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Do the Wealthy Risk More Money? An Experimental Comparison

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ABSTRACT

“Do the Wealthy Risk More Money? An Experimental Comparison”

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Are poor people more or less likely to take money risks than wealthy folks? We find that risk attraction is more prevalent among the wealthy when the amounts of money at risk are small (not surprising, since ten dollars is a smaller amount for a wealthy person than for a poor one), but, interestingly, for the larger amounts of money at risk the fraction of the nonwealthy displaying risk attraction exceeds that of the wealthy.

We also replicate our previous finding that many people display risk attraction for small money amounts, but risk aversion for large ones. We argue that preferences yielding “risk attraction for small money amounts, together with risk aversion for larger amounts, at all levels of wealth,” while contradicting the expected utility hypothesis, may be well-defined, independently of reference points, on the choice space.

Keywords: Risk Attraction, Risk Aversion, Wealth, Experiments
JEL Classification Numbers: C91, D81

"Do the Wealthy Risk More Money? An Experimental Comparison"[1]

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1. Introduction

Are poor people more or less likely to take pure money risks than wealthy folks? We experimentally address the dependence of risk attitudes (risk aversion or attraction) on wealth by conducting the same experiment on two groups of subjects, the Nonwealthy and the Wealthy.

Because we are interested in the dependence on wealth of risk attitude, rather that the degree of risk aversion, our subjects are required to choose between alternatives with the same expected money value: all risk averse individuals will then choose the safe alternative, no matter what their degree of risk aversion is.[2] Thus, our experiments do not directly address the related, and often-studied, issue of the dependence of absolute or relative risk aversion on wealth.[3]

Subjects were told that they would be randomly assigned, without replacement, to one of seven money amounts. But they had a 20% chance of losing the amount, and could buy an actuarially fair insurance against this loss. Subjects were asked to decide, before knowing to which group they would belong, whether to insure or not each of the seven possible amounts. If the subject chose not to insure a given money amount, then we say that he or she displayed risk attraction for, or that she risked, that amount. If, on the contrary, she chose to insure, then we say that he or she displayed risk aversion for that amount.

In a nutshell, we found that risk attraction was more prevalent among the Wealthy when the amounts of money at risk were small but, for the larger amounts of money at risk, we found that the fraction of the Nonwealthy displaying risk attraction exceeded that of the Wealthy.

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[1] Thanks are due to Albert Satorra who performed the statistical analysis. We also thank Antonio Cabrales, Gary Charness and Mark Machina for helpful comments, and Elena Jarocinska for assisting with the experiments.
[2] We will discuss risk neutrality when analyzing the experimental data.
[3] The large literature on this issue starts with the pioneering work of Kenneth Arrow (1965, 1970) and John Pratt (1964)

Replicating the feature evidenced in Bosch-Domènech and Silvestre (1999, 2003), we also find that a large majority of subjects display what we call the *standard pattern*: whenever risk attraction is displayed in a choice involving a given amount of money, risk attraction is also displayed for any smaller amount of money. We can then define a subject's highest risked amount (HRA) as highest money amount that she or he fails to insure (we set at zero the HRA of a subject who insures all amounts). In our experiments, the bottom 86% of the Wealthy distribution have a higher HRA than the bottom 86% of the Nonwealthy distribution, indicating that risk attraction is more prevalent among Wealthy than among Nonwealthy. But the top 14% of the Nonwealthy distribution have a higher HRA than the top 14% of the Wealthy distribution, i.e., the very risk-attracted Nonwealthy (relative to their fellow Nonwealthy) risk more that the very-risk attracted Wealthy.

Given our previous results showing that many people display risk attraction for small money amounts, but risk aversion for large ones, the finding that Wealthy are more likely to display risk attraction for small money amounts is not surprising: ten dollars represent a smaller sum for a wealthy person than for a poor one. But Nonwealthy's higher likelihood of displaying risk attraction when the amounts of money at stake are large is noteworthy.

Section 8 below discusses preferences yielding "risk attraction for small money amounts, together with risk aversion for larger amounts, at all levels of wealth" from the theoretical viewpoint. On the one hand, they do contradict expected utility theory, and, hence, they lie on the far side of the great divide between preferences that satisfy the expected utility hypothesis and those that do not. But, on the other hand, they are on the near side of a second great theoretical divide, namely between preferences that are well defined on the choice space, and reference-dependent preferences, which require a different map of indifference curves for each reference point.

2. The experiment

We run the experiment with two groups of Catalan subjects, all in their last year of "batxillerat," which is the university-bound track in high school. The two groups have the same age, identical formal education, and involve similar proportions of males and females.[4]

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[4] According to Luigi Guiso and Monica Paiella (2001, p. 9): "risk averse are younger and less educated; they are less likely to be male…" Empirical research on wealth and risk has to wrestle to separate the effects of different types of

The first group includes students of a public high school in a low-income neighborhood in Barcelona. The second group includes students attending a high-tuition private school in a plush area in the same city. We will call these groups Nonwealthy and Wealthy, respectively.[5] In Spain, public schools are free and, in large cities, attract mostly students from the neighborhood. A public school in a low-income neighborhood is unlikely to receive any applications from students living in well-to-do neighborhoods. Therefore, by choosing participants among the students in these two schools we were reasonably certain to observe children from families with middle to low incomes in one place and children from high--income families in the other. A questionnaire about family and social background, which the participants in the experiment had to answer, reveals that this assumption appears to be correct. In Table 1 we report their answers to the question about their parents' jobs, showing that the ratio of low-paid jobs over high-paid jobs is clearly higher among the Nonwealthy group.

Parents' jobs	Nonwealthy	Wealthy
Housewife	18%	0%
Blue collar	18%	0%
White collar	51%	21%
Professional	8%	43%
Small business owner	15%	21%
Business executive	0%	14%

Table 1. Distribution of parents' jobs in the two groups of Nonwealthy and Wealthy subjects, in percentage of answers. (Out of 42 possible answers for each group, we received 39 from Nonwealthy and 28 from Wealthy).

wealth, in particular, wealth measured in human capital and wealth measured in net assets, two types of wealth that often yield opposite effects on risk taking (see Martin Halek and Joseph Eisenhauer, 2001, p. 13 and 22). We have no such problem in our experiment, since we can safely assume that participants have similar amounts of human capital.

[5] Because family wealth is independent from the behavior of our young subjects, our method avoids possible problems of interdependence between risk attitudes and wealth.

While from the answers to the questionnaire we cannot ascertain the degree of wealth dispersion within the two groups, it appears unlikely that the highest levels of wealth in the Nonwealthy group could be above the lowest in the Wealthy group. We therefore confidently assume that Wealthy and Nonwealthy are two groups clearly separated by their wealth levels. Needless to say, characteristics other than wealth differences can be a factor in the experimental results. [6] Yet, the experimental subjects share those characteristics that are usually singled out as influencing risk attitudes, like religion, race, employment or marriage, in addition to age and education.

We performed the experiment with each group in a single session (no preliminary pilot sessions) using 21 subjects per group that were chosen randomly among the male and female volunteers. We tried to maintain a similar proportion of sexes in both experiments (the female/male ratio was 10/11 in Wealthy and 9/12 in Nonwealthy). Subjects were told that they would be randomly assigned, without replacement, to one of seven money amounts, denominated in the (former) Spanish currency, pesetas: 500, 1000, 2000, 5000, 7500, 10000 or 15000 (i.e., approximately, in PPP, from US$ 3 to US$ 100).[7] But subjects had a 20% chance of losing the amount, and could buy an actuarially fair insurance against this loss.[8] Subjects were asked to

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[6] We know from the responses to our questionnaire that 51% of parents' jobs among Nonwealthy are "white collar," while only 20% are of this type among Wealthy. Could it be that white collars, who tend to receive their salary on a regular basis, are less risk-takers than business executives and business owners? And, if so, could it be that children in these families have been socialized to become less risk-takers? Or, on the contrary, is it the case that professionals (many of whom, in Spain, could be civil servants with secure jobs) are less risk-taking and, representing 43% of Wealthy parents but only 8% of Non-Wealthy parents, have socialized a larger proportion of Wealthy respondents to being less risk-taking? Since the questionnaire was answered anonymously, we cannot associate observed behavior to parents jobs and, consequently, we cannot even try to answer these questions

[7] 15000 pesetas is a large amount of money for Catalan high school students. In the questionnaire mentioned above, we also asked participants to compare this amount of money with their monthly income. For Nonwealthy it represented an average of 175% (16 answers out of 21), while for Wealthy the average was lower and equal to 113% (12 answers out of 21).

[8] We avoided extreme probabilities: 0.2 seems to be above the range that tends to be overweighted (Malcolm Preston and Philip Baratta, 1948) and below the range that tends to be underweighted (0.3 to 0.8 according to Michele Cohen, Jean-Yves Jaffray and Tanios Said, 1985). Also, one observes in Steven Kachelmeier and Mohamed Shehata (1992) that, at a 0.8 probability of winning, subjects tend to be risk neutral, which is not the case for lower probabilities. One could be more confident, then, that the choice of a probability of winning of 0.8 may not bias, by itself, the degree of risk aversion. But Amos Tversky and Daniel Kahnemann (1992) suggest that there is overweighting at 0.2 and underweighting at 0.8 (Figure 3.3), whereas the earlier Figure 2.4 in Kahneman and Tversky (1979) suggests no overweighting at 0.2. At the other extreme, William Harbaugh, Kate Krause and Lise Vesterlund (2002) claim to observe overweighting at 0.8.

decide, before knowing to which group they would belong, whether for each of the seven possible amounts to insure or not to insure it.

