of the experiment. How you will be compensated is explained below.

The instructions that we have distributed to you are for your private information. Please do not communicate with the other participants during the experiment. Should you have any questions please raise your hand.

To ensure the anonymity of all participants' choices, the computer will assign you a random ID.

We will ask for a volunteer to come forward to be the monitor for today's study. The monitor will verify that the instructions, as they appear, have been followed, but will otherwise take part in the experiments as everybody else.

The experiment is divided into three parts. Once the first part is finished you will receive detailed information about the next part of the experiment.

INSTRUCTIONS FOR PART 1

In this part of the experiment you will be asked to make a series of choices in decision problems. How much you receive will depend partly on **chance** and partly on the **choices** you make. The decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose.

Each of the decision problems would be numbered 1 to 10 and would appear on a separate screen of the computer. In each, please state whether you prefer option A or option B. Though you will make choices in many decision problems, **one of the 10** will be randomly selected for payment. As any of the decisions can be chosen for payment, you should pay attention to the choice you make in every decision screen.

Here is an example of the choice that you will see on the screen.

Example: Option A yields a 60-40 chance of a payoff of either $12.00 or $9.60. Option B yields a 60-40 chance of either $23.10 or of $0.60. You have to state whether you prefer option A or B.

How will you be paid?

At the end of this part of the experiment, the monitor will randomly draw a ball out of the bingo cage containing balls numbered from **1 to 10**. The number on the ball determines which decision is going to be paid.

The outcome in each decision problem will be determined by another random draw of a ball out of the bingo cage containing balls numbered from **1** to **10.** The monitor will draw the ball.

If in the above example, you had chosen Option A, and the ball randomly drawn from the bingo cage was numbered between 1 and 6, then you earn $12.00. If the ball drawn was numbered 7-10, then you earn $9.60. Notice that the pie slice in the figure above is yellow for 60% of the pie and blue for 40% of the pie, (you will see the colours clearly on the screen). So the size of the pie slices show you chances of each possible outcome. The bars adjacent to the pie, show the outcome, ie: payoffs in dollars.

If in the above example, you had chosen Option B. Then if the ball drawn was between 1 and 6, your earnings would be $23.10 and if the ball was numbered 7-10, then your earnings would be $0.60. As with option A, the pie slices represent the fraction of the possible numbers that yield each payoff.

All earnings are in cash and are in addition to the $20.00 initial endowment that you receive as compensation for your time and effort in this and the following parts of the experiment.

Control Question

(This example aims to help you better understand the experiment and should not be used as a guide for decisions in the experiment)

1. Assume that in Part 1, the following decision was randomly picked for payment purposes:

You have chosen Option A in this decision. The ball drawn randomly from the bingo cage is numbered 4. What would your earnings be from this task?

Do you have any questions?

INSTRUCTIONS FOR PART 2

In this part of the experiment you will be asked to make a series of choices in decision problems. These decisions relate to water security and health in poor countries. One of the decisions will be randomly picked and the choice you made in that decision will have real implications for water security and health and sanitation in these countries. For this reason please think very carefully about each choice you are making.

Background Information

A number of international charities focus on the provision of water, sanitation and hygiene in poor countries. One of these is WaterAid, an international non- government organization charity that partners with local organisations to work with individuals and families in their communities. WaterAid is a fiscally responsible and financially reliable charity (http://www.wateraid.org). They help communities build and maintain water and sanitation projects.

Each project that they fund is unique, but all have the following in common:

- Technologies are low-cost and suited to local conditions
- Water, sanitation and hygiene education are combined to ensure people gain the maximum health benefits
- WaterAid works with local partner organisations, which are best placed to understand the communities' needs
- Local people are supported to plan, construct, manage and maintain their own projects

We will focus on two outcomes of this charity: providing Water Security and Improving Sanitation.

Water security is defined by WaterAid as the reliable access to water of sufficient quantity and quality for basic human needs, small-scale livelihoods and local ecosystem services, coupled with a well-managed risk of water related disasters.

Sanitation and health education can improve the quality of life in poor communities. Researchers have quantified the equivalent months of healthy life lost due to being in states of poor health or disability or due to premature death.

A mix of technologies, for example hand-dug wells versus boreholes versus gravity flow schemes, is used to deliver water to people living in these communities. Some of these technologies are more efficient or reliable than others, but not every technology is suitable in every situation. Similarly, education programs to improve hygiene and health standards may have more or less impact due to local geography or demographic characteristics. Hence the outcomes (water security and health and sanitation benefits) from a donation are affected by **chance**.

