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Minimum adjustment consensus optimization models with fuzzy preference relations: The perspective of cardinal and ordinal consensus

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***Abstract*—In group decision-making (GDM), traditional consensus models have primarily focused on cardinal consensus. In reality, irrespective of whether the objective of GDM is to select the optimal alternative or to rank alternatives, it is imperative to establish a ranking that garners the utmost assent from all decision-makers (DMs). When preferences are articulated through fuzzy preference relations (FPRs), cardinal information emerges in numerical form, quantifying the degree of preference for alternatives, while ordinal relations are implicitly embedded within pairwise comparisons. To delve into both cardinal and ordinal consensus among DMs, this study introduces two consensus optimization models that strive to minimize adjustments to FPRs while fostering consensus in terms of preference intensity and ranking. To this end, we first propose two ordinal consensus measurement methods: one precisely discerns whether DMs have achieved consensus on the selection of the best alternative, while the other assesses the consistency of different preference rankings, taking into account the importance of positions. Based on these methods, two systems of inequalities are designed to explicitly govern both types of ordinal consensus. Subsequently, two consensus control rules are formulated, tailored to distinct objectives. These rules necessitate not only cardinal consensus among all DMs but also their alignment in terms of either the selection of the best alternative or the preference ranking. Ultimately, these rules are integrated as constraints into two mixed-integer programming models aimed at minimizing preference adjustments. The proposed models have been applied in a case study, confirming their practicality, with thorough comparative analyses demonstrating their effectiveness.**

***Index Terms*—Group decision-making; Cardinal and ordinal consensus; Fuzzy preference relation; Mixed-integer programming model; Minimum adjustment.**

I. Introduction

GDM assumes a pivotal role across various domains [1]. Whether it pertains to formulating business strategies [2], assessing projects [3], or selecting contingency plans [4], a collective of DMs is imperative to articulate opinions on a finite set of alternatives [5]. Within this process, preference relations, particularly FPRs, demonstrate remarkable advantages [4], [6]. Relying on pairwise comparisons among alternatives, they not only evaluate their relative merits but also leverage multiple potential degrees of membership to capture the underlying intensity of such relations, thereby enriching the arsenal of tools for expressing individual opinions [7].

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In GDM, consensus reaching process (CRP) holds paramount significance and involves two stages [8], [9]: consensus measurement and feedback adjustment. Consensus measurement provides the directional guidance for adjustment, while feedback adjustment, by adjusting opinions and resolving discrepancies, fosters a continuous enhancement of consensus levels [11], [12]. Recent years have seen significant progress in research on the CRP. The majority of these studies focus on cardinal consensus, where a high level of consensus among DMs is assumed when they give similar evaluation values [2], [8], [9], [10], [11], [13]. However, the objectives of GDM vary depending on the type of decision problem, which also imposes different requirements on the CRP. Broadly, the objectives of GDM can be classified into two primary types:

(1) Firstly, the objective is to select the optimal alternative from a set of candidates [9], [12]. Such scenarios are ubiquitous in areas like supplier selection, facility location [1], [2], where DMs strive to identify the best solution based on economic considerations, ensuring the subsequent economic activities proceed efficiently and smoothly [13], [14].

(2) Secondly, the aim is to rank or rate the alternatives, a goal commonly encountered in service provider evaluations, project competitiveness rankings, and performance appraisals [16], [17]. DMs employ systematic evaluation frameworks to arrange the alternatives in descending order of merit [18], [19].

Both objectives entail prioritizing alternatives, implicitly necessitating a CRP that facilitates DMs in identifying a ranking that garners the broadest acceptance among them. Cardinal consensus models, which leverage distance metrics between individual preferences, are ill-suited for such scenarios [20], [21]. They readily steer towards sufficient similarity in preferences between pairs of DMs, yet their respective desired rankings of alternatives may conflict with each other's preferences [21]. In recent years, ordinal consensus has garnered increasing attention [20]. Contrasting cardinal consensus, ordinal consensus emphasizes the alignment of DMs' preferences in terms of ranking. It focuses on the relative merits and drawbacks among alternatives rather than the specific nuances of evaluation information [24]. While full cardinal consensus represents a stricter criterion than ordinal consensus, its achievement poses formidable challenges. Consequently, adhering to acceptable levels of both cardinal and ordinal consensus can be regarded as an indispensable principle in ensuring effective consensus among DMs. Nevertheless, as previously mentioned, the preponderance of existing research has predominantly centered on cardinal consensus

Graph Model for Conflict Resolution Considering Heterogeneous Behavior Based on Hesitant Fuzzy Preference and Social Network Analysis

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***Abstract*—Graph model for conflict resolution (GMCR) is an effective tool to solve conflicts, which determines the feasible states by modeling the conflict, and then analyzes the behavior of decision-makers (DMs) through stability analysis to find a solution to the conflict. This article studies the composite DMs (CDMs) and the heterogeneous behaviors of opponents in GMCR. Based on the social relationship between DMs, the social network is applied to analyze the individuals in CDMs and to identify the types of heterogeneous behaviors of DMs. Combining social network and aggregating operator, this article unifies the preferences of individuals in a CDM. Subsequently, an identification mechanism is designed to determine the kind of opponents' heterogeneous behaviors. Then, the mixed stabilities are extended to hesitant fuzzy mixed general meta-rationality (HFMGMR) and hesitant fuzzy mixed symmetric meta-rationality (HFMSMR). The matrix representations of two stabilities are developed to analyze the equilibrium of conflicts. Finally, a conflict in pollution rectification of industry enterprises is analyzed to demonstrate how social networks can be applied to GMCR with CDM and heterogeneous opponents. Hesitant fuzzy mixed stability analysis reveals the influence of heterogeneous behaviors in GMCR. Different types of DM behavior lead to different equilibrium results, which is concluded in this article.**

***Index Terms*—Composite decision-makers (CDM), graph model for conflict resolution (GMCR), hesitant fuzzy mixed stabilities, heterogeneous behaviors, social network analysis (SNA).**

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I. Introduction

IN PRACTICAL problems, conflicts are always common due to the different interests and purposes of each decision-maker (DM) involved in the problem. Conflicts may lead to many malignant incidents, ranging from daily life to international events [1], [2]. Therefore, properly analyzing and resolving conflicts is a problem worth studying. Researchers [3], [4], [5], [6] combined graph theory with game theory to systematically analyze conflicts to form the graph model for conflict resolution (GMCR). In GMCR, multiple DMs with different interests, backgrounds, and purposes are involved. Each DM has the option to change the current state of the conflict. In response, other DMs have options to change the state of conflict further. GMCR aims to find the equilibrium state where all DMs compromise so the conflict cannot proceed further.

Since the creation of GMCR, its modeling methodology [3], [5], DMs' game process [7], and preference representation [8] have been extensively researched, and a systematic system has been formed. The GMCR can be divided into two parts: 1) modeling and 2) analysis. When modeling a conflict, the DM's options in the conflict are first constructed based on the specific conflict background. Next, the states of the conflict are constructed based on the options of DMs, and the unreasonable states are excluded based on the specific background. Then, the state transition diagram of the DMs is constructed to complete the modeling. The analysis of the GMCR mainly includes stability analysis, status quo analysis, and sensitivity analysis. Among them, stability analysis is crucial to finding the equilibrium state of conflict. The equilibrium state is stable for all DMs. In an equilibrium state, all DMs cannot take further actions that would make the conflict continue. Therefore, the conflict ends, and the equilibrium state can be regarded as a resolution of the conflict.