To record their decisions, as in other similar experiments that we have run (Bosch-Domènech and Silvestre 1999, 2003), subjects were given a 7-page folder, one page for each possible money amount. Every page had five boxes arranged vertically. The amount 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 amount. The third box contained two check cells, one for insuring the amount, and another one for not insuring it. Below a separating horizontal line, two more boxes were later used to record first whether the money amount was lost and, second, the take-home sum. 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 money amount, and each of the seven amounts occurred three times. A piece of paper was randomly drawn: the experimenter and the subject then checked in the folder whether the subject had insured that particular amount. If he or she had, then the premium was subtracted from the money amount to obtain the take-home sum. If he or 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 amount, taking nothing home. Otherwise, he or she would take home the money amount. 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 all seven possible money amounts with the intention of obtaining a larger data set. This procedure tends to elicit the same choices as when subjects make only one choice (Chris Starmer and Robert Sugden, 1991), but we wanted to check this tendency. Consequently, we allowed each subject to reconsider her reported decision after her money amount was selected. Of the 42 subjects involved, only one, labeled JN, changed his mind (from non-insurance to insurance). 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 (Robin Hogarth and Hillel Einhorn, 1990).

The experimental data are presented in tables A1 and A2 in the Appendix.

3. Stylized facts

From the results in Tables A1 and A2, we can construct Table 2, which supports the following result:

Result 1. *On average, Wealthy subjects are more likely to risk (decline to insure) small money amounts, whereas Nonwealthy subjects are more likely to risk large money amounts.*[9]

In particular:

- For any amount lower than or equal to 5000, the number of Wealthy subjects who risk that amount exceeds that of Nonwealthy subjects.
- And for any amount larger than 5000, the number of Nonwealthy subjects who risk that amount exceeds that of wealthy subjects.

A preliminary conclusion would be, therefore, that wealthy subjects are more likely to display risk aversion than less wealthy subjects for large enough amounts of money at stake, but more likely to display risk attraction when the amounts of money are small.[10, 11]

[9] Note the contrast with the empirical data reported by Luigi Guiso and Monica Paiella (2001, p. 9): "…the risk-averse are significantly less wealthy than the risk lovers or neutrals." But notice that the authors characterize each individual by one single measure of risk aversion, while we observe that individuals may have different attitudes towards risk depending on the income at risk. Also, their statement should be qualified by their own conclusion (p. 31) that there is limited empirical evidence on the sign of the relationship between risk attitude and wealth. But see Bas Donkers, Bertrand Melenberg and Arthur Van Hoest (2001) p. 182, who observe that risk aversion appears to decrease with income using data from a questionnaire on hypothetical risks.

[10] A risk-neutral subject could choose either the certain or the uncertain prospect, his choice being random. But the likelihood that our samples consist of random variation is statistically undistinguishable from zero.

[11] While our experimental data show women being less risk averse than men for very small amounts (500 or 1000) and more risk averse for larger amounts, this effect is dominated by the effect of wealth.

	Amount of Money						
	500	1000	2000	5000	7500	10000	15000
Number of Nonwealthy Subjects Who Risk the Amount	11	7	3	4	5	2	4
Fraction of Nonwealthy Subjects Who Risk the Amount	0.52	0.33	0.14	0.19	0.24	0.10	0.19
Number of Wealthy Subjects Who Risk the Amount	18	11	6	5	1	1	2
Fraction of Wealthy Subjects Who Risk the Amount	0.86	0.52	0.29	0.24	0.05	0.05	0.10

Table 2. Number and fraction of subjects in the Wealthy and Nonwealthy groups that risk the various money amounts.

We say that an individual follows the standard pattern if, whenever she displays risk attraction in a choice involving a given amount of money, she also displays risk attraction for any smaller amount of money. The inspection of Tables A.1 and A.2 yields the following result.

Result 2. *A large proportion of subjects* (18/21= 86%) *follow the standard pattern in either group.*

4. The distribution of the degree of risk attraction

Within the standard pattern, we can rank a subject's risk attraction by the highest amount that she or he fails to insure: we call it *highest risked amount*, or HRA. We set at zero the HRA of a subject who insures all amounts.

If we disregard the subjects who violate the standard pattern, then our experimental observations, complemented by linear interpolation, generate a distribution of HRA for each of the two groups. Figure 1 shows the corresponding CDF's (the "types of behavior" are discussed in the following section), and Table 3 gives some of the statistics.

[Figure 1]

Percentile (Lowest HRA = Lowest Risk Attraction = Highest Risk Aversion)	HRA in Nonwealthy Group (Standard pattern)	HRA in Wealthy Group (Standard pattern)
17% lowest HRA (Bottom 17%)	0	**0**
25% (Bottom quartile)	0	**125**
44% (Bottom 44%)	0	**417**
50% (Median)	125	**500**
75% (Top quartile)	750	**1250**
85. 5% (Top 14. 4 %)	2600	2600
90% (Top 10%)	**5500**	3800
95% (Top 5%)	**8250**	5500
98% (Top 2%)	**12300**	8200

Table 3. Percentile distribution of the highest amount of money that subjects risked (with linear interpolation) in Nonwealthy and Wealthy groups. Higher HRA's per percentile group appear in bold.

We observe that

?? The bottom 17% of the Wealthy distribution, and the bottom 44 % of the Nonwealthy distribution, insure all risks.

?? The bottom 86% of the Wealthy distribution have a (weakly) higher HRA than the bottom 86% of the Nonwealthy distribution.

?? But the top 14% of the Nonwealthy distribution have a higher HRA than the top 14% of the Wealthy distribution, i.e., the very risk-attracted Nonwealthy (relative to their fellow Nonwealthy) risk more that the very-risk attracted Wealthy.

5. Individual behavior at different wealth levels

We ask the hypothetical question: if a Nonwealthy subject were wealthy, what would be her HRA? Assume that the distribution of HRA in either wealth category is invariant. Assume moreover than, when moving across wealth categories, a subject's position in the distribution of the HRA does not change, i.e., a subject who has the median HRA when non-wealthy also has the median HRA when wealthy. Similarly, a subject who, when non-wealthy, has a HRA in the 75% percentile of the distribution of non-wealthy HRA also is in the 75% percentile of the wealthy HRA when wealthy, and so on. Under these assumptions, we can use Figure 1 and Table 3 to identify the four types of behavior of Table 4.

Type	Percentage	Description
I	17%	Avoids all risks at all wealth levels
II	27%	Avoids all risks when nonwealthy; Takes very small risk when wealthy
III	42%	Takes a medium risk when nonwealthy; Takes larger, but not very large, risk when wealthy
IV	14%	Takes a relatively large risk when nonwealthy; Takes a lower risk when wealthy

Table 4
Types of behavior and their percentages.

Type I behavior is consistent with preferences on money lotteries that satisfy the expected utility hypothesis and display risk aversion: i.e., they can be represented via a strictly concave von Neumann-Morgenstern (vNM) utility function defined on (a subset of) the real line. But Types II-IV violate the canonical expected utility model to the extent that they take small risks, but not large ones, for a wide interval of wealth. Nevertheless, their preferences may be independent from a reference point, and, in this sense, all types may have well-defined, consistent preferences over the space of uncertain prospects. Section 8 below explains.

A Type III decision maker is willing to take small risks, but not large ones, at all levels of wealth, "small" being understood relative to her wealth. The interesting Type IV reverses Type III: the decision maker is willing to take larger risks when Nonwealthy than when Wealthy. It includes the extreme case of taking all risks when Nonwealthy, as one of our Nonwealthy subjects did.

Types III and IV (with the exception of the extreme case) share the feature: *at all levels of wealth, the decision maker is willing to take small risks, but not very large ones*. Our experimental results (including the ones reported here, the ones in Bosch-Domènech and Silvestre, 1999, 2003, and various classroom experiments) have convinced us that this is a highly realistic feature, well represented in real-life populations.

6. Statistical model

To tighten up the previous observations, we consider the logit regression model with random intercept (to allow for the heterogeneity of individual tastes represented by u_i),

$$\ln \frac{p_{ij}}{1 ? p_{ij}} = ? ?+ u_i + bz_j ,$$

$i ? \{1,\dots I\}$, where I is the number of subjects.

$j ? \{1, \dots, 7\}$, the seven levels of money

$z_j ? \{0.5, 1, 2, 5, 7.5, 10, 15\}$.

The variable p_{ij} is the probability that subject i chooses the certain alternative (and thus displays risk aversion) when the amount of money at stake is z_j in thousands of pesetas (so as to avoid too many decimals in the estimates of the regression coefficients). The individual effect u_i allows for heterogeneous individual tastes assumed to be normally distributed with mean zero and standard deviation ? ??so that ?(? ?+ u_i) is the random intercept.[12]

The results of the maximum likelihood estimation of this equation for the Nonwealthy and Wealthy groups, estimated separately (147 observations in each estimation)[13], are reported in tables 5 and 6.