How will you be paid?

The initial endowment of $20.00 that you received at the beginning of the experiment is intended to compensate you for your effort and careful consideration of each choice in this part of the experiment.

Description of the Decision Problem

These decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose. Though you will make choices in 30 decision problems, **one out of 30** will be randomly selected and the money associated with it will be donated by **us** to WaterAid. How much the charity receives will depend partly on **chance** and partly on the **choices** you make.

The donation amount is calculated on the basis of exchange rates that reflect the average outcomes to poor people in Africa and South East Asia from donations made to WaterAid. To give you some idea of how the money donated would be spent:

- A $5 dollar water donation would give 2 poor people access to safe water
- A $10 dollar water donation would give 4 poor people access to safe water
- A $20 dollar water donation would give 8 poor people access to safe water
- A $5 sanitation donation would prolong the life of each member of a poor family of four by 2 months

- A $10 sanitation donation would prolong the life of each member of a poor family of four by 4 months
- A $20 sanitation donation would prolong the life of each member of a poor family of four by 8 months
- A $5 dollar donation to water and sanitation would give 1 poor person access to safe water and would prolong the life of each member of a poor family of four by 1 month.
- A $10 dollar donation to water and sanitation would give 2 poor people access to safe water and would prolong the life of each member of a poor family of four by 2 months.
- A $20 dollar donation to water and sanitation would give 4 poor people access to safe water and would prolong the life of each member of a poor family of four by 4 months.

Donation Amount	Water Security (number of people)	Sanitation (number of months)	Water Security (number of people) and Sanitation (number of months)
$5	2	2	1,1
$10	4	4	2,2
$20	8	8	4,4

Here are some examples of the choice that you may see on the screen.

Example 1:

Option A yields a 60-40 chance that 5 or 4 people gain access to safe water due to the money donated. Option B yields a 60-40 chance that either 9 people or 1 person gains access to safe water as a result of the donation. Note that in these choices the outcomes (i.e., the number of people who gain access to safe water) remain the same in 10 decision problems. Only the chance changes in increments of 10%.

Example 2:

Here the outcomes are shown in terms of life months gained for each member of a family of four. Option A yields a 60-40 chance that either 5 or 4 life months would be gained for each member as a result of the donation. Option B has a 60-40 chance of either 9 or 1 life months gained for each member. Again, note that in these choices the outcomes (i.e., the number of months gained for each member of a family of four) remain the same in 10 decision problems. Only the chance changes in increments of 10%.

Example 3:

In this example, you see the outcomes in terms of both: access to safe water and the number of months by which the life of each member of a family of four will be prolonged. Option A gives a 60-40 chance: a 60 percent chance that 4 people will gain water security and 3 life months will be gained, and a 40 percent chance that 3 people gain water security and 4 life months are gained. In comparison, Option B yields a 60-40 chance: a 60 percent chance that 7 people gain water security and 7 life months are gained and a 40 percent chance that only 1 person gains water security and only 1 life month is gained as a result of the money donated. As before, in these choices the outcomes (i.e., the number of people who gain access to safe water and the number of months by which the life of a family of four is prolonged) remain the same in 10 decision problems. Only the chance changes in increments of 10%.

How much money would be donated by the Experimenter to the charity?

This depends on your decision and on chance

At the end of the experiment, after you have completed all your choices the monitor will randomly draw a ball out of the bingo cage containing balls numbered from **1 to 30**. The number on the ball determines which decision is going to be chosen for a donation from the experimenter.

The outcome of the decision will be determined by a randomly drawn ball numbered between 1 and 10 from the bingo cage. The monitor will draw a ball. The number on this ball will determine which of the outcomes occur and the donations will be based on that.

As the table below shows, if you had chosen Option A in Example 1, and the ball randomly drawn from the bingo cage was numbered between 1 and 6, then 5 times $2.50 = $12.50 would be donated by the experimenter to WaterAid so that 5 people gain access to safe water due to the donation. If the ball drawn was numbered 7-10, then 4 people would have access to safe water as 4 times $2.50 = $10.00 would have been donated by the experimenter. If you had chosen Option B in this example, and the ball drawn was numbered between 1 and 6, then 9 people would gain access to safe water due to the donation (9 times $2.50 = $22.50) made by the experimenter. If the ball drawn was numbered between 7-10, then 1 person would gain access to safe water (due to 1 times $2.50 = $2.50 donated). The exchange rate of $2.50 being used in these calculations arises from the information from WaterAid that: a $5 donation would give 2 poor people access to safe water. ($5/2 = $2.50).

