

Estimating Risk Attitudes in Conventional and Artefactual Lab Experiments: The importance of the underlying assumptions

Andreas C. Drichoutis¹ and Phoebe Koundouri²

¹Dept. of Economics, University of Ioannina, University campus, Ioannina, Greece, email: adrihout@cc.uoi.gr, tel: +30-26510-05954, corresponding author

² Dept. of International and European Economic Studies, Athens University of Economics and Business, 76 Patision st., 10434, Greece, email: pkoundouri@aueb.gr

Abstract

In this paper we assess the importance of sample type in the estimation of risk preferences. We elicit and compare risk preferences from student subjects and subjects drawn from the general population, using the multiple price list method devised by Holt and Laury (2002). We find evidence suggesting that under Rank Dependent Utility and an expo-power function, students exhibit similar risk attitudes to subjects drawn from the general population. However, when we assume an incorrect characterization of risk preferences, in particular we adopt the framework of Expected Utility theory and a Constant Relative Risk Aversion function, our estimation results lead to erroneous inferences. In this case, students are on average risk averse, while subjects drawn from the general population exhibit risk loving preferences. Our results have implications for economic policy making under uncertainty.

Keywords: Risk aversion, CRRA, expo-power, rank dependent utility, multiple price list

JEL codes: C91, D01, D81

1. Introduction

Economic lab experiments have been mainly performed in academic environments and students have therefore posed as the natural standard subject pool. Whether student samples provide a reliable sample for extrapolating results to the general population is an issue that is heavily criticized. Concerns on the use of students as research surrogates for consumers or adults in general, is rather old (Enis, et al., 1972, McNemar, 1946). Reasons are attributed to the fact

that students exhibit psychological, social and demographical differences from other segments of the population but also to the fact that students are not yet complete personalities.

In addition, most decisions in life and in the lab are made under conditions of uncertainty, rendering risk behavior as a fundamental concept in the economic decision making process. Risk preferences are important to decisions varying from career choice to stock picking (Barsky, et al., 1997), as well as production decisions (among many others, Just and Pope, 1979; Antle, 1987, 1983; Koundouri, et al., 2009, 2006) and agri-environmental policy making (see for example, Isik, 2002; Karagiannis, 1999; Xavier et al., 2011). If risk-neutrality is not a general characterization of the sample under investigation, it is important to know the subject's pool preferences over risk. Several studies in the literature have examined a plethora of issues on risk preference elicitation e.g., the stability of risk preferences across elicitation methods (Anderson & Mellor, 2009), risk preferences and physical prowess (Ball, et al., 2010) as well as the complexity of the elicitation method (Dave, et al., 2010). However, only a few studies have examined risk preferences with respect to the nature of the subject pool and results have not been uniform (Andersen, et al., 2010a, 2010b). This study sheds more light to risk preference elicitation in a conventional lab experiment (i.e., using a student subject pool) and an artefactual lab experiment (i.e., using a general population subject pool) in the Harrison and List (2004) terminology.

2. Experimental data

We compiled data from two previous experiments that involved risk preference elicitation tasks. These two experiments were part of a larger project on choice under risk, which also involved some standard experimental auction tasks. Experimental instructions for the experiments are available at <https://sites.google.com/site/riskprefs/>. The first experiment used a student subject pool, while the second experiment used a subject pool drawn from the general population. General population subjects were recruited by a professional company. The same proctor was used in both experiments, i.e., one of the authors.

In the student subject pool experiment, the purpose was to explore whether risk preferences can be manipulated by some treatment variables, so we only used data from the control treatment sessions. In the consumer subject pool experiment, risk preferences were not part of the experimental manipulation. In all, we used elicited risk preferences from 34 general population subjects and 23 student subjects. In the student subject pool experiment, in one session the auction task was placed after risk elicitation. For all other subjects, risk elicitation followed the auction. We use a dummy variable in our econometric estimation to control for this session-specific characteristic.

To elicit risk preferences we used the multiple price list (MPL) design devised by Holt and Laury (2002). In this design each subject is presented with a choice between two lotteries, A

or B as illustrated in Table 1. In the first row the subject is asked to make a choice between lottery A, which offers a 10% chance of receiving €2 and a 90% chance of receiving €1.6, and lottery B, which offers a 10% chance of receiving €3.85 and a 90% chance of receiving €0.1. The expected value of lottery A is €1.64 while for lottery B it is €0.475, which results in a difference of €1.17 between the expected values of the lotteries. Proceeding down the table to the last row, the expected values of the lotteries increase but increases much faster for lottery B.