<table>
<tr><th>v</th><th>Coef.</th><th>Std. Err.</th><th>t</th><th>P>|t|</th><th>[95% Conf.</th><th>Interval]</th></tr>
<tr><td>z</td><td>.1390</td><td>.0564</td><td>2.465</td><td>0.014</td><td>.02846</td><td>.2496</td></tr>
<tr><td>constant</td><td>1.0490</td><td>.6059</td><td>1.731</td><td>0.083</td><td>-.1385</td><td>2.2365</td></tr>
<tr><td>ln ?^{2}</td><td>1.2996</td><td>.5604</td><td>2.319</td><td>0.020</td><td>.2012</td><td>2.3980</td></tr>
<tr><td>?</td><td>1.915216</td><td>.5366</td><td></td><td></td><td>1.1058</td><td>3.3168</td></tr>
<tr><td>??????????????</td><td>.7857779</td><td>.0943</td><td></td><td></td><td>.5501</td><td>.9166</td></tr>
</table>

Table 5. Results of the ML estimation with the Nonwealthy data.

<table>
<tr><th>v</th><th>Coef.</th><th>Std. Err.</th><th>t</th><th>P>|t|</th><th>[95% Conf.</th><th>Interval]</th></tr>
<tr><td>z</td><td>.45028</td><td>.0988</td><td>4.555</td><td>0.000</td><td>.2564</td><td>.64392</td></tr>
<tr><td>constant</td><td>-.7903</td><td>.5248</td><td>-1.506</td><td>0.132</td><td>-1.8190</td><td>.2384</td></tr>
<tr><td>ln ?^{2}</td><td>.9916</td><td>.6110</td><td>1.623</td><td>0.105</td><td>-.2058</td><td>2.1892</td></tr>
<tr><td>?</td><td>1.6418</td><td>.5016</td><td></td><td></td><td>.9021</td><td>2.9880</td></tr>
<tr><td>?</td><td>.7294</td><td>.12058</td><td></td><td></td><td>.4487</td><td>.8992</td></tr>
</table>

Table 6. Results of the ML estimation with the Wealthy data.

If, for each group, we plot the probability of insuring with respect to the money amounts (divided by 1000), we obtain Figure 2.

[12] We adopt the same statistical model as in Bosch-Domènech and Silvestre (2003).

[13] We did an estimation of the joint data (294 observations) including a dummy group-variable. The joint estimation uses more data but forces a common intercept and slope. The estimation was not significant for some variables. The discussion below will help to understand why.

[Fig 2]

Notice first that all estimates are significant. Second, the graph seems to indicate that the two curves describe different behavior. To verify that the intercepts are statistically different, we computed a *t*-test of the equality of the two groups' intercepts (we used the fact that the two samples are independent) obtaining $t = 2.73$, a value that rejects the null hypothesis of equality of intercepts (*p*-value = 0.006 for a two-sided test).

On the basis of the estimated regression model for each group, we want now to verify that our assumption of heterogeneity of individual decisions is appropriate. For this we run a ?? test of the null hypothesis ??? ????The ?hypothesis indicates that there is no intraclass correlation of the individual decisions. But the test rejects the hypothesis for both groups with a *p*-value close to 0. Therefore, the individual effect is highly significant, as previous empirical analysis of risk had noticed, and can be confirmed by looking at the 95% confidence interval of ? ?

Finally, since exp (0.139) = 1.149, the statistical analysis also allows us to say that, for the Nonwealthy, the odds of insuring increase by 15% when the money amount increases by 1000 pesetas. Note also that for the Nonwealthy, the probability of insuring is high when the amount of money at risk is zero, namely, exp (1.049)/(1+ exp (1.049)) = 0.74, or 74%. For Wealthy, the odds of insuring increase by as much as 57% when the amount increases by 1000 pesetas, but the limit of the probability of insuring an amount that tends to zero is lower than for Nonwealthy and equal to 31%.

The statistical analysis confirms the previous observation that Nonwealthy insure small incomes at risk more than Wealthy.[14] The probability of insuring high amounts is close to one for both the Nonwealthy and the Wealthy, with the Wealthy insuring somewhat more frequently than the Nonwealthy. This analysis supports the preliminary conclusions stated as Result 1 in Section 3 above.

7. Risk attitudes and the amount of money at risk

We showed in Bosch-Domènech and Silvestre (1999) that experimental subjects become more likely to display risk aversion as the amount of the money at risk increases. All the results of the

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[14] Of course, we cannot rule out that the monetary rewards were too low for the Wealthy people to completely dominate nonmonetary influences.

experiments reported here confirm that the probability of insuring increases with the amount of money at risk.

In particular, if we add together the data from Wealthy and Nonwealthy (294 observations) and we run the same regression model as above with z_j as the independent variable and log of the odds as the dependent variable, we obtain the results in Table 7.

v	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
z	.2645	.0482	5.485	0.000	.1700	.3591
constant	.1416	.3648	0.388	0.698	-.5735	.8567
ln $?^2$	1.059611	.4158505	2.548	0.011	.2445586	1.874663
?	1.6986	.3531			1.1300	2.5531
?	.74261	.0794			.5608	.8669

Table 7. Results of the joint ML estimation with the Nonwealthy and Wealthy data.

Observe that there is a significant effect of the independent variable on the probability of insuring. Moreover, as shown in the previous estimations, there is an individual variation on the propensity to insure. This is captured by a random individual effect which is also significant (the hypothesis that individual correlation is zero being rejected by a chi-square test with p-value = 0.0000). More important, since exp(0.2646) is equal to 1.303, we can report that the odds of insuring increase by 30% for increases of 1000 pesetas in the amount of money at risk. Note also that the overall probability of insuring is high for very small amounts of money (1/(1 + exp(-0.142)) = 0.535, i.e. approximately 53%)

The regression clearly supports Result 2 in Section 3 above. This result, also observed in Bosch-Domènech and Silvestre (1999, 2003), agrees with the empirical evidence reported by Roel Beetsma and Peter Schotman (2001) who claim, p. 847, that "the required minimum probability of winning in a lottery […] rises from a 53% for a stake of *f*1,000 to 73% for a stake of *f*8,000". In other words, as the income at risk increases, so increases the degree of risk aversion. Similar results have been observed by Holt and Laury (2002). Strangely, Kachelmeier and Shehata (1992) observe that at an 80% probability of winning, the average risks attitudes are similar (risk neutrality in both cases) for two groups that risk incomes that are different by a factor of ten. In our experiments, the difference from the lowest to the largest income was a factor of thirty, and the slope of the estimated function of probability of insuring with respect to income was never flat.

8. Implications for preference theory

A subject in our experiments, with initial wealth w, has to choose between the risky prospect of a money gain of z with known probability p and the certain money gain of pz. Clearly, the risky prospect induces the contingent final money balances $(x_1, x_2) = (w,\ w + z)$, whereas the certain gain induces $(x_1, x_2) = (w + pz,\ w + pz)$

The person's choice displays *risk attraction* (resp. *aversion*) if she chooses the risky prospect (resp. the certain money gain pz). Our experiments have studied the dependence of risk attitudes on (i) the person's initial wealth, and (ii) whether the amount at risk z is large or small. This section discusses the two phenomena from the viewpoint of preference theory.

A person's attitude is *wealth-dependent* if she prefers the risky prospect at some wealth level, but prefers its certain expected money value at a different level of wealth.[15] We say that a person's risk attitude is *amount-dependent* if she displays risk attraction when the amounts at risk are small, but aversion for large ones, *at all levels of wealth* (or, at least, for a wide interval of wealth values).

Wealth-dependent attitudes are in principle compatible with the canonical expected utility model, witness Milton Friedman and Leonard Savage (1948). All it takes is a vNM utility function that is concave in part of its domain (that of wealth levels at which the person displays risk aversion for small risks), and convex in some other parts (attraction).[16]

On the other hand, amount-dependent attitudes would require, in the canonical expected utility model, the vNM utility function u to be locally convex everywhere, implying convexity on its domain, which would contradict the aversion to large risks.[17] Thus, amount-dependent attitudes

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[15] As noted in the introduction, the Arrow –Pratt literature considers a related issue within the canonical expected utility model: it assumes risk aversion and considers the acceptance or rejection of actuarially favourable risks of various sizes depending on the initial wealth: this leads to the discussion of increasing or decreasing absolute or relative risk aversion. Arrow (1965), for instance, argued that absolute risk aversion is decreasing in wealth. He also believed that individuals are less willing to subject a given percentage of wealth to risk, as their wealth increases, i.e., that relative risk aversion is increasing. But here we focus, so to speak, on the wealth-induced changes of the *sign*, rather than the *magnitude*, of the risk aversion coefficients.

[16] See the vNM utility function depicted in their famous Figure 3. However, justifying its shape is not trivial. Nathaniel Gregory (1980) postulates that wealth has two effects on utility: the usual direct effect, and a social rank effect, based on the comparison with the wealth of others, which will depend on the distribution of wealth in society. The shape of Friedman and Savage's Figure 3 is justified by the similarly motivated model of Arthur Robson (1992).

[17] In other words: the attraction to all small enough risks would imply, under differentiability, that $u''(x) > 0$ everywhere, and, thus, that u is a convex function.

are incompatible with the canonical expected utility model. In this sense, they reside in the far side of the great divide between preferences that satisfy the expected utility hypothesis and those that do not.

But, as emphasized by Machina (1982), there is a second great divide for both normative and positive analysis, namely between preferences that are well defined on the choice space, and reference-dependent preferences, which require a different map of indifference curves for each reference point (see Bosch-Domènech and Silvestre, 2003, for a discussion). We argue next that amount-dependent attitudes are on the near side of this second divide.