Take the conflict in pollution rectification of industry enterprises as an example. Industrial emissions have led to serious pollution. Therefore, residents have the option of appealing to the Government. Local Government has the option of fining the enterprise or issuing a rectification order. And the enterprise can choose to accept the rectification or not. Within the enterprise, different individuals may have different opinions on the order of Government, which leads to significant differences in individual preferences for the feasible state. Expressing an enterprise's opinion on the feasible states regarding an

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A social trust network-based classification consensus decision-making method with incomplete information: cross-classification adjustment perspective

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ABSTRACT

The consensus decision-making problem based on classification requires placing alternatives in a predetermined category in a specific order, occupying an important position in group decision-making. To achieve a high level of group identification with the output results, the current research primarily focuses on modifying expert evaluation opinions to indirectly adjust the classification of alternatives, which may result in a significant deviation between the revised and initial opinions. Consequently, this paper constructs a classification consensus decision method with incomplete information from the perspective of cross-classification adjustment and social network analysis technology. Firstly, the node strength in the PageRank algorithm is used to acquire the weight of experts, and incomplete information is supplemented based on social trust network and opinion evolution. Secondly, the classification threshold model of the maximum group consensus is established, and the unified classification threshold of alternatives is calculated. In addition, the consensus-reaching process is achieved through the optimization model of cross-classification minimum adjustment, which directly adjusts the classification of the alternatives and avoids excessive modification of opinions. Further, taking the rating of green tourist scenic area buildings as an example, the applicability of the proposed method is tested. Ultimately, the efficacy and advantage of the presented approach are demonstrated via sensitivity analysis and contrast with current methodologies.

1. Introduction

The vigorous development of the social economy and the rapid replacement of science and technology have made the decision-making environment unpredictable, and individual decision-makers (DMs) have shown obvious limitations in dealing with dynamic and multidimensional decision-making problems (Li et al., 2020, 2022). In this context, the group decision-making (GDM) model has gradually become a research hotspot by expanding from a single DM to multiple DMs collaborating (Wang et al., 2022; Zhang & Li, 2021). GDM has gradually expanded to multi-criteria group decision-making (MCGDM), which refers to the process in which multiple DMs participate in decision analysis based on different criteria (Liu et al., 2022; Wu, Zhou, Dong, Xu, Altalhi, & Herrera, 2022; Zhang, Li, & Gao, 2021). MCGDM systematically balances alternatives under various criteria by integrating the differentiated evaluation perspectives of experts from multiple fields, effectively enhancing the scientificity of complex decision-making problems. Currently, it has been widely applied in fields such as political consultation, economic planning, cultural evaluation, etc. (Morente-Molinera et al., 2017; Yu et al., 2017; Zhang et al., 2019).

In the actual MCGDM process, owing to the constraints of decision time and limited knowledge, the initial evaluation information given by DMs may be incomplete. However, incomplete information may compromise the integrity of the decision matrix, thereby affecting the normal operation of algorithms or models in subsequent decisions. At the same time, the presence of missing values can slow down the decision-making process, reduce the quality of decision-making, lead to biased decision results, and weaken the accuracy and reliability of

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技术专利许可下新能源汽车供应链的管理策略研究——是否引入职业经理人

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摘 要 在技术专利许可下, 根据企业是否引入职业经理人, 建立了四种管理策略 (不引入、供应商/制造商单独引入和都引入) 下新能源汽车供应链的分散决策博弈模型, 旨在深入探讨职业经理人引入对企业创新决策的影响. 此外, 从多个角度研究了供应链成员是否引入职业经理人的问题. 研究表明, 企业创新水平与激励水平负相关. 引入职业经理人的企业, 其利润随着自身设置的激励水平的增加而增加, 但随对方设置的激励水平的增加而减少. 从创新和市场需求角度来看, 都引入职业经理人是最明智的选择. 然而, 综合考虑各方利益的话, 双方的选择可能出现两种极端情况, 即都不引入或都引入. 但是, 在都引入策略下设计收益共享-成本分担契约可实现供应链成员利润的 Parto 优化. 这表明当供应链成员都引入职业经理人时, 设置合适的协调机制有助于促进企业创新和维护供应链的稳定运行.

关键词 新能源汽车供应链; 专利许可; 职业经理人; 管理策略

Research on the management strategy of a new energy vehicle supply chain under technology patent licensing — Whether to introduce professional manager

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Abstract In the context of technology patent licensing, the game models for the supply chain of new energy vehicles have been established based on four management strategies: no introduction, individual introduction by suppliers/manufacturers, and mutual introduction of professional managers. The aim is to comprehensively explore the impact of introducing professional managers on innovation decision-making within companies. Additionally, we have investigated the question of whether supply chain members should introduce professional managers from various

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Graph model for conflict resolution for mixed-stability combinatorial foresight based on the combination of regret theory and VIKOR method

Peide Liu, *Member, IEEE*, Xue Wang, Yingxin Fu and Peng Wang

***Abstract*—The graph model for conflict resolution (GMCR) is a branch of decision-making; therefore, how to scientifically abstract the evaluative thinking of decision-makers (DMs) has always been a core research point in decision science. In this context, further consideration of the heterogeneous behavior of competitors and their impact on the evolution of conflicts deserves special attention. Usually, DMs' evaluation thinking has certain ambiguity and uncertainty, and they are accustomed to giving qualitative evaluation information. Given the unique advantages of trapezoidal interval type-2 fuzzy sets (TrIT2FS) in the fusion of decision domains and transformational linguistic expressions, this paper constructs a theoretical framework for a graph model on TrIT2FS and proposes a method for calculating DMs preference ranking and a heterogeneous combinatorial foresight stability function. Firstly, the DMs will consider multiple factors in the decision evaluation process, and there are specific regret avoidance psychological behavior characteristics; thus, this paper integrates VIKOR and regret theory to solve the DM's preference ranking and expands on a new preference ranking method. Secondly, mixed stability definitions based on TrIT2FS are proposed to facilitate the description of different sanctioning behaviors of heterogeneous opponents. Subsequently, a heterogeneous combinatorial foresight stability function is proposed to quickly obtain conflict evolution solutions in complex dynamic conflict problems based on the extended mixed stability definitions. Finally, to thoroughly test the correctness and practicality of the proposed theory, the conflict between inputs and outputs of the technological transformation of enterprises under the low-carbon strategy is used as a specific application scenario and example for validation.**

***Index Terms*—Graph model for conflict resolution (GMCR), trapezoidal interval type-2 fuzzy sets (TrIT2FS), regret theory, VIKOR, heterogeneous opponents, combinatorial foresight.**

I. Introduction

In contemporary profit-driven societies, conflicts arising from the pursuit of maximizing individual or collective interests are prevalent in all fields. Since the uncontrolled development of conflicts can lead to many undesirable consequences, effective mediation must be employed to contain and resolve conflicts promptly. The graph model for conflict resolution (GMCR) effectively addresses the steady state of strategic conflict. The method requires only the relative preferences of decision-makers (DMs) in all feasible states. Based on the advantages and widespread use of the model, GMCR is used by experts and scholars in many fields of conflict problem-solving. In international conflicts, conflicts over water resources have become the focus of conflicting interests [1, 2]. In addition, Rêgo et al. [3] studied the Cuban Missile Crisis event between the United States and the Soviet Union using the GMCR. Although international disputes abound due to economic development needs, specific conflicts within each country urgently need to be resolved. Yang et al. [4] modeled the transboundary water resources conflict in the Yangtze River Delta in China. Qu et al. [5] also solved the large-scale engineering resumption conflict under the influence of epidemics using a newly proposed graphical model. In summary, the GMCR model has been widely applied in multiple fields with the deepening of research. However, there are relatively few GMCR research results related to environmental conflicts. With the intensification of global climate change and the deepening of sustainable development concepts, green and low-carbon development has become the international community's consensus and direction for action. Yin et al. [6] studied and analyzed the brownfield remediation conflict at a school in China. Zhang et al. [7] explored a dual-channel supply chain's carbon emission reduction conflict from the perspective of inverse graph modeling. The GMCR model has broad application prospects and the potential to solve real-world environmental conflicts.