For each row, a subject chooses A or B and one row is then randomly selected as binding for the payout. The last row is a simple test of whether subjects understood the instructions correctly. In our experiments subjects undertook three risk aversion tasks: they made choices from Table 1 (the 1x table), a table where payoffs were scaled up by 10 (the 10x table) and a table similar to Table 1 but without the last three rows (the framed table). The order of appearance of the tables for each subject was completely randomized to avoid order effects (Harrison, et al., 2005). One of these tables was chosen at the end as binding for the payout. Thus, to infer risk preferences, subjects were asked to provide 27 binary choices from the risk preference task. Table 1 also shows implied Relative Risk Aversion coefficients under the assumption of Expected Utility Theory (EUT).

3. Estimation and Results

To estimate risk attitudes and assess the importance of the sample type as well as the demographics on risk preferences, we follow similar procedures to Holt and Laury (2002) and Harrison, et al. (2007).

Let the utility function be the constant relative risk aversion (CRRA) specification:

$$U(M) = \frac{M^{1-r}}{1-r} \quad (1)$$

for $r \neq 1$, where r is the CRRA coefficient. In (1), $r=0$ denotes risk neutral behavior, $r>0$ denotes risk aversion behavior and $r<0$ denotes risk loving behavior.

The binary choices of the subjects in the risk preference tasks can be explained by different CRRA coefficients (as reported in Table 1).

If we assume that Expected Utility Theory holds for the choices over risky alternatives, the likelihood function for the choices that subjects make can be written for each lottery i as:

$$EU_i = \sum_{j=1,2} \left(p(M_j) \cdot U(M_j) \right) \quad (2)$$

where $p(M_j)$ are the probabilities for each outcome M_j that are induced by the experimenter. To specify the likelihoods conditional on the model, the Luce stochastic specification is used. The expected utility (EU) for each lottery pair is calculated for candidate estimate of r , and the ratio:

$$\nabla EU = \frac{EU_B^{1/\mu}}{EU_A^{1/\mu} + EU_B^{1/\mu}} \quad (3)$$

is then calculated where EU_A and EU_B refer to options A and B respectively, and μ is a structural noise parameter. The index in ∇EU is linked to observed choices by specifying that the option B is chosen when $\nabla EU > 1/2$.

The conditional log-likelihood can then be written as:

$$\ln L^{RA}(r, \mu; y, \mathbf{X}) = \sum_i \left((\ln(\nabla EU) | y_i = 1) + (\ln(1 - \nabla EU) | y_i = -1) \right) \quad (4)$$

where $y_i = 1(-1)$ denotes the choice of the option B (A) lottery in the risk preference task i . Each parameter in equation (4) is allowed to be a linear function of demographic and treatment variables as exhibited in Table 2. A portion of subject's fees was stochastic since this have been demonstrated to be very important for recruitment (Harrison, et al., 2009). In addition, recruitment practices necessitated a higher show-up fee for consumer subjects. Thus, a total fee endowment variable is included in the econometric model. Equation (4) can be maximized using standard numerical methods. The statistical specification also takes into account the multiple responses given by the same subject and allows for correlation between responses. Standard errors were computed using the delta method.

We can extend the analysis by accounting for probability weighting. Rank Dependent Utility (Quiggin, 1982) extends the EUT model by allowing for decision weights on lottery outcomes. To calculate decision weights under RDU one replaces expected utility defined by (2) with:

$$EU_i = \sum_{j=1,2} \left(w(p(M_j)) \cdot U(M_j) \right) = \sum_{j=1,2} \left(w_j \cdot U(M_j) \right) \quad (5)$$

where $w_2 = w(p_2 + p_1) - w(p_1) = 1 - w(p_1)$ and $w_1 = w(p_1)$, with outcomes ranked from worst (outcome 2) to best (outcome 1) and $w(\cdot)$ is the weighting function proposed by Tversky and Kahneman (1992) and assumes weights of the form:

$$w(p) = p^\gamma / \left[p^\gamma + (1-p)^\gamma \right]^{1/\gamma} \quad (6)$$

In (6), when $\gamma = 1$, it implies that $w(p) = p$ and this serves as a formal test of the hypothesis of no probability weighting.

The assumption of a CRRA function, implicitly assumes that risk aversion is constant across different prize domains. We can relax this assumption by adapting a more flexible form, the hybrid expo-power function of Saha (1993). The expo-power function can be defined as $u(M) = (1 - \exp(-aM^{1-r})) / a$, where M is income and a and r are parameters to be estimated.

