

Optimism and Attitude towards Risk*

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Abstract

Conventional wisdom suggests that optimism should be positively associated with risk taking. However, this has hardly been directly tested in the laboratory. In this paper, we report an experiment regarding risk perception and risk taking. Our data supports the hypothesis that two necessary conditions of the uncertain environment for a positive association between optimism and risk taking are (a) pure chance and (b) imprecise probabilities. Our findings bring forth some interesting implications on risk attitude, risk perception and related issues.

Keywords Risk perception, risk taking, pure chance, imprecise probabilities.

JEL classifiers: D80, D81, D84.

1 Introduction

Armor and Taylor (2002) put an intriguing question: *if the majority of human predictions are optimistically biased how can people choose effective courses of action*. Our research is an attempt to answer this question and we conclude that optimism may not be relevant in many forms of uncertainties faced by decision makers. We focus on risk perception, risk taking, and the relationship between them.

Keyes (1985) quotes the following statement by a wirewalker, i.e. a person who does a job that is commonly perceived as extremely risky: “*You can’t be both a risk taker and a wire walker. I take absolutely no risk.*” As this quotation suggests, the preference for objectively defined and subjectively perceived risks may be quite different. In risk perception tasks, one asks people to estimate their subjective probabilities of events (successes or failures) while in risk preference studies, one observes the actual objective risk taken by them.

A robust finding on risk perception is that most people tend to be optimistic when evaluating their own future. That is, comparing to objective criteria, people assign too high probabilities to their attainments of desired outcomes. For example, as shown by Buehler, Griffin, and Ross (1994), people unrealistically underestimate task completion times. Hoch (1985) found that MBA students overestimated various future realizations, such as the number of job offers, magnitude of their first salary, etc. Specifically, research has exhibited the so-called *optimistic bias* – the tendency to judge one’s own risk of a failure as less than the risk faced by others. This tendency has been shown for a variety of events. For example, people typically believe that they are less likely to be victims of auto accidents, crime, etc. (see for example, Helweg-Larsen and Shepperd, 2001).

Surprisingly, little experimental attention has been paid to the relationship between risk perception and risk taking. This is surprising because only from this type of research can we learn, if at all, about the degree of subjectively defined risk an individual prefers. This information can be available only when risk perception and risk preferences are studied in tandem.

Why to study the relationship between risk perception (or optimism) and risk taking? There are both theoretical and empirical reasons to do so. Standard expected utility theory suggests that a decision maker (DM) evaluates a risky situation in terms of utility of outcomes and the corresponding probabilities of these outcomes. For example, consider a lottery with outcomes (or returns) of +10 or -10 with probabilities $\frac{1}{2}$ each. Then, the vNM utility of this lottery is its expected value $u(10)\frac{1}{2} + u(-10)\frac{1}{2}$, where u is the Bernoulli utility function. This formulation does not readily include any role of (subjective) perception of uncertainty. For example, consider a DM who has the same Bernoulli utility function u but perceives, for whatever reasons, these probabilities as different from $\frac{1}{2}$.¹ Clearly, his evaluation of the same lottery is different from the above. Such evaluations of lotteries driven by differences in perception may lead to different choices. Accordingly, there should be a relationship between risk perception and risk taking. This also implies that when people differ in the level of objective risk taking, this difference in behavior may result either from the fact that they perceive the same level of risk (probabilities and hence variance), but some people take the risk while others do not (difference in Bernoulli utilities), or from the fact that for some people a given behavior seems less risky (optimism) than what it may seem to others, while both groups prefer the same level of risk (no difference in Bernoulli utilities). Perhaps this clarifies the above quotation from Keynes.

As far as empirical evidence is concerned, there is a common belief that representatives of some professions, such as mountaineers, entrepreneurs, etc., should have more positive attitudes towards risk than other people. Surprisingly however, laboratory research found that risk propensity in such groups does not differ from other groups. For example, laboratory evidence does not support the claim that entrepreneurs should exhibit higher risk seeking behavior than other people (Buseniz (1999); Brockhaus (1980)). Some claim that entrepreneurs (and may be other similar groups) perceive less risk in the ventures they undertake outside laboratories than others do (Kahneman and Lavallo, (1993)), that is, they overestimate the probability of positive events. However, this claim has been never directly tested, though, there is empirical evidence that entrepreneurs generally perceive their chances for success to be higher than fellow

¹ Davidson et al. (1957) were looking for a binary event with equal subjective probabilities for their experiment. It turned out that simple coin tossing and several other events were not satisfactory for this purpose. Eventually, they constructed a dice containing nonsense syllables Z EJ and Z O J on its sides, and only this met the requirement of equal subjective probabilities. This shows that even for such well-defined trials, subjectivity may have a role to play.

competitors starting a similar business (Cooper, Dunkelberg and Woo (1988)). The natural question that comes up at this stage is: *why this assumed optimism of entrepreneurs works outside laboratories but fails to do so in laboratory experiments?*

Any serious attempt to answer this question requires a deeper understanding of the relationship (if any) between optimism and objective risk taking. Conventional wisdom as well as expected utility theory suggests that optimism, or an *overestimation of the probability of a favorable event*, should lead to acceptance of more objectively defined risk. In accordance with this assumption, some experiments demonstrate that people who had optimistic expectations were more likely to take risk (Harris (1996); Helweg-Larsen and Shepperd (2001)). Findings like these point to a positive relationship between optimism and risk taking. However, in some other research (Taylor et al. (1992)), authors failed to confirm the conjecture that optimistic expectations predict more risky behavior where at times even an inverse relationship turned out to be true. Such contradicting results put in doubt the conventional wisdom that optimism should lead to acceptance of more risk.