The core implementation process in the GMCR theoretical framework is usually divided into two key steps: modeling and stability analysis. The essence of the modeling stage is to abstract the real conflict problem into a rigorous mathematical model, thus laying the foundation for the subsequent analysis. Each DM in the conflict independently prioritizes all feasible states based on personal interests and goal orientations, which is an essential step in the modeling stage and has a crucial impact on the final solution outcome. At first, DMs directly rank their preferences for feasible states based on their interests, a method known as the direct ranking method [8]. Then, with the increasing complexity of the conflict background, experts and scholars continue to explore new methods to give appropriate and persuasive preference ranking with rigorous mathematical reasoning. Therefore, two other commonly used preference ranking methods are the strategy weight ranking method and the strategy priority ranking method [4, 9]. Given the inherent ambiguity and uncertainty in DMs' cognitive and evaluative processes, scholars in the GMCR field have been actively incorporating various information forms to translate their evaluative feedback into mathematical terms more

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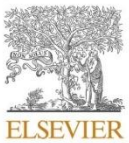

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A dynamic dual-trust network-based consensus model for individual non-cooperative behaviour management in group decision-making

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Non-cooperative behaviours

ABSTRACT

In group decision-making, trust relationships are the basis of interactions among decision makers (DMs) and play an important role in maintaining cooperation. However, DMs from different backgrounds may use the trust relationship to influence the opinion adjustment of other individuals and adopt non-cooperative behaviours, which will also consume trust among DMs, both of which are ignored by extant consensus models. To explore the mutual influence of trust relationships, consensus processes, and non-cooperative behaviour, a consensus model for individual non-cooperative behaviour management in group decision-making under a dynamic dual-trust network is proposed. First, to represent the trust relationship among DMs in a more realistic way, a dynamic dual-trust network based on familiarity-based trust and similarity-based trust is developed. This approach can comprehensively model the interpersonal relationship and opinion similarity among DMs, while dynamically updating according to their interactions. Second, a minimum adjustment consensus model based on a dual-trust relationship is proposed. This model can provide adjustment suggestions to DMs to retain initial opinions as much as possible while considering the impact of trust relationships on opinion adjustments. Subsequently, a non-cooperative behaviour management method based on non-cooperative willingness and trust risk is designed to classify the behaviour of DMs and then adjust their trust relationship and weight accordingly. Subsequently, an illustrative example is provided to demonstrate the effectiveness of the proposed method. Finally, the validity of the model is verified through a simulation and comparative analysis.

1. Introduction

Group decision-making (GDM) aims to select the best solution from a set of alternatives based on the preferences and opinions of a set of DMs [1,2]. In GDM, selecting the final solution is no longer the responsibility of an individual; rather, it is the outcome of fully leveraging collective intelligence. Therefore, the GDM method is widely used in addressing intricate societal issues [3,4]. However, owing to the divergent educational backgrounds, professional knowledge, and varying comprehension levels regarding decision-making issues among DMs, large differences exist in their evaluations of alternatives. The greater the difference in opinions, the lower the consensus level. At this time, the collective opinions obtained by directly gathering individual opinions may not be accepted

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Overlapping community-driven dynamic consensus reaching model of large-scale group decision making in social network

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Overlapping community detection
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ABSTRACT

Large-scale group decision-making (LSGDM) serves as a pivotal tool for facilitating consistent decision results through intricate interactions among individuals within the network. However, the impact of complex trust relationships within overlapping communities on consensus is often overlooked in many studies. Moreover, the dynamic interaction between overlapping communities and the consensus reaching process (CRP) is seldom taken into account. This paper aims to build an overlapping community-driven consensus reaching model for addressing LSGDM challenges in social network. Given the advantages of intuitionistic fuzzy numbers (IFNs) in uncertain information representation, IFNs are used to express evaluation information and trust information. Firstly, a novel overlapping community detection method is developed to divide subgroups and detect overlapping communities. Secondly, to determine reliable subgroup weights, this paper constructs a weight determination model that considers multiple factors and their internal correlations. Then, an overlapping community-driven dynamic consensus model is proposed, which provides a new way to resolve the opinion conflicts, considering the dynamic change of CRP. Simultaneously, the reverse effect of opinion adjustment on the social trust network is considered. Finally, the practicality of the proposed model is demonstrated through illustrative cases. Furthermore, through a comparative analysis, the superiority of the proposed model is demonstrated and the efficiency improvement for CRP is verified.

1. Introduction

LSGDM refers to the integration of the wisdom from large-scale decision-makers (DMs) to make the most reasonable decision [10,21,26]. In LSGDM, consensus plays an important role in improving decision quality, fostering teamwork, addressing complex problems, and bolstering decision acceptability [16]. Consensus means that group members reach a shared understanding and viewpoint on a certain issue. This shared perspective can mitigate decision-making risks and enhance the scientific and accuracy of decisions through collaborative brainstorming [17]. Therefore, it is crucial to cultivate a consensus-oriented mindset to facilitate scientific, democratic, and effective decision-making [3,15,40]. Meanwhile, due to the limited cognitive capabilities of DMs, their evaluation information is imprecise and unreliable. To align more closely with human semantic expression habits, IFNs are adopted to represent DMs' evaluation information [37]. It can effectively reduce the deviation between evaluation information and the actual intend meaning. Notably, DMs, as social beings, are not isolated entities in this process. The intricate web of social relationships among

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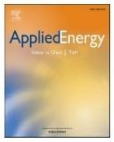

Regional productivity in the energy structure transition of the Yellow River Basin in China - estimation based on a restricted cost function

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HIGHLIGHTS

- Construct **simultaneous equations system** for the measurement of productivity
- Decompose and analyze the **key factors** of productivity changes
- Compare productivity **development trends and hindering factors** in different regions
- Analyze the **biased factors** of technological progress and energy structure adjustment
- Propose **strategies** for energy structure transformation in the Yellow River Basin

ARTICLE INFO

Keywords:
Yellow River Basin
Energy structure transformation
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ABSTRACT

The energy structure transformation (EST) is crucial for achieving the "dual carbon" goals and enhancing regional productivity. Based on panel data from provinces along the Yellow River Basin (YRB) from 2005 to 2021, this study incorporates the energy structure into a restricted cost function to explore the allocative efficiency, spatial dynamic evolution trends, and input factor biases of productivity in the YRB in the context of EST. The analysis shows the following. (i) The average annual productivity growth in the YRB reaches 8.25%, which shows a "U" shaped trend from 11.66% to 8.43%. The scale effect is the main driving force of productivity growth and the contribution of the effect of energy consumption has been amplified in recent years. (ii) Sub-basin analysis shows that productivity growth has the pattern of downstream > midstream > upstream. Although the effect of technological change in the upstream of the YRB is greater than that in the midstream and downstream, its low energy efficiency drags down its development. (iii) Markov chain analysis shows that the development trend of productivity growth in the provinces along the YRB is relatively stable, and it is not easy for provinces to jump ranks. (iv) The analysis of factor input bias shows that technological progress tends to favour the use of capital and energy, while saving the labour. For EST, there is a factor-saving bias for all factors. On this basis, countermeasures to optimize sustainable economic development and EST in the YRB are proposed from a systemic perspective.

1. Introduction

Energy is a crucial pillar and guarantee for national economic growth. The Yellow River Basin (YRB) serves as a crucial energy reserve and production hub in China, significantly contributing to the nation's economic growth. Over 40% of the YRB's area harbors coal resources, with coal production accounting for approximately 80% of the national total. Large-scale coal bases, each producing over 100 million tons, constitute 50% of the country's total number. Coal remains the primary source of energy consumption in the YRB. However, the high energy consumption dominated by coal and fossil fuels, along with increased carbon dioxide emissions, poses severe challenges to environmental protection and sustainable economic development in the YRB. The region faces issues of high resource and environmental load, ecological

Abbreviations: YRB, yellow river basin; EST, energy structure transformation; DEA, data envelopment analysis; APG, average productivity growth; SE, scale effect; CDE, energy consumption effect; SSR, energy structure effect; TCE, technological change effect; U, upstream; M, midstream; D, downstream.

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An improved FMEA method based on the expert trust network for maritime transportation risk management

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Maritime transportation
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Dynamic opinion interaction

ABSTRACT

The prosperity of international trade has driven the development of shipping. Thus, evaluating shipping risks can better avoid risks, improve shipping safety, and promote economic and cultural communication and development. Failure Mode and Effects Analysis (FMEA), as a reliable technique, can be used to identify and analyse the risk of oil spills at sea and improve the stability of maritime transport. Considering the relationship among multi-experts and the influence of the leader, this study intends to improve the FMEA method from some perspectives. First, the multi-party expert trust network is constructed and the expert trust relationship is supplemented as a pre-processing of the FMEA method. Second, a expert dynamic opinion interaction model is constructed to show the evolution of risk assessment information among experts. Which demonstrates the trsut relationships among experts and the leader's influence. Third, in this paper, the risk factor weights are determined by combining the different importance of multi-experts on risk factors and the maximizing deviation model, and the expert's weight is determined by considering the experts' relationships and risk assessment information. Moreover, to demonstrate the ambiguity and hesitation in expert evaluations, and show more assessment information, the hesitant fuzzy sets are employed in this paper. And the effectiveness and superiority of the improved FMEA method is demonstrated through case study and further discussion. The improvements of the FMEA method can help improve the efficiency of the risk assessment, protect the marine ecological environment, and safeguard the interests of investors.

