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Estimating Risk Attitudes in Conventional and Artefactual Lab Experiments: The Importance of the Underlying Assumptions

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Abstract In this paper the authors assess the importance of sample type in the estimation of risk preferences. The authors 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 (*Risk aversion and incentive effects*, 2002). The authors 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 the authors assume an incorrect characterization of risk preferences, in particular they adopt the framework of Expected Utility theory and a Constant Relative Risk Aversion function, their 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. The results have implications for economic policy making under uncertainty.

JEL C91, D01, D81

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

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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., 2011, 2010). 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 elicitations 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:

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

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:

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

where $p\left(M_j\right)$ 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:

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

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 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:

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

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:

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

where $w_2 = w\left(p_2 + p_1\right) - w\left(p_1\right) = 1 - w\left(p_1\right)$ and $w_1 = w\left(p_1\right)$, 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:

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

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 $u(M) = \left(1 - \exp\left(-aM^{1-r}\right)\right) / a$, 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 $a \to 0$).

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.

Table 3 shows estimates when assuming a CRRA function and EUT. It is obvious that even after controlling for all possible demographic effects general population subjects appear more risk averse than the student sample, *ceteris paribus*, and the difference is highly significant. Note also that risk aversion decreases with age. It is important to consider the interplay of these two variables because consumers are on average older than students and thus, it makes a difference in predictions. To illustrate this point, Table 4 exhibits average predictions of RRA coefficients across the two subjects pools. Although, confidence intervals span around zero, students appear more risk averse than consumers, 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 $a = 0$. Wald tests of whether $\gamma = 1$ or $a = 0$ as well as joint significance tests ($\gamma = 1$ and $a = 0$), highly 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 both the consumer dummy as well as the age variable have a statistically significant effect on all parameters of interest. 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. RRA increases across the prize domain. However, RRA is indistinguishable between students and consumers.

Overall, this implies that observed differences in risk attitudes in conventional and artefactual lab experiments can be sensitive on the assumptions. Indeed when we relax the restrictiveness of EUT and CRRA differences in risk attitudes are eliminated.

5. 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) students and subjects drawn from the general population exhibit similar risk preferences. However, when the characterization of risk attitudes is incorrect, students have higher relative risk aversion than others.

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., 2011) or that students are more risk averse (Andersen, et al., 2010). More studies examining differences in risk preferences between students and the general population are indeed warranted.

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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)	
p	€	*p*	€	*p*	€	*p*	€		
0.1	2	0.9	1.6	0.1	3.85	0.9	0.1	-∞	-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	+∞

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.*
Age	Subject's age	41.176	10.376	20.739	1.322
Gender	Dummy, 1=males, 0=females	0.324	0.475	0.391	0.499
Income	Dummy, household's economic position is above average=1, else=0	0.471	0.507	0.435	0.507
Education	Dummy, university graduate or higher=1, else=0	0.676	0.475	0	0
TotFee	Total fee endowment	23.794	6.594	16.717	1.146
ExpCharact	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)

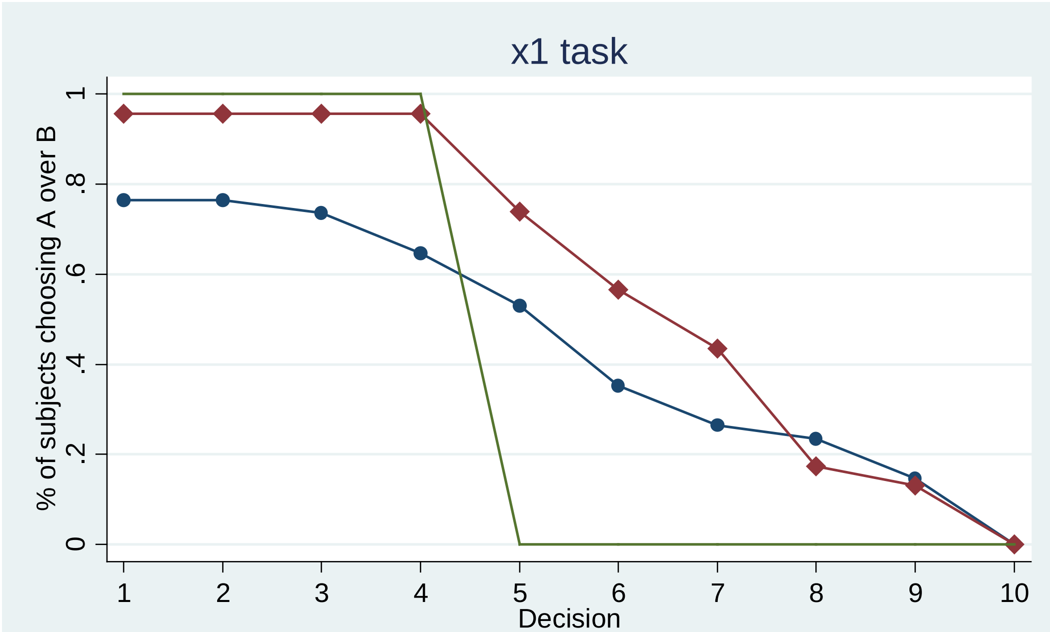
	r coefficient	
	Estimate	Std.Error
Consumers	0.877**	0.264
Age	-0.037**	0.015
Gender	-0.013	0.261
Income	0.069	0.186
Education	-0.308	0.216
ExpCharact	-0.136	0.257
TotFee	-0.040**	0.011
x10Task	0.071	0.076
FramedTask	-0.010	0.064
Constant	1.802*	0.279
μ	0.325**	0.053

