ELICITING RISK ATTITUDES, MEASURING RISK AVERSION, AND ESTIMATING RISK PREMIUMS USING INDIRECT UTILITY FUNCTIONS: A Laboratory Experiment

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Abstract:

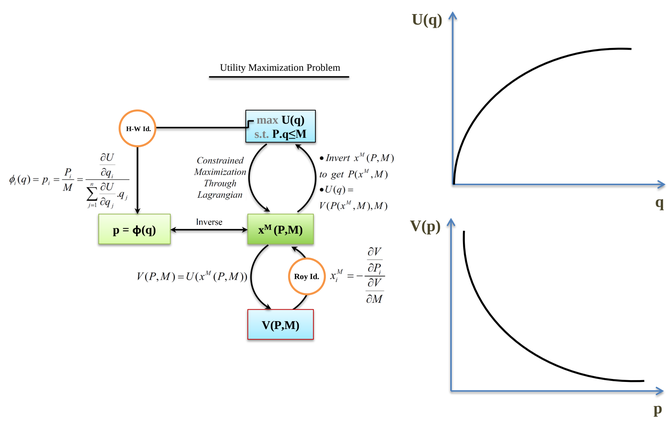
- Duality Theory (DT) implicitly suggests that the degree of risk-aversion that a given rational subject exhibits in the context of Direct Utility Function (**DUF**) must be equivalent to their degree of risk-aversion elicited through the context of Indirect Utility Function (**IUF**). We use a laboratory experiment to test the accuracy of this theoretical prediction. Our key findings indicate that the implicit suggestion of DT concerning the degree of risk aversion being equivalent under DUF and IUF is rejected. We show that Price Risk Aversion (**PrRA**) is greater than Payoff Risk Aversion (**PaRA**). All of these results are robust across different MPL designs and different approaches that we have utilized. Our other experimental findings are reported throughout the poster.

Key Words: Risk Aversion, Risk Attitudes, Multiple Price List, Direct and Indirect Utility Function
JEL Classification: C90, C91, D01, D81, D9, G4, G22

Introduction:

- Eliciting risk attitudes and estimating the degree of risk aversion are of crucial importance in economics. Duality Theory (DT) in modern microeconomics indicates that Direct Utility Function (**DUF**) and Indirect Utility Function (**IUF**) are dual to each other. Figure 1 summarizes this dual relationship in a visual form. As such, duality theory implicitly suggests that the degree of risk-aversion (or -seeking) that a given (rational) subject exhibits in the context of DUF must be equivalent to their degree of risk-aversion (or -seeking) elicited through the context of IUF. This paper is an attempt to test the accuracy of this theoretical prediction through a lab experiment.

Figure 1: *Components of the Wheel of Duality in the Utility Maximization Problem in Consumer Theory*



- Our methodology relies on elicitations that use **payoff-based** lottery choices (which are based on DUF and uncertainty about payoffs) versus their equivalent **price-based** lottery choices (which are based on IUF and uncertainty about prices).
- In the literature of experimental economics, many elicitation procedures have been used for the elicitation of risk attitudes and the degree of risk aversion in the lab using non-interactive settings. One of the most popular set of elicitation procedures has been the Multiple Price List (MPL) method. Among the most well-known MPL designs are **(1)** Holt & Laury (2002) – which has the advantage of "varying probabilities" (aka, "probability weighting"), **(2)** Binswanger (1980) – which has the advantage of "varying payoffs" (i.e. weighting payoffs), and **(3)** the Certainty-versus-Uncertainty design – which has the advantage of investigating decision making under both "certainty vs. uncertainty" (henceforth, **H&L**, **Bins.**, and **CVU** designs, respectively). Accordingly, we have a 3x2 design, as shown on the next column.
- We have adopted and calibrated **six equivalent risk elicitation designs** in such a way that, given Expected Utility Theory (EUT) and DT, each should elicit the same degree of risk aversion exhibited by a given rational individual, although the designs differ in form, in terms of their approach (i.e. DUF vs. IUF) and their MPL designs (i.e. H&L, Bins., and CVU). Table 1 presents risk-aversion classifications elicited from the mentioned six designs based on the options chosen.

