Decision, uncertainty and decision-maker behavior: some new questions

Didier Dubois
IRIT, CNRS et Université de Toulouse
France

Uncertainty

- Uncertainty is pervading human activities, and especially decision.
- **What is uncertainty**: not knowing if an event of interest will (has) occurr(ed), if a state of facts is true.
- **Sources of uncertainty**
  - **Variability:** repeatable changing events (risk)
  - **Lack of information** (ambiguity)
  - **Too much information** (contradiction)

Decision-making under uncertainty

- It is often assumed that only the state of affairs influencing the result of decisions is ill-known
  - **Decision under risk**: known frequencies of variable factors (Von Neumann)
  - **Decision under uncertainty** (proper) : unknown frequencies replaced by subjective probabilities (Savage)

  Mathematically, the same.

Decision criteria under ambiguity

- It is important not to use the same approach in the situations of measurable risk and when objective probabilities are ill-known (works by Schmeidler, Gilboa, Jaffray, Chateauneuf, Wakker, Marinacci…)
- The attitude of DM in front of a lack of information matters
  - **Ellsberg paradox**: people act pessimistic, not with a single subjective probability (lower expectation)
  - **Hurwicz criterion** : trade-off between pessimism and optimism in total uncertainty

Case of more than one agent

- If more than one agent is involved in the decision process, there are additional sources of uncertainty:
- In the industrial sector:
  - one agent 1 may have to anticipate what decisions another agent 2 will make, if agent 1 decisions are affected by agent 2's decisions
  - Agent 1 will declare some production objective that another agent will not completely believe.

Decision with ill-known criteria

- The criterion to be optimized depend on the agent's strategy.
- The agent may be unsure of which criterion is good to optimize.
  - Discrete set of possible criteria, and uncertainty weights assigned to them;
  - Hurwicz criterion with ill-known degree of pessimism

Collaborative purchasing processes in supply chains

- Agent 1 has to place orders to be processed by an independent Agent 2 who must make decisions to process this order by producing parts.
- *Agent 1's order decisions can be influenced by the production decisions made by agent 2*
- But Agent 1 only has partial knowledge of Agent 2's criteria, and maybe of his own criteria.
- For each strategy (d_1, d_2), find possible criteria for the two agents such that is this strategy is optimal
- The best strategy for agent 1 is the one that is optimal for the most likely criteria of agent 2 as perceived by agent 1.

Mistrust in declared production objectives

- An agent declares a production objective (e.g. nb of parts per month, …)
- However this announcement is affected by the behavior of this agent
  - Partial incompetence
  - Pessimism /optimism
  - Hiding information….
- *How to interpret the production objectives based on uncertain knowledge of the agent ‘s behavior ?*

A theory of unreliable testimonies

- We can address the issue using Shafer's theory of evidence
- It has roots in the problem of modeling unreliable testimonies in courts of law studied in the XVIIth century
  - Modeling information forwarded by witnesses
  - Merging these pieces of information

The incompetent liar

- Witness says *he saw a big car*.
- C: set of cars;
- $A \subset C$, set of big cars.
- The witness can be
  - incompetent (irrelevant, useless information) with probability p
  - a liar with probability q

The incompetent liar

- So the testimony «c $\in A$» can be modelled by a mass function m from 2^C to [0, 1] such that
  - m(A) = (1-p)(1-q) (the witness is competent ant truthful)
  - m(A^c) = (1-p)q (the witness is competent and lies)
  - m(C) = p (the witness is incompetent)
- The receiver believes «c $\in A$» to degree (1-p)(1-q)
- Can be generalized to several witnesses and the combination of information

General setting

- A finite probability space Ω of witness features
- A probability distribution p on Ω.
- A set C of possible answers to the question.
- A mapping $f : 2^C \times \Omega$ to 2^C such that if
  - the witness declares «$c \in A$»
  - and his behaviour class is $w \in \Omega$,
  - then the piece of information should be interpreted as

    $B = f(A, w) \subseteq C$ with probability $p(w)$.
- One gets a belief function with

  $m(B) = \sum\{p(w): B = f(A, w)\}$

Example

- The head of production process declares he will produce 100 parts per week
- But there is some chance that he is
  - Not precise : [80, 120]
  - Optimistic : [50, 80]
  - Pessimistic: [120, 150]
  - …..

Conclusion

- Uncertainty modeling can be used beyond the use of the usual preference functionals (expected utility and their extensions)
  - The presence of several agents involved in the decision process is an additional source of subjective uncertainty for decision-makers
  - Pieces of information in the form of unreliable testimonies can be exploited in the production management context (work in progress)

References

- R. Guillaume, G. Marques, C. Thierry, D. Dubois. Decision support with ill-known criteria in the collaborative supply chain context*. Engineering Applications of Artificial Intelligence*, Vol. 36, p. 1-11, 2014.
- F. Pichon, D. Dubois, T. Denœux Relevance and truthfulness in information correction and fusion *International Journal of Approximate Reasoning*, *53, 2012, 159-175.*