Table 4. Average predictions of RRA under EUT

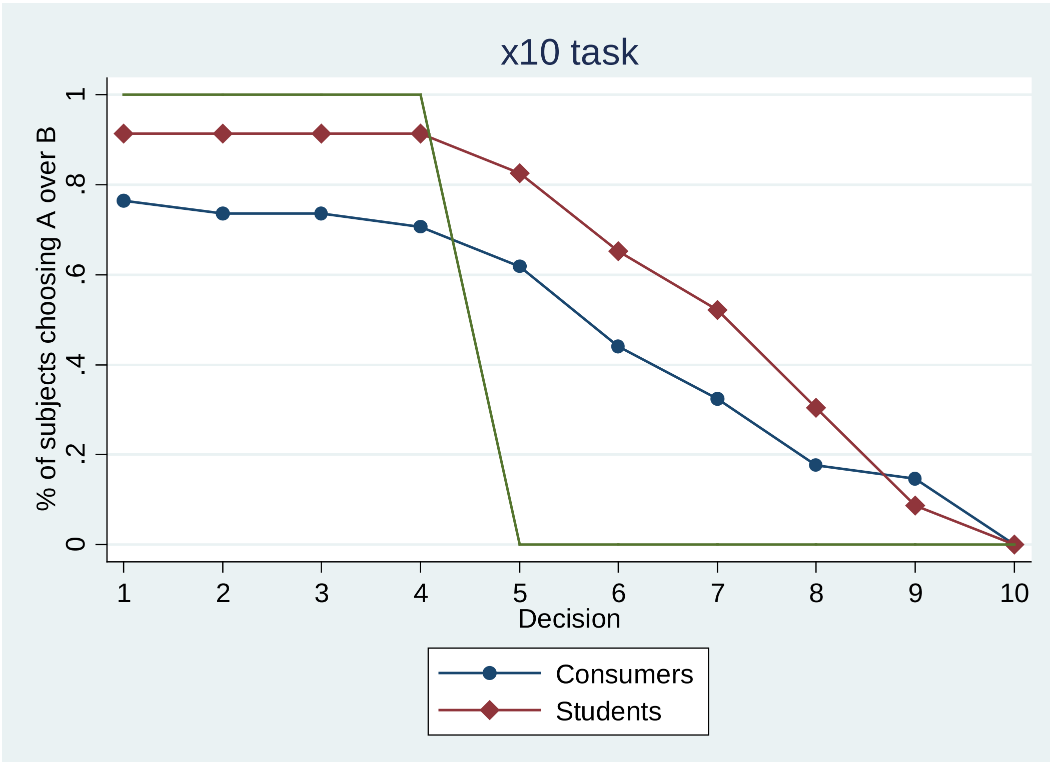
	RRA	**95% Confidence Intervals**	
Consumers	-0.135	-0.678	0.408
Students	0.312	-0.152	0.776