Let the probability of the gain be $p = 0.8$ and let our consumer display risk attraction for $z = 100$, but risk aversion for $z = 200$, both when her initial wealth is 1000 and when her initial wealth is 920. Choosing the risky gain of 100 when her wealth is 1000 means that she chooses the random variable $\tilde{x}^1$, that gives a money balance of 1000 with probability 0.2 and a balance of 1100 with probability 0.8, to the degenerate random variable $\tilde{x}^0$, that gives the certain balance of 1080. Note that the two random variables have the same expectation of 1080, and that $\tilde{x}^0$ second-order stochastically dominates (SOSD) $\tilde{x}^1$. Thus, the consumer's choice shows attraction to a pure risk, but one that is relatively small.

On the other hand, by choosing the certain gain of 160 over the 0.8 chance to gain 200 when her wealth is 920, she chooses $\tilde{x}^0$ over the random variable $\tilde{x}^2$, that gives a money balance of 1120 with probability 0.8 and of 920 with probability 0.2. Again, $E\tilde{x}^2 = E\tilde{x}^0 = E\tilde{x}^1 = 1080$, and $\tilde{x}^0$ SOSD $\tilde{x}^1$ SOSD $\tilde{x}^2$. Thus, she is attracted to the relatively small pure risk of $\tilde{x}^1$, but averse to the larger pure risk of $\tilde{x}^2$.

Figure 3 illustrates a conceivable map of indifference curves for amount-dependent attitudes: parallel lines of slope – 1/4 are fair-odds lines (or iso-expected money balances) for the probabilities $(1-p, p) = (0.2, 0.8)$, where $(1-p)$ is the probability of the state that corresponds to the horizontal axis (the bad state). Consider points *C*, *S* and *L*, which correspond to the random variables $\tilde{x}^0$, $\tilde{x}^1$ and $\tilde{x}^2$, respectively. Relative to *C*, points in the segment (*B*, *C*) are small pure risks, preferred to *C*, whereas those northwest of *B* on the fair-odds line are large pure risks, dispreferred to *C*. The risk at the borderline point *B* makes the consumer indifferent between taking and not taking it. By considering alternative fair-odds lines, we will have similar points, labeled *B*', *B*''…

Figure 3, while displaying amount-dependent attitudes, does not display wealth-dependent risk attitudes. Indeed, the points *B*, *B*', *B*" … are on a 45^0 line, at the same distance from the certainty line along their fair-odds line.[18] This special case reflects the idea that the largest acceptable pure risk does not change with wealth.

Our next three figures depict preferences that combine *wealth-dependent attitudes* with *amount-dependent attitudes.* Figure 4 corresponds to the Type III preferences of Section 5: the person is always attracted to small enough risks, and averse to large ones, but the borderline between "large" and "small" increases with wealth: there are net risks that are too large to be taken at low wealth levels, but small enough to be taken at high wealth levels. This may reflect the fact that the risk of losing $100 is a big risk when you are poor, but a small one when you are wealthy.

Figure 5 corresponds to Type IV of Section 5: the maximal acceptable risk now decreases with wealth. You are more inclined to play it unsafe when poor than when rich. In principle, the relationship between the maximal acceptable risk and wealth may be non-monotonic. Perhaps at low levels of wealth it decreases with wealth, but it increases with wealth when wealth is high, as illustrated in Figure 6. Or the pattern may conceivably be reversed.

Figures 3-7 illustrate the possibility of consistent, endowment-independent preferences for the amount-dependent attitudes case even though, as argued above, these preferences cannot be represented by a utility function of the expected utility form $(1 - p)\ u(x_1) + p\ u(x_2)$.

An illustrative example of a utility function that does display risk attraction for small amounts of money at risk and risk aversion for large amounts can be constructed as follows.

[18] If person with the preferences of Figure 3 and with nonrandom wealth faced actuarially favorable terms of trade, then she would risk the same amount at all levels of wealth. Her behavior would be then qualitatively similar to that of a risk-averse person with constant absolute risk aversion (CARA). But, contrary to CARA preferences, those of Figure 3 would yield risk-taking at actuarially fair terms. Parallel comments apply to Figures 3-7 below.

Define $U : ? \, ^{2}_{?} \; ? \, [0,1] \, ? \quad ? \;$:

$$U(x_1, x_2, p) \; ? \; \begin{cases} \dfrac{\left((1 ? \, p)\left(\dfrac{x_2}{?(p)} \right)^{1? ?^?} \; ? \; p x_2^{\,1? ?^?} \right)^{\frac{1}{1??^?}}}{\left((1 ? \, p)\left(\dfrac{x_2}{?(p)} \right)^{1? ?^?} \; ? \; p x_2^{\,1? ?^?} \right)^{\frac{1}{1??^?}}} \left((1 ? \, p) x_1^{\,1??^?} \; ? \; p x_2^{\,1??^?} \right)^{\frac{1}{1??^?}}, \text{ if } \; x_2 \; ? \; ?(p) x_1 \\ \left((1 ? \, p) x_1^{\,1??^?} \; ? \; p x_2^{\,1??^?} \right)^{\frac{1}{1??^?}}, \text{ if } \; x_2 \; ? \; [\dfrac{x_1}{?(p)}, ?(p) x_1] \\ \dfrac{\left((1 ? \, p) x_1^{\,1??^?} \; ? \; p \left(\dfrac{x_1}{?(p)} \right)^{1??^?} \right)^{\frac{1}{1??^?}}}{\left((1 ? \, p) x_1^{\,1??^?} \; ? \; p \left(\dfrac{x_1}{?(p)} \right)^{1??^?} \right)^{\frac{1}{1??^?}}} \left((1 ? \, p) x_1^{\,1??^?} \; ? \; p x_2^{\,1??^?} \right)^{\frac{1}{1??^?}}, \text{ if } \; x_2 \; ? \; \dfrac{x_1}{?(p)} \end{cases}$$

where $?^- < 0$, $?^+ > 0$, and p (resp. 1- p) is the probability of the state where x_2 (resp. x_1) occurs. It can be checked that $U(x, x, p) \; ? \; x$, that $\dfrac{?U}{?x_1} \; ? \; 0$ if $p < 1$ (zero if $p = 1$), and that $\dfrac{?U}{?x_2} \; ? \; 0$ if $p > 0$ (zero if $p = 0$).[19] Moreover, computation shows that $\operatorname{sgn} \dfrac{?U}{?p} \; ? \; \operatorname{sgn}(x_2 \; ? \; x_1)$ for a variety of values of $?^-$ and $?^+$, and for several specifications of $?$. Figure 7 displays the contour lines of U in the space of contingent money balances (x_1, x_2), for $p = 0.5$, $?^- = -0.5$, $?^+ = 0.5$ and $?(p) = 1.5 + p$.

This example reproduces the qualitative features of Figure 4, i.e., the maximal acceptable risk increases with wealth.

9. Relation to the literature

[19] When the partial derivatives are defined. Clearly, U is homogeneous of degree one in (x_1, x_2) and differentiable everywhere in the interior of the quadrant except along the rays $x_2 \; ? \; ?(p) x_1$ and $x_2 \; ? \; \dfrac{x_1}{?(p)}$.

Experimental work has always shown interest in socio-demographic characteristics of subjects, like sex or age, and many experiments deal with other non-demographic or cultural effects on behavior.[20] All this has influenced the experimental research on risk attitudes, resulting in experiments that relate risk-taking to age (Harbaugh, Krause and Vesterlund, 2002), to sex (Renate Schubert, Martin Brown, Matthias Gysler and Hans Brachinger, 1999, Catherine Eckel and Philip Grossman, forthcoming), and to non-demographic factors, like the effects of the experimental medium (i.e., the lab or the internet, see Tal Shavit, Doron Sonsino and Uri Benzion, 2001), or the frequency of evaluation (Uri Gneezy and Jan Potters, 1997).[21] Yet, surprisingly, economists have not shown much interest in the effect of differences in personal or family wealth on experimental behavior.[22] This is particularly odd -even considering the difficulty of finding the relevant information- concerning, as it does, economists, and the oversight is even more striking when it refers to the study of risk aversion, because of the long-standing awareness that risk aversion may vary with wealth and that this relation "is of the greatest importance for prediction of economic reactions in the presence of uncertainty" (Kenneth Arrow, 1965). But the fact is that differences in personal wealth among subjects from the same culture do not appear to have ever been controlled in the lab, or used as a treatment to explain behavior.[23]

Field studies by development economists and anthropologist provide some information on whether wealthy people are more or less likely to exhibit attraction to money risks.[24] Frank Cancian (1972) reports on a variety of studies, including his own in an area of Chiapas, that relate the degree of risk taking (measured by an index of the speed or depth in the adoption of various innovations in the production or marketing of corn) to the person's position in a four-tier wealth

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[20] From Alvin E. Roth, Vesna Prasnikar, Masahiro Okuno-Fujiwara and Shmuel Zamir (1991) to Joseph Henrich, Robert Boyd, Samuel Bowles, Colin Camerer, Ernst Fehr, Herber Gintis and Richard McElreath (2001).

[21] There is also a growing field of evidence about risk attitudes from natural experiments, mostly television games or racetrack betting. See, e.g., Roel Beetsma and Peter Schotman (2001), Bruno Jullien and Bernard Salanié (2000), and the references mentioned there.

