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Review of Risk Decision-Making Theory

Xinyi Wu *

School of management, Southwest Petroleum University, Chendu 610500, China

* **Corresponding author**: Xinyi Wu (Email: 1720673660@qq.com)

Abstract: This paper describes the development course, present situation and future trend of risk decision theory. Since the middle of the 20th century, the theory of risk decision-making has become a hot topic in economics, psychology and management. With the advancement of globalization and technological innovation, decision makers are facing a more complicated risk environment. This paper discusses several key theoretical models in risk decision theory, including prospect theory, cumulative prospect theory and opportunity threat theory, and analyzes the influence of frame effect, individual differences, environmental factors and social and cultural factors on risk decision. At the same time, the paper also discusses the problem of risk decision-making in big data and dynamic environment, as well as the application expansion of comprehensive risk management and emerging risk decision-making. The future research direction of risk decision theory is prospected, and the importance of theoretical innovation, interdisciplinary integration and technical application is emphasized. This paper aims to provide a more comprehensive understanding of risk decision theory for current research and point out the direction for future research.

Keywords: Risk decision, integrated development, application development.

1. Introduction

Since the middle of the 20th century, the theory of risk decision-making has become the focus of common concern in many disciplines such as economics, psychology and management. The development and application of this theory has had a far-reaching impact in academic circles, and it has shown its unique value and broad application potential in key industries such as insurance, finance and health management. With the acceleration of globalization and the rapid development of technological innovation, the risk environment we are in is becoming more and more complex and changeable. In this context, the challenges faced by decision makers are increasing day by day. They need to deeply understand the inherent nature of risks and master the ability to make wise decisions in an uncertain environment. The risk decision theory provides such a powerful analytical tool and a comprehensive theoretical framework. Through a series of scientific methodologies, it guides decision makers how to identify and evaluate potential risks, how to make the most reasonable decision among many possible choices, and take effective actions to deal with risks. These tools and frameworks not only help decision-makers to make more informed choices in complex situations, but also improve the efficiency and effectiveness of decision-making, enabling decision-makers to respond to various uncertainties and risks more flexibly. In addition, with the rapid development of information technology, risk decision theory is constantly integrating new technical means, such as big data analysis, artificial intelligence, etc., in order to improve its accuracy and practicality in practical applications and further promote the development and innovation of decision science.

2. Research Background

2.1. The Oretical Background and Importance

In the real world, decision makers often need to make decisions with incomplete information, and these decisions are often accompanied by uncertainty and potential risks. The research background of risk decision theory and its importance in real-world decision-making lies in that it can help us understand and predict how decision makers make choices in the presence of risks. The application of this theory is not limited to commercial decision-making, but also involves many fields such as public policy making, medical diagnosis and environmental management, which is of great significance for improving the quality of decision-making and reducing the negative impact brought by risks.

2.2. The Purpose and Scope of The Review

This review aims to reveal the development thread, main achievements and future research direction of risk decision theory through the review of relevant literature at home and abroad. The purpose is to provide a comprehensive overview of risk decision theory, including the basic concepts, decision-making methods, decision-making criteria and the application of these theories in different fields. In addition, this review will also discuss the challenges and limitations faced by the current theory, and how to overcome these challenges through interdisciplinary research and promote the further development of risk decision theory. In writing this review, systematic literature retrieval and screening methods are adopted to ensure that a wide range of academic resources are covered. The research depth will focus on the in-depth analysis of the theory and the critical evaluation of the application practice, in order to provide readers with a literature review with both theoretical depth and practical value. In this way, this review hopes to promote academic exchanges, inspire new research ideas, and provide decision support for decision makers in related fields. It is expected that this review can provide valuable insights for academic and practical circles and point out the direction for future research.

3. An Overview of The Development of Risk Decision Theory

3.1. The Context of Historical Development

The development of risk decision theory is an evolutionary history from abstract concept to practical application. Initially,

the expected utility theory put forward by Neumann and Morgenstern in 1947 laid the foundation for risk decision-making. This theory quantifies the preference of decision-makers when facing risks through mathematical models. Subsequently, the expectation theory put forward by Kahneman and Tversky in 1979 challenged the traditional expected utility theory, introduced the psychological perspective, and emphasized the irrational factors in human decision-making. In the 21st century, the theory of risk decision-making has developed further, from the hypothetical description of as-if model to the empirical analysis of process model, which emphasizes the actual behavior and psychological mechanism in the decision-making process.