Table 1: *Risk-Aversion Classifications*

Risk-Aversion Classifications Based on Options Chosen

Number of Safe Choices (For HL & CVU Designs)	Selected Decision Number (For Bins. Design)	Range of the Implied Coefficients of RRA for the CRRA Utility Function	Risk Attitude Classifications
0-1	**1**	**r < -0.95**	Highly risk-loving
2	**2**	**-0.95 < r < -0.49**	Very risk-loving
3	**3**	**-0.49 < r < -0.15**	Risk-loving
4	**4**	**-0.15 < r < 0.15**	Risk neutral
5	**5**	**0.15 < r < 0.41**	Slightly risk-averse
6	**6**	**0.41 < r < 0.68**	Risk-averse
7	**7**	**0.68 < r < 0.97**	Very risk-averse
8	**8**	**0.97 < r < 1.37**	Highly risk-averse
9-10	**9 or 10**	**r > 1.37**	Stay in bed (Extremely risk-averse)

Note: The implied CRRA coefficients apply to all the three designs in the way outlined in the table. In fact, the task designs have been arranged such that these classifications hold true for all the three designs.

Designs and Results:

Figure 2: *A Visual Depicting the Theoretical Equivalency of the Six Tasks*

Equivalent (Given EUT)

H&L Design - Direct

Table 1) Lottery with Payoff Odds – Scaled-Up Version of Holt and Laury (2002) Design

Decision #	Option A – (Your Monetary Payoff)	Option B – (Your Monetary Payoff)	Do you choose A or B?
1	1/10 of **($12.00)**, 9/10 of **($9.60)**	1/10 of **($23.05)**, 9/10 of **($0.60)**	.....
2	2/10 of **($12.00)**, 8/10 of **($9.60)**	2/10 of **($23.05)**, 8/10 of **($0.60)**	.....
3	3/10 of **($12.00)**, 7/10 of **($9.60)**	3/10 of **($23.05)**, 7/10 of **($0.60)**	.....
4	4/10 of **($12.00)**, 6/10 of **($9.60)**	4/10 of **($23.05)**, 6/10 of **($0.60)**	.....
5	5/10 of **($12.00)**, 5/10 of **($9.60)**	5/10 of **($23.05)**, 5/10 of **($0.60)**	.....
6	6/10 of **($12.00)**, 4/10 of **($9.60)**	6/10 of **($23.05)**, 4/10 of **($0.60)**	.....
7	7/10 of **($12.00)**, 3/10 of **($9.60)**	7/10 of **($23.05)**, 3/10 of **($0.60)**	.....
8	8/10 of **($12.00)**, 2/10 of **($9.60)**	8/10 of **($23.05)**, 2/10 of **($0.60)**	.....
9	9/10 of **($12.00)**, 1/10 of **($9.60)**	9/10 of **($23.05)**, 1/10 of **($0.60)**	.....
10	10/10 of **($12.00)**, 0/10 of **($9.60)**	10/10 of **($23.05)**, 0/10 of **($0.60)**	.....

CVU Design - Direct

Table 2) Lottery with Payoff Odds – Certainty vs. Uncertainty Design

Decision #	Option A – (Sure Payoff) (Your Monetary Payoff)	Option B – (Risky Payoff) (Your Monetary Payoff)	Do you choose A or B?
1	**$14.43**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
2	**$14.10**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
3	**$12.83**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
4	**$11.62**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
5	**$10.34**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
6	**$9.11**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
7	**$7.78**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
8	**$6.50**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
9	**$5.00**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....
10	**$4.00**	5/10 of **($2.00)**, 5/10 of **($20.00)**	.....