Relative risk aversion (RRA) is then $r + a(1-r)M^{1-r}$, so RRA varies with income if $a \neq 0$. The expo-power function nests CRRA (as $a \rightarrow 0$).

4. Results

Figure 1 illustrates the proportion of subjects choosing option A over B across the three risk preference tasks. Results are consistent across tasks; students appear to be more risk averse than consumers. A t-test of the number of times option A was chosen across each risk aversion task, shows that the differences are statistically significant at the 10% level for the x1 and the x10 HL tasks (p-value=0.062 and 0.078 respectively) but not for the framed task (p-value=0.236). This implies that the gap between the lines in figures 1a and 1b is statistically significant but not for figure 1c. An ANOVA test of whether the three HL tasks (x1, x10, framed) elicit different switch-points (i.e., different number of times the A choice was selected) fails to reject the null (p-value=0.206).

Table 3 shows estimates when assuming a CRRA function and EUT. We use the *Age* variable as the variable that differentiates the groups of students and subjects from the general population. Another option would be to include a dummy variable for subjects but the age variable contains more information than a dummy. Entering both variables at the model would lead to possible multicollinearity problems since the variables are highly correlated. Table 3 shows that results with and without demographics for gender, income and education are fairly robust. Results shows that age has a negative and statistically significant effect on risk aversion implying that general population subjects (which are older than students) have a lower coefficient of relative risk aversion. Table 4 exhibits predictions of RRA coefficients (r) averaged across subjects, by subject pools. Predicted RRA for consumer subjects is negative which points to risk loving preferences, on average, while the coefficient for student subjects is positive which suggests that risk preferences are characterized by risk aversion. Note, however, that confidence intervals for consumer subjects span around zero. Overall, it appears as if student subjects are significantly more risk averse than consumer subjects, confirming insights gained from Figure 1.

Table 5 shows parameter estimates when assuming RDU instead of EUT and an expo-power function instead of CRRA. The model collapses to CRRA and/or EUT when $\gamma = 1$ and/or $\alpha = 0$. Wald tests of whether $\gamma = 1$ or $\alpha = 0$ as well as joint significance tests ($\gamma = 1$ and $\alpha = 0$), reject the null. Thus there is support that RDU and an expo-power function are a better characterization of our samples risk attitudes. In Table 5, it is evident that the age variable has a statistically significant effect on the r parameters. To better grasp what those effects imply for the characterization of risk attitudes of our consumer and student sample, figure 2 illustrates RRA predictions for the range of prizes given at the experiment. Both models (with and without demographics) imply risk neutrality for students since confidence intervals span around zero. For the consumer subject pool, both models imply risk loving preferences albeit when demographics are included confidence intervals span around zero for higher prizes.

Overall, our results imply that observed differences in risk attitudes in conventional and artefactual lab experiments can be sensitive on the assumptions. Although both competing models (CRRA/EUT and expo-power/RDU) imply that subjects from the general population are less risk averse than students, the models imply different characterizations of risk attitudes. For example assuming CRRA/EUT we would have incorrectly characterized students as risk averse while the expo-power/RDU model implies risk neutrality. Similarly, subjects from the general population would have incorrectly been characterized as risk neutral while the expo-power/RDU model shows they exhibit risk loving preferences.

4. Concluding Remarks

In this article we tested whether risk preferences of subjects drawn from the general population differ with respect to a standard student subject pool. In summary, we found evidence suggesting that under a proper characterization of risk attitudes (i.e., RDU and expo-power) subjects drawn from the general population exhibit risk loving preferences while students exhibit risk neutrality. However, when the characterization of risk attitudes is incorrect (i.e., EUT and CRRA), students appear as risk averse and subjects from the general population as risk neutral.

Our findings have significant implications for conventional laboratory experiments practice given the importance of risk preferences in everyday economic decision and policy making. In particular, our results have implications on decision making at the household, firm and policy levels. To give an example from the agri-environmental literature, various environmental policies have been proposed to control agricultural runoff of nutrients and pesticides. The impact of these policies on input use depends on farmers' risk attitudes, as well as the form of production uncertainty, risk-input relationships and degrees of output price and production uncertainty (see for example Antle, 1987; Koundouri, et al., 2009; Karagiannis, 1999; Xavier et al., 2011). Our work highlights the importance of adopting a proper characterization of risk attitudes, when using experimental techniques to estimate the relevant risk preferences, as the assumptions employed for the estimation of risk, will affect the estimated preferences differently under varying sample choices. Given that risk-preferences are an integral part of the construction of the optimal agri-environmental policies our results contribute to the correct development of such policies.