3.2. Contemporary Research Trends

At present, the research of risk decision theory is undergoing an innovation. The cross-integration of cognitive science and behavioral economics provides a new perspective for understanding how decision makers deal with risks. In particular, the application of eye tracking technology enables researchers to accurately capture the distribution of visual attention in the decision-making process, thus revealing the cognitive mechanism of the formation of decision preferences. The arrival of the era of big data provides rich empirical analysis materials for risk decision theory. The big data analysis method enables researchers to identify patterns, predict trends and evaluate the effects of different decision strategies from massive data. The application of these technologies deepens the understanding of risk decision-making behavior and provides more accurate guidance for actual decision-making. With the continuous progress of technology and the innovation of research methods, the theory of risk decision-making is expanding to a deeper and wider field, and its theory and application prospects show unlimited possibilities.

4. The Research Status and Main Achievements

4.1. Main Progress and Achievements

The research of domestic risk decision theory has made remarkable progress in recent years. Researchers have made great efforts in exploring the localization theory of risk decision-making. The risk decision theory based on the double criteria of value and risk is a typical example, which comprehensively considers the two dimensions of value maximization and risk minimization, and provides a new idea for decision makers to balance benefits and risks. In addition, the research on the theory and method of large group risk decision-making has also made a breakthrough, especially in the dynamic evolution of group behavior and the formation mechanism of collective wisdom. Domestic scholars have put forward a series of innovative theoretical models and empirical analysis methods. These research results enrich the connotation of risk decision theory and provide strong theoretical support for the actual risk management practice. In the fields of financial investment, enterprise strategic planning, public safety management, etc., the research results of domestic scholars' risk decision-making have been applied and achieved certain economic benefits and social impacts.

4.2. Comparison with International Studies

Compared with international research, domestic research on risk decision theory has its unique characteristics and advantages. On the one hand, on the basis of drawing lessons from foreign advanced theories and methods, domestic research pays more attention to combining China's social and cultural background and actual national conditions, and explores risk decision-making theories and models suitable for China's characteristics. This localization research orientation makes the domestic risk decision theory closer to reality, with more explanatory power and application value. On the other hand, China has shown obvious advantages in the application of big data and artificial intelligence technology. With the rapid development of economy and society in China, the accumulation of big data resources and the progress of artificial intelligence technology provide new opportunities for the study of risk decision theory. Domestic scholars have begun to use these emerging technologies to improve the risk decision-making model and improve the intelligent level of decision-making. For example, through big data analysis technology, researchers can more accurately predict market risks and evaluate decision-making effects; The application of artificial intelligence algorithm makes the decision-making model better adapt to the complex and changeable decision-making environment.

Compared with the international advanced level, there is still a certain gap in the theoretical research of risk decision-making in China. In terms of theoretical innovation, research methods and international influence, domestic scholars still need to make continuous efforts to strengthen exchanges and cooperation with international academic circles. By absorbing foreign advanced research ideas and methods, combined with the actual situation in China, domestic risk decision theory research is expected to achieve greater development in the future. The research of domestic risk decision theory is in a stage of rapid development. With the deepening of research and the accumulation of practice, domestic scholars are expected to make more original contributions in the field of risk decision-making and occupy a place in international academic circles. Strengthening the combination of theory and practice, risk decision theory will also play a greater role in promoting the harmonious development of China society and steady economic growth.