1. Introduction

With the gradual increase of international trade, marine transportation has become the preferred way of international trade transportation with its large volume and low cost. According to statistics, marine transportation undertaken more than 2/3 of the total international trade (Sirimanne et al., 2019). It not only promotes economic development but also political and social communications. To develop the maritime economy, a stable maritime transportation environment is essential. However, it is threatened by natural calamities and accidents, such as heavy weather, lightning, stranding, striking a reef, collisions, etc. Marine accidents are rare but led to economic and environmental consequences (Siddiqui, Sarhadi, & Verma, 2023). And oil spills are one of the key issues, with potentially disastrous environmental, social, and economic consequences (Sevgili, Fiskin, & Cakir, 2022; Siqueira, Moura, & Duarte, 2023). Therefore, monitoring and managing oil spills have considerable economic, social, and practical implications (Li, Yu, Xu, & Luo, 2022). And the trend of continuous growth in maritime activities has increased the urgency of the development of innovative methods for the monitoring and management of potential oil spill damage (Afenyo, Jiang, Ng, & Lee, 2022).

In recent years, many efficient tools for identifying and analyzing risks have emerged, such as quantitative risk assessment (QRA) technology, hazard and operability study (HAZOP), fault tree analysis (FTA), failure mode and effect analysis (FMEA) method. Among them, the FTA method can describe possible failure scenarios of a system (Purba, Sony Tjahyani, Ekariansyah, & Tjahjono, 2015). It starts from undesired outcomes and analyzes the causes according to the cause-effect

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碳政策选择对网络外部性下低碳电商供应链的决策影响研究

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摘要：低碳经济环境下，中小型制造商为了缓解碳减排资金压力，选择依托电商平台进行线上销售。基于由电商平台主导的低碳电商供应链系统，本文将产品的网络外部性纳入模型，构建了碳交易政策和碳税政策下的供应链决策模型，研究政府和低碳电商供应链“共赢”的最佳碳政策。研究发现：(1)探讨各成员企业的最佳碳政策时，制造商的实际碳排放量与政府碳配额的大小关系是重要的影响因素。当实际碳排放量超过政府规定的碳配额时，若碳交易价格超过一个特定的阈值，碳交易政策的惩罚力度大于碳税政策，此时对于供应链成员和政府而言，实施碳税政策更有利；若碳交易价格小于该阈值，则反之。当实际碳排放量小于政府规定的碳配额时，对供应链成员和政府而言，碳交易政策是最佳碳政策。(2)产品的网络外部性对产品价格、市场需求和供应链成员的利润都有正向作用。这些结论为电商供应链成员在低碳背景下的决策提供了参考。

关键词：低碳电商供应链；碳税；碳交易政策；网络外部性
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0 引言

随着经济的发展，全球变暖和环境污染等问题日益突出，各国政府和人民越来越注重低碳经济发展。如何减少碳排放成为人们关注的热点话题之一[1]。为响应政府低碳生产的号召，加大低碳技术投入，进行低碳转型生产成为制造商战略发展的必然选择。例如 2020 年 9 月，亚马逊启动气候友好项目，提供超过 25000 种“气候友好”型产品。低碳转型生产会提高企业形象，吸引低碳消费者。但由于低碳生产需要在技术、选材等方面投入较大资金，使得制造商面临高昂的生产成本，如格力电器为对产品进行节能升级，每年投入近 1 亿元进行技术研发[2]。而对技术研发水平低、收益较少的中小制造商来说，高昂成本无疑是雪上加霜[3]。如在中国珠三角地区，从事传统加工制造的中小企业占很大比重，但其产品竞争力不足，缺乏技术创新能力，市场空间和盈利空间都在收缩。在 2014 年，东莞市关停了 428 家企业，其中传统加工制造企业就有 287 家[4]。

与此同时，随着电子商务的兴起和迅速发展，电商平台的出现为苦于低碳转型的中小型制造商带来了希望。电商平台可以聚集大量的消费者，使产品的网络外部性强度增大[5-6]。产品的网络外部性强度越大，蕴含的经济效益越大，所以网络外部性在电商供应链的生产运营方面起着重要的作用。中小型制造商依托电商平台销售产品时无须花费较多的广告宣传、物流、售后服务等成本，加之电商平台具有网络外部性显著的特性，使得中小制造商可以迅速扩大消费者市场，获得更多的利润。因此，为了减缓资金压力，增大盈利空间，依托电商平台进行线上销售成为中小型制造商的最佳选择。

促使中小型制造商进行低碳转型也是目前政府工作的重点。一般而言，政府采用的碳政策有碳补贴、碳税、碳交易、碳补偿政策等，其中碳交易机制和碳税是最常见的碳政策。碳交易政策具有灵活性和易操作性，全球已有碳排放权交易市场的国家和地区超过 20 个，运行成熟、交易规模较大的碳交易市场有欧盟和美国加州碳排放交易市场[7]。碳税政策作为另一种有效的政策，能够创造环境红利和社会福利[8]。碳税政策也早已在丹麦、日本、荷兰等国家实施，并取得了显著成效[9]。那么，对于依托电商平台销售的中小型制造商而言，碳交易政策和碳税政策中哪种碳政策更有效？企业和社会必须明确这一问题，这是因为：

(1) 入驻电商平台的中小型制造商普遍具有资金少、实力弱的特点，在市场竞争中抗风险能力弱，

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An Improved Failure Mode and Effect Analysis Model for Automatic Transmission Risk Assessment Considering the Risk Interaction

Peide Liu, Yiqiao Xu, and Ying Li

***Abstract*—Failure mode and effect analysis (FMEA) is a powerful tool for reliability management that has been widely applied in a variety of areas. The interaction relationship exists in the whole process of FMEA risk assessment, and has an important impact on it. However, few scholars consider the interaction among experts, risk factors, and failure modes in the FMEA framework. Therefore, we propose an improved FMEA method, which comprehensively considers the interaction between each part. First, the Choquet integral is used to improve the incomplete part of the social trust network, then the importance of experts is determined. Second, the Shapley-LINMAP linear programming method based on cloud model is proposed to calculate the weight of risk factors. Finally, the improved decision-making trial and evaluation laboratory method based on cloud model is used to rank the failure modes. By applying the method proposed in this article to the case of automatic transmission (AMT) of new energy vehicles, the effectiveness and superiority can be verified from the comparison analysis with other methods, which enriches the theoretical research of the FMEA method and improves the reliability of risk assessment of AMT.**

***Index Terms*—Cloud model, decision-making trial and evaluation laboratory (DEMATEL), failure mode and effect analysis, interaction, Shapley-LINMAP.**

I. Introduction

With the rapid expansion of the social economy, various industries represented by the field of transportation have demonstrated great momentum. However, when the government's environmental protection strategy is developed and people's awareness of environmental protection grows, people realize that rapid economic development is usually carried out at the cost of environmental pollution and resource loss. Therefore, the contradiction between economic development and environmental protection is becoming increasingly serious. How to further protect the environment while maintaining economic development is a hot issue in current research. Among them, the development of science and technology has brought new ideas. The transportation industry initially tries to launch new energy vehicles driven by improved energy to alleviate the problems of energy shortage and environmental pollution [6]. However, as one of the key components of new energy vehicles, the quality and reliability of automatic transmission (AMT) have always restricted the development of the new energy vehicle industry. With the development of science and technology, the electronic degree of AMT is increasing, resulting in an increase in risk factors and types. The reliability of AMT and the safety of the whole vehicle can be greatly improved, and the loss can be minimized if these risks can be identified and mitigated in advance. Therefore, selecting a robust reliability management tool for the risk assessment of AMT is necessary and meaningful to improve the quality and reliability of AMT [5], [24].