Various arguments may be posed against such a relationship. First, one may argue that such a positive association is not obvious since a risk-taker's actions depend primarily on the utility function (or more generally the objective function) that may differ significantly from the standard Bernoulli specifications and expected utility maximization. For example, in the finance literature (particularly since Markowitz (1927)) it is often assumed that naïve decision makers value a risky environment simply by use of two fundamental properties of the uncertainty they face: the mean and the variance of the return. Hence, facing a lottery (x, p) where x is a random variable and p is its probability distribution, such a DM values this lottery by use of a *mean-variance utility function*² of the form $U(x; p) = E_p(x) - a\rho V_p(x)$, where $E_p(x)$ is the expectation operator, $V_p(x)$ is the variance operator under the given probability distribution p , while a is some positive real number and ρ is the measure of absolute risk aversion of the DM which depends on his Bernoulli utility function for money. Hence, a DM with a higher ρ necessarily derives a greater displeasure from the variance of a given return. For such a scenario, one can show that an optimist may indeed end up taking less objective risk than a realist. The intuition is as follows: the act of taking risk for such a naïve DM may be interpreted as an act similar to that of a profit

² It is well known that if the Bernoulli utility function is exponential and the return has a Normal distribution, expected utility maximization is equivalent to mean-variance utility maximization.

maximizing firm that decides upon a costly production level to generate revenue. With such an interpretation of the objective function of the DM, the revenue is the expected return $E_p(x)$ while the cost is the term $a\rho V_p(x)$. Now one may ask the following question: *why would such a naïve DM take risk at all?* The most intuitive answer would be that a DM has a payoff aspiration level and takes risk because he believes that without risk he cannot expect to achieve his target (similar to that of a firm's decisions to incur production costs without which it cannot generate revenues). Indeed it is this idea that underlies the concept of a mean-variance utility maximization rule. Following this argument, an optimist would tell himself: *"I am lucky anyway and will achieve my payoff target, so why take risk?"* while a pessimist would tell himself: *"I am such an unlucky fellow, so how can I expect to achieve my target if I am not willing to undertake enough risk?"*

There is another approach involving income and substitution effects in order to solve this apparent counter-intuitive phenomenon of an optimist taking less risk. There is a large literature that studies the effect of an increase in risk on the portfolio decision of an investor and decomposes such an effect into an income and substitution effect, similar to that of an increase in price of a commodity and its effect on the Marshallian demand (for example, see Hadar and Seo (1992)). In such a scenario, it may happen that the demand for one of the assets that become relatively more risky may actually increase. Typically, the substitution effect of such a rise in risk is negative, but if the measure of *risk aversion* is increasing significantly in the wealth of the investor, the income effect can explode and overshadow the negative substitution effect, leading to a net increase in the demand for an asset that gets more risky.

Finally, another argument to explain this lack of correlation results from the hypothesis that some DMs are *ex ante regret averse* (see for example, Bell (1982) and Loomes and Sugden (1982)). In this approach, it is assumed that the DM has a standard expected utility formulation of the problem excepting that in his valuation of a lottery, he incorporates a numerical value (or disutility) to a fear that is generated from an expected regret that he would experience if a highly risky decision, taken in hope or expectation of gaining a very high return, leads to a loss which he could have averted had he taken a moderate level of risk. In this sense, suppose we look at two DMs who are equally regret averse. Since an optimist has a higher expectation of a favorable

return than a pessimist (or a realist), his regret will be higher in case of an eventual loss.³ This fear may then make an optimist take less risk than a realist.

Second, and more important, a distinction should be made between purely chance-related risks and skill-related risks. In a majority of experimental studies on risk taking, simple lotteries are used where the subject has no control over the outcome - e.g. tossing of a coin. Analysis and behavior in such situations of uncertainty may be quite different from those that depend upon the skill of the subjects (for example, taking part in a competitive quiz). Risk taking in these two types of situations may not be necessarily based on the same principles. For example, people generally seem to be more risk prone in skill-related tasks than in pure chance-related tasks. Benabou and Tirole (2000) implicitly use the distinction between optimism on external uncertainties as against that in personal domains. The DM perceives all his past experiences either as *external*, that is those environments where he believes he had no control over outcomes, or as *internal*, that is those environments where he thinks he had at least some control over the outcomes. Any experience leads a DM to form some belief about future outcomes. Beliefs formed from external experiences result in *belief in luck*, while those formed from internal experiences result in *self-confidence*. Hence, depending upon the DM's perception of the environment as either external or internal, either optimism-pessimism (belief in luck as is understood here) or self-confidence matters. This may imply that "pure" optimism (or belief in luck) may not be related to risk taking in skill-related tasks where self-confidence is more appropriate.