4.3. The Status Quo of Foreign Research

4.3.1. Important research results

On the international stage of risk decision-making theory, a series of innovative researches are constantly emerging, which promotes the in-depth development of this field. The risk decision theory put forward by Yates and Stones provides a new perspective for understanding the behavior of decision makers in the face of uncertainty by introducing psychological principles. In addition, the multi-criteria decision-making method based on fuzzy measure and cumulative prospect theory provides a new way to deal with complex decision-making problems, which shows its unique advantages in dealing with incomplete information and subjective judgment. Foreign research achievements have made remarkable progress in many aspects of risk decision theory. Researchers have deeply discussed the psychological mechanism of how decision makers deal with information, evaluate risks and make choices. Especially under the influence of cognitive bias and situational factors, the behavior pattern of decision makers has been widely concerned. In addition, some research focuses on how to design a decision support system to help decision makers better understand and manage risks. These research results

not only enrich the connotation of risk decision theory, but also provide theoretical basis and practical guidance for actual risk management.

4.3.2. Research trends and frontiers

At present, the trend of foreign research shows that researchers are working hard to incorporate cognitive bias and situational factors into risk decision-making models. This trend reflects the pursuit of a more comprehensive understanding of the behavior of decision makers and the concern of improving the prediction ability of models. Researchers are exploring how to combine the knowledge of psychology, neuroscience and data science to build a more accurate and practical risk decision-making model. Future research directions may also include the application of emerging technologies, such as artificial intelligence and machine learning, in risk decision-making, and how these technologies can help decision makers deal with the increasing information and complexity. With the deepening of these studies, risk decision theory is expected to make new breakthroughs in both theory and practice. Especially in the fields of financial investment, medical diagnosis and environmental policy making, the application prospect of risk decision theory is broad. Researchers are constantly exploring new areas of risk decision-making through interdisciplinary research methods, in order to provide more scientific and reasonable decision-making tools and strategies for decision makers. It is expected that in the future, risk decision theory will continue to be an important branch of decision science and make greater contributions to the development of human society.

4.4. The Development of Theoretical Models

4.4.1. Prospect theory

Since Kahneman and Tversky put forward the prospect theory in 1979, it has become the cornerstone of risk decision research. Prospect theory breaks through the framework of traditional expected utility theory, and better explains people's decision-making behavior in the face of potential losses by introducing concepts such as loss aversion. The core of this theory is that people's aversion to loss is far greater than their preference for the same income, which has been widely used in many fields such as economic decision-making and insurance purchase. Cumulative prospect theory, as an extension of prospect theory, further refines the ranking dependence in decision-making process and provides a new perspective for solving some normative problems. CPT makes the theory more accurate in describing and predicting the actual decision-making behavior by considering the cumulative evaluation of the results by decision makers.

4.4.2. Opportunity threat theory

The opportunity threat theory put forward in 2018 regards risk decision-making as a dual process of seeking opportunities and avoiding threats. This theoretical framework not only explains the phenomena that traditional theories can't explain, but also provides new theoretical support for understanding how decision makers balance risks and opportunities in a complex environment.

4.4.3. Risk decision-making based on big data and dynamic environment

With the development of big data and artificial intelligence technology, the research of risk decision theory began to pay attention to how to make effective decisions in the rapidly changing information environment. This requires that the theoretical model can adapt to the dynamic environment, deal with a large number of real-time data, and provide timely decision support for decision makers.

4.4.4. Exploration of influencing factors

The discovery of frame effect reveals the influence of problem expression on decision preference, which has important applications in many fields such as economy, medical care and policy making. The study of frame effect promotes a deeper understanding of human cognitive bias and provides a theoretical basis for designing a more reasonable decision-making environment. The influence of individual differences and environmental factors on risk decision-making is an important content of research. Research shows that different individuals may make different decisions when facing the same risks due to differences in cognitive ability, experience and cultural background. In addition, environmental factors such as social pressure and information availability will also have a significant impact on decision-making. In large group risk decision-making, how to realize the psychological and behavioral coordination among decision-making members is a hot issue in current research. This involves how to achieve effective risk communication, consensus formation and collective action in social networks, which is of great significance to emergency management, public policy and other fields.