For AMT, a complex system, the failure of a small component may lead to the paralysis of the whole system and even causes great danger to drivers and the environment. In the past, there were few studies on failure analysis of AMT. The fuzzy fault tree method [24] was used to analyze reliability of AMT. To explore the possible failures of AMT and the impact of failures, Chen et al. [5] used traditional failure mode and effect analysis (FMEA) method to analyze the failure modes (FMs) of AMT. FMEA is a powerful tool to enhance the reliability and safety of products and systems, that was first used in the aerospace industry in the 1960s [1]. FMEA is to predict the impact of failures by analyzing potential FMs, focusing on high-risk failures, and reducing the losses caused by failures. During risk management of AMT, FMEA is not only simple to operate, but also can accurately prioritize failure modes and improve the reliability of the systems. However, the traditional FMEA method also has the following limitations [8], [25], [50].

1) In traditional FMEA method, severity (S), occurrence (O), and detection (D) are given the same weight without considering their relative importance of them.
2) The experts' weight is not taken into account in traditional FMEA procedures.
3) In traditional FMEA method, the values of O, S, D are scored by experts, but it is extremely difficult to evaluate them with accurate numbers.
4) The traditional FMEA technique determines FM rankings based on the comparison of risk priority numbers (RPN),

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Unit consensus cost-based approach for group decision-making with incomplete probabilistic linguistic preference relations

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ABSTRACT

In group decision-making, the incomplete probabilistic linguistic preference relation (InPLPR) has been widely studied because it can flexibly reflect the decision psychology of decision makers (DMs). In addition, to help DMs revise their opinions and reach a consensus, a large number of scholars have conducted research on the consensus reaching process. Therefore, this study proposes a group consensus decision approach based on InPLPR, considering consistency, the social trust network (STN), and unit cost consensus adjustment. First, an InPLPR consistency measure formula is proposed, based on which a multi-stage missing value estimation method based on optimal consistency and STN is offered for the missing information problem in InPLPR. Thereafter, the hesitation index and unit consensus cost measurement formulas are presented for incomplete probabilistic linguistic term set. Subsequently, consensus reaching and ranking selection are performed based on the proposed unit minimum cost consensus model. Finally, a numerical example of the future development choice problem for new energy vehicle enterprises is provided to demonstrate the applicability of the decision process, and the advantages of the method are derived through comparative analysis.

1. Introduction

Group decision-making (GDM) is a form of decision-making that effectively avoids the problems of an individual's decision errors. These problems primarily originate from the deficiencies of the individuals themselves, including knowledge and experience, ability level, and information sources. The GDM problem generally consists of four stages: expression of individual opinions, consensus reaching process (CRP), aggregation process, and selection and ranking. In GDM, preference decision-making (PDM) is popular because it is simple for the decision maker (DM) to compare the two alternatives individually. In PDM, in contrast to GDM, each DM requires to provide the decision preference judgment matrix of pairwise comparison, and test the consistency level of the decision matrix. Once the individual's consistency requirements are met, the subsequent steps (CRP, aggregation, selection and ranking) are the same as those in the traditional GDM framework.

Initially, the individuals used real numbers to express their opinions. However, experts are more accustomed and prefer to use linguistic scales such as poor, average, and good for information evaluation. In 1975, Zadeh [1] first proposed the use of linguistic terms to express preference information, and breaking the monolithic situation that was limited to describing

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Risk assessment based on failure mode and effects analysis (FMEA) and WASPAS methods under probabilistic double hierarchy linguistic term sets

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Multiple criteria group decision making

ABSTRACT

Failure mode and effects analysis (FMEA) is regarded as an efficient tool in identifying and eliminating system failures and important tool in safety and reliability analysis. However, the traditional FMEA method has some drawbacks, for example, in the process of risk assessment, traditional FMEA method usually ignores the influence factors of weight. Simultaneously, when represent risk assessment information, crisp numbers and fuzzy sets cannot represent complex linguistic information forms accurately. Moreover, the traditional FMEA method ranks risk failures through simple product. Thus, based on these disadvantages, this paper aims to present an improved FMEA method combines with the Weighted Aggregates Sum Product Assessment (WASPAS) method and weight determination method to address the risk assessment problems under probabilistic double hierarchy linguistic (PDHL) environment. In assessment process, the probabilistic double hierarchy linguistic term sets (PDHLTSs) can indicate the probability distribution as a linguistic tool to describe the information reasonably and precisely. The contribution s of this paper can be incarnated as below. Firstly, the PDHLTSs are utilized to provide the linguistic information of failure modes and construct risk evaluation model in risk assessment. Secondly, FMEA method is combined with WASPAS method to overcoming some drawbacks existing in traditional FMEA such as without consideration of the weight of three aspects in Severity (*S*), Occurrence (*O*) and Detection (*D*) and too simple to evaluate the risk factors using Risk Priority Number (RPN) values. Meanwhile, in response to the issue of traditional FMEA method neglecting expert weights, weight determination method is established based on the SNA method under the PDHL context. Additionally, the FMs are ranked through the multi-attribute decision-making method WASPAS, and the final risk ranking result is obtained. Finally, the proposed method is applied to the marine risk assessment faced in the development of marine economy. Based on the assessment results, suggestions are given for the risk problems. In addition, we also carried out sensitivity analysis and accuracy analysis on the evaluation results. At the same time, comparison analysis with existing methods is given to illustrate the superiority of the proposed method.

1. Introduction

Due to the increasing complexity of the decision-making environment, the fuzzy set (FS) (Zadeh, 1965) is proposed. The FS can describe fuzzy information that cannot be described by crisp numbers in complicated environment. The increasing prevalence of linguistic evaluation information has led to the proposal of linguistic term set (LTS) (Zadeh, 1975). Subsequently, some extended forms based on the LTS have been proposed, such as hesitant fuzzy LTSs and its expanded forms (Liu et al., 2022; Xiong et al., 2023), Probabilistic LTSs (Hao et al., 2023), unbalanced hesitant fuzzy LTSs (Liang et al., 2022) and so on. With the uncertainty of the evaluation information becomes more apparent, more evaluation details need to be expressed when describing evaluation information. The evaluation information of these details is easily overlooked and has not been expressed. For this reason, the double hierarchy LTS (DHLTS) and double hierarchy hesitant fuzzy LTS (DHHFLTS) has been presented by Gou et al. (Gou et al., 2017). The DHLTS can describe more details using the two-hierarchy linguistic term (Gou et al., 2017; Gou et al., 2018). Aiming at the problem that the frequency or the important rate of each DHLTS under DHHFLTS cannot be represented by the DHHFLTS and considering the advantages of probabilistic LTS (PLTS) (Pang et al., 2016), a probabilistic DHLTS

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Competitive firms' low-carbon technology diffusion under pollution regulations: A network-based evolutionary analysis

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Low-carbon technology diffusion
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ABSTRACT

To investigate the diffusion degree of low-carbon technology in competitive firms and the influence of different pollution regulations, we constructed an evolutionary game model representing three environmental mechanisms: total amount control and trading, carbon tax, and subsidy, within a complex firm network. By analyzing the effects of carbon quotas, tax rates, and subsidy rates, we comprehensively assessed the performance of these mechanisms in terms of diffusion degree, firm profits, consumer surplus, environmental damage, and social welfare. The study results demonstrated distinct outcomes for each environmental mechanism. Under the subsidy mechanism, low-carbon technology exhibited the highest diffusion degree, suggesting its efficacy in promoting widespread adoption. However, it is worth noting that the higher the subsidy, the more environmental pollution it led to, which presents a trade-off between environmental benefits and financial incentives. On the other hand, the carbon tax mechanism resulted in minimal pollution, reflecting its potential as an effective tool for environmental regulation. Finally, the cap-and-trade mechanism emerged as the most favorable option, as it maximized social welfare while effectively addressing environmental concerns.