Number on the Ball Drawn	Donation to Charity
If you had chosen Option A	
1-6	$12.50
7-10	$10.00
If you had chosen Option B	
1-6	$22.50
7-10	$2.50

The method of calculating how the charity would be paid in situations where the decision is relating to the number of life months gained for a family of four is similar to the example shown above. The exchange rate of $2.50 is also used here: as a $5 donation would prolong the life of each member of a poor family of four by two months. ($5/2 = $2.50).

The table below shows how much would be donated by the experimenter to WaterAid in Example 3, in which both the outcomes are present. If you had chosen Option A, and the ball randomly drawn from the bingo cage was numbered between 1 and 6, then 4 times $2.50 + 3 times $2.50 = $17.50 would be donated by us to WaterAid. This donation would ensure that 4 people would gain access to safe water and 3 months would be gained for each member. If the ball drawn was numbered 7-10, then 3 people would have access to safe water and 4 life months would be gained, as 3 times $2.50 + 4 times $2.50 = $17.50 would have been donated by the experimenter. If you had chosen Option B in this example, and the ball drawn was numbered between 1 and 6, then 7 people would gain access to safe water and 7 months would be gained due to the donation (7 times $2.50 + 7 times $2.50 = $35.00) made by the experimenter. If the ball drawn was between 7-10, then 1 person would gain access to safe water and 1 life month would be gained (due to 1 times $2.50 + 1 times $2.50 = $5.00 donated).

Number on the Ball Drawn	Donation to Charity
If you had chosen Option A	
1-6	$17.50
7-10	$17.50
If you had chosen Option B	
1-6	$35.00
7-10	$5.00

At the end of the entire experiment, the monitor and the experimenter will calculate the total amount collected from the randomly chosen choice of all the participants and donate this amount to WaterAid. The experimenter will make the donation directly on their website as verified by the monitor. You will be informed of the total amounts then.

Control Question
(This example aims to help you better understand the experiment and should not be used as a guide for decisions in the experiment)

1. Assume that in Part 2, the following decision was randomly picked for donation purposes:

You have chosen Option A in this decision. The ball drawn randomly from the bingo cage is numbered 4. How much money will be donated to the charity by the experimenter due to the decision made by you?

Do you have any questions?

