ISSN 2616-7433 Vol. 5, Issue 3: 58-63, DOI: 10.25236/FSST.2023.050311

A Review of Decision Theory and Methods

Shufen Cao

School of Economics and Management, Southwest Petroleum University, Chengdu, China

Abstract: *With the development of the economic system, traditional decision making methods can no longer adapt to today's complex decision making environment, various decision making methods have emerged, and decision making theories and methods have become a hot topic of research at home and abroad. To this end, this paper reviews the debate and research status of decision theory from five aspects: multi-criteria decision making, group decision making, behavioral decision making, uncertainty decision making, and decision theory, and gives an outlook on the future of subsequent decision theories and methods.*

Keywords: *decision theory; multi-criteria decision making; group decision making; behavioral decision making; uncertain decision making*

1. Research background

According to Simon, the Nobel laureate in economics, "management is decision making". Decision making is about choosing from multiple options. What we want is to get the best result behind each choice, but the choice is often uncertain, how to choose? What is the basis for the choice? Decision theory and methods is a new discipline that studies decision making behavior, combining knowledge from different disciplines such as management, statistics, operations research, and systems science. Decision theory and methods are known as decision analysis. Decision analysis first appeared in the 18th century, pioneered by BBERNOULLI, and began to develop rapidly after World War II, after which the development of several scholars such as SAVAGE again formed the classical expected utility theory. Although expected utility theory played an important role in decision analysis and laid the foundation for the subsequent development of decision science, it still had many shortcomings. After the 20th century, scholars began to incorporate psychology into decision analysis, of which EDWARDS was the first to apply psychology to the descriptive study of decision analysis.

Decision science started late in China, and after nearly 40 years of theoretical research and development, the research on decision theory and methods in China has seen a fully blossoming result. The development of decision science depends not only on the efforts of scholars but also on the support of the state. Since 1987, the Department of Management Science of the National Endowment Committee has funded research on decision theory and methods, and research projects on decision theory and methods have grown steadily with the support of the state. This study will summarize, sort out and analyze the research literature about decision theory and methods in the past 20 years at home and abroad initially, and clarify the research status and application of decision theory and methods in recent years.

2. Controversial focus

In recent years, the continuous research of decision theory and methods has become an important research focus. From the perspective of decision problems, the research focus of decision theory and methods is concentrated in the empirical research, and it is in the empirical research that the corresponding decision measurement laws are found by analyzing the decision behavior, to construct model hypotheses for research, and this kind of research appears very frequently in the fields of economics and management.

In recent years, the debate on decision making has focused on the following aspects: (1) whether one should make every effort to analyze decisions to develop theoretically "optimal" decisions. (2) The influence of pre-information processing systems on the conscious processing of decisions. In addition, it is believed that in some cases subconscious processes override conscious processes. Consciousness plays a supporting and rationalizing role in behavior, but not in decision making. Furthermore, scholars

ISSN 2616-7433 Vol. 5, Issue 3: 58-63, DOI: 10.25236/FSST.2023.050311

such as Moshman, Klaczynski, and impress argue that although decisions are sometimes made unconsciously, this does not mean that they lack rationality. The key issue that has given rise to these debates is the role and importance of conscious decision making processes and whether they are more likely to lead to appropriate outcomes than conscious, deliberate decisions.

3. Literature review

A total of 2,250 papers were collected on the Internet using the keywords decision theory and decision science, and the research on decision theory and methods showed an overall increasing trend, with the number of relevant studies increasing every year. The research on decision theory and methods is much more than just these 2000 papers, and many studies focus on the application of decision analysis. In this paper, the research related to decision theory and methods is broadly divided into five areas through literature combing: decision grounded theory, multi-criteria decision making, group decision making, behavioral decision making, uncertainty decision making, and decision theory. The following five aspects are described in detail through literature review, integration, and summary.

3.1 Decision base theory

Decision theory is a theoretical approach that is applied to management decision problems formed by the synthesis of multiple disciplines such as system theory, operations research, and computer science, and the diverse development of decision theory is based on decision grounded theory. The earliest basic theory of decision making is the expected utility model proposed by Bbernoulli, and then the modern theory of utility functions was formed based on the V-M system of the expected utility model established by Neumann. After that, several scholars extended the system. Utility theory research was the earliest research in decision analysis, focusing on the outcome and monetary utility in the early years, and after 1970, the focus shifted to evaluating the utility and multi-attribute utility functions. There are many utility models, functions, and systems in addition to utility theory. With the development of science and technology and theory, research on the basic theory of decision making can be broadly divided into two areas: research on decision methods and research on decision information.

