“Does risk aversion or attraction depend on income? An experiment”

by

Antoni Bosch-Domènech
Universitat Pompeu Fabra
<bosch@upf.es>

and

Joaquim Silvestre*
University of California, Davis
<jbsilvestre@ucdavis.edu>

May 1999 version

1. Introduction

Our subjects were given a list of seven amounts of money, to be called Initial Experimental Incomes, or IEI's. They were asked whether or not they would insure them. We wanted to learn in what way the willingness to insure an IEI may depend on its amount. If we may identify the decision to insure with risk aversion, and the decision not to insure with risk attraction, then the question can be rephrased as: Does the risk attitude (aversion or attraction) on IEI vary with the IEI? To the extent that decisions regarding the insurance of experimental income reflect nonexperimental economic decisions on insuring income risks, our results cast light on the possible dependence of the attitude towards income risks on the level of the income at risk.

2. The experiment

We performed the experiment in a single session (no preliminary pilot sessions) using 21 undergraduates: we deliberately excluded any students in economics or business. Subjects were seated in visually-isolated booths in the LeeX lab at the Universitat Pompeu Fabra. They were told

---

* We are indebted to Albert Satorra for the statistical analysis, and to Gary Charness and Robin Hogarth for comments and suggestions. Financial support by the Spanish Ministry of Education under contract SEC-1853-CE and from the EU-TMR Research Network ENDERA (FMRX-CT98-0238) is gratefully acknowledged.

that they would receive at random one of the following amounts of money (or IEI's), denominated in the Spanish currency : 500, 1000, 2000, 5000, 7500, 10000 or 15000 (i.e., from US$3.50 to US$ 103). Once the IEI was assigned, there was a 20% chance of losing it, but subjects could buy an actuarially fair insurance against this loss[1]. Subjects were asked to decide, before knowing the IEI obtained, whether or not to insure each of the potential IEI's.

To record their decisions, subjects were given a 7-page folder, one page for each possible IEI. Every page had five boxes arranged vertically. The IEI was printed in the first box, and the insurance premium in the second one, with the statement that the premium was exactly 20% of the IEI. The third box contained two check cells, one for insuring the IEI, and another one for not insuring it. Below a separating horizontal line, two more boxes were later used to record first whether the IEI was lost and, and then the take-home amount. In order to facilitate decisions, a matrix on the back of the page showed all the payoffs. The information was given to the subjects as written instructions (available on request), which were read aloud by the experimenter. The experiment began after all questions were privately answered.

Once all subjects had registered their decisions (under no time constraint: nobody used more than 15 minutes), their pages were collected. Subjects were then called one by one to an office with an urn that initially contained 21 pieces of paper: each piece indicated one IEI, and each of the seven IEI's occurred three times. A piece of paper was randomly drawn (without replacement): the experimenter and the subject then checked in the folder whether she had insured that particular IEI. If she had, then the premium was subtracted from the IEI to obtain the take-home amount. If she had not, then a number from 1 to 5 was randomly chosen from another urn. If the number 1 was drawn, then the subject would lose the IEI, taking nothing home. Otherwise, she would take home the IEI. The subject was then paid and dismissed, and the next subject was escorted into the office.

The following element of the experiment was not included in the written instructions. As described above, we asked subjects to consider several possible IEI's for the sake of obtaining a larger data set. This procedure tends to elicit the same choices as when subjects make only one

---

[1] We avoided extreme probabilities: 0.2 seems to be above the range that tends to be overweighed (Preston and Baratta, 1948) and below the range that tends to be underweighed (0.3 to 0.8 according to Cohen, Jaffray and Said, 1985).

choice (Starmer and Sugden, 1991), but we wanted to check this tendency. Consequently, we allowed each subject to reconsider her reported decision after her IEI was selected. Of the 21 subjects involved, only one, labeled G, changed his mind (from non-insurance to insurance, at the borderline between his previous noninsurance and insurance decisions). This observation seems insufficient to negate the overall reliability of hypothetical decisions as accurate descriptions of real choices, but it does exemplify a higher likelihood of risk aversion in played games (Hogarth and Einhorn, 1990).

3. Results

See Table 1. Each row corresponds to the decisions to insure (y) or not to insure (n) the seven IEI's by each one of the 21 subjects, who are labeled A to U. For example, an "y" in column 2000, row A, means "subject A decides to insure the amount ω if ω is 2000". A capital letter indicates the IEI that the corresponding subject received. As explained, subject G, after he obtained the IEI of 5000 and was allowed to reconsider, did switch to insurance.