[22] There is a variety of experiments that link so-called wealth with different behaviour. But what is called wealth in these experiments is not what we mean here. It is either the endowed income provided by the experimenter as, for instance, in Olivier Armentier (2001), or the accumulated earnings of subjects as they keep participating in an experiment, as in Kachelmeier and Shehata (1992). Charles Holt and Susan Laury (2003), p. 11, report, almost as an afterthought, that "income seems to have a mildly negative effect on risk aversion". But, as will be described below, anthropologists and development economists do appear to be interested in the effect of wealth on risk behaviour.

[23] However, there is a literature of experiments in the field that uses wealth and wealth differences as parametric factors for explaining cooperative behaviour. See, e.g., Juan-Camilo Cárdenas (1999) and the references he provides

[24] Here we focus on money, rather than lifestyle, risks. The conventional wisdom is that a low income tends to increase lifestyle risky behaviour, such as smoking, unprotected sex or excessive drinking, in particular for those behaviours that do not require purchases, such as seat-belt use. See Thomas Dee and William Evans (2001) and Phillip Levine (2001).

classification: low, low middle, high middle and high. The main observation is that the relation is increasing except for the middle-high group, i.e., low and middle high take fewer risks that middle low, which in turn take fewer risks than high. The findings do not directly address the issue of risk attraction, but suggest that it is more likely to be found in the low-middle and the high groups than in the low or high middle.

John Dillon and Pasquale Scandizzo (1978) studied the risk attitudes of two groups of subsistence farmers in the Brazilian Sertão, namely small owners and shareholders. The two groups showed different socioeconomic characteristics: in particular, small owners were wealthier, with an average income which was 140% that of the sharecroppers. Their risk attitudes were elicited by two sets of hypothetical questions, one of which involved a potential fall below subsistence. Even though risk aversion was more common in either group, a non-negligible fraction displayed risk attraction, and this fraction was substantially higher for the (relatively) poor shareholders than for the small owners. These observations agree with the conclusion of Hans Binswanger's (1980) study in rural India that tenant farmers are more risk attracted than landowners.

Lawrence Kuznar (2001) adopts a similar method in his study of Andean pastoralists, and the questions are targeted to elicit the probability premium for given lotteries involving hypothetical herds of goats, sheep or cows. (The probability premium is the excess of winning probability over fair odds that makes the individual indifferent between a certain amount and a symmetric lottery centered in that amount: it is an index of risk aversion, with negative values corresponding to risk attraction). He finds that these premia are lowest for the poorest herders (with one instance of risk attraction), highest for herders with mean wealth, and relatively low for the wealthiest herders.

Joseph Henrich and Richard McElreath (2002) report on several experiments, with real payoffs, involving four groups of subjects: they find widespread risk attraction. A first experiment, involving Huinca and Mapuche subjects in Southern Chile, elicits the certainty equivalent of a fifty-fifty lottery of 2000 pesos (about $30) or nothing. A whopping 80% of the Mapuche show certainty equivalents above the expected value of 1000 pesos, evidencing risk attraction, whereas among the Huinca only 16% display risk attraction. It is interesting to note that the more risk loving Mapuches are considered (both by Mapuche and by Huincas) to be poorer and of lower social status.

They also perform an experiment with three groups of subjects: Mapuche, Sangu (Tanzanian agro-pastoralists) and UCLA undergraduates. They make binary choices between a certain gain of (the equivalent to) $15 and various actuarially fair lotteries of increasing variance. In all three groups, the lottery is preferred by more than 70% of the subjects when the odds of winning are 50% (i.e., the lottery gives $30 with probability 50%), evidencing pervasive risk attraction. When the lottery becomes riskier (say, 20% chance of winning $75, or 5% chance of winning $300), then only 20% of the UCLA undergraduates take the risk, versus at least 65% for the Mapuche and the Sengu. Thus, strong risk attraction seems to be more prevalent among Mapuche and Sangu than among the comparatively better-off UCLA undergraduates.

Finally, empirical work on risk based on surveys taken in developed countries seems to indicate that some socio-economic variables, like earnings, age, sex, employment experience and wealth, have a bearing on risk attitudes, but that these variables can only explain a small amount of the variability in attitudes towards risks, reflecting genuine differences in tastes (see Guiso and Paiella, 2001).[25] In particular, there seems to be limited empirical evidence of the sign of the relationship between risk attitudes and wealth.[26] This enhances the need for further experiments.

10. Conclusions

A fraction of our subjects display risk aversion for all amounts of money at risk, but many do not, displaying risk attraction for small amounts of money, and risk aversion for higher amounts. We compare the likelihood of displaying risk attraction for various amounts of money between the Wealthy and Nonwealthy groups.

The novel finding in our experiment is the higher frequency of risk attraction for large amounts of money at risk in the Nonwealthy groups than in the Wealthy group: Nonwealthy subjects at the higher end of the risk-attraction scale (relative to their fellow Nonwealthy) risk higher amounts, in absolute value and thus, a fortiori, as a fraction of their wealth, than the corresponding risk-attracted Wealthy. On the other hand, and not surprisingly, the Nonwealthy are more likely to display risk aversion for small amounts of money at stake, in agreement with

[25] Willem Saris, in a personal communication, confirms the heterogeneity of risk attitudes observed in a national household survey conducted in Holland for a private investment company. Unfortunately the study that resulted from this survey is private information and cannot be quoted. See also Robert Barsky, F. Thomas Juster, Miles Kimball and Matthew Shapiro (1997) who confirm the heterogeneity of risk preferences.

[26] Halek and Eisenhauer (2001) find a parabolic relation between relative risk aversion and wealth, whereas Donkers *et al*. (2001) a negative relation between income and risk aversion.

the intuition that a given amount of dollars may be seen as “small” by a wealthy person, yet large by a poor one.

We view our work as a first exploration of an important issue. From the empirical viewpoint, because our (statistically significant) result is admittedly based on only a few observations, its robustness should be tested by further experiments with larger samples. Conceptually, our findings that Wealthy subjects take, as a group, more risks when the stakes are low, but fewer when high, suggest a complex relationship between wealth and risk attitudes towards money that invites further analysis.

Appendix. Experimental Data

	Amount of Money						
	500	1000	2000	5000	7500	10000	15000
Subject *AN*	*Y*	*y*	*y*	*y*	*y*	*y*	*y*
Subject *BN*	*y*	*y*	*Y*	*y*	*y*	*y*	*y*
Subject *CN*	*Y*	*y*	*y*	*y*	*y*	*y*	*y*
Subject *DN*	*y*	*Y*	*y*	*y*	*y*	*y*	*y*
Subject *EN*	*y*	*y*	*y*	*y*	*y*	*y*	*Y*
Subject *FN*	*y*	*y*	*Y*	*y*	*y*	*y*	*y*
Subject *GN*	*y*	*y*	*Y*	*y*	*y*	*y*	*y*
Subject *HN*	*y*	*y*	*y*	*y*	*y*	*Y*	*y*
Subject *IN*	*N*	*y*	*y*	*y*	*y*	*y*	*y*
Subject *JN*	*n*	*y*	*y*	*y*	*y*	*n,Y*	*y*
Subject *KN*	*n*	*y*	*y*	*y*	*Y*	*y*	*y*
Subject *LN*	*n*	*Y*	*y*	*y*	*y*	*y*	*y*
Subject *MN*	*n*	*n*	*y*	*y*	*y*	*y*	*Y*
Subject *NN*	*n*	*n*	*y*	*Y*	*y*	*y*	*y*
Subject *ON*	*n*	*n*	*y*	*Y*	*y*	*y*	*y*
Subject *PN*	*n*	*n*	*n*	*N*	*y*	*y*	*y*
Subject *QN*	*n*	*n*	*n*	*n*	*N*	*y*	*y*
Subject *RN*	*n*	*n*	*n*	*n*	*n*	*n*	*N*
Subject *SN*	*y*	*y*	*y*	*n*	*N*	*y*	*n*
Subject *TN*	*y*	*Y*	*y*	*Y*	*n*	*n*	*n*
Subject *UN*	*n*	*n*	*y*	*y*	*n*	*Y*	*n*

Table A1. Nonwealthy subjects. A letter *y* indicates insuring (thus displaying risk aversion), while a letter *n* indicates no insuring (thus displaying risk attraction). Capitals indicate the actual decision implemented. Subject *JN* changed his mind from no insuring to insuring when was confronted with the real choice. In this table, as in a similar table below, subjects have been ordered to help reading the table.