4.4.5. Expansion of application fields

The application fields of risk decision theory are expanding, which provides theoretical support and practical guidance for decision-making in different fields. Total risk management is one of the latest research trends of risk management theory. It emphasizes the comprehensive identification, evaluation, monitoring and control of risks, not only focusing on the management of a single risk, but also emphasizing the mutual influence between risks and the control of the overall risk. The goal of total risk management is to improve the organization's risk management ability through integrated hedging tools and frameworks. Emerging risks, such as COVID-19 pandemic and network security, pose new challenges to the existing risk decision theory. Faced with these emerging risks, researchers put forward the method of "decision priority", that is, before making risk analysis, the objectives and scope of decision-making should be made clear, and then risk analysis and decision support should be made according to these objectives and scope to improve the pertinence and effectiveness of decision-making. With the development of society and the progress of science and technology, risk decision theory will continue to face new challenges and opportunities. In order to adapt to the changing decision-making environment and provide more scientific and effective decision-making support for the development of human society, future research needs to be deeply explored in theoretical innovation, method improvement and interdisciplinary integration.

5. Research Methods and Decision-Making Criteria

5.1. The Main Decision-Making Methods

In the rich field of risk decision theory, various decision-making methods, like different tools in the toolbox, play a key role in different decision-making scenarios. Expected utility theory, as the cornerstone of decision-making theory, helps decision-makers to make choices in uncertainty by providing a framework for quantifying expected results. Based on utility

function and probability distribution, this theory calculates the expected utility value of different choices, thus guiding decision makers to choose the result of maximizing expected utility.

The law of definite equivalence adopts a more simplified method, which transforms uncertain cash flow into a definite equivalent through the concept of definite equivalence, thus simplifying the decision-making process. This method is especially suitable for those decision makers who prefer to avoid complex probability calculation. Besides these, there are more complicated methods such as decision tree and Monte Carlo simulation. Decision tree shows different decision paths and possible results by constructing a branch structure diagram, so that decision makers can clearly see the potential consequences of each decision point. Monte Carlo simulation uses random sampling technology to simulate the possible distribution of results, which provides a powerful tool for decision makers to evaluate the uncertainty of complex systems.

5.2. The Application of Decision-Making Criteria

Decision criteria are guiding principles in the decision-making process, which help decision-makers to evaluate and choose schemes according to their own preferences and goals. The maximum expected return decision criterion (EMV) is an intuitive criterion, which guides decision makers to choose the scheme with the maximum expected return by calculating the expected return of each scheme. This criterion applies to those decision makers who are willing to take certain risks in exchange for higher returns. Contrary to EMV, the minimum opportunity loss decision criterion (EOL) takes into account the sensitivity of decision makers to losses and guides decision-making by minimizing the maximum potential losses. EOL criterion is very useful for those risk-averse decision makers. The satisfaction criterion provides a more flexible decision-making method, which allows decision makers to choose schemes according to their satisfaction thresholds. This method is suitable for those decision-making scenarios where the pursuit of the optimal solution is not as concerned as the satisfaction with the acceptable solution.

The minimum variance criterion focuses on the stability of the results, and it encourages decision makers to choose those schemes with the least fluctuation of income. This criterion is particularly important for those decision makers who prefer prudent strategies and want to avoid drastic fluctuations. In practical application, decision makers often formulate strategies according to specific conditions and combining various decision-making methods and criteria. For example, in investment decision-making, a risk-neutral investor may use EMV criterion combined with expected utility theory to find the optimal portfolio, while a risk-averse investor may prefer to use EOL criterion and certain equivalent method to ensure capital safety. With the constant change of decision-making environment and the emergence of new challenges, researchers and practitioners are constantly exploring new decision-making methods and criteria to meet the complex and changeable decision-making needs. These innovations not only enrich the connotation of risk decision theory, but also provide more choices and more effective decision support for decision makers. With the deepening of interdisciplinary research, future decision-making theories and criteria will be more refined and personalized to meet the unique needs of different decision makers.

6. Existing Problems and Challenges

6.1. The Oretical Basis and Methodology Issues

The cornerstone of risk decision theory lies in the accurate definition and quantification of risk, which is one of the bottlenecks in the development of this field. Risk quantification involves uncertainty and complexity, which requires researchers not only to understand probability theory, but also to master how to make inferences under incomplete information. The confusion of traditional methods, such as chance constrained programming (CCP) and stochastic programming (SPR), in concept transformation highlights the shortcomings of existing methodology. This leads to the loss of utility in practical application, which reflects the need to develop more refined and diversified methods to deal with uncertainty and complexity. In order to overcome these challenges, researchers need to explore new mathematical tools and calculation models to enhance the applicability and flexibility of the theory.