INSTRUCTIONS FOR PART 3

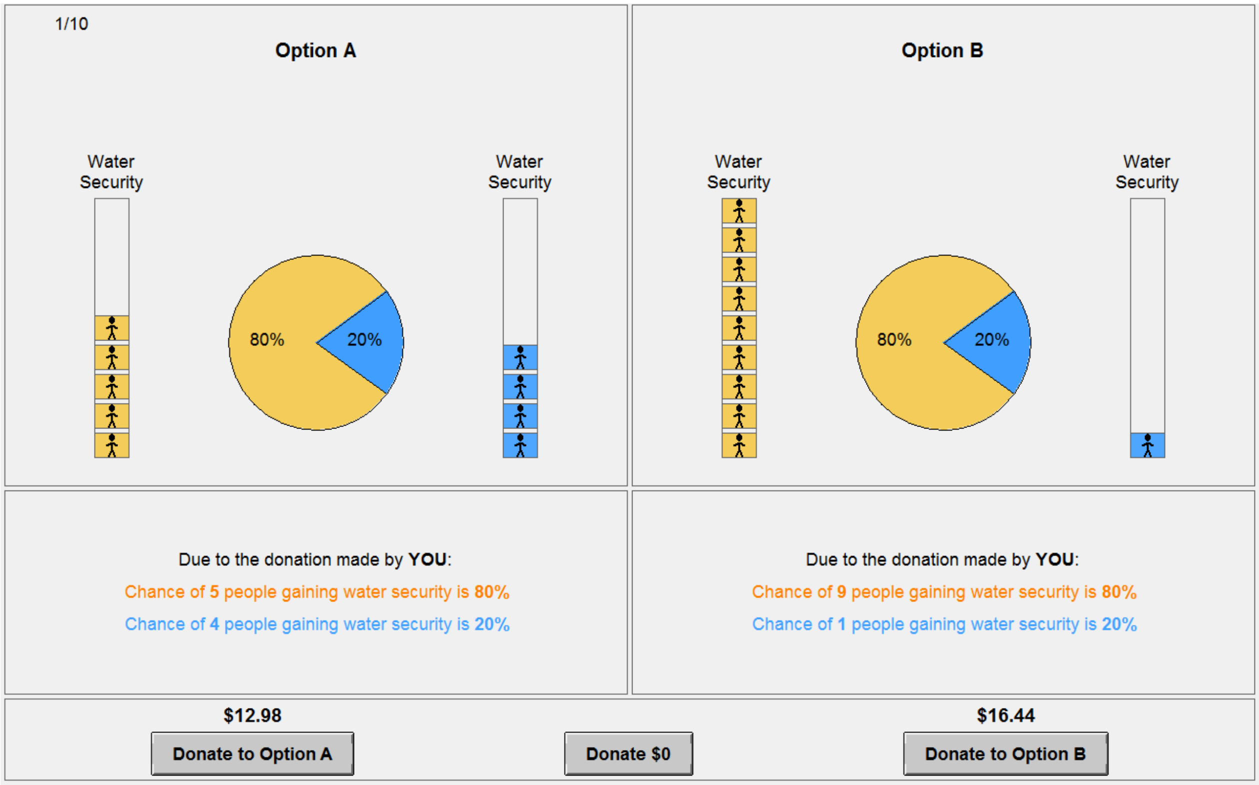
At the beginning of this part of the experiment, you will be reminded of your earnings from Part 1 of the experiment. You may use your combined earnings from your $20.00 endowment and your earnings in Part 1 in your decision making in this part. In each decision you will be given the opportunity to make a donation to the charity WaterAid. As before, one of these decisions will be picked at random and the corresponding donation amount deducted from **your** total earnings.

You will be asked to make a series of choices in decision problems. Your choices will be made privately. As before, these decision problems are not designed to test you in any way. What we want to know is what choices you would make in them. The only right answer is what you really would choose. Though you will make choices in many decision problems, **one out of 30** will be randomly selected and the money associated with it will be donated. How much of your earnings the charity receives will depend partly on **chance** and partly on the **choices** you make.

In this part, you will be choosing between options that have a monetary amount associated with it. In the 1st decision problem you see, you will be asked to provide the amount that you would like to donate to a water or sanitation project that will benefit the recipients of WaterAid. The next decisions problems numbered 1-10 will give you 3 options, two of them would have a positive donation amount associated with it and the third option carries no donation. You need to choose one of the options. The next decision problem you see, will again ask for a donation towards a project that yields water and sanitation benefits. Another 20 decision problems follow. They are numbered 1-20 and provide specific donation amounts in 3 options that you can choose from.