Finally, our findings complement the empirical literature that has found either no difference in risk aversion between students and the general adult population (Andersen, et al., 2010a) or that students are more risk averse (Andersen, et al., 2010b). More studies examining differences in risk preferences between students and the general population are indeed warranted.

5. References

- Andersen, S., G.W. Harrison, M.I. Lau, & E.E. Rutström. 2010a. Discounting behavior: A reconsideration. *WORKING PAPER*.
- Andersen, S., G.W. Harrison, M.I. Lau, & E.E. Rutström. 2010b. Preference heterogeneity in experiments: Comparing the field and laboratory. *Journal of Economic Behavior and Organization* 73(2):209-224.
- Anderson, L., & J. Mellor. 2009. Are risk preferences stable? Comparing an experimental measure with a validated survey-based measure. *Journal of Risk and Uncertainty* 39(2):137-160.
- Antle, J., 1983. Testing the Stochastic Structure of Production: A Flexible MomentBased Approach. *Journal of Business and Economic Statistics*. 1: 192-201.
- Antle, J., 1987. Econometric Estimation of Producers' Risk Attitudes. *American Journal of Agricultural Economics*, 69(3): 509-522
- Ball, S., C. Eckel, & M. Heracleous. 2010. Risk aversion and physical prowess: Prediction, choice and bias. *Journal of Risk and Uncertainty* 41(3):167-193.
- Barsky, R.B., F.T. Juster, M.S. Kimball, & M.D. Shapiro. 1997. Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study. *Quarterly Journal of Economics* 112(2):537-579.
- Clarke, K.A. 2003. Nonparametric model discrimination in international relations. *Journal of Conflict Resolution* 47(1):72-93.
- Dave, C., C. Eckel, C. Johnson, & C. Rojas. 2010. Eliciting risk preferences: When is simple better? *Journal of Risk and Uncertainty* 41(3):219-243.
- Enis, B.M., K.K. Cox, & J.E. Stafford. 1972. Students as subjects in consumer behavior experiments. *Journal of Marketing Research* 9(1):72-74.
- Harrison, G.W. 2008. Maximum likelihood estimation of utility functions using Stata. *Working Paper 06-12, Department of Economics, College of Business Administration, University of Central Florida*.
- Harrison, G.W., E. Johnson, M.M. McInnes, & E.E. Rutström. 2005. Risk aversion and incentive effects: Comment. *The American Economic Review* 95(3):897-901.
- Harrison, G.W., M.I. Lau, & E.E. Rutstrom. 2007. Estimating risk attitudes in Denmark: A field experiment. *Scandinavian Journal of Economics* 109(2):341-368.
- Harrison, G.W., M.I. Lau, & E.E. Rutström. 2009. Risk attitudes, randomization to treatment, and self-selection into experiments. *Journal of Economic Behavior & Organization* 70(3):498-507.
- Harrison, G.W., & J.A. List. 2004. Field experiments. *Journal of Economic Literature* 42(4):1009-1055.
- Harrison, G.W., & E.E. Rutstrom 2008. Risk aversion in the laboratory, ed. J.C. Cox, & G.W. Harrison, vol. 12. Bingley, UK, Emerald Group Publishing Limited, pp. 41-196.
- Harrison, G.W., & E.E. Rutström. 2009. Expected utility theory and prospect theory: One wedding and a decent funeral. *Experimental Economics* 12(2):133-158.

- Holt, C.A., & S.K. Laury. 2002. Risk aversion and incentive effects. *The American Economic Review* 92(5):1644-1655.
- Isik, M. 2002. Resource Management under Production and Output Price Uncertainty: Implications for Environmental Policy. *American Journal of Agricultural Economics* 84(3): 557–571.
- Just, R. and R. Pope, 1979. Production Function Estimation and Related Risk Considerations. *American Journal of Agricultural Economics* 61(2): 276-284.
- Karagiannis, Giannis, 1999. Proportional Profit Taxes And Resource Management Under Production Uncertainty. *Journal of Agricultural and Resource Economics* 24(2): 525-535.
- Koundouri, P., M. Laukkanen, S. Myyrä and C. Nauges 2009. The effects of EU agricultural policy changes on farmers' risk attitudes *European Review of Agricultural Economics* 36(1):53-77.
- Koundouri, P., C. Nauges, & V. Tzouvelekas. 2006. Technology Adoption under Production Uncertainty: Theory and Application to Irrigation Technology. *American Journal of Agricultural Economics* 88(3):657-670.
- McNemar, Q. 1946. Opinion-attitude methodology. *Psychological Bulletin* 43:289-374.
- Ozanne, A., Hogan, T. and Colman, D. 2001. Moral Hazard, Risk Aversion and Compliance Monitoring in Agri-Environmental Policy. *European Review of Agricultural Economics* 28 (3):329-348.
- Saha, A. 1993. Expo-power utility: A flexible form for absolute and relative risk aversion. *American Journal of Agricultural Economics* 75(4):905-913.
- Tversky, A., & D. Kahneman. 1992. Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty* 5(297-323).
- Xavier, V., Di Falco, S., and O'Donoghue, C. 2011. Risk Preferences and Voluntary Agri-environmental Schemes: Does Risk Aversion Explain the Uptake of the Rural Environment Protection Scheme? *2011 International Congress, August 30-September 2, 2011, Zurich, Switzerland, European Association of Agricultural Economists*.
- Vuong, Q.H. 1989. Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica* 57(2):307-333.