Third, and perhaps most important, optimism is typically measured in a context when there is a lack of well-defined probabilities of various possible outcomes. After all, we do not ask subjects to estimate the subjective probabilities of such events as coin tossing (or other events with precisely specified probabilities) while trying to recover their risk perceptions. In decision theory, the distinction between *precise* versus *ambiguous* probabilities is well established since Ellsberg's (1961) pioneering work on "Knightian uncertainty". For example, consider two urns, A and B. We know that A contains 5 white balls and 5 black balls while we only know that B contains 10 white and black balls but we do not know the exact proportions. One may speculate that subjectivity can hardly be applied to situations like A where probabilities are precisely understood, and hence there is little room for optimism to "flourish". On the other hand, it may be

³ To be sure, by definition an optimist expects that it is most likely that he will not have to regret. However, he also knows that if he does not "tame" his optimism, the size of the regret would be large. The total effect is hence ambiguous and depends upon the degree of regret aversion.

applied to situations like B where probabilities are imprecise. Consequently, one could expect some relationship between optimism and risk taking in situations with imprecise probabilities but not with precisely specified ones.

We conduct two experiments. The preliminary experiment was to test the claim that there are differences in optimism among various professional groups. More exactly, we tested the claim that groups exposed to high risk in their professional activities are more likely to be more optimistic than those who are less exposed to risk. On the other hand, the purpose of the main experiment was to test *under what conditions would one expect a positive correlation between optimism and risk taking?*

The rest of the paper is structured as follows. In section 2 we report and analyze our preliminary experiment. Section 3 is our main section where we first take a closer look at several types of uncertain environments and then describe the main experiment and report our results. The paper concludes in section 4 with some general discussions on the topic and some possible future research proposals.

2 Preliminary research: are some professional groups more optimistic than others?

There are stereotypes concerning risk attitudes across different professions. For example, investors and entrepreneurs are considered to be risk lovers while librarians and lawyers are considered to be risk averse. Such stereotypes, and a process of self-selection, may lead some professional groups to be more risk prone than others in reality. Perhaps it is this that led such economists as Schumpeter or Keynes to presume that entrepreneurs and investors are risk takers. As Warneryd (1988, page 407) put it, “... *there seems to be general agreement that risk bearing is a necessary ... prerequisite for being called an entrepreneur*”. This, along with the conventional wisdom that risk taking and risk perception have positive association, made Schumpeter and Keynes claim that these professionals are more optimistic than others. However, to the best of our knowledge, no direct test of the claim that some professionals are more optimistic than others was conducted.

We conduct our preliminary experiment to check the following three claims that arise from the above discussion:

- a) there are professional groups that take more risk than others;
- b) there are professional groups that are more optimistic than others; and
- c) there is a positive association between level of risk taking and degree of optimism.

2.1 Method

Three target groups comprising of entrepreneurs, financial analysts, and legal advisers (a total of 110 subjects) from Warsaw participated in the experiment.

A questionnaire for testing optimism was constructed. It consisted of 14 items describing different events: *non-personal* (concerning risky problems faced by an enterprise), and *personal positive and negative* life events (for example, answering a series of questions in a quiz, being victimized by burglary, etc.). Responses to each item were made on a 0 to 100 percentage scale. Then, each subject was told that for answering the questions, he/she has earned 300 points that, by the end of the entire experiment, will be exchanged for money (no specification of the exchange rate was given). Finally, individuals were put to tasks in three risky environments, one of which (Task 2) is shown in Table 1 (all numerical entries in the table are in equivalent points). They were to make a choice between alternatives A to F. They were told that once they choose, a coin will be tossed and they would receive the left-hand amounts if heads came up and the right-hand amounts otherwise.⁴

⁴ Our procedure is similar to that in Binswanger (1980).

Table 1: The returns in the benchmark environment (Task 2)

Alternatives	Head	Tail
A	50	50
B	40	100
C	30	150
D	20	200
E	10	250
F	0	300

Two other risky environments were constructed from this one: one that transformed positive returns into negative ones (multiplied by -1 , Task 1), while the other one multiplied the returns by 10 (Task 3). The two risky environments with positive entries shared the property that lower alternatives in the list were associated with higher expected return and higher *variance*, which is *our proxy for a measure of objective risk*. This construction allows one to learn about a decision maker's preferences between risk and return. To this, we included the environment with negative entries in order to check if the domain of decision (that is gains or losses) could affect our findings in any way. The environment with negative entries had the property that lower alternatives had a higher risk but gave the opportunity of a lower loss.

The first risky environment offered to the subjects was with negative entries. The subjects were informed that they could only lose points they already earned for filling the questionnaire. In that sense, they knew that their pre-experiment income could not fall. In the two other environments, subjects could only gain points.

2.2 Results

2.2.1 Probability assessments

No difference in optimism among the three professional groups was found for the four questions concerning non-personal events. Factor analysis was performed on the 10 items of the risk assessment questionnaire using the scores from 110 respondents. Exploratory factor analysis with VARIMAX rotation revealed two factors (Cattell's screen-test). As Table 2 shows, Factor 1 contained *negative personal events*, Factors 2 contained *positive personal events*.

Table 2: Factor loadings of 10 items and the total variance explained. Bolded are the items assigned to adequate factors.

Questions	Factor 1	Factor 2
Q1 – NEG	.313	.433
Q2 – NEG	.273	.406
Q3 – POS	.837	.012
Q4 – POS	.536	.256
Q5 – NEG	-.119	-.847
Q6 – NEG	.144	.366
Q7 – POS	.876	-.072
Q8 – POS	.234	-.419
Q9 – POS	.558	.140
Q10 – NEG	-.029	.803
Total variance	2.330	2.116

For the ten personal events and for the two subsets of positive and negative events, the Cronbach's alphas were calculated. They were equal to 0.64 for the whole set of ten questions,

and to 0.61 for the subsets of positive and negative events. As Figure 1 shows, the average probability assessments over these ten questions involving personal events had a “close to normal” distribution. Thus we can claim that our measure of optimism is quite reliable.

