Decision-making process model in the context of individual preferences change

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Abstract

This research is focused on elucidating the intricacies associated with the application of the Gibbs-James principle in scenarios involving two and three potential environmental states during the modeling of decision-making processes grounded in diverse preferences. Within this framework, decision-making scenarios are methodically formulated, considering multiple criteria, including the maximization of mathematical expectation, risk minimization, gains maximization, among others.

Keywords: Decision-making process model, social preferences, strategic interactions

1. INTRODUCTION

Traditional economic rationality faces a challenge from social preferences, which consider others' well-being and economic conditions, prompting a reassessment of decision-making models for strategic interaction. This fact introduces complexity into decision-making processes, prompting inquiries into the dominance of intuition versus reasoning and the influence of contextual factors.

This research is focused on elucidating the intricacies associated with the application of the Gibbs-James principle in scenarios involving two and three potential environmental states during the modeling of decision-making processes grounded in diverse preferences. Within this framework, decision-making scenarios were methodically formulated, considering multiple criteria, including the maximization of mathematical expectation, risk minimization, gains maximization, among others.

2. REVIEW OF THE LITERATURE

Morselli A. (2015) delves into the intricate connection between economics and psychology in comprehending decision-making and advocates for a holistic approach incorporating psychological insights into economic decision-making theories. The revelation of social preferences introduces complexity by challenging the traditional concept of economic rationality centered on individual utility. Social preferences compel the consideration of others' well-being and economic conditions (Monroy et al., 2017; Caraballo et al., 2023; Zapata et al., 2023) leading to a cognitive duplicity where rational logic and emotions coexist. The abovementioned challenges existing decision-making models and raises questions about the prevalence of intuition, the role of reasoning, and the impact of contextual factors on decision-making, complicating the understanding of this process.

Traditionally, economic decisions were exclusively tied to individual utility, neglecting the well-being of others. The revelation prompts radical changes in models of strategic interaction, highlighting the role of intuition and reasoning, and recognizing the decisive influence of contextual factors in the intricate and non-linear dynamics among diverse economic agents. This complexity makes developing comprehensive predictive models challenging, underscoring the impossibility of explaining economic phenomena without considering individual economic actions and their cognitive foundations.

Existing papers (Liu et al., 2022; Hoff & Stiglitz, 2015) suggest that individual preferences in decision-making models are influenced by personal characteristics, social and cultural factors, social diversity (Buitrago & Caraballo, 2022) and contextual elements (including previous experiences, neighbours' preferences, and social dynamics). Researchers broaden economic discourse by incorporating insights from sociology, highlighting the importance of social contexts and cultural and mental models in shaping individual behaviour and decision-making. Some authors (Sagoff, 1988) have followed a somewhat different line of thought and have argued that it is important to distinguish between the individual's roles as a consumer and as a citizen: "As a citizen, I am concerned with the public interest, rather than my own interest; with the good of the community, rather than simply the well-being of my own family. (…) In my role as a consumer, (…) I pursue the goals I have as an individual." (Sagoff, 1988, p. 8). The individual's switch between roles in the decision-making process also depends on the state of the environment, which shapes the context of decision-making and influences changes in individual preferences.

Researchers (Bröder & Schiffer, 2003) have reported that the Bayesian method effectively assesses cognitive strategies in multi-attribute decision-making, enabling inferences from behavioural data to cognitive theories. The Bayesian approach allows for taking into account changes in individual preferences depending on the state of the environment and, therefore, for switching the decision-making agents' roles. This line of research draws on game theory, mathematical statistics, and decision theory, taking into account the varying degrees of uncertainty, with the Bayesian approach being a vital tool in addressing such problems. Within decision science, the Bayesian approach embodies the principle of maximising the information used throughout the decision-making process, involving continuous review and information reassessment at each stage. Methods rooted in the Bayesian approach operate on the premise that practically any assertion or event carries a prior probability of being true, no matter how small. If a hypothesis is deemed probable, there must be a set of conditions supporting it. The absence of such conditions would halt the assessment, leaving the prior probability unchanged. However, in the presence of messages related to the problem, the prior probability can be adjusted to derive the posterior probability of the same hypothesis, considering the new information. In essence, the Bayesian approach facilitates the computation of the validity of competing hypotheses by accounting for the influence and presence of accompanying evidence.

3. METHODOLOGY

Based on the above mentioned literature, the decision-making situation is described by set - $\{X, \theta, F\}$, where: $X = \{x_1, x_2, .., x_m\}$ - set of possible decisions, $\theta = \{\theta_1, \theta_2, .., \theta_m\}$ — set of environment states, $F = \{f_{kj}\}$ – assessment matrix, as defined on Casterian product $\theta \times X$, $f_{kj} = f(x_k, \theta_j)$, $k = \overline{1, m}$, $j = \overline{1, n}$. In the expanded form, the decision-making situation is represented as a matrix, the components of which are real numbers f_{kj} - quantitative assessments of possible decision $x_k \in X$, given that the environment is in a particular state - $\theta_j \in \theta$:

$$f = \begin{pmatrix} & \theta_1 & \dots & \theta_j & \dots & \theta_n \\ x_1 & f_{11} & \dots & f_{1j} & \dots & f_{1n} \\ \dots & & \dots & & \dots & \\ x_k & f_{k1} & \dots & f_{kj} & \dots & f_{kn} \\ \dots & & \dots & & \dots & \\ x_m & f_{m1} & \dots & f_{mj} & \dots & f_{mn} \end{pmatrix}. \tag{1}$$

Values f_{kj} , typically, are denominated in monetary units, and they signify either potential losses or gains. For optimal decision-making probabilities of the particular environmental states are necessary to know $P(\theta_1) = p_1, P(\theta_2) = p_2, \dots, P(\theta_n) = p_n$, at the same time $p_1 + p_2 + \dots + p_n = 1$. In case when f_{kj} are gains the better decision is maximum value of $\sum_{j=1}^{n} f_{kj} p_j$, $k = \overline{1, m}$:

$$B^+(x_{k_0}, p) = \max_{k=\overline{1,m}} \sum_{j=1}^{n} (p_j f_{kj}^+), \tag{2}$$

This type of decisions is acceptable without probabilities expertise. However, if such an assessment is conducted to make a more weighted decision, its results should be taken into account according to the following scheme.

