5 On The Correlated Impact Of The Factors Of Risk Aversion On Decision-Making

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Risk aversion is among the most advertised and complex factors influencing a decision, but it is itself subject to an intricate complex of both objective and subjective factors. The present paper set out to investigate some of the factors that would have appeared obvious in influencing attitudes towards risk, such as value of options, probability of options, level of information (specifically on probability) and position of the respondent relative to the outcome of the risk (loss or gain). For this purpose we devised a survey testing each of these elements and allowing for interpretation of their interdependence. After analyzing hypothetical situations, we also investigated how these were reflected in self-assessment and real-life behavior. What we found is that, although these factors do play their intuitive role in fundamenting decisions in contexts of risk, they are ill correlated to one another and may themselves not be coherent across different contexts.

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Introduction

Risk aversion is among the most advertised and complex factors influencing a decision. Indeed, attitude towards risk lies at the border of

objective and subjective criteria in analyzing a decision – while some elements such as probabilities, associated values, and other context-specific features remain objective, the decision-maker's inclination towards a gamble cannot be fully accounted for through abstract economic modeling. The present paper seeks to investigate some of the factors that may explain risk aversion; the investigation does not treat factors independently, but in relation to one another in order to observe the overview that may be created from their joint influences, and indeed if a comprehensive formal model incorporating part or all of these factors would be pertinent.

Since Pratt [1] and Arrow [2] introduced the concept of risk aversion, various researchers have investigated some of the implications risk aversion may have on decisions and some of the implications other factors may have on risk aversion. MacCrimmon and Wehrung [3], for instance, observed how demographic and social characteristics of executives influenced their risk-taking behaviour, while Weber and Hsee assessed cross-cultural perceptions and attitudes towards risk [4]. Halek and Eisenhauer also concluded as to how a range of demographic factors influenced the willingness of the population to take on pure and speculative risk [5]. Roth and Kroll have even attempted to explain the relationship between two personal characteristics such as gender and religiosity through the intermediary of risk aversion – the hypothesis tested was that women are generally more risk-averse, and being religious prevents the risk of some "divine punishment", and hence women's increased religiosity may have been explained by their relatively increased risk aversion [6]. Although their research concluded that "risk preference is not the mechanism that produces women's generally higher religiosity", the study opened up the perspective of partial causality of one personal characteristic of the decision-maker over another.

The testing tool

We devised a questionnaire that tested a series of specific attitudes related to risk. As prescribed by MacCrimmon and Wehrung [3], we sought to define risk attitude by three measures:

1. Measures derived from behavior in hypothetical situations
2. Measures derived from natural behavior

3. Measures derived from self-assessment, or "self-reported attitudes toward risks"

Measures derived from behavior in hypothetical situations

This is typically the researcher's ground, where different scenarios can be imagined depending on the factors or hypothesis that want to be tested. In risk-taking situations, we separated the following factors that enter into the equation:

- Value of the expected outcome of the risky situation, or stakes
- Probability associated with the risk
- The measure in which this probability is either known (or can be calculated) or unknown, meaning whether the situation is actually one of risk or uncertainty
- The nature of the risk as either pure or speculative, meaning whether the decision-maker is placed in a situation where he/she stands to either loose or gain should the risk materialize, in the first case, and not materialize in the second.

Admittedly, one additional factor among those most apparent to influence risk-taking decisions is the involvement of others, in other words whether the consequences of the risk are to be borne by the decision-maker alone or if there are a number of different stakeholders affected to different degrees. While the latter scenario seems more widely-spread in real-life interwoven and complex issues, this is a self-standing debate of its own, concerned with ethics, negotiation, and virtually every field of study involved with human interaction. We shall therefore concern the present paper with the more straightforward factors listed above and leave the impact on others as a subject for further research.

A first set of questions tested whether respondent's willingness to gamble was influenced by the stakes of the gamble. The first question was a simple risk-aversion one: the respondent had to choose between a certain prize of 10 €, a gamble with 50% chances of gaining 10€, 25% chances of gaining 20€ and 25% chances of not gaining anything and another gamble with 50% chances of gaining 20€ and 50% chances of not gaining anything.

The second question was identical with one difference: the sums of money involved were a thousand times greater.