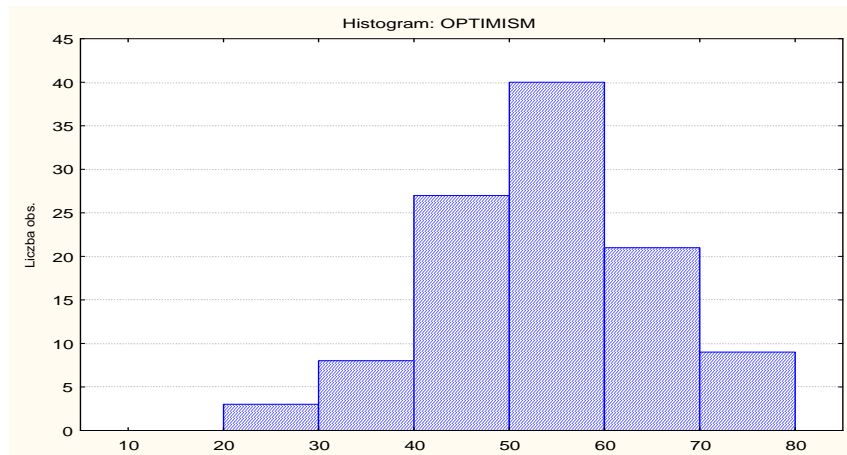


Figure 1: Distribution of the average probability assessments over ten questions

Simple ANOVA applied to these average probability assessments revealed significant effect of the group ($F = 5.423$, $p < 0.01$). As can be seen from Figure 2, the probability assessments of financial analysts were more optimistic than those of the entrepreneurs and legal advisers.

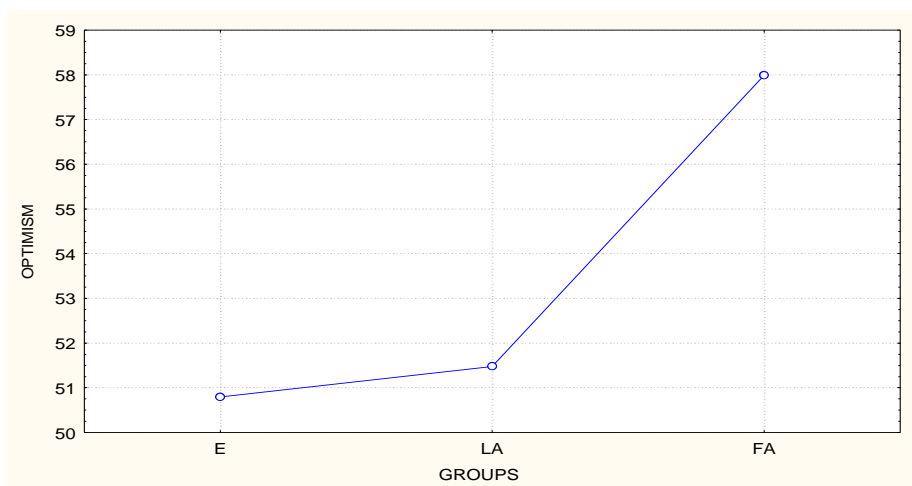


Figure 2: Probability assessments of entrepreneurs (E), legal advisers (LA), and financial analysts (FA).

In turn, 3 (professional groups) x 2 (repeated measures of event-types) ANOVA applied to the probability assessments separately for positive and negative events revealed significant effect of both the group in question ($F = 5.423, p < 0.01$), and the type of events ($F = 87.184, p < 0.001$). The probability assessments of negative personal events were higher than those of positive personal events.⁵ There was also some significant interaction ($F = 12.848, p < 0.001$). Legal advisers, whose assessments of positive events were the lowest, were the most optimistic for negative events although post-hoc analysis (Tukey Test) showed that the group differences in assessments of negative events were insignificant.

2.2.2 Risk taking

Figure 3 compares the average levels of risk acceptance across our three tasks. Since the variance of the alternatives (excepting alternative A) in Task 3 was significantly higher than that in the other two tasks, the y-axis is simply the average rank of the alternatives chosen by the groups in each task. Hence, for each task, alternative A was ranked 1 while alternative F was ranked 5, and so on. As Figure 3 shows, we found no differences among the three groups in the level of objectively defined risk acceptance.

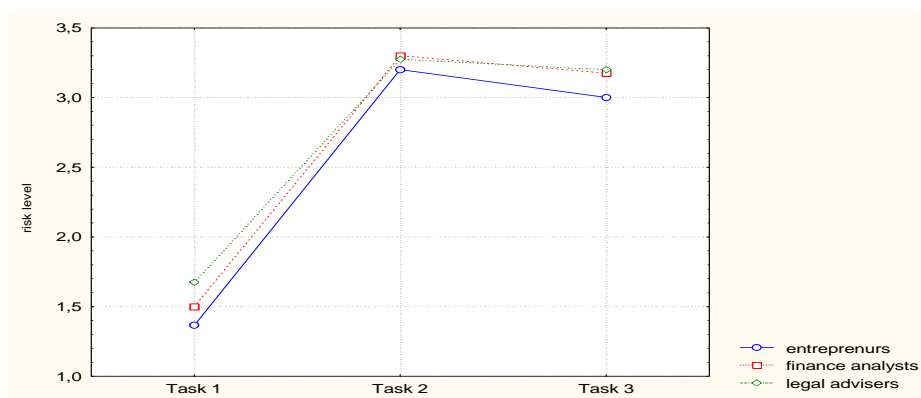


Figure 3: The level of risk acceptance in three tasks in the three groups.