The relevant concepts and systematic analysis methods proposed to solve future decision problems with uncertainty are called decision methods, which mainly assist decision making by improving the decision process. As far as decision analysis is concerned, decision methods mainly focus on various aspects of decision methods such as graph theory, gray theory, lattice theory, optimization techniques, and comprehensive evaluation. Among them, Cao & Wang used graph theory to study the supply chain under the uncertainty of the new crown epidemic[1]. Yi et.al used graph theory and machine learning methods to infer the traffic volume[2]. Optimization techniques are mathematically based and used for solving various engineering problems with optimal solutions and are mainly reflected in various optimization algorithms. Optimization algorithms are very richly developed and so far there have been very many optimization calculations, namely, Ant Colony Algorithm (ACO), Hill Climbing Algorithm, Taboo Algorithm (Tabu Search), Particle Swarm Algorithm (PSO), Fireworks Algorithm (FWA), Firefly Algorithm (FA), and many other algorithms, and also many scholars have applied optimization analysis to the above algorithms according to the different realistic situations.

According to the decision making needs before the decision needs to be made certain decision information to be able to make a correct and accurate decision. According to the source of information, decision information can be divided into internal information and external information, and both types of information can lead to incomplete information due to their characteristics and dissemination channels, which makes decision making difficult. In The Art of War, Sun Tzu wrote, "If you know yourself and your enemy, you will never lose a hundred battles." Simon also said that "the connection of information is essential in the decision making process." All these prove that decision information is very important in decision analysis. Gong Zaiwu scholars use computer technology to explore how to make decision processing under disabled information and how to make effective analyses through individual judgment and group judgment.

3.2 Multi-criteria decision making

A decision to choose among a finite (infinite) set of conflicting and non-commensurable options is a multi-criteria decision. Multi-criteria decision making (MCDM) is divided into two categories, namely multi-attribute decision making (MADM) and multi-objective decision making (MODM).

ISSN 2616-7433 Vol. 5, Issue 3: 58-63, DOI: 10.25236/FSST.2023.050311

Multi-attribute decision making is finite solution multi-objective decision making and is a decision problem in which the optimal alternative is selected or ranking of options is performed considering multiple attributes. In multi-attribute decision making, a suitable integrated analysis method can be chosen depending on the given information. For example, when there is no information about any attribute in the decision matrix, the analysis can be based on a pessimistic criterion, optimistic criterion, equal probability respect, and minimum chance loss decision criterion, etc.; if the minimum reception level of each attribute is given, the methods of combining and analyzing can be chosen; if the information given is not a specific value, only relative comparability can be chosen, such as dictionary order method and ranking method. If the values of individual attribute weights are known, various methods such as the simple weighted sum method, weighted product method, and deletion selection method can be used. Many scholars in the study of how to determine the target attribute weights have created many methods to try in different types of research settings and information. For example, the least square weight method, maximum entropy weight method, feature vector method, and hierarchical analysis method. Many of the above methods are used in various environments, and each method has its advantages and disadvantages, which should be reasonably analyzed when applied to clarify whether the method used is tried or not. Wang et.al proposed a clustering MCDM method based on D-S theory, hierarchical analysis, and Silhouette coefficients, which can better solve multi-criteria decision making[3]. Aljaghoub et.al, on the other hand, used multi-criteria decision making to analyze solar PV clean technology to better achieve sustainable development goals[4].