6.2. The Challenges of Interdisciplinary Integration

The depth and breadth of risk decision theory require it to become an interdisciplinary integration field. This requires not only insight from social science, but also technical support from engineering, behavioral science, statistics and other disciplines. The challenge of interdisciplinary integration is to establish a common language and framework so that experts in different fields can communicate and cooperate effectively. In addition, the differences in research paradigms and methodologies of different disciplines also constitute obstacles to the integration of theory and practice. In order to achieve effective interdisciplinary integration, it is necessary to establish an interdisciplinary education and research platform, promote the exchange and integration of knowledge in different fields, and develop a set of general research principles and methods.

6.3. The Handling of Information Uncertainty

Information uncertainty is an inevitable problem in risk decision. Decision-makers will change their decision-making behavior when faced with different degrees of information clarity. This requires that risk decision theory should not only pay attention to the collection and analysis of information, but also study how to make decisions under the condition of incomplete or fuzzy information. The development of effective information processing strategies and decision support tools is very important for improving the quality of decision. In addition, researchers need to explore how to understand the psychological mechanism and behavior pattern of decision makers under uncertainty from the perspective of psychology and behavioral science.

6.4. The Impact of Social and Cultural Factors

Risk decision-making does not happen in a vacuum, it is deeply influenced by social and cultural factors. Different social and cultural backgrounds will lead to different perceptions and acceptance of risks. For example, in the decision-making of public risk response, the differences in interests, values and political positions among different groups often lead to differences and conflicts in the decision-making process. This requires that the risk decision theory must consider the role of social and cultural factors and how

to balance the needs and expectations of different groups when formulating strategies. In addition, risk communication and public participation are also important links in the process of risk decision-making, which play an important role in forming social consensus and improving the acceptability of decision-making.

New challenges brought by technological progress. Technological progress, especially the development of artificial intelligence and big data technology, has brought unprecedented opportunities and challenges to risk decision theory. These technologies provide powerful data analysis and processing capabilities, and help to improve the accuracy of risk assessment and the efficiency of decision-making. However, it also brings some concerns about data privacy, algorithm transparency and ethical issues. How to ensure the rationality and fairness of technology application and prevent technology abuse has become a new problem for risk decision theory. In addition, with the continuous evolution of technology, the theory of risk decision-making needs to be constantly updated to adapt to the new situation and needs brought about by technological development.

7. Conclusion

Risk decision theory is an indispensable tool to understand the complex decision-making process, which combines the research results of economics, psychology and management. From the expected utility theory to the prospect theory, and then to the multi-dimensional analysis of the behavior of decision makers in modern times, the theory of risk decision-making has evolved continuously, deepening our understanding of rational and irrational factors in decision-making. This review highlights the core concepts, main methods, decision criteria and wide application of risk decision theory in different fields. At the same time, it also points out the limitations of current research, such as the gap between theory and actual decision-making and the lack of research methods.

Looking into the future, the development potential of risk decision theory is huge, and the research direction is increasingly diversified. Theoretical innovation will continue to promote the development of this field, especially the cross-integration of behavioral economics, neuroscience and data science, which will provide new perspectives and tools for risk decision theory. Technological progress, especially the application of big data and artificial intelligence, will make the risk decision-making process more intelligent and accurate, and improve the efficiency and effectiveness of decision-making. Interdisciplinary research will become an important trend in the development of risk decision theory, integrating the knowledge and methods of different disciplines to provide a new perspective and solution for solving complex risk decision problems. Education and training will also play an important role in cultivating interdisciplinary talents and supporting research and practice in this field. With the deepening of globalization and social informatization, risk decision theory will face more new challenges and opportunities. Risk management in the fields of climate change, network security and public health will become the focus of future research. Through continuous theoretical innovation and practical exploration, risk decision theory is expected to make an important contribution to building a safer, more stable and prosperous world.

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