⁵ This is in agreement with some previous findings (Harris (1996); Helweg-Larsen and Shepperd (2001)) that most people reveal the optimistic bias in particular with respect to negative personal events.

The relatively low level of risk acceptance for Task 1 is due to the fact that in case of negative outcomes alternatives with higher risk were also associated with lower expectations. One can speculate that the subjects were in a state of an inner conflict: one hand and in accordance with mean-variance utility theory, they could see no reason to take risk; but on the other hand, and in accordance with prospect theory, they perhaps took some risk to avoid loss. Hence, as we can see, on average they decided to take some risk, but on a rather low level.

Finally, and most importantly, no correlation between the level of optimism in any type of events and risk taking in any of the three choice tasks was found.

2.2.3 Discussion

Summarizing our results from the preliminary experiment, we have the following:

1. no evidence for the claim that groups that, according to the stereotype, are risk lovers actually took more risk;
2. we found a group exhibiting higher level of optimism than other groups; however this group comprised of financial analysts and not entrepreneurs;
3. no correlation between optimism and risk taking was found.

Conclusion 1 is in accordance with some other experiments (Buseniz, 1999; Brockhaus, 1980). The question is why entrepreneurs for whom risk bearing is a *necessary prerequisite*, repeatedly do not take risk in laboratories. As mentioned before, an explanation could be that the nature of uncertainty faced by entrepreneurs in their professional life is different from what they faced in our laboratory. While in our laboratory, we presented to the subjects pure chance-related risky environments, risk faced by entrepreneurs may be described as skill-related. There is no reason why attitude towards risk in these two different environments should be the same. As Shapira (1994) found in his research, top managers who were taking professional risks claimed they would never take purely chance related risk (like gambling).

As far as optimism is concerned (Conclusion 2), we found differences between professional groups. Surprisingly however they were not entrepreneurs who were the most optimistic, but

rather financial analysts. One may wonder that, like in conclusion 1, the answer is related once again to the nature of uncertainty faced by these two professions. Perhaps, skill-related risks faced by entrepreneurs enhance self-confidence and not optimism. On the other hand, financial analysts deal with environments with chance-related tasks and therefore, optimism (belief in luck) matters in their professional activities.

Finally, no correlation between risk assessments and risk taking was found (Conclusion 3). This finding is in disagreement with the conventional wisdom and brings us to our main section. *What can such a lack of correlation mean?* A simple answer is that optimistic beliefs from the perception task may not have been reflected in any over-estimation of the probability of positive events in the second task. Several reasons may be responsible for this. As we will see in the next experiment, the nature of the risky task may be essential for the relationship between optimism and level of risk acceptance. In order to identify them, we conduct experiment 2.

3 Main research: under what conditions would an optimist take more risk?

Two factors seem to be important for the relation between optimism and risk taking. One is the nature of the risky situation; that is, whether the DM perceives the environment as *external* or *internal*. As discussed above, when an environment is perceived as internal, what is important is self-confidence of the DM; that is, whether he considers himself as competent or not in that choice domain. Indeed, Heath and Tversky (1991) showed that in skill related tasks, people were sensitive to their beliefs about their own knowledge. Hence, pure optimism may not be relevant in such types of situations. On the other hand, when an environment is perceived as external, *belief in luck* should influence the DM's choices.

The second important factor for the relation between optimism and risk taking is the DM's knowledge about the probabilities of the uncertain environment; that is, whether the probabilities are precise or ambiguous. If he happens to know exactly these probabilities, there is perhaps no room for applying his optimistic or pessimistic judgments (it would be hard to feel optimistic about the outcome from tossing a coin which you know is unbiased). On the other hand, when it

is vague, an optimist can perceive probabilities differently than a pessimist (that is, being told that there is an urn of unknown proportions of “good” and “bad” balls, an optimist may tend to think that there are more goods while a pessimist would rather feel more comfortable to think that there are more bads).

These two considerations lead us to formulate the following hypothesis:

Hypothesis 1 *Two necessary conditions of the uncertain environment for a DM's actions to exhibit a positive correlation between optimism and risk taking are:*

- (i) *pure chance related risk and*
- (ii) *imprecise probabilities.*

There is a question concerning how to compare risk across two uncertain environments, one with precise while the other with imprecise probabilities. In this paper we use a measure of objective variance under imprecise probabilities that assume that the DM believes all “included” lotteries are equally likely. We provide more on this issue in Appendix A.

3.1 Method

Four groups of students (30 participants in each group) of Warsaw Agriculture University participated in the experiment. First, the same questionnaire as in our preliminary experiment, but reduced to ten personal positive and negative life events, was applied to each subject. Responses to each item were made on a 0 to 100 percentage scale.