Multi-objective decision making, also known as multi-objective optimization, refers to the selection of a system solution based on the degree of satisfaction of multiple objectives, the counterpart of multi-objective decision making is single-objective decision making, i.e., single-objective optimization, which is the selection of a decision based on only one indicator, which in practical applications is mostly cost, profit, efficiency, etc. For example, in the development of a company, the primary consideration is the company's profit, but in addition to enhancing profit, it is also necessary to consider product quality, production costs, environmental issues, and other indicators, which cannot be solved by single-objective decision making alone. Therefore, the multi-objective decision problem is derived. Multi-objective optimization was first proposed by Pareto in 1896, mainly by transforming multiple incomparable objectives into one objective through certain methods. In 1961, A. Charnas and W. Cooper proposed objective planning. multi-objective decision making started to be applied in China in the 1970s and has since produced a wealth of application results. At present, there are various methods of multi-objective decision making, such as linear programming and objective programming. Scholars' research on multi-objective decision making mainly focuses on how to solve and how to construct a suitable model. The basic theory and techniques of multi-objective decision making methods are described in detail in the book "Multi-objective Decision Theory Methods and Applications". Huang et.al explored the traditional Chinese restaurant dish scheduling based on hybrid multi-criteria decision making and double queuing structure, expecting to improve dish scheduling automation and customer satisfaction[5]. Many scholars have also explored how to make multi-objective decisions in techno-economic analysis, what application principles should be used and how specific studies should be analyzed and explored.

3.3 Group Decision Making

Group Decision Making (GDM) originates from Western research. As problems become more complex and rapidly changing, the influence of decisions becomes more and more important and requires not only people with multiple knowledge and experience and people related to the consequences of decisions to form groups to assist in decision making. There are four types of group decisions: voting decisions, authoritative decisions, consensus decisions, and non-disagreement decisions. The most important goal of group decision making is to optimize the goal by giving full play to group wisdom, but group decision making has certain disadvantages compared to individual decision making, such as being slow and time-consuming. This situation has led to the emergence of two types of group decision theories: collaborative decision making and compromise decision making. Scholars on collaborative decision making focus on how to facilitate mutual communication among individuals to improve the final strategy. In compromise strategies, conflicts can arise due to the inconsistent goals of the participants, and conflicts are an important research component of group decision making. Chu et.al proposed a decision model algorithm for three-way group conflict based on the characteristics of groups with conflicting decisions and summarized the resultant forms of group conflict for the development of Chinese medicine[6]. Brian & Jessica, on the other hand, conducted a study on the relationship between both group conflict and group cohesion study, which found that group conflict negatively affects group cohesion and that the influence of group conflict on the group should be

ISSN 2616-7433 Vol. 5, Issue 3: 58-63, DOI: 10.25236/FSST.2023.050311

considered more in future group decision making[7]. At the same time, it is also extremely important to find how each conflict affects group decision making through risk perception in large group conflicts in emergency decision making. Currently, methods for finding compromise points in the decision making process include the Shapley value and the Banzlaff power index.

Research on group decision making is also manifested in the study of the behavioral mechanisms of group decision making and group decision information, focusing on the impossibility theorem. The impossibility theorem refers to the impossibility of having a social welfare function that applies to all individual preference types in a non-authoritarian situation. In this area of research, Yuda Hu has proposed the Arrow condition and the impossibility theorem. The study of group decision information focuses on uncertain information. There are various cases of uncertain information, such as interval-valued information, variable information, random variables and information probabilities, fuzzy information, likelihood information, inconsistent information, hesitation information, and basic uncertain information. How to determine the corresponding decision in uncertain information becomes the difficulty and focus of group decision making. Among them, Yager proposed an uncertain information fusion method-ordered weighted average (OWA) by simulating decision makers' preferences[8]. After that, many scholars studied its optimization. In addition, fuzzy integration is also one of the methods to solve uncertain decision problems.

There are many methods to achieve group decision making, for example, the nominal group method, the ladder method, the brainstorming method, and the Delphi method. These methods are also very widely used, and numerous scholars have applied brainstorming methods in medicine, literature, economics, and other research fields, respectively. The Delphi method is mostly used in the construction of evaluation index systems. With the development of the times, many problems have become extremely complicated, and a single method cannot meet the research needs, so some scholars conduct comprehensive research and analysis by using multiple methods.

3.4 Behavioral Decision Making

Behavioral decision theory takes human decision making behavior as the basic factor of analysis, and analyzes, summarizes, and generalizes human behavior in the decision making process through empirical methods to form a series of theoretical perspectives. The important research contents of behavioral decision theory are as follows: First, the limited rationality hypothesis. This theory was proposed by Simon to refute the "economic man" in classical economics. Secondly, the successful management model (Pieters-Nietermann). Third, is the social model. Based on psychology, Freud believed that human behavior comes from the subconscious mind, so there is no way to make rational decisions. In the study of behavioral decision making most of the practical scientific methods such as the experimental method and survey method are used.

