City University of New York (CUNY)
CUNY Academic Works

International Conference on Hydroinformatics

2014

Exploring Behavioral Economics Concepts In Flood Forecast Decision-Making Under Uncertainty

Leonardo Alfonso

Schalk-Jan Van Andel

How does access to this work benefit you? Let us know!

More information about this work at: https://academicworks.cuny.edu/cc_conf_hic/305
Discover additional works at: https://academicworks.cuny.edu

This work is made publicly available by the City University of New York (CUNY).
Contact: AcademicWorks@cuny.edu

EXPLORING BEHAVIORAL ECONOMICS CONCEPTS IN FLOOD FORECAST DECISION-MAKING UNDER UNCERTAINTY

LEONARDO ALFONSO (1), SCHALK JAN VAN ANDEL (1)
(1): UNESCO-IHE, IWSG Department, Hydroinformatics Chair. Westvest 7 2611AX Delft, The Netherlands

This research presents the preliminary results of an ongoing research that further explores the results obtained during the decision-making game "Do probabilistic forecasts lead to better decisions?", which Ramos et al (2012) conducted at the EGU General Assembly 2012 in the city of Vienna. In that game, several cases of flood forecasts with and without uncertainty information were presented to the participants, together with choices of actions to take. As decision-makers, they had to decide whether to open or not a gate which was the inlet of a retention basin designed to protect a town and face the consequences of making a bad decision: if they decided to open the gate, the retention basin was flooded and the farmers in this basin demanded a compensation for flooding their land; if they decided not to open the gate and a flood occurred on the river, the town was flooded and they had to pay a fine to the town. A conclusion of that game was that, in the absence of uncertainty information, decision makers are compelled towards a more risk-averse attitude. In order to explore to what extent the answers were driven by the way the questions were framed, we repeated exactly the same experiment with a group of students that followed the Hydroinformatics for Decision Support module, at UNESCO-IHE, Delft. In addition to the original experiment, we introduced a slight variation consisting on choosing between a sure value (for either loosing or winning with a giving probability) and a gamble, in a similar way that the one presented by Kahneman and Tversky (1979). Results show that the way how the questions are posed plays an important role in decision making and that Prospect Theory concepts are promising to be included in future modeling approaches, for instance Agent-Based Models.

INTRODUCTION

The process required to translate information about natural hazards into meaningful decisions often follows a path that considers data collection, modelling and decision-making. However, in practice, each of these steps has an associated uncertainty and therefore the decision-making process carried out at the end is often difficult. A typical example is the decision whether or not to issue an alert for either evacuating an urban area or not, given a potential flood thread, based on forecasting systems that are imperfect and that may result in false alarms and missed events [1]. In this respect, during the last years important research efforts have been invested in increasing the reliability of probabilistic hydro-meteorological forecasts as well as ways of communicating the probabilistic forecasts to decision-makers [2]. However, as pointed out by [3] "The risk associated with environmental hazards depends not only on physical conditions, but also on human actions, conditions, decisions and culture". Although literature on risk decisions from physical and behavioural sciences is varied and extensive, they are not yet integrated and the nature of the decision maker is rarely considered.

To contribute to the discussion regarding the use of deterministic or probabilistic information for decision-making, we explore the effects of different representation of this information on the decision-maker, analyzing how the rationality of the decisions may be hindered by the way the information is presented. To this end, the concept of Prospect Theory [4] is used as a step forward on the understanding of how decision-makers of different nature can deviate from rational decisions.

PROSPECT THEORY

The basic idea of Prospect Theory is that people make decisions based on the potential value of losses and gains rather than the final outcome [4]. This implies that rational decisions are not necessarily chosen even if those are totally based on facts. Far from defining rational as a synonym of wise or lucid, we define a rational as the individual that always prefer the option that gives more over the option that gives less. In other words, a rational decision maker will always choose the alternative with the highest expected value.

The on the most famous examples of Prospect Theory is given in [5], in which a group of people are confronted to the following problem:

Your country is preparing for an outbreak of a disease which is expected to kill 600 people. Choose between the following two options:

Program A: will save 200 for sure
Program B: There is 1/3 probability that 600 will be saved

For which the majority chose program A. In a second experiment, the same question is posed, now selecting between the following options:

Program C: 400 will die for sure
Program D: There is 1/3 probability that nobody will die

For which the majority chose program D, which is interesting because both problems are the same, so the choice C would be the same as the choice D.

Prospect Theory states that, in general, people 1) have different risk attitudes towards gains and losses; 2) care more about potential losses than potential gains; 3) tend to overweight extreme but improbable events and underweight common events.