Then, the participant was presented a risky choice scenario as shown in Table 3 (all numerical entries in the table are in PLN – Polish currency [1 USD = 3.5 PLN]). He/she was to make a choice between alternatives A to F. However, across the four groups of subjects, different kinds of risky scenarios were employed. They differed in two respects. Skill-related vs. chance-related risks. Chance related risky tasks were constructed by using urns containing white and black balls. Skill related scenarios were constructed by asking each subject general knowledge questions. Another differentiation concerned precise and imprecise specifications of probabilities. The precise chance related tasks were constructed by presenting an urn containing 5 white and 5 black

balls (and of course announcing this proportion). Precise skill related tasks were constructed by telling the subject that he/she will receive a question (to be answered), which was tested in the past and was answered correctly by 50% of his/her colleagues. Imprecise chance related tasks were constructed by presenting two indistinguishable urns, one containing 1 white and 9 black balls while the other containing 9 white and 1 black ball. Prior to any other act in the experiment, the subjects were asked to select one of these urns. Imprecise skill related tasks were constructed by presenting subjects with two questions, informing them that one of them has been selected from an “easy” set of questions (where 90% of their colleagues answered such questions correctly in the past) and the other has been selected from a “difficult” set of questions (where 10% of their colleagues answered such questions correctly in the past). As before, prior to any other act in the experiment, the subjects were asked to select one of these questions.

Thus, our four experimental groups received one of the following risky scenarios:

- (i) Skill-related risk and precise probabilities;
- (ii) Skill-related risk and imprecise probabilities;
- (iii) Chance-related risk and precise probabilities;
- (iv) Chance-related risk and imprecise probabilities.

In each group the participant was told that once he/she chooses the alternative, a trial will be performed according to the nature of the specified uncertainty (that is cases (i) through (iv)), and he/she would receive either the left-hand or the right-hand amounts in PLN as depicted in Table 3 below.⁶

⁶ After some early trials we found that the subjects got involved seriously in the choice tasks only when actual currency was put on the table in front of the subjects.

Table 3: The returns in experiment 2

Alternatives	Unfavorable event	Favorable event
A	10	10
B	8	20
C	6	30
D	4	40
E	2	50
F	0	60

3.2 Results

As in section 2.2.1, the Cronbach's alphas were calculated for the subsets of positive and negative events and for the whole set of ten questions. They equaled 0.61 for both subsets and 0.55 for the entire set of ten questions. Also as in previous research, the level of optimism for negative questions (average value: 47.3%) was significantly higher ($t = 2.219$; $p < 0.05$) than for positive questions (average value: 42.8%).

No significant distributional differences among the four groups in the level of optimism and in the level of risk acceptance (variance of the chosen lottery) were found. This suggests that our four groups were equivalent with respect to our measure of optimism and the level of risk acceptance. This also means that the nature of the risky task did not influence the level of risk acceptance.

However, the male subjects were generally more optimistic than the female ones as their averages were 47 and 43 respectively (and that this difference was statistically significant, $t = 9.812$, $p = 0.05$). Similarly, and in accordance with many other experiments, the male subjects tended to accept more level of risk (average variance = 375) than the female ones (average variance = 327), although this difference was not significant.

Table 4 shows the correlation coefficients between optimism (for all questions and separately for positive and negative events) and risk taking for the four experimental groups. As can be seen, in accordance with our hypothesis, this correlation is significant only for the group taking chance-related risk with imprecise probabilities, and only for all questions and positive events.

Table 4: Correlation coefficients between optimism and risk taking for the four experimental groups

	Skill-related risk and precise probabilities	Skill-related risk and imprecise probabilities	Chance-related risk and precise probabilities	Chance-related risk and imprecise probabilities
All questions	0.17	0.10	-0.26	0.51
Positive events	0.10	0.05	-0.18	0.51
Negative events	0.11	0.10	-0.18	0.33

Moreover, according to Fisher's z test, the correlation coefficient between optimism (for all questions jointly, and separately for positive events) and risk taking is significantly higher for the "chance-related risk and imprecise probabilities" group than for all other groups (all p's are smaller than 5%, except for skill-related risk and precise probabilities for which p equals 8%). Thus, Hypothesis 1 is supported.

4 General Discussion

Our experiment shows that two necessary conditions for a positive relationship between optimism and risk taking are: *pure chance* related risk and *imprecise probabilities*. This means that we should not expect any relationship between optimism and risk taking, for example in case of a

poker player since poker is a skill-related risky task and thus optimism does not matter, but self-confidence may. Nor should we expect any such relationship in case of roulette played by a sophisticated gambler since for such a sophisticated mind, roulette is a purely chance-related risky task with precise specifications of probabilities, and hence optimism does not have a role to play. However, we should expect a positive relationship between optimism and risk taking in case of gambling-machine players since such games are purely chance-related risky tasks and moreover the probability specifications are truly imprecise, and hence the amount of risk taken should depend on optimism. Similarly, in case of roulette played by an unsophisticated gambler, the possible lack of computational ability on part of the gambler transforms a standard interpretation of a game of roulette into a purely chance-related risky task and with imprecise specifications of probabilities, and hence optimism of the gambler should matter.