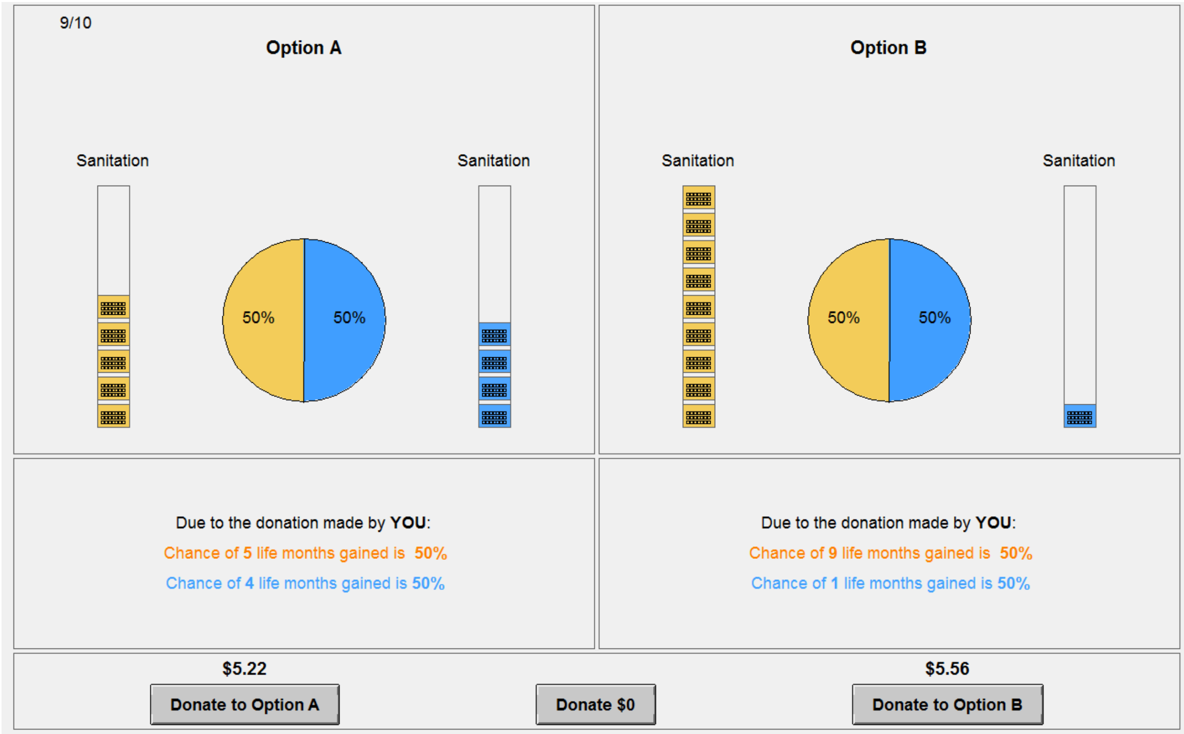
Here are examples of choices that you may see on the screen after having made your initial donation decisions:

Example 1:



You can choose between 3 options: **Option A** requires a donation of $12.98 for an 80-20 chance that 5 or 4 people gain water security. **Option B** requires a donation of $16.44 for an 80-20 chance that 9 or 1 person gains water security. The **third option** requires no donation and carries no aid benefits. In these choices the outcomes (i.e., the number of people who gain access to safe water) remain the same in 10 decision problems. Only the chance and the donation amounts for Options A and B change.

Example 2:



You can choose between 3 options or a Sanitation project: **Option A** requires a donation of $5.22 for a 50-50 chance that 5 or 4 life months are gained for each member of a family of four. **Option B** requires a donation of $5.56 for a 50-50 chance that 9 or 1 life month are gained. The **third option** requires no donation and carries no aid benefits. In these choices the outcomes (i.e., the number of disability adjusted life months saved) remain the same in 10 decision problems. Only the chance and the donation amounts for Options A and B change.

Example 3:

In this example, you see the outcomes in terms of both: access to safe water and life months gained. You can choose between 3 options: **Option A** requires a donation of $12.74 for an 80-20 chance. An 80 per cent chance that 4 people gain water security and 3 life months are gained; and a 20 per cent chance that 3 people gain water security and 4 disability adjusted life-months are saved. **Option B** requires a donation of $16.57 for an 80-20 chance: 80 per cent chance that 7 people gain water security and 7 life months are saved and a 20 percent chance that only 1 person gains water security and only one life months is saved. The **third option** requires no donation and carries no aid benefits. In these choices the outcomes (i.e., the number of people who gain access to safe water and the number of life months saved) remain the same in 10 decision problems. Only the chance and the donation amounts for Options A and B change.

What does your earnings balance look like?

At the end of the experiment, after you have completed all your choices the monitor will randomly draw a ball out of the bingo cage containing balls numbered from **1 to 30**. The number on the ball determines which decision will be played out of the 30 numbered decision problems.

Your earnings balance (ie, the amount after deducting your donation from your total earnings) would be determined by the choice you have made in that decision. If you had chosen option A in Example 3, your earnings would be equal to the following:

Your earnings balance = your initial endowment + your earnings from Part 1 – $12.74.

If you had chosen option B in Example 3, your earnings would be equal to the following:

Your earnings balance = your initial endowment + your earnings from Part 1 – $16.57.

If you had chosen the third option in this example, your earnings would be equal to the following:

Your earnings balance = your initial endowment + your earnings from Part 1.

How much money would the charity receive as a result of the donation made by YOU?

This depends on your decision and on chance

The outcome of your choice in the randomly drawn decision will be determined by a random number between 1 and 10. The monitor will draw one ball. The number on this ball will determine which of the outcomes occur with respect to water security and the number of life months saved. The donation paid to the charity will be based on these two outcomes, while also taking into account the amount you donated.