In order to test calculation of probability, we used a restatement of the Saint Petersburg paradox [7]. A coin is tossed until the "tails" face appears, ending the game. If the "tails" face appears on the first toss, the player receives 1 coin, and then the payoff doubles each time the "heads" face appears (if the "tails" face appeared at the second toss, the player would receive 2 coins, if it appeared after the third toss, he/she would receive 4 coins and so forth). To add a dimension of risk to the story, we also introduced a price that the player pays not for entering the game as in the original version, but for each toss of the coin. If the game had a "fixed fee" for playing, then this would act as a break-even point and in marking the number of tosses the coin would have to make in order for the game to be profitable. Although the "price per toss" acts in a similar way, its perceptual impact may be greater in that it distorts respondent's sense of what the break-even point actually is, on one hand, and it may create a sense of risk perceived for each toss, on the other hand, although analysis dictates that the break-even principle still applies.

The influence of probability was more specifically tested in a set of choices between certain and risky outcomes. Suppose three boats carrying cargo of 10.000€ each were shipwrecked at sea. In the first question, the decision-maker had to chose between a full-proof plan to save the cargo on one of the boats, worth 10.000€, and a plan with one out of three chances to salvage the whole 30.000€ cargo and two out of three chances to not salvage anything. In the second question, the decision-maker had to chose between a full-proof plan to save the cargo on two of the boats, worth 20.000€, and a plan with two out of three chances to salvage the whole 30.000€ cargo and one out of three chances to not salvage anything. In both questions, the expected value of two alternatives is the same.

In order to test aversion towards uncertainty, we used another paradox, namely the Ellsberg paradox [8] where respondents have to chose between two gambles – one whose odds they know and one whose odds they don't know. The scenario tells of an urn in which there are 90 balls – 30 red and 60 of other colors, black and yellow. One ball is extracted from the urn. In the first question, the respondent has to choose between a gamble where he/she is awarded a prize if the ball extracted is red and a gamble where

he/she is awarded a prize if the ball extracted is black. In the second question, the respondent has to choose between a gamble where he/she is awarded a prize if the ball extracted is either red or yellow and a gamble where he/she is awarded a prize if the ball extracted is either black or yellow. In the first choice, the probability of the first alternative is obviously 33%, as in the second choice the probability of the second choice is 67%. However, the probabilities of the remaining two alternatives are unknown and depend on the ratio between black and yellow balls. If the respondent assumed that there are more yellow balls then there are black, then the number of black balls would be less than 30 and therefore he would bet on the red instead of the black ball in the first gamble. Similarly, this assumption entails that there are more than 30 yellow balls, therefore there are more than 60 red and yellow balls, and he/she would therefore bet on the first gamble in the second question as well. If the assumption was opposite, meaning that there are more black balls that there are yellow, then the other set of alternatives would be preferred, as shown in Table 1 below. The Ellsberg paradox states that actual decision-makers choose those alternatives whose odds they can measure, therefore making a suboptimal choice regardless of the distribution between black and yellow balls.

Table 1: The Ellsberg Paradox

	Option 1	*Option 2*	*Options chosen under the assumption that there are more black balls then yellow*	*Options chosen under the assumption that there are more yellow balls then black*	*Options chosen out of uncertainty aversion under the Ellsberg paradox*
Choice 1	Prize if the ball drawn is red	Prize if the ball drawn is black	Prize if the ball drawn is black	Prize if the ball drawn is red	Prize if the ball drawn is red
Choice 2	Prize if the ball drawn is	Prize if the ball drawn is either	Prize if the ball drawn is either black	Prize if the ball drawn is either red or	Prize if the ball drawn is either black

	either red or yellow	black or yellow	or yellow	yellow	or yellow

Measures derived from natural behavior

To categorize natural behavior, we chose two particular instances; the level of insurance was a measure in the same time at-hand, relevant and easily quantifiable. As a second measure we chose to look into respondents' working environments and the manner in which it either fosters individual responsibility or imposes measures to minimize risk through standardized rules, procedures, authorizations and strict hierarchical roles and responsibilities. The working environment is a measure that works both ways for two categories of decision-makers: if the respondent is in a managerial position high enough up the hierarchical ladder, than he/ she has enough authority to significantly influence daily operations at the workplace. He/she would therefore be the one to have determined the manner in which the organization, branch or department in the organization deals with risk; the working environment would therefore be an accurate reflection of the respondent's own approach towards risk. If, on the other hand, the respondent is in a specialist or execution position with little impact on corporate culture, then his/ her choice of profession and workplace may be seen as corresponding to the respondent's preferred attitude towards risk – it may be said that a person inherently risk-avert would feel uncomfortable as a stock broker, just as an entrepreneurial risk-seeker would feel ill at ease in a job of insurance actuary or accountant.