Table 1. Sample payoff matrix for the risk preferences tasks

Lottery A				Lottery B				Open CRRA interval if subject switches to Lottery B (EUT is assumed)	
<i>p</i>	€	<i>p</i>	€	<i>p</i>	€	<i>p</i>	€		
0.1	2	0.9	1.6	0.1	3.85	0.9	0.1	$-\infty$	-1.71
0.2	2	0.8	1.6	0.2	3.85	0.8	0.1	-1.71	-0.95
0.3	2	0.7	1.6	0.3	3.85	0.7	0.1	-0.95	-0.49
0.4	2	0.6	1.6	0.4	3.85	0.6	0.1	-0.49	-0.15
0.5	2	0.5	1.6	0.5	3.85	0.5	0.1	-0.15	0.14
0.6	2	0.4	1.6	0.6	3.85	0.4	0.1	0.14	0.41
0.7	2	0.3	1.6	0.7	3.85	0.3	0.1	0.41	0.68
0.8	2	0.2	1.6	0.8	3.85	0.2	0.1	0.68	0.97
0.9	2	0.1	1.6	0.9	3.85	0.1	0.1	0.97	1.37
1	2	0	1.6	1	3.85	0	0.1	1.37	$+\infty$

Note: Last two columns showing implied CRRA intervals were not shown to subjects.

Table 2. Variable description

Variable	Description	General population subject pool		Student subject pool	
		Mean	Std.dev.	Mean	Std.dev.
<i>Age</i>	Subject's age	41.176	10.376	20.739	1.322
<i>Gender</i>	Dummy, 1=males, 0=females	0.324	0.475	0.391	0.499
<i>Income</i>	Dummy, household's economic position is above average=1, else=0	0.471	0.507	0.435	0.507
<i>Education</i>	Dummy, university graduate or higher=1, else=0	0.676	0.475	0	0
<i>TotFee</i>	Total fee endowment	23.794	6.594	16.717	1.146
<i>ExpCharact</i>	Dummy, risk preference task was conducted after an auction, else=0	1	0	0.522	0.511

Table 3. Estimates of risk preferences (CRRA function-EUT)

	<i>r</i> coefficient			
	Estimate	Std.Error	Estimate	Std.Error
<i>Age</i>	-0.028**	0.013	-0.029**	0.013
<i>Gender</i>	0.061	0.271	-	-
<i>Income</i>	-0.088	0.172	-	-
<i>Education</i>	-0.117	0.208	-	-
<i>ExpCharact</i>	0.257	0.196	0.206	0.162
<i>TotFee</i>	-0.020	0.017	-0.021	0.016
<i>Constant</i>	1.333**	0.282	1.348**	0.272
μ	0.326**	0.051	0.334**	0.050
<i>Log-Likelihood</i>	-772.155		-774.483	