	IEI						
	500	**1000**	**2000**	**5000**	**7500**	**10000**	**15000**
Subject							
A	y	y	y	Y	y	y	y
B	n	N	n	y	y	y	y
C	Y	y	y	y	y	y	y
D	n	N	n	y	y	y	y
E	n	y	y	n	y	Y	y
F	n	n	y	Y	y	y	y
G	n	n	n	n $\rightarrow$ Y	y	y	y
H	y	y	Y	y	y	n	y
I	y	y	y	y	Y	y	y
J	n	n	n	y	y	Y	y
K	y	y	Y	y	y	y	y
L	n	y	n	y	y	y	Y
M	y	y	y	y	y	y	Y

N	y	y	y	y	y	y	Y
O	n	Y	y	y	y	y	y
P	Y	y	y	y	y	y	y
Q	n	n	n	y	n	N	y
R	y	y	Y	y	y	y	y
S	Y	y	y	y	y	y	y
T	y	y	y	y	Y	y	y
U	n	y	y	y	Y	y	y

Table 1. Decisions taken by the 21 subjects to insure (y) or not to insure (n) the seven IEI’s.

4. Analysis

We claim that Table 1 supports the following assertion.

Fact I. In the aggregate, the decision to insure is positively correlated with the level of IEI.

Note, first, that all subjects insure the highest IEI (15000). Second, from Table 1 we can construct the following Table, which shows an positive relation (with a single exception at the IEI of 10000) between a common value for IEI and the fraction of people that would chose to insure.

If Everybody's Initial Experimental Income Were	Then the Fraction of People That Would Choose to Insure Would Be
$\omega = 500$	0.524
$\omega = 1000$	0.714
$\omega = 2000$	0.714
$\omega = 5000$	0.952
$\omega = 7500$	0.952
$\omega = 10000$	0.905
$\omega = 15000$	1.000

Table 2

Third, consider a probit regression model with random intercept (to allow for dependency among observations of the same subject), specified as

$$\Phi^{-1}(\pi) = \alpha + b \ln \omega, \quad \alpha \sim N(a, \sigma^2),$$

(Φ denotes the cumulative normal N(0,1) distribution function, and π the probability of insuring) where all the observations in the same row of Table 1 are assumed to correspond to the same realization of the random variable α. The estimation of the model yields the following results;

observe, in column 5, the statistical significance of the regression coefficient b.

Parameter	Estimator	Robust Std. Err.[2]	z	P > |z|	95% Conf. Interval
b	0.552	0.127	4.340	0.000	(0.303 , 0.802)
a	-3.383	1.031	-3.281	0.001	(-5.405 , -1.362)

Table 3.

Looking now at each row of Table 1, we find two well-represented patterns, and two infrequent ones.

Pattern 1: always yes. Subjects displaying this pattern buy fair insurance at any level of IEI. This is the most frequent pattern, displayed by 10 subjects, or 47.6 % of the subject pool.

Pattern 2: no-yes. A subject displaying this pattern does not buy insurance if the IEI is low, but she does if it is high. This pattern is the second most frequent one: subjects B, D, F, G, J, O and U (33.3% of the pool) display it.

Pattern 3: no-yes-no-yes. This pattern appears as a distant third (subjects E, L and Q, or 14.3 % of the pool). Pattern 3 is a variation on Pattern 2: do not buy insurance if IEI is low, and buy if IEI is high. But Pattern 3 has an added twist for medium IEI's: insure medium-low, but not medium-high, IEI's.

Pattern 4: yes-no-yes. Subject H chose to insure every amount of IEI except 10000.

The pattern frequencies imply the following facts.

[2] These standard errors are robust against the misspecification of the distribution of the random variable α.

<u>Fact II</u>. Different people may display different insurance patterns.