Psychology believes that different people have different preferences when it comes to choices, and such preferences may lead to the eventual formation of different strategies. Therefore many scholars focus on decision preferences and preference decision models under different environmental attributes. Yang Boru et.al studied large group decision preferences under weak relationships and complemented the theoretical notation of preference cross-fertilization under soft constraints in group decision making[9]. Christopher et.al explored individuals' willingness to accept, willingness to pay, and choice by examining their subjective preferences in the preference reversal problem. The final study showed that Chinese people prefer risk over Americans when it comes to acquisition; and risk aversion when it comes to lose. Behavioral decision theory and methods have been widely applied in various fields[10]. For example, Etemadi & Khashei applied behavioral decision theory to the medical field and proposed a modeling approach for medical decision-making based on behavioral decision theory to achieve high accuracy and reliability[11].

3.5 Uncertainty decision making

With the rapid development of society and technology, the riskiness of uncertainty faced in decision making is increasing. Based on this, it is not enough for people to rely only on objective facts and experience to make decisions. Therefore, the continuous development of techniques such as data mining, knowledge mining and knowledge discovery in databases to improve the design and implementation of expert systems, decision support systems, and knowledge management systems can help to carry out uncertain decision making. In addition, there is the exploration of evaluation, reasoning, and self-learning processes and factors influencing decision maker behavior based on

ISSN 2616-7433 Vol. 5, Issue 3: 58-63, DOI: 10.25236/FSST.2023.050311

heuristic learning.

The research on uncertainty decision-making is mainly distributed in the areas of fuzzy decision making and rough set decision making. Fuzzy decision making refers to the mathematical theory and methods for making decisions in a fuzzy environment. Most of the real decisions are fuzzy decisions, while in practice fuzzy decisions are generally applied in large systems at the time of research. Madasi et.al designed and developed a fuzzy decision support system for the condition of prostate cancer, which is more beneficial for the diagnosis and grading of cancer[12].In 2021, Fiori Simone improved and evaluated the fuzzy algorithm based on independent component analysis[13]. Scholars at home and abroad have conducted a lot of research on fuzzy decision making in uncertainty analysis in recent years, mainly focusing on the improvement of fuzzy decision algorithms and the practical application of fuzzy decision making.

Rough set decision making is also a kind of uncertain decision making, based on inductive learning techniques of rough set theory, using a variety of intelligent techniques to build models reflecting decision makers' preferences according to different types of multi-criteria decision problems, and proposing the concepts of decision matrix and decision function. The rough set decision model was pioneered by Yao et al. in 1990, and three years later Ziarko based on it, proposed the variable precision rough set model, which expanded the research field of rough sets[14]. After that several domestic and foreign scholars expanded the research field of rough sets and proposed the concept of rough affiliation function, Bayesian rough set model, parametric rough set model, and game rough set model, respectively.

4. Research Review

In recent years, the research focused on decision theory and methods focused on group decision making, behavioral decision making, and emergency decision making in fuzzy decision making. The main reason is that with the development of the times, decision making requires a large amount of knowledge in various aspects, which can no longer be done by one person, so it is necessary to gather the wisdom of many people for decision making, so group decision making has become an important research hotspot; decision making is not a completely rational process, in the decision making process, decision information and decision results are affected by the decision behavior, to understand and sort out the final results of decision making research decision In recent years, major disasters and crises have occurred repeatedly, and emergency management and emergency decision making have started to receive attention from scholars, and the study of emergency decision making has a significant role in the safe and harmonious development of the whole society.

From the development of decision theory and methods as a whole, the development of multiple decision parts of decision theory and methods is uneven, and in the early development of decision theory and methods, the study of behavioral decision making is almost absent and not recognized by some scholars. However, with the later development of psychology, psychology gradually integrated into several disciplines before it began to enter the study of decision theory and methods. In terms of current research, the overall decision theory research focuses on two major areas: first, the practical application of decision theory and methods, i.e., the practical consideration of the application of the methods in a specific research setting. This is one of the most common research methods, but there is a major drawback in the research application of the method, which is simply the application of the method without considering whether the method is inadequate or needs to be improved. Second, the improvement of a certain method. With the development of computer and big data technology, many scholars have conducted algorithm research and improvement in recent years. Such research is an expansion of decision theory and methods, which is beneficial to the application of the method in practice.