1. Introduction

Greenhouse gases are responsible for global climate change and a series of natural disasters. The Paris Agreement sets a crucial target for global greenhouse gas emissions, requiring them to peak as soon as possible and achieve net-zero emissions by 2050. Among greenhouse gases, carbon dioxide stands as a main component, making its reduction a strategic goal for nations worldwide. Low-carbon technology is recognized as an innovative solution to meet emission reduction objectives. E.M [1]. explained the diffusion of innovation as the process through which novel ideas, products, and technologies spread and become widespread within a specific social system over time. Regarding low-carbon technology (LCT) diffusion, its denotes the extent to which it has been adopted and promoted within its domain [2]. For instance, in the automotive industry, considering new energy vehicles as low-carbon technology, the number of such vehicles in China increased by 59.25% in 2022 compared to 2021. According to the New Energy Vehicle Industry Development Plan (2021–2035), China aims to have 100 million pure electric vehicles by 2030, resulting in a substantial reduction of approximately 220 million tons of carbon dioxide emissions. Thus, the diffusion of LCT carries immense importance in enhancing productivity, achieving emission reduction goals, and fostering sustainable development. As mentioned by Ref. [3]; the diffusion of innovation holds greater significance than the innovation itself. For low-carbon technology, its economic and environmental value can only be realized when it is embraced and adopted by more firms and commercialized.

Firms, as the key players in achieving carbon emission reduction goals, establish economic relationships, such as cooperation, competition, and alliances among themselves. These relationships possess distinct topological structures and serve as conduits for the diffusion of LCT. Complex network theory identifies WS small world networks and scale-free networks as the most common types of network relations. The Watts-Strogatz small world network, in particular, exhibits a higher clustering coefficient and shorter average path, it more suitable for describing closely connected firms without significant heterogeneity [4]. Therefore, our papaer believe that the firms we study are closely connected economic systems that conform to the characteristics of small world networks.

However, it is important to note that not all firms adopt LCT due to higher costs and technological barriers [5]. Simultaneously, firm returns are not solely determined by their individual strategies, but are also influenced by other firms' strategies within their network relationships.

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Energy structure dividend, factor allocation efficiency and regional productivity growth-- An empirical examination of energy restructuring in China

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Energy structure
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ABSTRACT

This paper introduces the energy structure variables into the generalized cost function from the dual perspective of energy "structural dividend" and factor allocation distortion. It quantitatively estimates the factor allocative efficiency, cost elasticity and marginal cost of the energy decarbonization practice in China from 2004 to 2019. Estimation results show that: (i) there is a "structural dividend" effect of energy restructuring in China. On average, a 1% increase in the level of decarbonization of the energy structure reduces the total cost by 0.57% and the marginal cost by 5.846 billion yuan. Specifically, a 1% reduction in the share of coal consumption reduces the marginal cost by 4.590 billion yuan. (ii)Energy restructuring has accelerated factor allocation distortions in recent years. In terms of the impact of energy decarbonization on productivity growth, the inhibition of factor allocation distortion on productivity growth mainly comes from scale effect. (iii)Energy restructuring has a heterogeneous impact on productivity growth across provinces. Productivity growth in energy-consuming regions is lower than that in energy-supplying regions, while the regions where factor allocation distortions have a greater impact on productivity growth are mostly found in the central and western parts of the country where factor markets are less developed.

1. Introduction

For a long time, the expansion of energy supply to meet demand has been the general keynote of China's energy development. However, with the rapid growth of economic and social development and energy "hard demand", China's coal-based high-carbon energy structure has brought about serious ecological and environmental problems in sustainability. In September 2020, China proposed a "dual carbon" goal, which aims to achieve a carbon peak by 2030 and carbon neutrality by 2060. In October 2021, the Central Committee of the Communist Party of China and the State Council issued the "Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy", which clearly defined the general direction and key tasks of energy transformation under the "double carbon" target. Then, the State Council issued the "Action Plan to Reach the Carbon Peak by 2030", making the "green and low-carbon energy transformation action" the first of the "ten actions to reach the carbon peak". Promoting energy restructuring and building a clean, low-carbon, safe and efficient energy system has become a fundamental and critical task to achieve the "double carbon" goal.

Under the severe double carbon constraint and low-carbon energy orientation, the whole country has accelerated the pace of energy transformation, focusing on coal control, coal restriction and low-carbon energy development and use. The policy-makers also introduced a series of measures to "double control" the total energy consumption and intensity and cut the backwards production capacity by energy structure adjustment, "up large and down small "and industrial structure optimization to drop high energy consumption, high emissions, and excess backwards production capacity to promote regional production efficiency and low-carbon transformation (Shao et al., 2022). However, there is an inherent mismatch between the demand for energy decarbonization and China's "coal-rich, oil-poor, and gas-poor" resource reserves. The differences in resources, technology, and economic development levels among regions determine the heterogeneity and uncertainty of the impact of energy decarbonization on local economic development; at the same time, local governments have the motive to

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Probabilistic accumulation grey forecasting model and its properties

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ABSTRACT

In grey system theory, the performance of an established grey forecasting model largely depends on how efficiently the grey information can be measured from data. Most existing grey forecasting models use grey accumulating generators to obtain grey information. However, not all grey information helps improve the performance of grey forecasting models. Consequently, simple accumulation leads to the accumulation of error from invalid grey information, which deteriorates the model performance. To address this issue, valid and invalid grey information were defined in this study according their contributions to the model performance. Further, it was proposed to use a Bernoulli distribution to simulate the distribution of *valid/invalid grey information*. Based on that probability, a *probabilistic accumulation operator* was designed to compute grey information, and this grey information was utilized to establish *a probabilistic accumulation operator-based grey forecasting model* (PGM(1,1)). PGM(1,1) is advanced in terms of forecasting because it is not negatively affected by invalid grey information. PGM(1,1) was tested on five public datasets and compared to other grey models as well as a wide range of other forecasting models, achieving state-of-the-art performance. In addition, a comprehensive analysis was conducted to demonstrate how the forecasting performance benefits from identifying valid/invalid grey information in PGM (1,1).

1. Introduction

Information mining is an important means of understanding the evolution law of things. Technological progress has accelerated the generation of information, both valid and invalid (Gupta & George, 2016). Valid information has value attributes and can meet the needs of users (Jiang et al., 2021). However, due to the existence of external disturbance factors, invalid information usually appears along with valid information (Groenhof et al., 2020). This mixed information increases the system uncertainty. Therefore, stripping invalid information from valid information is a feasible method of enhancing system stability (Hakak et al., 2021). The rapid development of machine learning has improved the efficiency of obtaining valid information (Sousa et al., 2022). When the amount of data is sufficiently large, machine learning can replace manual labor, algorithms can be designed according to requirements, and valid information extraction can be achieved (Kiluk, 2017). However, machine learning has limitations when the sample size is not sufficiently large (Ma, Yang, & Sun, 2021; Xian, & Che, 2022; Yang, Tian, & Hao, 2022). Small-sample information also has the potential for information mining (Feng, & Chen, 2021). There are numerous small-sample information application scenarios in emerging industries and emerging economies (Ceylan, 2021; Saxena, 2021; Yang, Sun, Hao, & Wang, 2022). Hence, realizing the mining of small-sample information has important practical significance for guiding social production activities. Grey system theory focuses on the study of small-sample data and advocates accurate prediction of the evolution law of things based on small-sample data (Chen et al., 2020).