Note: ** (*) Statistically significant at the 5% (10%) level

Table 4. Average predicted RRA under EUT

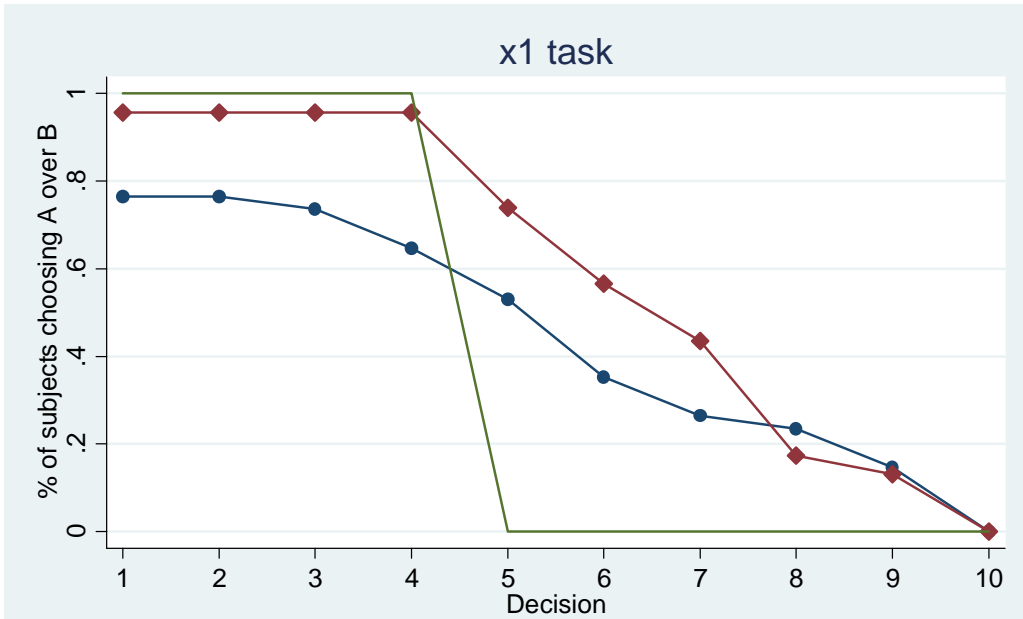
		RRA	95% Confidence Intervals	
With demographics	Consumers	-0.153	-0.697	0.390
	Students	0.532	0.121	0.942
Without demographics	Consumers	-0.153	-0.565	0.259
	Students	0.497	0.269	0.726

Table 5. Estimates of risk preferences (expo-power function-RDU)

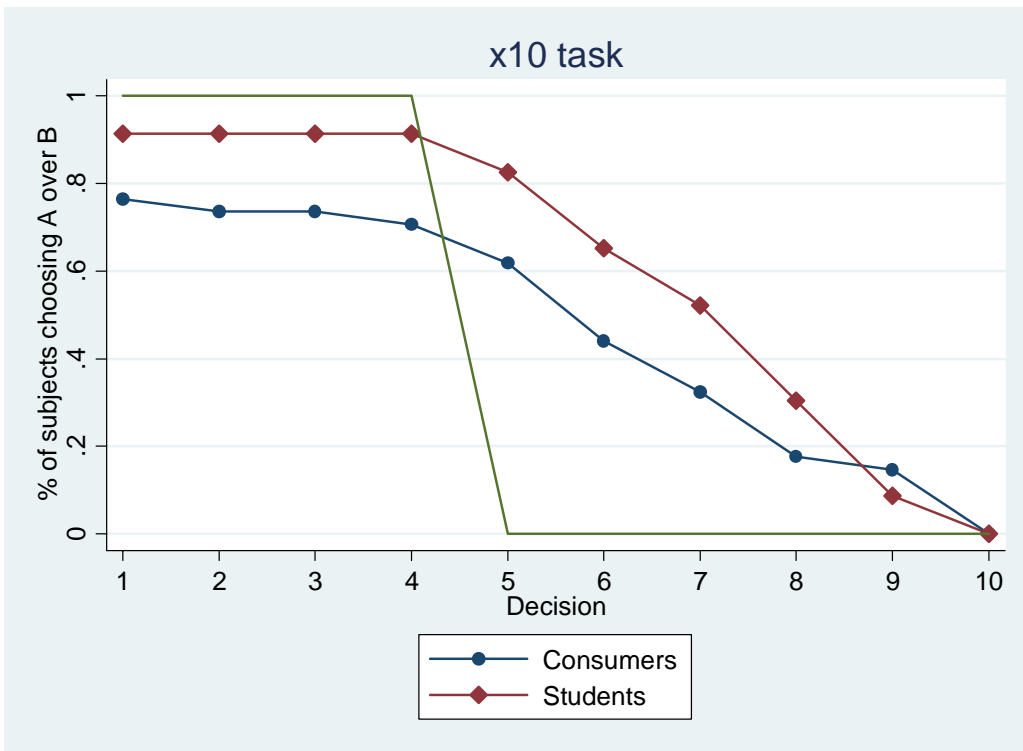
	<i>r</i> coefficient		α coefficient		γ coefficient	
	Estimate	Std.Error	Estimate	Std.Error	Estimate	Std.Error