Combined with the above literature, the research in recent years lacks the exploration of new decision theories and methods, and future research on decision theories and methods may focus on two aspects: on the one hand, actively exploring new decision theories and methods. With the development of the times, the applicability of earlier methods to modern decision problems is weakened, and newer decision theories and decision methods are needed. On the other hand, the application of decision theories and decision making is more extensive and extended to various fields for practical applications to assist decision making and play a role.

ISSN 2616-7433 Vol. 5, Issue 3: 58-63, DOI: 10.25236/FSST.2023.050311

References

[1] Cao Wei, Wang Xifu. Brittleness Evolution Model of the Supply Chain Network Based on Adaptive Agent Graph Theory under the COVID-19 Pandemic [J]. Sustainability,2022,14(19).
[2] Yi Zhiyan, Liu Xiaoyue Cathy, Markovic Nikola, Phillips Jeff. Inferencing hourly traffic volume using data-driven machine learning and graph theory [J]. Computers, Environment and Urban Systems, 2021, 85.
[3] Wang Siyuan, Ma Wenjun, Zhan Jieyu. A Clustering Multi-Criteria Decision-Making Method for Large-Scale Discrete and Continuous Uncertain Evaluation. [J]. Entropy (Basel, Switzerland), 2022, 24(11).
[4] Aljaghoub Haya, Abumadi Farah, AlMallahi Maryam Nooman, Obaideen Khaled, Alami Abdul Hai. Solar PV cleaning techniques contribute to Sustainable Development Goals (SDGs) using Multi-criteria decision-making (MCDM): Assessment and review [J]. International Journal of Thermofluids, 2022, 16.
[5] Huang Feng, Chuang Yenching, Zhang Yonghua, Lu Bin, Xu Honglan. A Dish Scheduling Model for Traditional Chinese Restaurants Based on Hybrid Multiple Criteria Decision-Making Algorithms and a Double-Layer Queuing Structure [J]. Mathematical Problems in Engineering,2 022,2022.
[6] Xiaoli Chu, Bingzhen Sun, Qingchun Huang, Yan Zhang. Preference degree-based multi-granularity sequential three-way group conflict decisions approach to the integration of TCM and Western medicine [J]. Computers & Industrial Engineering, 2020, 143(prepublish).
[7] Manata Brian, Bozeman Jessica. Documenting the Longitudinal Relationship between Group Conflict and Group Cohesion [J]. Communication Studies, 2022, 73(3).
[8] Yager R R.On ordered weighted averaging aggregation operators in multicriteria decisionmaking [J]. IEEI Transactions on systems,Man,and Cybernetics,1988,18(1):183-190
[9] Yang Boru, Xu Chenglei, Zhang Hongxun, Feng Yan. Dynamic Fusion Simulation Method of Intertemporal Decision Preferences of Large Groups in Weak Relationships [J]. Mathematical Problems in Engineering, 2022, 2022.
[10] Christopher K. Hsee, ElaineHatfield,ClaudeChemtob. Assessments of the Emotional States of Others: Conscious Judgments Versus Emotional Contagion [J]. Journal of Social and Clinical Psychology, 1992,11(2).
[11] Etemadi Sepideh, Khashei Mehdi. Accuracy versus reliability-based modelling approaches for medical decision making [J]. Computers in Biology and Medicine,2022,141.
[12] Madasi Joseph David,AlShbeil Isra,Cătaş Adriana,Aloraini Najla,Gulistan Muhammad,Azhar Muhammad. A Neutrosophic Cubic Hesitant Fuzzy Decision Support System, Application in the Diagnosis and Grading of Prostate Cancer[J]. Fractal and Fractional,2022,6(11).
[13] Fiori Simone. Improvement and Assessment of a Blind Image Deblurring Algorithm Based on Independent Component Analysis[J]. Computation,2021,9(7).
[14] Ziarko W. Variable precision rough set model. J Comput Syst Sci[J]. Journal of Computer and System Sciences, 1993, 46(1):39-59.