Grey system theory has been active in various areas of the economy and society since it was proposed (Ye, Xu, & Gou, 2022; Emmanuel Sapnken, & Gaston Tamba, 2022; Meng, Yang, & Huang, 2018). As a research method for uncertainty systems, grey system theory focuses on the study of small samples. Because small-sample data can provide less information directly than large-sample data, traditional research methods cannot solve such problems well. Grey system theory deeply mines grey information in small samples through technologies such as information superposition and sequence operators, creating a new field of small-sample research (Deng, 1989). Grey prediction is the main topic in grey system theory, and grey prediction models can achieve excellent performance in small-sample data prediction (Duman, Kongar, & Gupta, 2020). According to the number of input variables, grey prediction models can be divided into univariate and multivariate prediction

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Predicting bioenergy power generation structure using a newly developed grey compositional data model: A case study in China

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ABSTRACT

Accurate short-term prediction of bioenergy power generation structure can optimize the bioenergy structure and help achieve carbon neutrality. However, there are currently few related studies, and most of them present long-term predictions on the development potential of bioenergy, which cannot meet the modeling requirements of predicting structure. Hence, the Fractional-order-accumulation grey Compositional data Model with Particle swarm is proposed in this paper (PFCM (1,1)) for forecasting bioenergy power generation structure. The proposed model satisfies the modeling requirements by introducing the fractional accumulation operator to ensure the prediction accuracy, and constructing the spherical mapping space to reduce the data dimension. The empirical studies prove that the newly developed model performs better than other models, which is successfully employed to predict bioenergy power generation structure of China for 2020–2024. The results show that the share of renewable municipal waste in bioenergy power generation will exceed that of solid biofuels by 2023 and the share of biogas power generation has not changed much. Furthermore, although the total amount of bioenergy power generation in China is growing rapidly, unbalanced development and small share of power are two important challenges.

1. Introduction

This section describes the development of China's bioenergy power generation and relevant government policies. A literature review related to the research object is provided in Section 1.2. The contributions and innovations of this paper are stated in Section 1.3.

1.1. Background

As China promised at the United Nations General Assembly, China's carbon emission reduction target is divided into two phases. China aims to achieve the carbon peak goal by 2030 and the carbon neutral goal by 2060. Bioenergy has zero-carbon properties and plays a role in reducing carbon and climate change mitigation [1,2]. After the global oil crisis in the 1970s, clean energy represented by bioenergy has been valued worldwide [3–7]. Presently, the annual output of China's main biomass resources is approximately 3.494 billion tons, and the development potential of biomass resources as an energy source is valued at 460 million tons of standard coal [8,9]. It can be observed that China has great potential for bioenergy development. However, due to the relatively short time available for China to develop bioenergy, the share of bioenergy in China's energy is relatively low, lower than the world average [10,11]. China has taken a series of measures for increasing this proportion because of the goal of carbon reduction [12].

Bioenergy has various classification methods, such as the classification of the chemical nature of the raw materials and the classification of the source of the raw materials. Additionally, bioenergy can be placed in the following categories: agricultural waste and forestry waste, organic sewage, livestock manure, domestic waste, etc. [13,14]. For the convenience of description and statistics, bioenergy is divided into biogas [15], renewable municipal waste [16], and solid biofuels [17] in this paper. It can be observed from Fig. 1 that China's bioenergy power generation has been rising for 2010–2019, and biogas, renewable municipal waste and solid biofuels in the bioenergy power generation structure are rising. This is related to the CO_2 emission reduction target made by China at the United Nations (UN) Climate Change Conference in Copenhagen in December 2009. Presently, this goal has been completed ahead of schedule. In 2018, carbon dioxide emissions per unit of GDP decreased by 45.8% compared to 2005, and non-fossil energy accounted for 14.3% of total energy consumption [18]. There is no

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Integrated one-stage models considering undesirable outputs and weighting preference in slacks-based measure of efficiency and superefficiency

Peide Liu & Hongxue Xu

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Transformer-based attention network for stock movement prediction

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ABSTRACT

Stock movement prediction is an important field of study that can help market traders make better trading decisions and earn more profit. The fusion of text from social media platforms such as Twitter and actual stock prices is an effective but difficult approach for stock movement prediction. Although some previous methods have explored this approach, there are still difficulties with the temporal dependence of financial data and insufficient effectiveness of fusing text and stock prices. To solve these problems, we propose the novel Transformer Encoder-based Attention Network (TEANet) framework, which is based on precise description through small-sample feature engineering and uses a small sample of 5 calendar days to capture the temporal dependence of financial data. In addition, this deep learning framework uses the Transformer model and multiple attention mechanisms to achieve feature extraction and effective analysis of financial data to achieve accurate prediction. Extensive experiments on four datasets demonstrate the effectiveness of our framework. Further simulations show that an actual trading strategy based on our proposed model can significantly increase profit and has practical application value.

1. Introduction

Stock movement prediction has attracted the attention of both investors and researchers for decades due to its great value in seeking to maximize stock profit (Hu et al., 2018). Early approaches mainly relied on historical stock prices and time series analysis methods (Akaike, 1969). However, stock movement prediction is quite a challenging issue because of the highly volatile and nonstationary nature of the stock market. Moreover, the stock market is affected by random noise generated by participants with different viewpoints, making its movements complicated and difficult to predict. The efficient market hypothesis (EMH) argues that stock prices are driven by all observable information and relevant news (Fama, 1965; Fama et al., 1969). This classical theory opens the door to predicting financial market trends and movements, and many experts have dedicated themselves to improving the accuracy of such predictions, which may lead to better trading decisions.

Based on Fama's hypothesis, the scientific community has developed a large number of different ways to predict the stock market (Cavalcante et al., 2016). The most common method of stock market prediction in the early literature was to take stock prices or indicators extracted from them as input (Aguilar-Rivera et al., 2015; Atsalakis & Valavanis, 2009). It was believed that all new information, such as news and social media discourse, is fully reflected in the stock price and that it is thus sufficient to predict the stock market simply by analyzing the patterns of price movements. The related indicators have been widely studied and used as signals to buy or sell stocks, reflecting the current state of the stock market (Farias Nazário et al., 2017; Yang et al., 2019). However, research has shown that the effectiveness of using price or indicator data alone to make trading decisions is limited (Park & Irwin, 2007).

Since it is difficult to establish a model to comprehend stock fluctuations, the most commonly used information is related to macroeconomic time series, such as GDP, interest rates, currency exchange rates, and consumer price indices (Boyacioglu & Avci, 2010). Other sources of information include general financial news reports; however, their unstructured nature and discontinuous behavior make them difficult to use. Consequently, natural language processing (NLP) techniques have been applied to address this complexity. Several studies have focused on news and social media analytics and have gradually formed the

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Unbalanced double hierarchy linguistic group decision-making method based on SWARA and S-ARAS for multiple attribute group decision-making problems

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Abstract
Curriculum evaluation shoulders the important task of measuring the realization of talent cultivation. Effective curriculum evaluation enables the school to optimally arrange courses and improve the overall quality of students. To implement the curriculum evaluation effectively, this paper constructs a multiple attribute group decision-making (MAGDM) method according to the characteristics of curriculum evaluation. In view of the nonlinearity and hesitation of decision maker's cognition, unbalanced double hierarchy linguistic term sets (UDHLTSs) are utilized to fully represent the individual cognition of decision makers. Based on this, a novel MAGDM method with UDHLTSs is proposed. Firstly, to facilitate the analysis and treatment of UDHLTSs, the basic theories of UDHLTSs are perfected or complemented. Based on this, the unbalanced double hierarchy linguistic aggregation operator is defined and its properties are analyzed. Secondly, the weight determination method based on SWARA model is proposed to determinate the importance of each evaluation index under UDHLTSs environment. Thirdly, given the appetite of different decision-makers towards risk, an extended S-ARAS method is proposed based on S-utility function. Finally, to illustrate its effectiveness and rationality, the proposed method is applied in the case study of curriculum evaluation in university and compare with other methods.