Similar conjectures in business environments follow from our experimental results. For example, one could expect that in financial markets, where risk is purely chance-related and vague,⁷ a positive attitude towards risk will be positively correlated with optimism. On the other hand, in entrepreneurial tasks where risk is skill-related, no correlation between optimism and the level of risk acceptance should be expected. Indeed, risk taking in entrepreneurship reminds us of the situation studied in an early work by Cohen (1960)). They performed an experiment at a bus drivers' training school. The task was to drive a bus between two wooden posts. The driver first estimated the number of times (out of five) that he would drive through the posts without touching them. Then, actual performance was assessed by asking the drivers to drive through these gaps of a given size five times. One of their main findings was that generally the drivers showed over-confidence, i.e. their assessments of how good their performance would be were significantly higher than their actual performance. In another research Cohen et al. (1958) request the drivers to choose among gaps of different sizes. Among others, they found that drivers who were under the influence of alcohol attempted smaller gaps, i.e. drivers under the influence of alcohol became more risk prone. On the other hand, alcohol had no effect on the self-estimates of likelihood that the driver would successfully drive through a gap of the size that he attempted. Thus, alcohol increased the risk of the bus drivers' actions but had no effect on their estimates of

⁷ We all understand that price trends in stock markets do reflect many attributes of the stock in question and investor sentiments, and that there are several economic indicators from which one may try to predict such trends. However, no matter how much experience and information a DM acquires in this respect, perception of the uncertainty still remains imprecise in such a volatile scenario. Hence we believe that an act of investing in a stock market is associated very closely to a purely chance related task with imprecise probabilities.

risk. The authors do not report whether there was a correlation between the level of risk taken by the drivers and their estimates of risk. However, the result regarding the effect of alcohol suggests that *factors affecting risk preferences need not affect risk perceptions*.

Let us now assume *vNM* expected utility theory (and its extensions to subjective expected utility theory) according to which, choice in a risky situation is a result of preferences and subjective probabilities. It generally follows from this theory that optimism (that is increase in the probability of success) leads to more objective risk taking. Under this theory, our three findings - (a) the lack of differences among the four groups in the level of optimism, (b) the lack of differences in the level of risk acceptance (variance), and (c) the positive correlation between optimism and the level of risk taking – lead us to the following interesting conclusion. Let us first notice that in our two tasks – precise probabilities (P henceforth) and imprecise probabilities (I henceforth) - **for the pessimist**, the imprecise situation should be less attractive than the precise one, since he should believe that chances for a good outcome in I are pretty low. For such a person moving from situation I to P is an attractive change and he can decide for higher level of risk in P than in I. **For an optimist** it is the reverse: for him the imprecise situation should be more attractive than the precise one, since he should believe that chances for a good outcome in I are pretty high. For such a person moving from situation I to P is an unattractive change, and he may decide for a lower risk in P than in I. A surprising conclusion that follows from our research is that *an individual who took low risk in P could only be an optimist, while an individual who took high risk in P could only be a pessimist*. To see this, let us consider a simplification with only two individuals A and B such that in situation P it is observed that individual A takes low risk while individual B takes high risk. Imagine that both these individuals move to situation I. How would optimism and pessimism affect their choices?

To be sure, first let us present the actual distribution of choices in P and I.

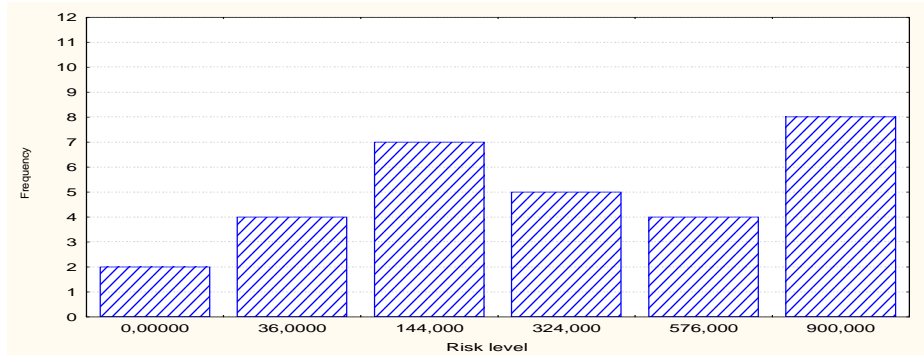


Figure 4a: Frequency of choices of lotteries with different variance in the group facing **precise** probabilities.

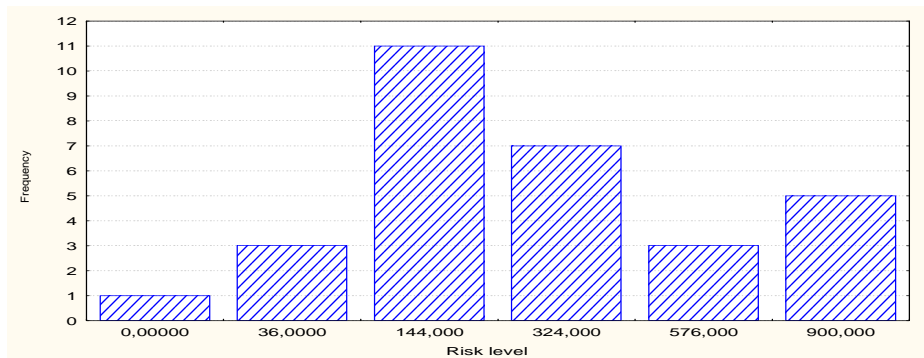


Figure 4b: Frequency of choices of lotteries with different variance in the group facing **imprecise** probabilities.