A. With demographics (Log-Likelihood= -652.237)						
<i>Age</i>	-0.029**	0.013	0.005	0.009	-0.003	0.002
<i>Gender</i>	-0.157	0.341	0.125	0.203	-0.009	0.055
<i>Income</i>	0.294	0.332	0.069	0.204	0.051	0.059
<i>Education</i>	0.549	0.533	-0.188	0.257	0.080	0.091
<i>ExpCharact</i>	-1.085**	0.407	-0.452	0.661	-0.382	0.462
<i>TotFee</i>	0.005	0.012	-0.012*	0.007	0.001	0.002
<i>Constant</i>	0.725	0.566	0.628	0.678	0.742	0.508
μ	0.122**	0.018				
B. Without demographics (Log-Likelihood= -655.709)						
<i>Age</i>	-0.043**	0.009	-0.001	0.006	-0.005**	0.002
<i>ExpCharact</i>	-0.984**	0.414	-0.592	0.456	-1.130**	0.273
<i>TotFee</i>	0.073**	0.009	0.005	0.005	0.009**	0.003
<i>Constant</i>	0.114	0.241	0.651	0.450	1.471**	0.288
μ	0.129**	0.019				

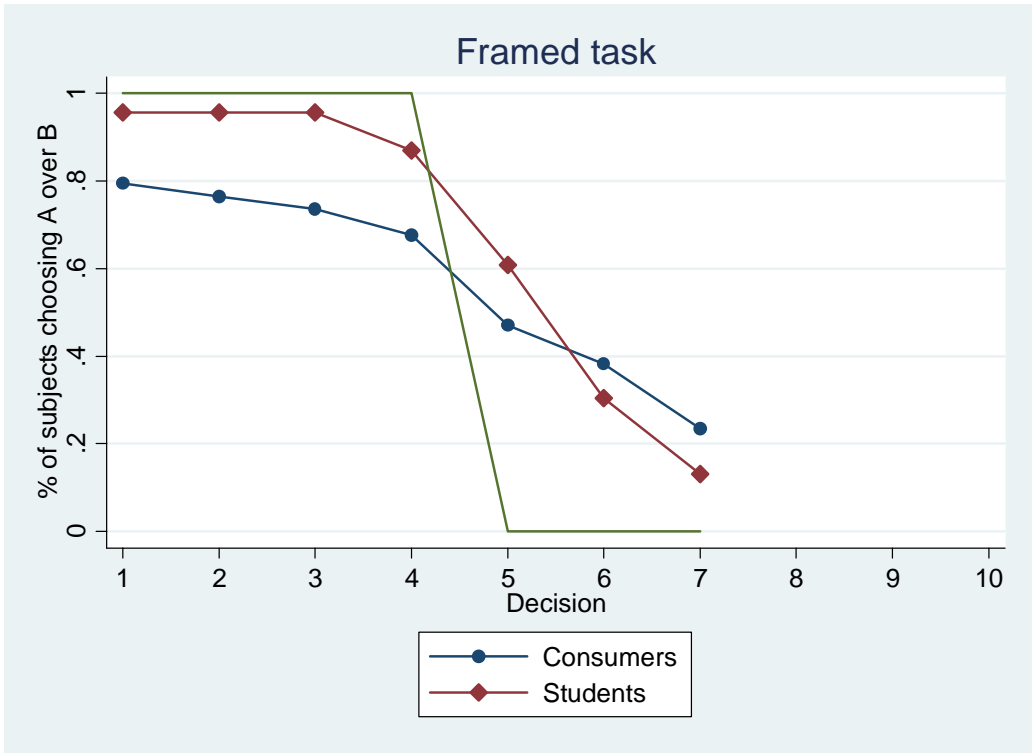
Note: ** (*) Statistically significant at the 5% (10%) level



(a)