	Amount of Money						
	500	1000	2000	5000	7500	10000	15000
Subject *AW*	*y*	*y*	*y*	*y*	*y*	*y*	*Y*
Subject *BW*	*Y*	*y*	*y*	*y*	*y*	*y*	*y*
Subject *CW*	*y*	*y*	*Y*	*y*	*y*	*y*	*y*
Subject *DW*	*n*	*y*	*y*	*y*	*y*	*Y*	*y*
Subject *EW*	*n*	*y*	*Y*	*y*	*y*	*y*	*y*
Subject *FW*	*n*	*y*	*Y*	*y*	*y*	*y*	*y*
Subject *GW*	*n*	*y*	*y*	*Y*	*y*	*y*	*y*
Subject *HW*	*n*	*y*	*y*	*y*	*y*	*y*	*Y*
Subject *IW*	*n*	*y*	*y*	*Y*	*y*	*y*	*y*
Subject *JW*	*n*	*n*	*y*	*y*	*Y*	*y*	*y*
Subject *KW*	*n*	*n*	*y*	*y*	*y*	*Y*	*y*
Subject *LW*	*n*	*n*	*y*	*y*	*y*	*y*	*Y*
Subject *MW*	*n*	*n*	*y*	*y*	*Y*	*y*	*y*
Subject *NW*	*n*	*n*	*n*	*y*	*Y*	*y*	*y*
Subject *OW*	*n*	*N*	*n*	*y*	*y*	*y*	*y*
Subject *PW*	*n*	*N*	*n*	*n*	*y*	*y*	*y*
Subject *QW*	*n*	*n*	*n*	*n*	*y*	*Y*	*y*
Subject *RW*	*n*	*n*	*n*	*N*	*n*	*n*	*y*
Subject *SW*	*N*	*y*	*y*	*y*	*y*	*y*	*n*
Subject *TW*	*N*	*n*	*y*	*n*	*y*	*y*	*y*
Subject *UW*	*n*	*N*	*n*	*n*	*y*	*y*	*n*

Table A2. Wealthy subjects. A letter *y* indicates insuring (thus displaying risk aversion), while a letter *n* indicates no insuring (thus displaying risk attraction). Capitals indicate the actual decision implemented.

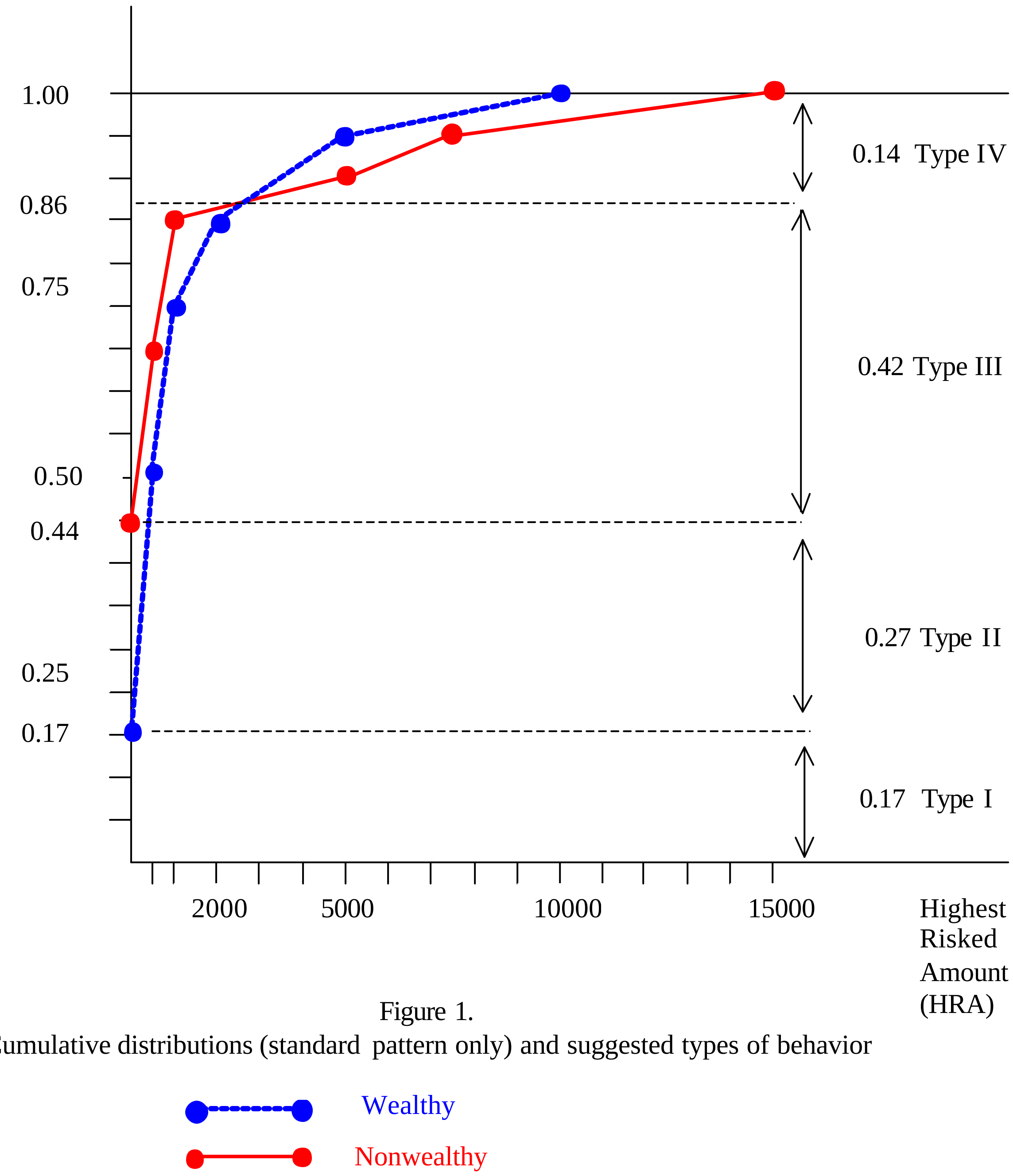

Figure 1.
Cumulative distributions (standard pattern only) and suggested types of behavior

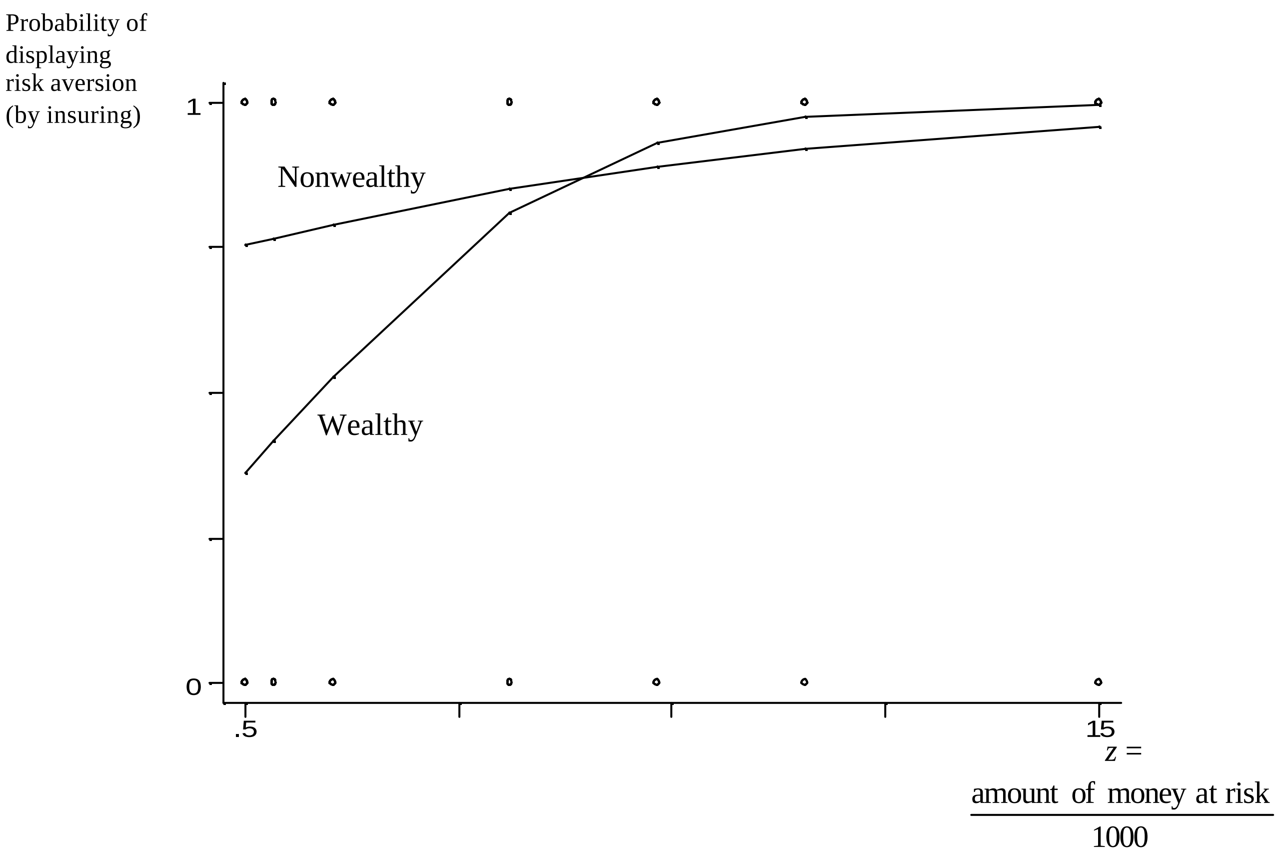

Figure 2. Estimated functional relations between the amount of money at risk and the probability of displaying risk aversion (by insuring it) in Wealthy and Nonwealthy subjects.