Bins. Design - Direct

Table 3) Lottery with Payoff Odds – One Choice among Ten Lotteries (Binswanger's Design)

Choice #	Options (Your Monetary Payoff)	Which Lottery do you choose? (Pick only one out of the ten choices!)
1	5/10 of **($0.16)**, 5/10 of **($22.16)**	.....
2	5/10 of **($2.00)**, 5/10 of **($22.04)**	.....
3	5/10 of **($3.20)**, 5/10 of **($21.88)**	.....
4	5/10 of **($4.80)**, 5/10 of **($21.16)**	.....
5	5/10 of **($6.40)**, 5/10 of **($19.84)**	.....
6	5/10 of **($7.20)**, 5/10 of **($18.92)**	.....
7	5/10 of **($8.00)**, 5/10 of **($17.76)**	.....
8	5/10 of **($8.80)**, 5/10 of **($16.48)**	.....
9	5/10 of **($10.40)**, 5/10 of **($13.96)**	.....
10	5/10 of **($12.00)**, 5/10 of **($12.00)**	.....

H&L Design - Indirect

Table 6) Lottery with Price Odds – Price-Based Version of Holt and Laury (2002) Design

ecision #	Option A – (Your Buying Prices)	Option B – (Your Buying Prices)	Do you choose A or B?
1	1/10 of **($1.25)**, 9/10 of **($1.56)**	1/10 of **($0.65)**, 9/10 of **($25.00)**	.....
2	2/10 of **($1.25)**, 8/10 of **($1.56)**	2/10 of **($0.65)**, 8/10 of **($25.00)**	.....
3	3/10 of **($1.25)**, 7/10 of **($1.56)**	3/10 of **($0.65)**, 7/10 of **($25.00)**	.....
4	4/10 of **($1.25)**, 6/10 of **($1.56)**	4/10 of **($0.65)**, 6/10 of **($25.00)**	.....
5	5/10 of **($1.25)**, 5/10 of **($1.56)**	5/10 of **($0.65)**, 5/10 of **($25.00)**	.....
6	6/10 of **($1.25)**, 4/10 of **($1.56)**	6/10 of **($0.65)**, 4/10 of **($25.00)**	.....
7	7/10 of **($1.25)**, 3/10 of **($1.56)**	7/10 of **($0.65)**, 3/10 of **($25.00)**	.....
8	8/10 of **($1.25)**, 2/10 of **($1.56)**	8/10 of **($0.65)**, 2/10 of **($25.00)**	.....
9	9/10 of **($1.25)**, 1/10 of **($1.56)**	9/10 of **($0.65)**, 1/10 of **($25.00)**	.....
10	10/10 of **($1.25)**, 0/10 of **($1.56)**	10/10 of **($0.65)**, 0/10 of **($25.00)**	.....

CVU Design - Indirect

Table 5) Lottery with Price Odds – Certainty vs. Uncertainty Design (Price-Based Version)

ecision #	Option A - (Certain Price) (Your Buying Prices)	Option B - (Random Price) (Your Buying Prices)	Do you choose A or B?
1	**$1.04**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
2	**$1.06**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
3	**$1.17**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
4	**$1.29**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
5	**$1.45**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
6	**$1.65**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
7	**$1.93**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
8	**$2.31**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
9	**$3.00**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....
10	**$3.75**	5/10 of **($7.50)**, 5/10 of **($0.75)**	.....