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

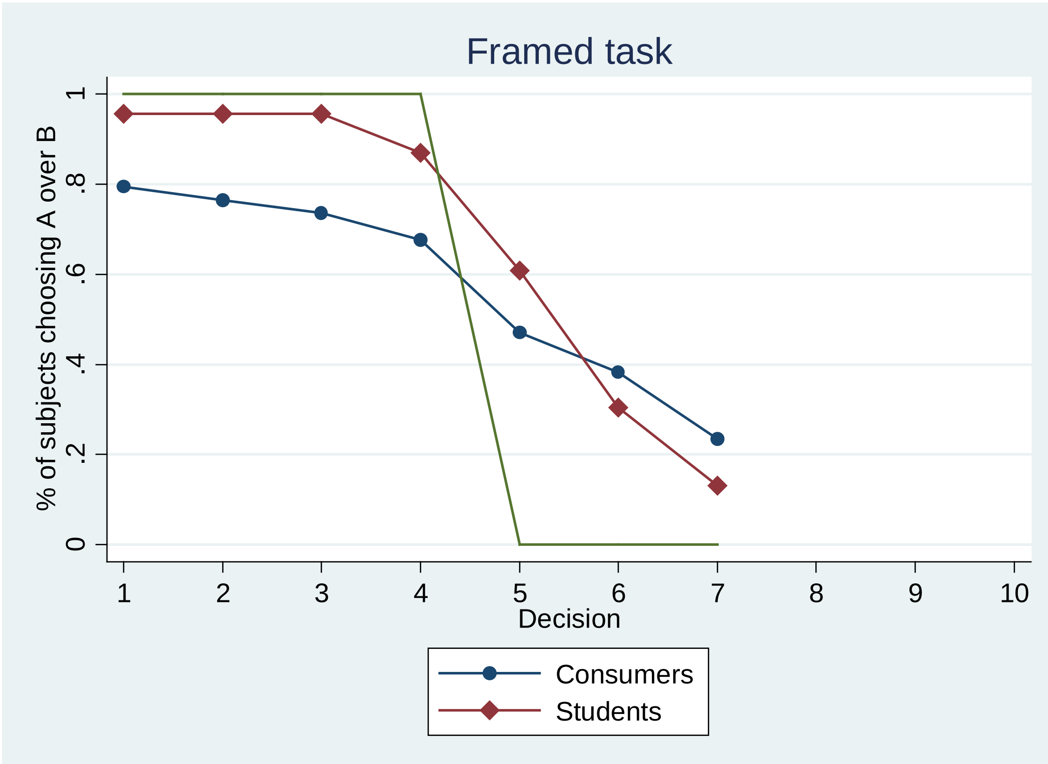
	r coefficient		α *coefficient*		γ *coefficient*	
	Estimate	Std.Error	Estimate	Std.Error	Estimate	Std.Error
Consumers	2.193**	0.441	-14.453	13.241	0.314**	0.087
Age	-0.088**	0.008	0.772**	0.319	-0.012**	0.002
Gender	-0.240	0.188	0.383	1.943	-0.025	0.026
Income	0.057*	0.033	0.204	1.038	0.007	0.012
Education	0.317*	0.181	-10.964**	4.426	0.050**	0.022
ExpCharact	-2.057**	0.340	18.792*	10.345	-0.355**	0.155
TotFee	0.013*	0.007	-0.281	0.436	0.005*	0.002
x10Task	-4.301**	0.669	31.532**	13.632	0.025	0.023
FramedTask	0.008	0.011	-1.429**	0.620	0.004	0.003
Constant	2.421**	0.148	-16.575	12.842	0.820**	0.163
μ	0.086**	0.008				


x1 task
% of subjects choosing A over B
0
.2
.4
.6
.8
1
1
2
3
4
5
6
7
8
9
10
Decision

(a)


x10 task
% of subjects choosing A over B
0
.2
.4
.6
.8
1
1
2
3
4
5
6
7
8
9
10
Decision
Consumers
Students

(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)

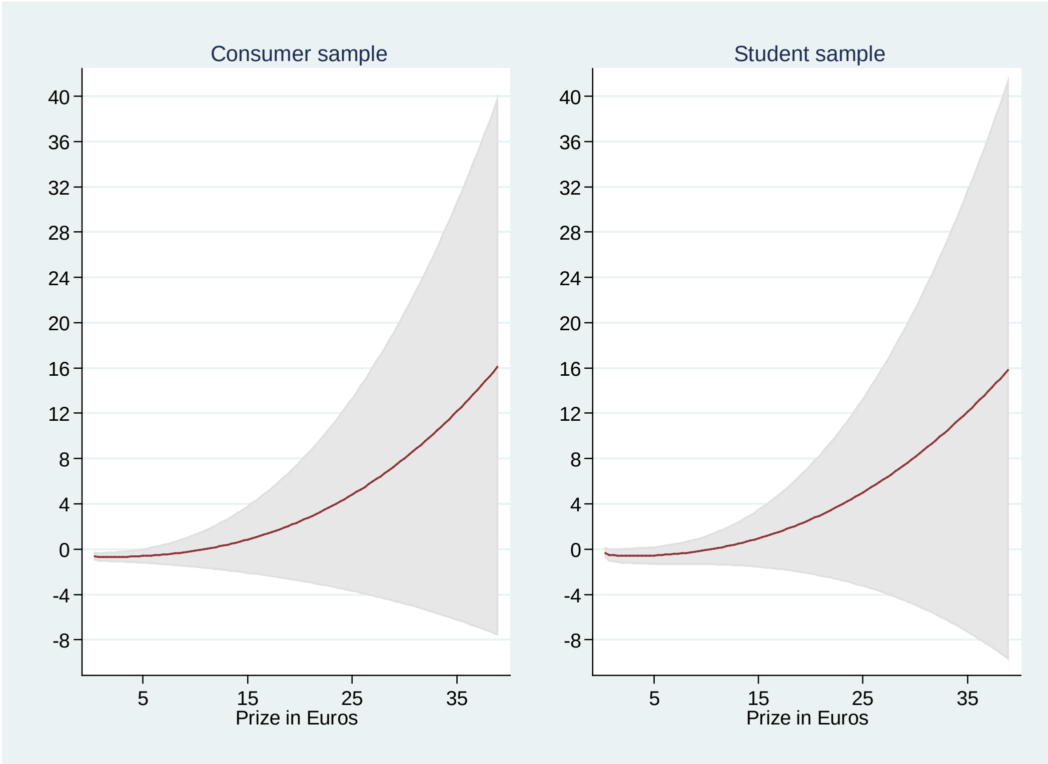


Figure 2. RRA predictions and confidence intervals