Let $\xi_1, \xi_2, \dots, \xi_N$ denote possible outcomes of the experiment. Then, according to the rules of probability theory, it is necessary to calculate the conditional probabilities $P\left(\frac{\xi_\nu}{\theta_j}\right), (\nu = \overline{1, N}, j = \overline{1, m})$ of obtaining the result ξ_ν given the economic state θ_j. Subsequently, having a specific result of the experiment ξ_{ν_0}, Bayesian formulas are used to calculate the posterior probabilities of the states:

$$P(\theta_j/\xi_{\nu_0}) = \frac{P(\xi_{\nu_0}/\theta_j)P(\theta_j)}{\sum_{j=1}^{n} P(\xi_\nu/\theta_j)P(\theta_j)}.$$

The obtained probabilities are then used to find the minimum or maximum of the functional $\sum_{j=1}^{n} f_{kj} P(\frac{\theta_j}{\xi_{\nu_0}})$. If this result significantly differs from that based on prior probabilities, it is advisable to conduct additional scrutiny in this case. When the probabilities $p_j(j = \overline{1,n})$ are unknown, the Bernoulli-Laplace criterion or the principle of maximum entropy (Gibbs-James principle) is employed to select the optimal decision solution. According to Bernoulli's principle, probabilities $p_j(j = \overline{1,n})$ should be considered equal if there is no information to consider any state θ from the set $\theta = \{\theta_1, \theta_2, .., \theta_n\}$ more probable than any other. Therefore, based on the Bernoulli-Laplace criterion, a decision is considered optimal if

$$B^+(x_{k_0}, p) = max \frac{1}{n} \sum_{j=1}^{n} {f_{kj}}^+. \quad (3)$$

While recommendations based on probabilistic methods may sometimes lead to suboptimal decisions, with frequent repetitions of similar decision-making situations, they generally yield better results than intuitive decision-making.

4. WORK IN PROGRESS

The above methodology is applied for scenarios involving several potential environmental states during the modeling of decision-making processes where agents show diverse preferences.

References

Bröder, A., & Schiffer, S. (2003). Bayesian strategy assessment in multi-attribute decision making. Journal of Behavioral Decision Making, 16, 193-213. https://doi.org/10.1002/BDM.442.

Buitrago, E. M., & Caraballo, M. A. (2022). Measuring social diversity in economic literature: An overview for cross-country studies. Journal of Economic Surveys, 36(4), 880–934. https://doi.org/10.1111/joes.12484

Caraballo, M.A., Zapata, A., Monroy, L. & Mármol, A.M. (2023). Environmental Damage Reduction: When Countries Face Conflicting Objectives. In P. Cappanera et al. (eds.), Optimization and Decision Science: Operations Research, Inclusion and Equity, AIRO Springer Series 9, pp. 27-35. https://doi.org/10.1007/978-3-031-28863-0_3

Giacchi, E., Corrente, S., Stefano, A., Greco, S., Corte, A., & Scatá, M. (2016). A context-aware and social model of dynamic multiple criteria preferences. Decision Analytics, 3, 1-24. https://doi.org/10.1186/S40165-016-0020-3.

Harris, P., Whitty, J., Kendall, E., Ratcliffe, J., Wilson, A., Littlejohns, P., & Scuffham, P. (2017). The importance of population differences: Influence of individual characteristics on the Australian public's preferences for emergency care.. Health policy, 122 2, 115-125 . https://doi.org/10.1016/j.healthpol.2017.11.006.

Hoff, K., & Stiglitz, J. (2015). Striving for Balance in Economics: Towards a Theory of the Social Determination of Behavior. ERN: Behavioral Economics (Topic). https://doi.org/10.1016/J.JEBO.2016.01.005.

Liu, Z., Deng, Y., & Yager, R. (2022). Measure-Based Group Decision-Making With Principle-Guided Social Interaction Influence for Incomplete Information: A Game Theoretic Perspective. IEEE Transactions on Fuzzy Systems, 30, 1149-1163. https://doi.org/10.1109/TFUZZ.2021.3053324.

Mallpress, D., Fawcett, T., Houston, A., & McNamara, J. (2015). Risk attitudes in a changing environment: An evolutionary model of the fourfold pattern of risk preferences.. Psychological review, 122 2, 364-75 . https://doi.org/10.1037/a0038970.

Monroy, L., Caraballo, M.Á., Mármol, A.M., & Zapata, A. (2017). Agents with other-regarding preferences in the commons. Metroeconomica, 68, 947–965. https://doi.org/10.1111/meca.12158

Morselli, A. (2015). The Decision-Making Process between Convention and Cognition. Economics & Sociology, 8, 205-221. https://doi.org/10.14254/2071-789X.2015/8-1/16.

Mukherjee, K. (2010). A dual system model of preferences under risk.. Psychological review, 117 1, 243-55 . https://doi.org/10.1037/a0017884.

Sagoff, M. (1988). The Economy of the Earth. Cambridge University Press, Cambridge.

Zapata, A., Mármol, A.M., Monroy, L. & Caraballo, M.A. (2023). Altruistic preferences in global emission games. Central European Journal of Operations Research. https://doi.org/10.1007/s10100-023-00890-0