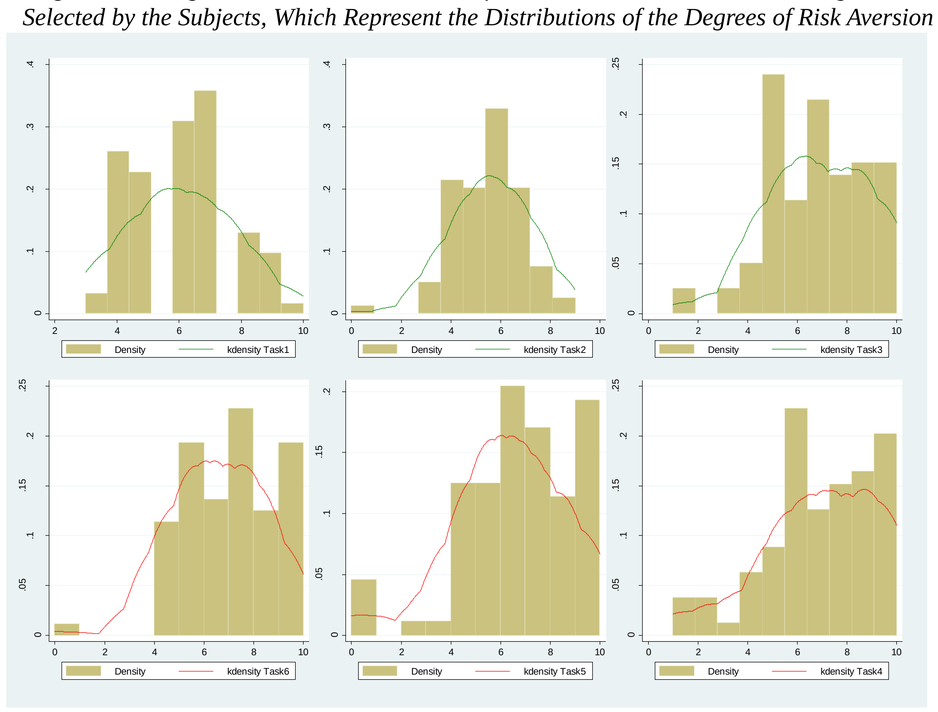
Bins. Design - Indirect

Table 4) Lottery with Price Odds – 1 Choice among 10 Lotteries (Price-Based Version of Binswanger)

Choice #	Options (Your Buying Prices)	Which Lottery do you choose? (Pick only one out of the ten choices!)
1	5/10 of **($93.75)**, 5/10 of **($0.67)**	.....
2	5/10 of **($7.50)**, 5/10 of **($0.68)**	.....
3	5/10 of **($4.69)**, 5/10 of **($0.69)**	.....
4	5/10 of **($3.13)**, 5/10 of **($0.71)**	.....
5	5/10 of **($2.34)**, 5/10 of **($0.76)**	.....
6	5/10 of **($2.08)**, 5/10 of **($0.79)**	.....
7	5/10 of **($1.88)**, 5/10 of **($0.85)**	.....
8	5/10 of **($1.70)**, 5/10 of **($0.91)**	.....
9	5/10 of **($1.44)**, 5/10 of **($1.07)**	.....
10	5/10 of **($1.25)**, 5/10 of **($1.25)**	.....

Equivalent (Given DT)

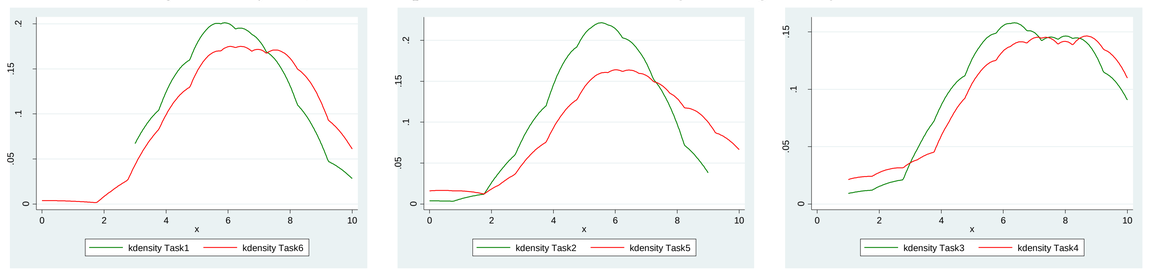
Figure 3: *Histograms and Kernel Densities of the Choice Numbers and Switching Points Selected by the Subjects, Which Represent the Distributions of the Degrees of Risk Aversion*