<u>Fact III</u>. A large majority (Patterns 1 and 2, totaling 80.9% *of the sample) satisfy the following rules:*

(a) if they insure the IEI ω*, then they also insure any* $\omega' > \omega$*;*

(b) if they do not insure the IEI ω*, then they do not insure any* $\omega' < \omega$*.*

<u>Fact IV</u>. A large minority (Pattern 1, 47.6%*) chooses to insure all levels of IEI.*

*<u>Fact V.</u> An equally sized minority (*47.6%*) chooses instead not to insure low levels of IEI, but to insure high levels;* 70% *within this group (Pattern 2) switch from not insuring to insuring only once, whereas the remaining* 30% *(Pattern 3) display a further reversal for intermediate levels of IEI.*

5. Risk attitudes and the shape of the utility function

We shall identify risk aversion with the decision to insure IEI at a fair premium, and risk attraction with the decision not to insure. Strictly speaking, either insurance or noninsurance are compatible with risk neutrality, and we cannot rule out risk neutrality in our subjects, particularly in those who switch more than once (Patterns 3 and 4). But our presentation disregards the knife-edge case of risk neutrality because we think that, on average, it is unlikely. Indeed, under risk neutrality the subject should be indifferent between insuring or not, and, therefore, the YES or NO answers would basically be chance variations. Yet the likelihood that our complete sample consists of random variations is statistically indistinguishable from zero.

Contrary to a long tradition in experimental economics, we made no attempt to test the expected utility theory, and we have nothing to contribute on this issue. But our results can be expressed in the language of the utility or value functions that appear in expected utility theory or some of its generalizations.

Write $\Omega \equiv \{500, 1000, 2000, 5000, 7500, 10000, 15000\}$, the set of the seven possible IEI's. For each $\omega \in \Omega$, experimental subject i chooses either [ω with prob. 0.8 & 0 with prob. 0.2] or [0.8 ω for sure]. Write X ≡ {0, 400, 500, 800, 1000, 1600, 2000, 4000, 5000, 8000, 10000, 12000, 15000}, the set of the 15 conceivable take-home money amounts. Assume that, given i, there are 15 real numbers, denoted $u_i(x)$, $x \in X$, such that, for $\omega \in \Omega$,

$$0.8\, u_i(\omega) + 0.2\, u_i(0) \leq u_i(0.8\, \omega),$$

whenever i chooses to insure the IEI ω, and

$$0.8\, u_i(\omega) + 0.2\, u_i(0) \geq u_i(0.8\, \omega),$$

otherwise. Writing u_i for the function that assigns $u_i(x)$ to x, $x \in X$, the first (resp. second) inequality is equivalent to the concavity (resp. convexity) of u_i on the domain $\{0, 0.8\, \omega, \omega\}$. Thus, a particular sequence of seven "y" or "n" can be reworded as a sequence of seven expressions "concavity on $\{0, 0.8\, \omega, \omega\}$" or "convexity on $\{0, 0.8\, \omega, \omega\}$".

These sequences can be naturally associated with the curvature patterns of a smooth function defined on a real interval. First, Pattern 1, which now corresponds to "concavity for all domains of the type $\{0, 0.8\, \omega, \omega\}$," is naturally associated to a concave function, as in Figure 1, whereas Pattern 2 can be associated with convexity for low x and concavity for high x, see Figure 2. The less frequent Patterns 3 and 4 can naturally be associated with Figures 3 and 4, respectively. Our experimental results now support the following claim:

$$\textit{The form of utility function in Figure } \begin{Bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{Bmatrix} \textit{ is consistent with the behavior of } \begin{Bmatrix} 47.6 \\ 33.3 \\ 14.3 \\ 4.8 \end{Bmatrix} \%\ \textit{of our subjects.}$$

6. Relation to the literature

Figures 1-4 can be compared to some shapes of utility or value functions present in the literature, although under substantive qualifications concerning the various interpretations (and allowable signs) of the variable in the horizontal axis. Of course, in our case the variable is the take-home amount of money, a nonnegative number.

Figure 1 is the conventional one. Our Figure 4 is Figure 3 of Friedman and Savage (1948), who interpreted the variable on the horizontal axis as the total wealth of the decision maker. As noted, this shape does show up in our experiment, but only once.

Figures 2 and 3 are of more interest. The shape in our Figure 3 is the one in Markowitz's (1952) Figure 5, but he interpreted the horizontal axis as deviations from a reference point, variously called "present wealth" or "customary wealth," with the zero placed at inflection point I* of our Figure 3. Note that, if restricted to the right of point I*, then our Figure 3 (as well as Markowitz's Figure 5 when restricted to the positive half-axis) has the shape of our Figure 2 (same as Markowitz's Figure 4).