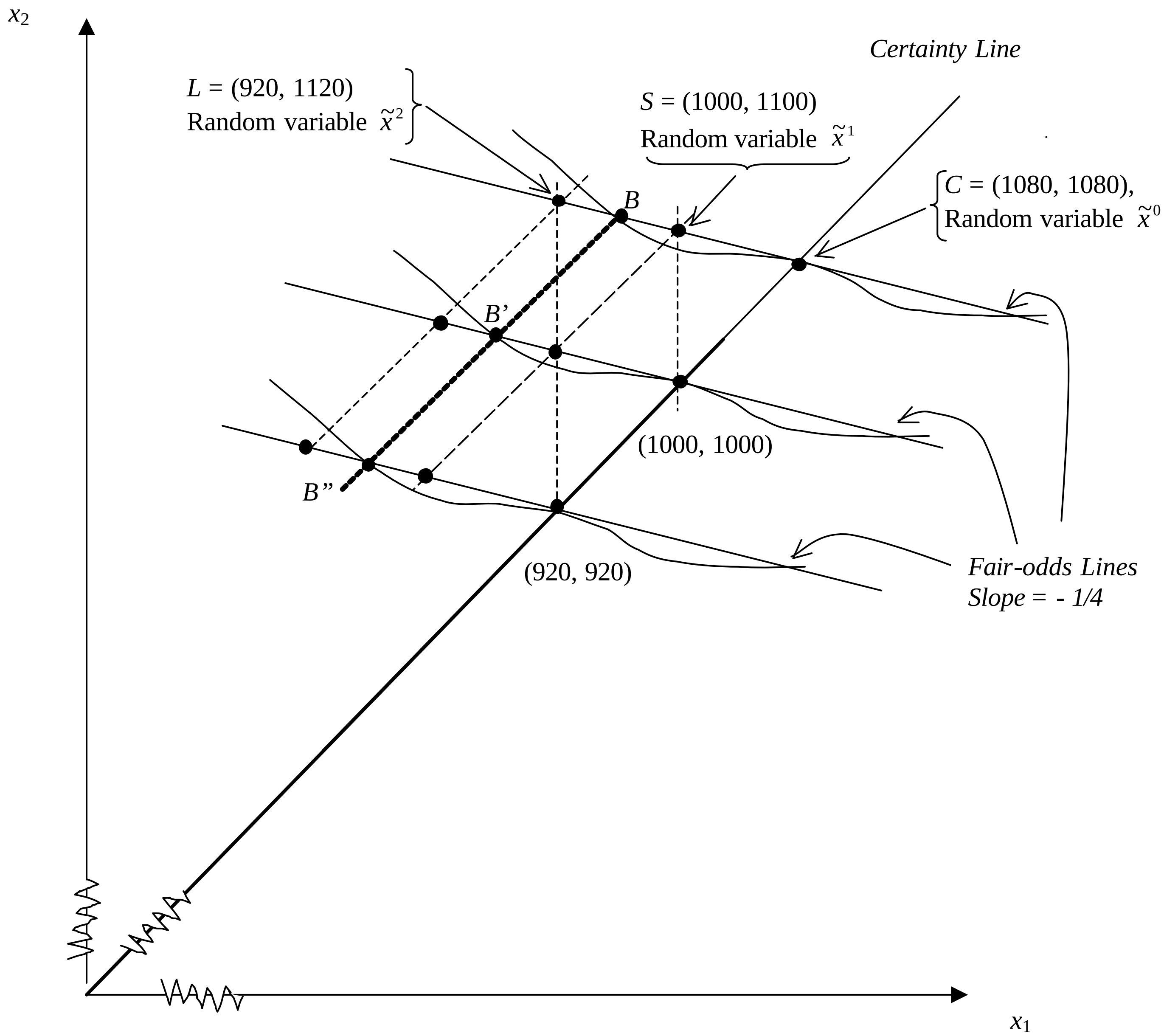

Figure 3.
Consistent indifference curves for small/large dependent attitudes
in the space of contingent balances.
The case of wealth independence.

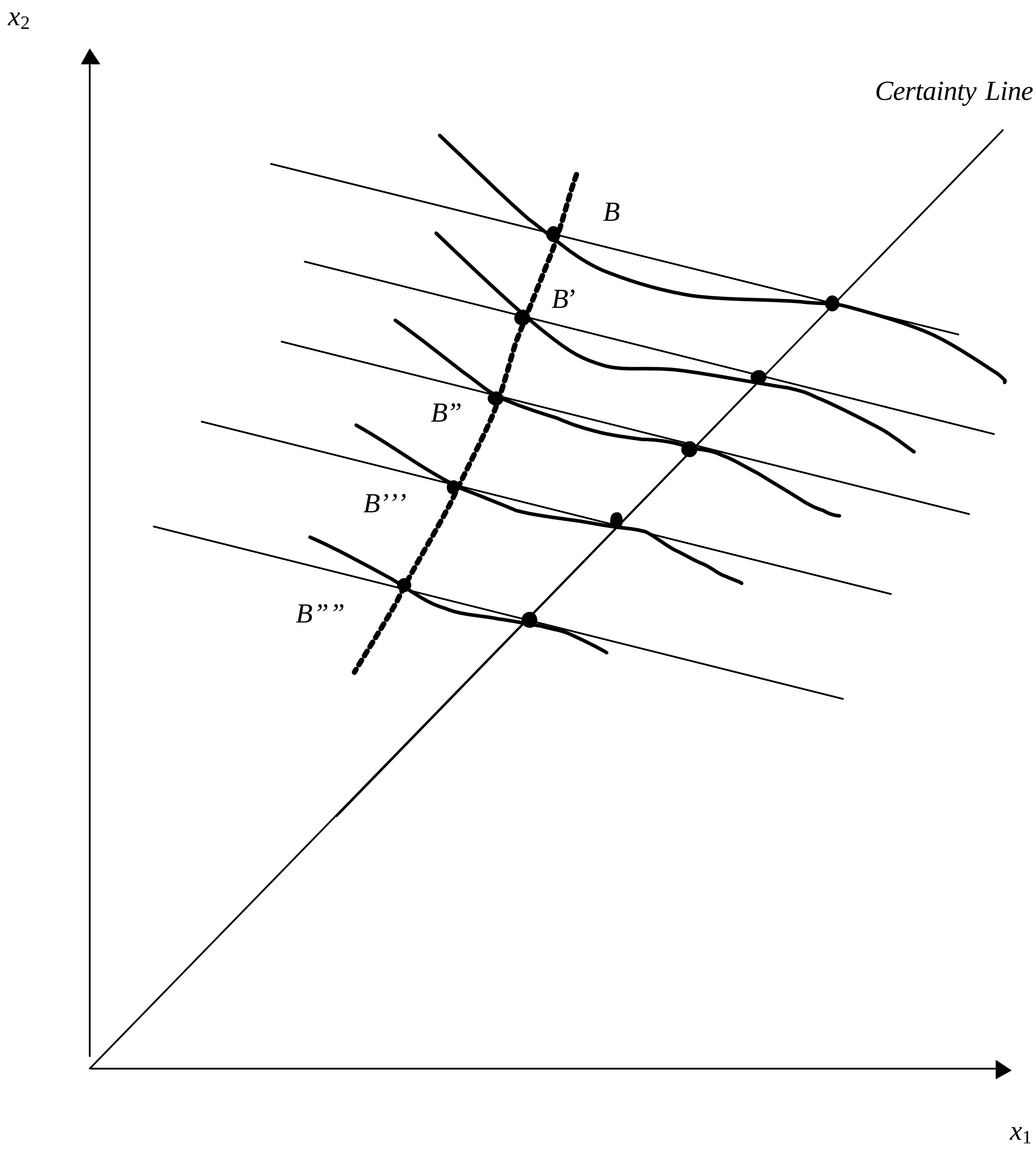

Figure 4.
Consistent indifference curves for amount-dependent attitudes
in the space of contingent balances.
Maximal acceptable risk increases with wealth.