PaRA

PrRA

Figure 4: *Kernel Densities of the Choice Numbers and Switching Points Selected by the Subjects, Which Represent the Distributions of the Degrees of Risk Aversion*

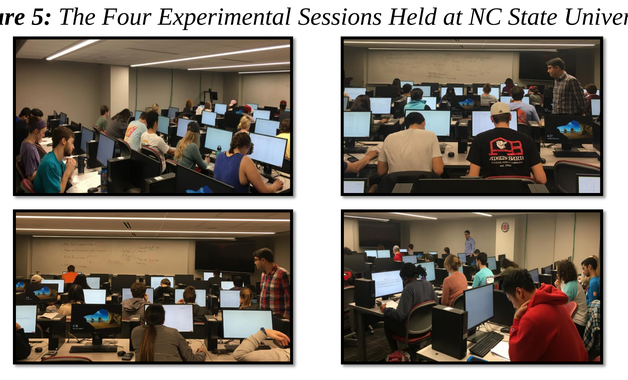


PaRA << PrRA

The Experiment Procedures:

We used a 3×2 design. Each of the three risk elicitation procedures (H&L, Bins., and CVU) is examined in the context of DUF as well as that of IUF. For each of the six treatments, four independent sessions were carried out. The order of tasks in each session was randomly assigned to account for potential order effect and learning effect. We also controlled for numerous demographic variables, whose discussion is beyond the scope of this poster. The subjects were students studying at North Carolina State University. Altogether, 88 students from a range of disciplines participated in the experiments, and the average payoff was $16.76 (including a $5 participation payment). Each session lasted approximately 75 minutes, with the first 15–20 minutes being used for instructions. All the subjects participating in the experiment conducted the tasks by the computers in the experimental economics laboratory of the Department of Economics at North Carolina State University. The popular experimental economics software zTree was employed for the purpose of this lab experiment.

Figure 5: *The Four Experimental Sessions Held at NC State University*



Discussion and Conclusion:

- The findings of the study show that the vast majority of subjects are risk-averse, regardless of whether the elicitation approach is direct (through DUF) or indirect (through IUF). In fact, only few (less than 5%) of them exhibit risk-loving attitudes, and the rest are either risk-neutral (about 12%) or risk-averse (about 83%), averaged across the tasks.
- As demonstrated in Figures 3 and 4, the subjects exhibit statistically significantly greater degrees of risk aversion when faced with **random prices** (PrRA) compared to when faced with **random payoffs** (PaRA). This observation can easily be made if one pays attention to the fact that in all the three pairs of designs, the kernel density representing the degree of PrRA lies to the right of its counterpart that represents the degree of PaRA. This is a remarkable result and a thought-provoking observation.
- More specifically, the findings indicate that the average of the estimated midpoint CRRAs is equal to 0.597 for PaRA (which implies '**risk-averse**' attitude), while it is equal to 0.708 for PrRA (which implies '**very risk-averse**' attitude).
- More interestingly, this result (i.e. **PaRA < PrRA**) is robust across all the MPL designs that we have used, which indicates the observed anomalies in the degrees of risk aversion exhibited by the subjects are quite systematic, and as such, can reasonably and convincingly be attributed to the nature of each approach (i.e., the inherently different risk preferences that subjects exhibit with respect to random payoffs and random payoffs).
- For the purpose of statistical hypothesis-testing, we have used a wide range of relevant statistical tests including Wilcoxon Signed-Rank Test, Arbuthnott-Snedecor-Cochran Sign Test, Kolmogorov-Smirnov Equality-of-Distributions Test, and Spearman Rank-Correlation Test, and the great majority of the above-mentioned statistical tests confirm that **PrRA is statistically significantly greater than PaRA**.
- This implicitly suggests that individuals, in general, have higher Willingness To Pay for price-guaranteeing insurance premiums than those guaranteeing payoff quantities. It also indicates that risk-preference-related implications of DT are rejected from a behavioral point of view, since experimental evidence shows that there is a systematic distance from rationality when subjects are exposed to random payoffs versus random prices.