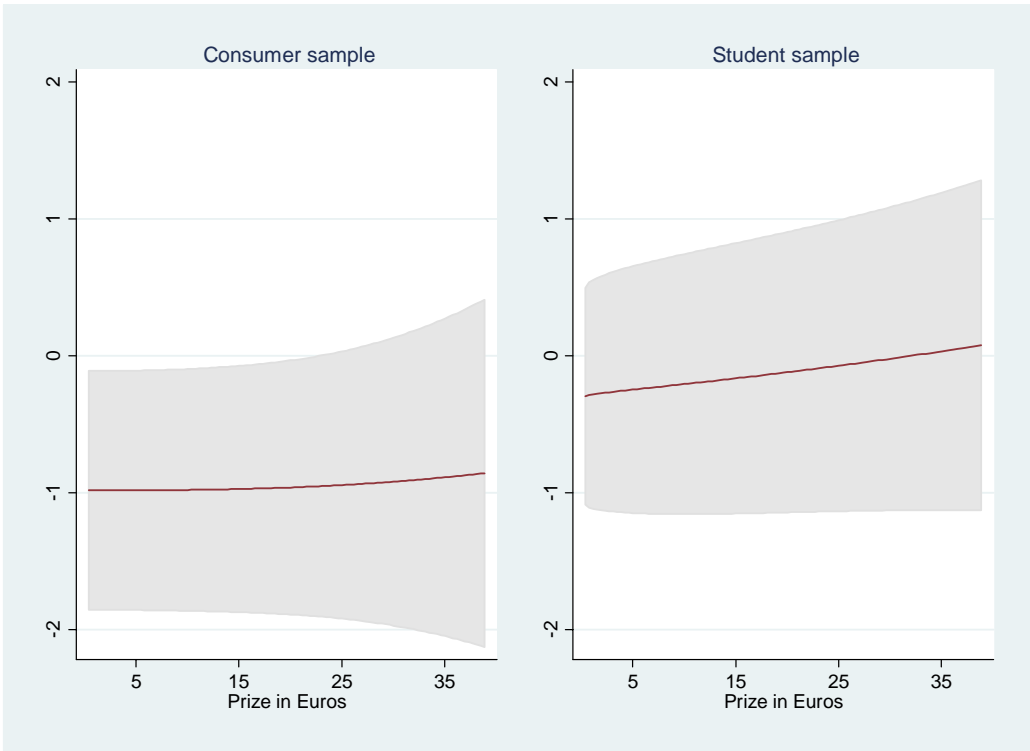


(b)

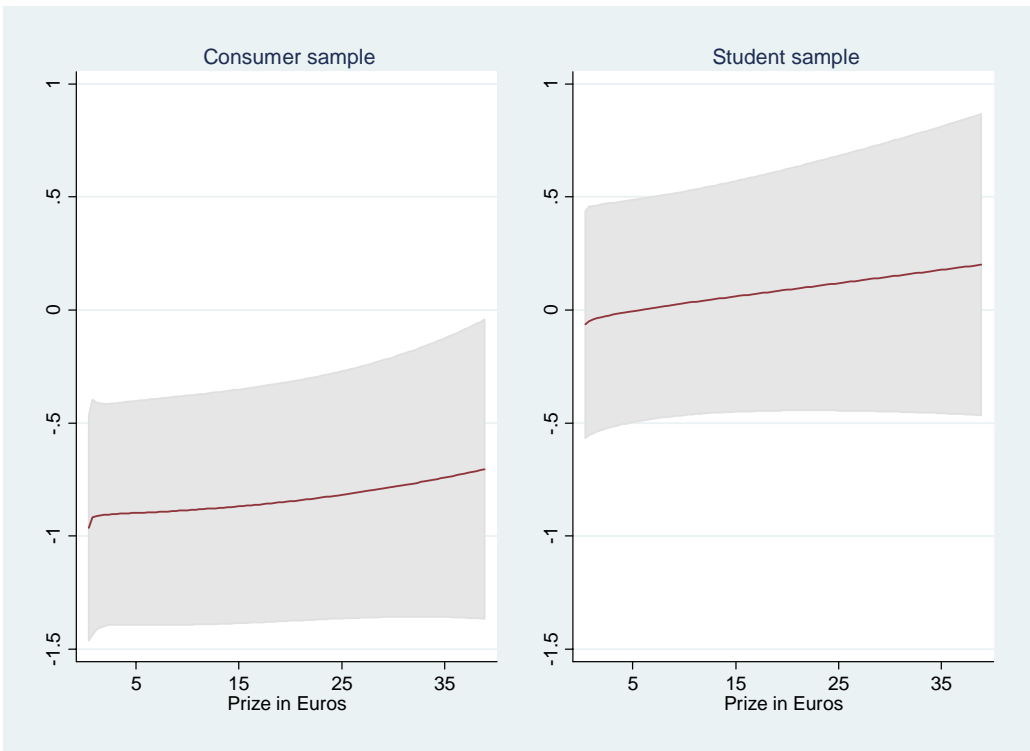


(c)

Figure 1. Proportion of choices in each decision for (a) the x1 task (b) the x10 task and (c) the framed task (solid line without markers represents risk neutrality under EUT)



(a)



(b)

Figure 2. Average RRA predictions and confidence intervals