METHODOLGY

We explore Prospect Theory concepts using the decision-making game "Do probabilistic forecasts lead to better decisions?" conducted at the EGU General Assembly 2012 in the city of Vienna and that is fully described and analyzed by [2]. In that game, several cases of flood forecasts with and without uncertainty information were presented to the participants, together with choices of actions to take. As decision-makers, they had to decide whether to open or not a gate which was the inlet of a retention basin designed to protect a town and face the consequences of making a bad decision: if they decided to open the gate, the retention basin was flooded and the farmers in this basin demanded a compensation of 2000 tokens for flooding their land; if they decided not to open the gate and a flood occurred on the river, the town was flooded and they had to pay a fine of 7000 tokens to the town. A conclusion of that game was that, in the absence of uncertainty information, decision makers are compelled towards a more risk-averse attitude.

In order to explore to what extent the answers were driven by the way the questions were framed, we repeated exactly the same experiment with a group of students that followed the Hydroinformatics for Decision Support module, at UNESCO-IHE, Delft. In addition to the original experiment, we introduced a slight variation consisting on choosing between a sure value (for either loosing or winning with a giving probability) and a gamble, in a similar way that the one presented by [4]. We rephrase the problem (Game 1) as follows:

What option would you prefer?
Option 1: lose 2000 for sure
Option 2: the following gamble:

- *Lose 7000 with a probability P*
- *Lose nothing with a probability of 1-P*

Where the probability P corresponds to those used in the Vienna's game at each round. Option 1 corresponds to the situation where the gate is opened (so 2000 tokens would have to be paid), and the option 2 corresponds to the situation where the gate is closed, case that can be seen as a gamble, in which the probability P of flooding occurrence determines the likelihood of having to pay the fine of 7000 tokens. A new round (Game 2) was made framing now the question as follows:

What option would you prefer?
Option 1: the following gamble:

- *Win 7000 with a probability P*
- *Win nothing with a probability of 1-P*

Option 2: win 2000 for sure

In Game1 the question is framed on losses and the gamble is the Option 2, whereas in Game2 the question is framed on gains and the gamble is the Option 1. Both games are equivalent in terms of the expected value of the choices.

PRELIMINARY RESULTS AND FUTURE WORK

Table 1 summarizes the results obtained after playing the original game (with probabilistic information) and the modified game (rephrased as a choice between a sure outcome and a gamble) with 37 students. Both followed exactly the same order of the questions as presented in [2]. In addition, the table includes the resulting response if expected value is used and the outcome of the event (flooded / not flooded).

Table 1. Choices for gate opening for the original and modified game

Game 1	Option 1 Open (lose for sure)	Option 2 don't open (P of losing 7000)	Expected Value of loosing		Rational choice	% students choosing gamble	Group choice	Group choice Original Game (2)
			Opt 1	Opt 2				
Q1	2000	0.10	2000	681.8	Gamble	84%	Gamble	0 (gamble)
Q2	2000	0.48	2000	3378.9	Sure loss	19%	Sure loss	1 (sure loss)
Q3	2000	0.13	2000	877.1	Gamble	81%	Gamble	0 (gamble)
Q4	2000	0.24	2000	1651.3	Gamble	57%	Gamble	1 (sure loss)
Q5	2000	0.20	2000	1407	Gamble	76%	Gamble	1 (sure loss)
Q6	2000	0.53	2000	3721.9	Sure loss	0%	Sure loss	1 (sure loss)

*game involving probabilities, see [2] for details

Results indicate that framing the EGU 2012 problem as selecting between a gamble and a sure loss is beneficial, in the sense that rational choices were selected. The choices in the proposed Game 1 are different to the choices poised in the original game for questions Q4 and Q5, which involve probabilities 0.24 and 0.20 respectively.

In addition, answers to questions Q4 and Q5 show stronger disagreement among students of the same groups. The gamble was not selected in questions involving probabilities around 50% (Q2 and Q6) as occurred with the group choice in the original game.

Although the experiment carried out independently for the two groups of students gave the same figures, more experiments must be carried out to confirm the conclusions.

Prospect Theory provides the basis to understand how framing the questions in probabilistic hydro-meteorological forecasting and decision making. Future work includes the demonstration of the consequences of different decisions, leading to different future scenarios as a new way to account for social aspects within the hydrological practice and modelling, and contributing to the development of rules for Agent-Based Models.

REFERENCES

[1] Verkade, J.; Werner, M., "Estimating the benefits of single value and probability forecasting for flood warning". Hydrol. Earth Syst. Sci. Discuss (2011), 8, 6639-6681.

[2] Ramos, M.H.; van Andel, S.J.; Pappenberger, F., "Do probabilistic forecasts lead to better decisions?". Hydrol. Earth Syst. Sci. (2013), 17, 2219-2232.

[3] ISCU "A science plan for integrated research on disaster risk: Addressing the challenge of natural and human-induced environmental hazards"; 978-0-930357-66-5; International Council for Science: Paris, France, 2008.

[4] Kahneman, D.; Tversky, A., "Prospect theory: An analysis of decision under risk". Econometrica: Journal of the Econometric Society (1979), 263-291.

[5] Tversky, A.; Kahneman, D., "The framing of decisions and the psychology of choice". Science (1981), 211, 453-458.