We rule out any predominance of realistic (or rather, “average”) perceptions because we know that our data exhibited positive association between optimism and risk taking in I. Now, optimists can only increase the risk of their choice while pessimists can only decrease it. However we also found that the distribution of choices across P and I are similar, as shown in Figures 4a and 4b. Now consider table below which depict all possible directions of choice with the set of alternative lotteries being $\{a,b,c,d\}$, with latter lotteries having higher risk and return (as in the case with our actual experiments). Under task P, let A choose lottery b while B choose lottery c . The fact that the distribution of choices across P and I are similar, it must be that the same lotteries b and c are chosen in I, that is neither a nor d can appear.

Now consider the following table that summarizes this observation.

Decision Makers	Choice in Precise task	Perception	Change in choice
A	<i>b</i>	Pessimist	Decrease
	<i>b</i>	Optimist	Increase
B	<i>c</i>	Pessimist	Decrease
	<i>c</i>	Optimist	Increase

But this means that A could not decrease his risk level and so he could only be an optimist. Similarly, B could not increase his risk level and hence he could only be a pessimist. This basic argument can be at least qualitatively extended to cases with more DMs.

Finally, our research also brings forth some open and challenging questions. First, while risk aversion has several measures, not enough work has been done on the issue of measuring ambiguity aversion (with the well known exception of Epstein (1999)), though the existence of this attitude has been time and again established in several experimental studies. Given an ambiguous environment and some observations of actions of two decision makers, can we compare them in any reasonable way in the dimension of aversion from ambiguity? Would such a measure depend, if at all, on the DM's Bernoulli utility function and if so in what way?

Second, and in line with Prospect theory, it is well established that individuals tend to be risk averse in domains of gains but they exhibit risk-loving attitudes in domains of losses. Can such a phenomenon or reversal of attitude be obtained in a reasonable measure of ambiguity aversion? In other words, could it be that individuals are ambiguity averse in the domain of gains but ambiguity lovers in domains of losses, or even vice versa?

Appendix A

Choquet Expectations and ambiguity-neutral variance

Consider the following table that depicts one such ambiguous scenario.

	Gain	Loss
Amount of money	10	- 10
Lottery 1 probabilities	1/10	9/10
Lottery 2 probabilities	9/10	1/10

The uncertain environment depicted above consists of two outcomes, one where the DM receives 10 while the other where he loses 10. He is told that one of the two lotteries depict the true probability distribution but is not informed at all which one. Two questions arise here. First, what is the expected value of the return, and second what is a reasonable measure of its variance and hence risk? In order to answer these questions, we must first formulate the process of belief formation. Suppose there are two decision makers, 1 and 2 and that for whatever reason 1 believes that lottery 1 is more likely while 2 believes that it is lottery 2. Of course 2 is an optimist vis a vis 1. How would such beliefs over lotteries be derived from beliefs over outcomes? One way of approaching this issue is to first compute what are called the *lower probabilities*. These are outcome specific lowest attainable probabilities in the given specification. Hence, the lower probability of gain equals $\min\{1/10, 9/10\} = 1/10$, which is also the lower probability of loss. Lower probabilities reflect the *minimum probabilistic guarantee* of an outcome to occur (that is under this scenario, the probability of the gain or the loss cannot fall below 1/10). If one adds up these lower probabilities across all states and subtracts the sum from 1, what remains is a fraction, in this case equal to $8/10 = 1 - (1/10 + 1/10)$, which is used as a *measure of vagueness* of the scenario (see for example Camerer and Weber (1992)). Notice hence, that higher is the sum of these lower probabilities, lower is the vagueness of the scenario; in fact, if the uncertain scenario has fully precise probability specifications, then this sum is 1 and hence there is no vagueness. The DM has now to decide how to distribute this remaining probability mass equal to 8/10 across the two states, as once this is done it is easy to take expectations for the return. The most well

known expectation operator in this regard is called the Choquet Expectation (as in Gilboa (1987), Schmeidler (1989), Sarin and Wakker (1992)). It suggests that the entire probability mass of vagueness should be assigned to the worst outcome (here a loss of -10). In that sense, the Choquet expected utility (CEU) of the above scenario is $10(1/10) + (-10)(1/10) + (-10)(8/10) = 10(1/10) + (-10)(9/10)$. Observe that the right hand side of the above equation is simply the standard expectation under lottery 1. Indeed, one may formulate and use more general expectation operators. This is done in Roy and Sen (2005) where the volume of vagueness ($8/10$) is distributed according to a more general weighting scheme. For example, another type of DM could assign this entire vagueness of the environment to his most preferred outcome, resulting in this example to an expected value of $10(1/10) + (-10)(1/10) + (10)(8/10) = 10(9/10) + (-10)(1/10)$ and so on.

Having established a reasonable process of belief formation and appropriate expectation operators, the issue of computing variance is a ready consequence of applying the standard notion of variance.⁸ In our measure of variance, we use what we call *ambiguity-neutral variance* that comes from a belief formation process where the amount of vagueness in the environment is distributed uniformly across all states. With such an approach in measuring variance in ambiguous environments, the task presented in the above table becomes risk equivalent to the same task where 10 and -10 occur with equal probabilities.

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⁸ To be sure, we admit that the concept of variance in ambiguous situations may be addressed independent of the notion of expectations. There is no such approach so far in the literature and the issue is beyond the scope of our current research.

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