If in Example 3 you had chosen Option A, the donation to WaterAid would be determined as follows:

If the ball randomly drawn from the bingo cage was numbered from 1-8, then the donation made to WaterAid would ensure that 4 people would gain access to safe water and 3 life months are gained.

If the ball randomly drawn from the bingo cage was numbered 9 or 10, then the donation to WaterAid would ensure that 3 people would gain access to safe water and 4 life months would be gained.

If in Example 3 you had chosen Option B, the donation to WaterAid would be determined as follows:

If the ball randomly drawn from the bingo cage was numbered from 1-8, then the donation to WaterAid would ensure that 7 people would gain access to safe water and 7 life months would be gained.

If the ball randomly drawn from the bingo cage was numbered 9 or 10, then the donation to WaterAid would ensure that 1 person would gain access to safe water and 1 life month would be gained.

If in Example 3 you had chosen the third option, no donation would be made to WaterAid At the end of the entire experiment, the experimenter will calculate the total amount collected from the choices of all the participants and donate this amount to WaterAid. The monitor will verify that the experimenter has made the donation directly on the WaterAid website. Any differences between the calculated donation amounts to the charity and the amount you have contributed from your earnings in Part 3 will be taken from or returned to the experimental money pool.

Control Question

(This example aims to help you better understand the experiment and should not be used as a guide for decisions in the experiment)

1. Assume that in Part 3, the following decision was randomly picked for payment purposes:

You have chosen Option A in this decision. The ball drawn randomly from the bingo cage is numbered 3. What donation amount will be deducted from your total earnings?

Do you have any questions?

Appendix C: Structural Estimation

Consider the identification of risk preferences in the simplest possible model of decision-making under risk. We initially assume that EUT holds for the choices over risky alternatives, and that the utility function is the constant relative risk aversion (CRRA) specification

$$U(M) = M^{(1-r)}/(1-r) \tag{1}$$

for $r \neq 1$, where r is the CRRA coefficient. With this functional form for utility, and under EUT, $r=0$ denotes risk neutral behavior, $r>0$ denotes risk aversion, and $r<0$ denotes risk loving behavior. We write M as the argument, to suggest that utility for risk aversion is normally defined over money. But of course our focus here is on three attributes, of which money is but one. We generalize the notation below when needed for the non-additive specification.

We can write out the likelihood function for the choices that our subjects made and estimate the risk parameter r. Probabilities for each outcome M_j, $p(M_j)$, are those that are induced by the experimenter, so expected utility is simply the probability weighted utility of each outcome in each lottery. Since there were two outcomes in each lottery, the EU for lottery i is

$$EU_i = \sum_{j=1,2} [\ p(M_j) \times U(M_j)\ ]. \tag{2}$$

The EU for each lottery pair is calculated for candidate estimates of r and μ, and the difference

$$\nabla EU = (EU_B - EU_A)/\mu \tag{3}$$

calculated, where EU_A refers to Option A and EU_B refers to Option B, and μ is a structural "noise parameter" used to allow some errors from the perspective of the deterministic EUT model. The latent index ∇EU is in the form of a cumulative probability distribution function defined over differences in the EU of the two lotteries and the noise parameter μ. Thus, as $\mu \rightarrow 0$ this specification collapses to the deterministic choice EUT model, where the choice is strictly determined by the EU of the two lotteries; but as μ gets larger and larger the choice essentially becomes random. This is one of several different types of error story that could be used (Wilcox, 2008).

Thus the likelihood of the risk aversion responses, conditional on the EUT and CRRA specifications being true, depends on the estimates of r and μ, and the observed choices. The conditional log-likelihood is

$$\ln L(r, \mu; y, \mathbf{X}) = \sum_i [(\ln \Phi(\nabla EU) \times \mathbf{I}(y_i = 1)) + (\ln \Phi(1-\nabla EU) \times \mathbf{I}(y_i = -1))] \quad (4)$$

where $I(\cdot)$ is the indicator function, $y_i = 1(-1)$ denotes the choice of the Option B (A) lottery in risk aversion task i, and X is a vector of individual or treatment characteristics reflecting sex or task order, for example. The parameter r is defined as a linear function of the characteristics in vector X.

The extension to consider the joint estimation of all parameters from all tasks follows the logic developed by Andersen, Harrison, Lau and Rutström (2008), explained further in Harrison and Rutström (2008).