Measures derived from self-assessment

For self-assessment, respondents were asked to frame their behavior in the face of risk according to three standards: avoiding risk, managing risk and taking risk. To put the respondents more at ease and to provide them with a more tangible understanding of the types of attitudes referred to, the question was formulated in more descriptive terms: "Which of the following characterizations would best describe you: I prefer clear situations and I generally avoid risk / I generally take the necessary measures to insure

against risk / I consider it worth to assume the risks associated to opportunities."

The questionnaire was available in off-line and on-line format and was distributed to professionals in management consulting, researchers in the economic field as well as professionals in the financial industry. These segments were chosen as likely to poses significant formal and practical knowledge in the art of decision-making. The analysis below was done based on a number of 120 answers.

The results

Consider the problem of salvaging the cargo of sinking vessels. When faced with the issue of choosing between a sure gain and a gamble, the chances of a gamble seemed to have been a less important factor in the decision namely:

- a majority of 65% chose the safe alternative, regardless of the gamble's chances for success
- another 17.5% chose to take the risk, also regardless of the gamble's chances for success, as shown in Table 2 below
- only 12.5% chose to take the safe alternative for a small probability that the gamble will play out and the risky alternative if the probability looks encouraging. This percentage is of all the smaller importance considering that
- 5% of respondents chose a rather counter-intuitive course of action: take the risky alternative when it has little chances of success and take the certain alternative when the risky one would have had large chances of success. From a contextual point of view, these respondents may have viewed the sure gain associated to the advantageous gamble as sufficient, and may not have wanted to risk it for a chance of gaining 50% more; on the other hand, they may have considered the sure gain associated to the risky gamble as unsatisfactory, and therefore they would have been willing to try a course of action, be it a risky one, that could have improved the outcome by 200%.

Table 2: Percent of respondents choosing certain or risky alternatives depending on the probability associated with the risk

Chosen option		Choice between a certain option and a risky one with low chances of success		***Total***
		safe	*risky*	
Choice between a certain option and a risky one with high chances of success	*safe*	65.0%	5.0%	*70%*
	risky	12.5%	17.5%	*30%*
Total		*77.5%*	*22.5%*	*100%*

A first interpretation would seem to indicate that the choice to gamble is primarily guided by one's inherent availability towards risk and only secondarily by the actual chances of the gamble's chances of success, or, in other words, that the availability or inclination towards risk pertains to the decision-maker's person rather than the actual chances he/she has of overcoming the risk. A moderate degree of correlation between availability towards risk in conditions of high and respectively low probabilities – corresponding to a correlation coefficient of 0.562 – supports the claim that most of those willing and unwilling to gamble pay little attention to odds (1).

An argument in this respect may be that a slight correlation may only be observed between availability to enter the modified version of the Saint Petersburg game and availability to play a high-probability gamble against a certain gain: those willing to play the Saint Petersburg game are more likely to prefer a high-probability gamble then to accept a certain gain. This correlation does not however extend to playing a low-probability gamble. Admittedly, this modified version of the Saint Petersburg game only yields results if the coin is tossed at least four times, as shown in the following pay-off calculation.

The sum gained if the coin is tossed for n times is $E(n) = 2^{n-1} - 2n$. If $n \geq 3$ then $E'(n) = 2^{n-1}ln2 - 2 > 0$ and therefore $E(n)$ is an increasing function of n.

$E(1) = 1 - 2 = -1$

$E(2) = 2 - 2*2 = -2$

$E(3) = 4 - 3*2 = -2$

$E(4) = 8 - 4*2 = 0$, and henceforth the gain $E(n)$ increases in value.

So in order for the player to have an actual gain, the coin has to be tossed at least 5 times, meaning that the "heads" face needs to appear at least 4 times, and the chances of that are $\left(\frac{1}{2}\right)^4 = 6.25\%$.