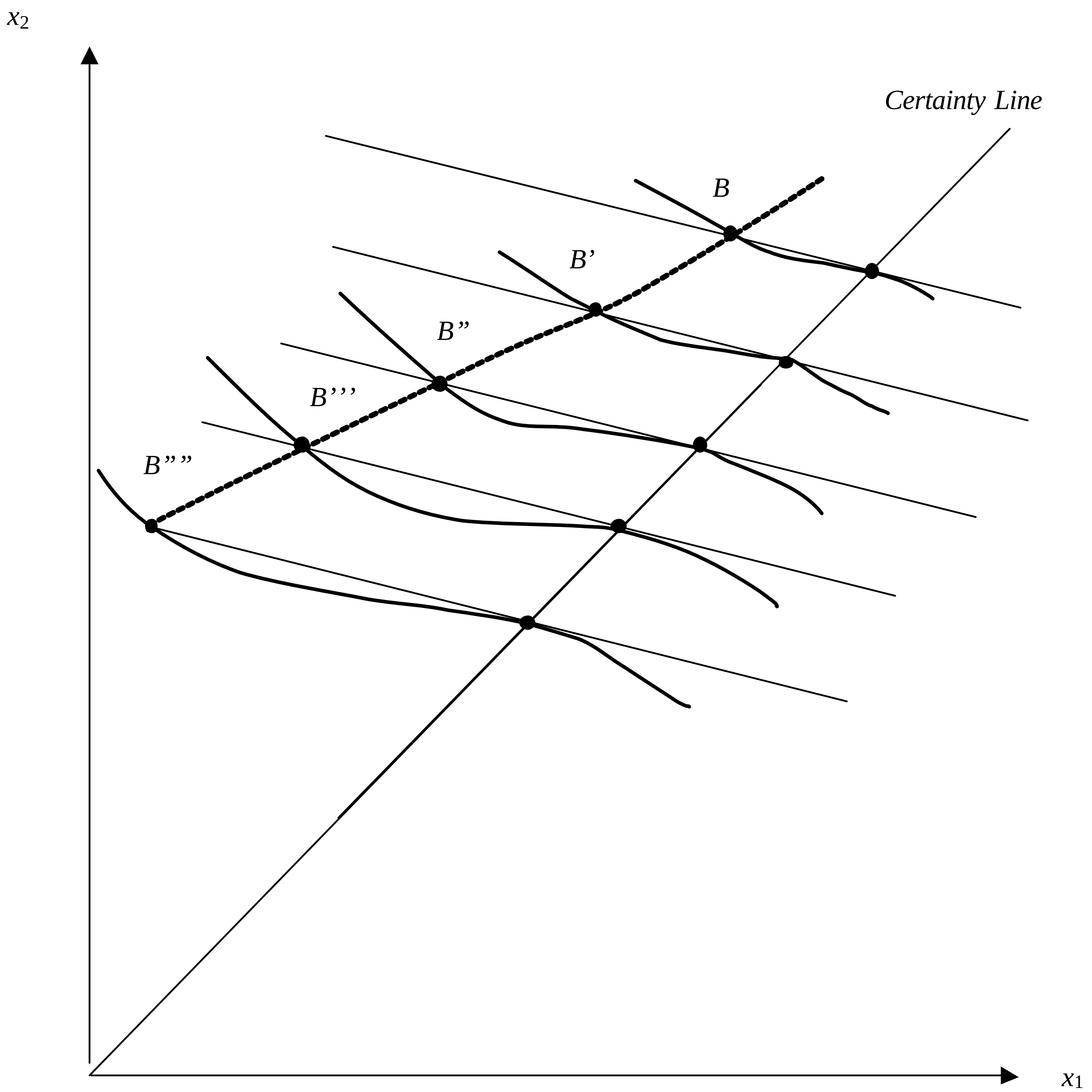

Figure 5.
Consistent indifference curves amount-dependent attitudes
in the space of contingent balances.
Maximal acceptable risk decreases with wealth.

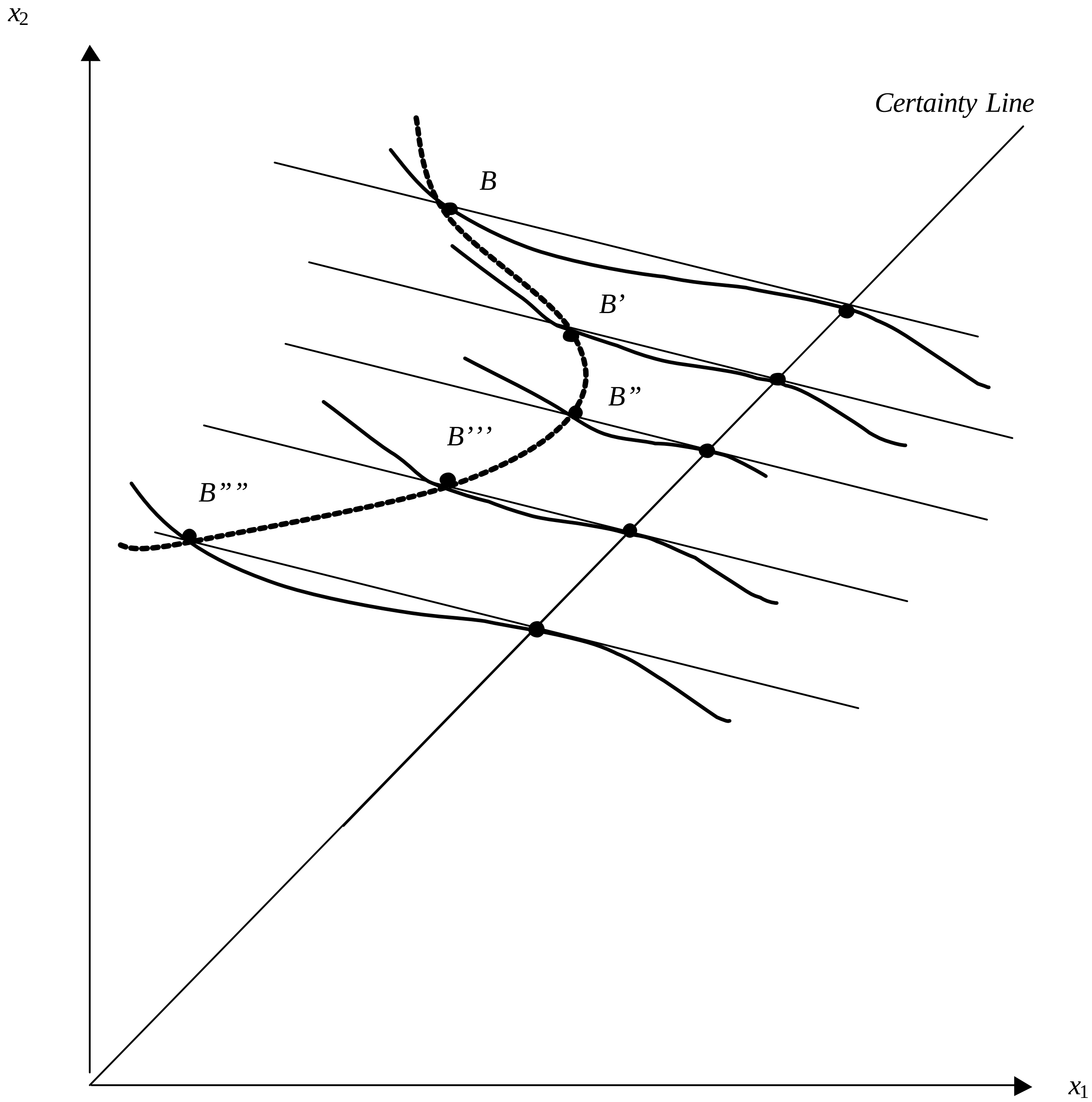

Figure 6.
Consistent indifference curves for amount-dependent attitudes
in the space of contingent balances.
Maximal acceptable risk first decreases and then increases with wealth.

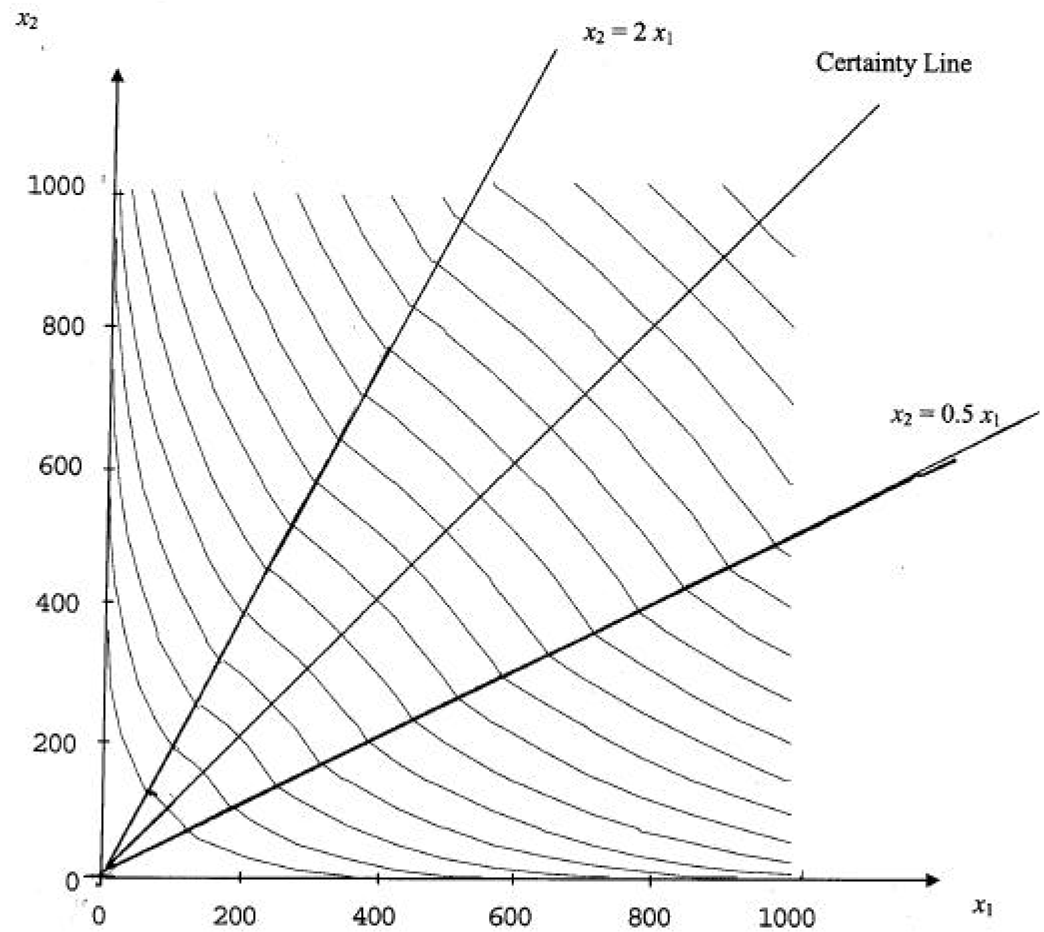

Figure 8
Contour lines of U ($p = 0.5$)
Maximal acceptable risk proportional to wealth

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