Which one of the patterns we observe is in line with Markowitz's ideas? The answer depends on how one translates Markowitz's reference points into our experimental setup, and, in particular, on whether his reference point is viewed as changing with our IEI.

Markowitz (page 155) identifies the reference point with "customary wealth". Its natural counterpart here is the aggregate, nonexperimental wealth of the subject. Under this interpretation, the origin of our x axes coincides with that of Figures 4 and 5 in Markowitz, and his view agrees with Pattern 2 of our experiment, because his Figure 4 has the shape of our Figure 2.

But he also discusses potential discrepancies between "present wealth" and "customary wealth." "Present wealth" could certainly be translated here as the subject's nonexperimental wealth (same as "customary wealth"). But another interpretation is conceivable, where "present wealth" equals the sum of the subject's nonexperimental wealth and the IEI. If the take-home amount x deviates from the IEI ω (due either to the payment of the insurance premium or the loss of an uninsured ω), then the relevant argument in Markowitz's formulation is $x - \omega$, a negative number, and the relevant half of the horizontal axis in his Figure 5 is the negative half, where we see risk aversion for small absolute values (low IEI), and risk attraction for large ones. This pattern has not been observed in our experiment.

Kahneman and Tversky (1979, Figure 3) follow Markowitz in drawing the utility curve (called "value curve") in terms of deviations from a reference point: they posit concavity for positive deviations (gains) and convexity for negative ones (losses). Again, any harmony of their ideas with our experimental findings crucially depends on how we interpret their notion of a reference point, i.e., on what a gain or a loss is in the eyes of a subject. As in the previous paragraph, if the subject takes her nonexperimental wealth as reference, then she views any take-home amount of money x as a gain. Alternatively, if she takes the nonexperimental wealth plus the IEI ω as reference, then she perceives $x - \omega$ as a loss.

We see no reason to favor one of the two interpretations in our context. Imagine a subject filling in her YES-NO answers, and contemplating the insurance of an IEI of 10000. Does she think: if I insure, I will gain only 8000? Or, on the contrary, does she think: if I insure, I will lose 2000?

In any event, if the reference point is taken to be the subject's nonexperimental wealth, then the relevant half of the horizontal axis of Kahneman and Tversky's Figure 3 is the positive one, which now agrees with our Figure 1. Alternatively, if the reference point is the sum of the nonexperimental wealth and the IEI, then the relevant half-axis in their Figure 3 is the negative one, displaying convexity for all levels of losses, a pattern not observed in our experiment. Of course, while maintaining this interpretation of a reference point, one could modify their Figure 3 so that the function becomes concave for x negative and large in absolute value: one would then obtain something qualitatively similar to our Figure 2.[3]

Figure 3 of Kahneman and Tversky (minus its kink) could be seen as a translation of our Figure 2 where their zero is located at our I. Indeed, up to a horizontal translation, results consistent with the shape of our Figure 2 appear in a variety of other work. Nonconvexity suggests indivisibility, and the initial nonconvexity of our Figure 2 can be attributed to some indivisibility in the mind of the decision maker, a "target level," "aspiration level" or "threshold" that induces risk-seeking behavior below it.

REFERENCES

Cohen, M., J.-Y Jaffray and T. Said (1985) "Individual Behavior under Risk and under Uncertainty: An Experimental Study," Theory and Decision 18, 203-28.

Friedman, M., and L. J. Savage (1948) "The Utility Analysis of Choices Involving Risk," Journal of Political Economy 56, 279-304.

Hogarth, R. M., and H .J. Einhorn (1990) "Venture Theory: A Model of Decision Weights," Management Science 36, 780-803.

[3] Because Kahneman and Tversky (1979) in addition postulate a "decision weight function" with values that do not necessarily coincide with the probabilities, their model weakens the connection between risk aversion and the concavity of the function.

Kahneman, D., and A. Tversky (1979) “Prospect Theory: An Analysis of Decision Under Risk,” Econometrica 47, 263-291.

Markowitz, H. (1952) “The Utility of Wealth,” Journal of Political Economy 60, 151-158.

Preston, M. G., and P. Baratta (1948) “An Experimental Study of the Auction Value of an Uncertain Outcome,” American Journal of Psychology 61, 183-93.

Starmer, C., and R. Sugden (1991) ”Does the Random-Lottery Incentive System Elicit True Preferences? An Experimental Investigation,” American Economic Review 81 (4), 971-978.