The expected gain E is

$$E = \frac{1}{2}(1-2) + \frac{1}{2^2}(2-2) + \frac{1}{2^3}(2^2-2) + \cdots + \frac{1}{2^n}(2^{n-1}-2)$$

$$E = \frac{1}{2}(1+1+1+\cdots) - \left(1 + \frac{1}{2} + \frac{1}{2^2} + \cdots\right) = \lim_{n\to\infty}\left(\frac{n}{2} - \frac{\left(\frac{1}{2}\right)^{n+1} - 1}{\frac{1}{2} - 1}\right) = \infty$$

In words, the sum a player may win is infinite, but the chances of actually winning anything are slim. Despite this, 35% of respondents would still have chosen to participate in such a game. This is not, however, the same 35% that would have chosen either one or both risky gambles as opposed to sure gains, as detailed in Table 4 below. For ease of expression we will employ a system of codes for the various combination of options available in the cargo problem, as shown in Table 3 below. Let "s" mark the preference for the safe, or certain alternative and "r" the preference for the risky one in the question of salvaging cargo analyzed above. "L" would be the code for the choice involving a risk with low chances of success and "h" would code the choice involving a risk with high chances of success.

Table 3: Coding of the set of options available in the cargo problem

Code used	Choice between certainty and a risk	
	safe	risky

Choice between certainty and a risk with high chances of success	safe	ls-hs	lr-hs
	risky	ls-hr	lr-hr

Table 4: Correlation between answers to the cargo problem and answers to the Saint Petersburg game (percent of respondents)

		Set of options chosen in the cargo problem				***Total***
		ls-hs	*ls-hr*	*lr-hs*	*lr-hr*	
Willingness to participate in the Saint Petersburg game	*Yes*	17.5%	7.5%	0.0%	10.0%	*35.0%*
	No	47.5%	5.0%	5.0%	7.5%	*65.0%*
Total		*65.0%*	*12.5%*	*5.0%*	*17.5%*	*100.0%*

The only correlation that can be observed here is that, if one chose a high-probability gamble over a safe gain, then one may be somewhat more inclined to participate in a game with huge possible gain, but insignificant odds of success. 47% of respondents, however, chose to neither participate in a Sankt-Petersburg game nor engage in a gamble, regardless of its odds, over a certain gain. Again, one can observe some remote consistency of risk-taking behavior, but unrelated to probability of gain. For instance:

- The majority of those choosing a certain gain if a gamble had little odds and a gamble if it had high odds still chose to participate in the Sankt Petersburg game – if considerations of probability were the determining factor in their choice, they would have dismissed a game with such little chances of success as 6.25%.
- In reverse, all of those choosing a gamble when it had little odds and a certain gain over a high-probability gamble chose to decline the Sankt Petersburg game, despite it actually being a high-stake gamble with little odds much their initial choice.

The conclusion therefore stands that probability was not the driver of their choice, but rather contextual reasoning (2). In the first scenario, respondents were told that the certain option was to salvage 33% of the

value and loose 66% of it – this unsatisfactory perspective might have caused respondents to seek an alternative, however risky, rather than some form of urge to face the odds. Considering that, when the certain alternative improved, they no longer sought the gamble, it can be concluded that this group only appealed to the risky option as a chance to improve an already dire situation.

Another argument is that the responses to the Ellsberg paradox are also uncorrelated to risk-taking in situations of either low or high chances: 40% of respondents fell into the trap of the Ellsberg paradox, but this percentage is maintained throughout all four groups of respondents to the questions of probability-related risk, as shown in Table 5 below.

Table 5: Correlation between risk versus certainty choices in situations of loss (the cargo problem) and gain (percent of respondents)

		Set of options chosen in the cargo problem				***Total***
		ls-hs	*ls-hr*	*lr-hs*	*lr-hr*	
Set of options chosen in stakes preference	Safe is low stakes, safe if high stakes	27.5%	5.0%	0.0%	7.5%	*40.0%*
	Risky is low stakes, safe if high stakes	10.0%	5.0%	0.0%	2.5%	*17.5%*
	Safe is low stakes, risky if high stakes	25.0%	2.5%	5.0%	5.0%	*37.5%*
	Risky is low stakes, risky if high stakes	2.5%	0.0%	0.0%	2.5%	*5.0%*
Total		*65.0%*	*12.5%*	*5.0%*	*17.5%*	*100.0%*
Percent of respondents who fell into the Ellsberg paradox		42.3%	40.0%	0.0%	42.9%	*40%*

Interestingly, 42% of those who would take the gamble if they knew the odds, whether high or low, would prefer the safe alternatives in a context of uncertainty, where they would have to make presumptions as to the odds of an event. It can be therefore concluded that aversion towards uncertainty biases the decisions of risk-averts and risk-takers alike; it is not necessarily associated to risk aversion and it is therefore not a bias that can be suspected particularly among risk-averts (3).

Finally, when asked straight-forward whether they would prefer a certain gain or a gamble in two scenarios of various stakes, neither of the answers provided correlated with the answers in the situation of choosing between losses rather than gains, even if the general framework is basically the same, as the correlation coefficients in Table 6 below outline (4).

Table 6: Correlation coefficients between availability to gamble in situations of loss (the cargo problem) and gain

	Willingness to risk when the chances of success in the cargo problem are low	Willingness to risk when the chances of success in the cargo problem are high
Availability to risk if the stakes are low	-0,087	0,076
Availability to risk if the stakes are high	0,242	0,252

To sum up,

- Most of those willing to gamble would pursue this urge regardless of odds for success (1)
- The context of the gamble may have a larger influence over the decision to participate then the odds for success (2), (4)
- Aversion towards guessing probabilities or odds for success are uncorrelated to willingness to pursue risk (3)

It can be therefore stated that actual probabilities associated with risk are secondary factors when taking a decision involving risky options, and not a determinant argument.

We will then look into the other aspect in calculating expected value – the stakes, or actual values involved:

- 42.5% of respondents would still choose the safe alternative as opposed to the gamble whether the values involved are high or low
- 32.5% of respondents would be willing to gamble if they stand little to gain from a certain option but would rather settle for a certain high gain then to risk it against equal odds of winning even more or of not winning anything
- another 20% would gamble whatever the odds, and finally
- 5% would gamble if the stakes are high but chose the safe gain if the stakes are low.

A correlation coefficient of 0.318 indicates to a certain disposition to adopt the same attitude towards risk whatever the value of the gain involved – the majority of 62.5% either chose safe or chose to gamble regardless of the stakes. So while this factor may play a small role in the decision (as indicated by the 32.5%), it is still not decisive.

Table 7: Correlation of willingness towards risk in situations of high and low stakes (percent of respondents)

		Degree of risk assumed in a situation of high stakes			***Total***
		low	medium	high	
Degree of risk assumed in a situation of low stakes	low	42.5%	2.5%	2.5%	*47.5%*
	medium	17.5%	7.5%	0.0%	*25.0%*
	high	15.0%	5.0%	7.5%	*27.5%*
Total		*75.0%*	*15.0%*	*10.0%*	*100.0%*

A final part of the analysis investigates the correlation established between measures derived from behavior in hypothetical situations, measures derived from natural behavior and measures derived from self-assessment, or "self-reported attitudes toward risks". Surprisingly, correlation coefficients indicate no such link between self-assessment,

assessment of real-life behavior and answers to the hypothetical questions. Two exceptions do occur: a correlation coefficient of 0.321 between self-assessment and the answer to the cargo problem is the instance of low chances for the risky alternative to succeed, meaning that people who view themselves as risk-taking may act out of desperation when faced with loss and choose a highly risky alternative over an unsatisfactory certain outcome. This lack of correlation proves rather disconcerting for the coherence of efforts in the study of attitudes towards risk and points to a need for thorough investigation of the drivers underlying responses to risk.

Conclusions

We set out to investigate some of the factors that would have appeared obvious in influencing attitudes towards risk, such as value of options, probability of options, level of information (specifically on probability) and position of the respondent relative to the outcome of the risk (loss or gain). What we found is that, although these factors do play their intuitive role in fundamenting decisions in contexts of risk, they are ill correlated to one another and may themselves not be coherent across different contexts. The construct of a complicated formal model of risk-taking based on such variables would therefore not capture well enough the complexities of real-life processes. Most interestingly, there appeared to be no significant correlation between measures derived from behavior in hypothetical situations, measures derived from natural behavior and measures derived from self-assessment. The factors driving reactions to risk can therefore be supposed to be greatly dependent on the decision-maker him-/herself rather than objective criteria; there is therefore room for research seeking what prompts us to react so differently in various issues involving risk.

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