Keywords Unbalanced double hierarchy linguistic term set · Extended Additive Ratio Assessment method · SWARA method · S-utility function · Curriculum evaluation

1 Introduction

Decision-making problems are widely existed in the sociology, management, economics and other fields. In view of the uncertainty and fuzziness existed in decision-making problems, fuzzy set is firstly proposed to address uncertain information (Xue et al. 2021). As the complexity of decision-making environment increase, fuzzy set has been constantly extended and improved to construct many information representations models, such as

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考虑产品质量和销售服务的三级电商供应链的主导模型研究

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摘要：针对由制造商、零售商和电商平台组成的三级电商供应链，本文建立了电商平台主导下，制造商权力大于零售商、零售商权力大于制造商的两种分散决策模型以及集中决策模型，分析比较了这三种模式下的最优决策。在此基础上，本文对 Shapley 值进行优化并设计了新的协调机制，使利润的分配更加合理公平。最后，通过数值分析验证了结论和协调机制的有效性。研究表明：(1) 三级电商供应链中各节点的利润随着产品质量及销售服务水平的提高而有所增长，且产品质量的提高与服务水平的增长，对消费者购买商品意愿的影响方向是一致的；(2) 电商平台若不断提高佣金率，不仅会造成零售商利润的下降，而且在佣金率高达一定水平后，也会削减电商平台及供应链整体的利润；(3) 在三级电商供应链中，制造商主导零售商时，制造商获利更高；零售商主导制造商时，零售商获利更高；优化 Shapley 值法协调后的集中决策比以上两种状况更优，且集中决策时各节点企业的利润对产品质量及服务水平的变动非常敏感。

关键词：三级电商供应链；优化 Shapley 值；产品质量；服务水平
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0 引言

随着电子商务的发展及人们消费模式的转变，电商平台与供应链的结合愈发紧密，逐步形成了电商供应链（E-commerce supply chain，简称 EC-SC）。电商供应链将电商平台作为供应链中的重要环节，利用平台特有的信息交互及销售服务优势，缓解了传统供应链中众多节点的效率及成本问题，也成为国内外学者研究的重要领域之一。

目前，国内外学者对电商供应链的研究，不断丰富了电商供应链的理论体系并拓宽了其学科外延，其中包括：(1) 对电商供应链主导模式的研究。Zhao 等[1] 考虑制造商的线上销售渠道，对四种主导模式下的定价策略及最大利润进行探讨；Wang 和 Yu[2] 考虑产品定价及广告策略，对二级电商供应链进行了主导模式研究；王玉燕和李璟[3] 将网络平台的公平关切引入二级电商供应链，并对不同主导模式下的销售、回收问题进行了研究；王玉燕和于兆青[4] 考虑了平台佣金的作用，对二级电商供应链不同主导模式间的差异进行了探究。这些研究丰富了电商供应链渠道模式的研究，但其大多针对二级供应链，研究中涉及的供应链成员较少，且此类研究缺乏对供应链中衔接关键企业的其他节点企业的细致分析，导致研究结论不利于对二级以上供应链，尤其是三级电商供应链进行指导。(2) 对电商供应链协调问题的研究。Panda 等[5] 构建了制造商主导的双渠道供应链定价模型，并通过批发价格调整的利润共享机制解决了渠道冲突；Liu 等[6] 考虑了快递服务提供商和在线零售商构成的电商供应链，并引入期权契约实现了多方共赢；Dong 等[7] 建立了两期电商供应链模型，并在随机需求情景中使用收益分享合同实现了供应链协调；李诗杨等[8] 设计了药品的双渠道供应链模型，并从系统内部利润转移及政府补贴两个角度，分别设计契约以达到协调。但此类协调机制大多没有将电商平台作为决策主体，且协调契约很难扩展到多个决策主体，并不能很好地适用于多级电商供应链。因此，为了迎合电商供应链的快速发展，有必要对三级电商供应链的主导模式及协调进行深入探讨。

此外，随着全民经济水平的提高以及消费观念的更新，产品质量和销售服务成了影响消费者购买意愿的重要因素[9]。学者们也对此进行了探讨：(1) 考虑产品质量的供应链研究。Baiman 等[10] 在传统的供应链中考虑了供应商和销售商的质量决策，对产品质量的控制策略及决策模型进行了研究；Chao 等[11] 将提高产品质量作为最终目标，通过召回成本分担契约协议，诱导供应链各方进行产品质量改进；申强等[12] 在双渠道销售模式下，对制造商产品质量控制问题进行了探讨。(2) 考虑销售服务的供应链研究。易余胤和姚俊江[13] 考虑了网络外部性的影响，探讨和比较了传统供应链中的延保服务定价及服务质量决策；Taleizadeh 等[14] 在不同市场权力结构下，探讨了服务价值对双渠道供应链的影响；Vakulenko 等[15] 将销售服务问题

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Consistency- and consensus-based group decision-making method with incomplete probabilistic linguistic preference relations

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***Abstract*—The use of incomplete probabilistic linguistic term sets (InPLTSs) can enrich the flexibility of qualitative decision-making information expression, especially in decision-making situations with high time pressure and insufficient knowledge. In this study, we develop a method for group decision-making (GDM) with incomplete probabilistic linguistic preference relations (InPLPRs), considering consistency and consensus simultaneously. First, to fully explore the ability of InPLTSs to express uncertain information, InPLTSs are specifically classified. Then, an expected multiplicative consistency of InPLPRs is introduced, which is conductive to estimating the missing information more accurately and effectively. Subsequently, considering the consensus of GDM problems, a consensus index, which considers the principle of majority and minority, is developed to measure the agreement degree among multiple individuals. Because individual InPLPRs may not all meet acceptable consistency after reaching consensus, a consistency- and consensus-improving mathematical programing model considering information distortion is presented. Then, to aggregate all individual preference relationships into a collective one, a reliability induced ordered weighted geometric operator is introduced, whose induced variable reliability is determined by the confidence degree and consistency index of individual preference relationships. Furthermore, a multi-phase algorithm with InPLPRs is developed to solve GDM problems. Finally, a numerical example about fire emergency decisions is presented to illustrate the applicability of the proposed method, and a detailed validity test and comparative analysis are conducted to highlight the advantages of the proposed method.**

***Index Terms*—Group decision-making; incomplete probabilistic linguistic preference relation; expected multiplicative consistency; consensus; mathematical programing model; induced ordered weighted geometric operator.**

NOMENCLATURE

AHP	Analytic hierarchy process
BUM	Basic unit-interval monotonic
CPLTS	Complete probabilistic linguistic term set
CPLPR	Complete probabilistic linguistic preference relation
DLPR	Distribution linguistic preference relation
EV-CPLPR	Expected value-based complete probabilistic linguistic preference relationship
EHFLTS	Extended hesitant fuzzy linguistic term
GDM	Group decision-making
HFLT	Hesitant fuzzy linguistic term
HFLTS	Hesitant fuzzy linguistic term set
HFLPR	Hesitant fuzzy linguistic preference relation
InPLE	Incomplete probabilistic linguistic element
InPLTS	Incomplete probabilistic linguistic term set
InPLPR	Incomplete probabilistic linguistic preference relation
IOWG	Induced ordered weighted geometric
LDA	Linguistic distribution assessment
LT	Linguistic term
LTS	Linguistic term set
MLT-InPLTS	Missing LT in InPLTS
MP-InPLTS	Missing probability in InPLTS
OWG	Ordered weighted geometric
PD-HFLTS	Possibility distribution for HFLTS
PDM	Preference decision-making
PLPR	Probabilistic linguistic preference relation
PLTS	Probabilistic linguistic term set
PHFLTS	Proportional HFLTS
QGDD	Quantifier-guider dominance degree
R-IOWG	Reliability-IOWG

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I. INTRODUCTION

OWING to the increasing complexity of decision-making problems and the uncertainty of the decision-making environment, more experts are needed to participate in decision-making, thus GDM should be considered [1, 2]. Generally speaking, the evaluation of an object can be performed in many ways, e.g., through multi-attribute decision-making, which involves evaluating multiple attributes of an object and then obtaining a comprehensive evaluation result based on the values of each attribute [3, 4]. However, in some decision-making situations with high time pressure and insufficient knowledge, PDM is more effective. Through an AHP, Saaty [5] reported preference relation, which is a form of pairwise comparison between alternatives that allows experts to generate reasonable preference information about each object compared based on specific criteria. Preference relation is highly consistent with people's evaluation habits and has become the most common evaluation tool for presenting judgment information in decision-making.

The research of preference relationship in GDM mainly focuses on consistency and consensus. Consistency research involves consistency tests and improvement processes. In practical decision-making, it is very difficult to obtain a preference decision matrix that represents a completely reasonable logical relationship. Therefore, a consistency test is the first and key step in the decision-making process. At present, the most commonly used consistency measures are additive consistency [1, 6-8] and multiplicative consistency [9-11]. In addition, because the inconsistent judgment matrix seriously restricts the accuracy of the decision results, the improvement mechanism of consistency has also attracted considerable attention [11-13]. There are two typical methods to improve the consistency, namely iterative and optimization adjustment. For instance, Zhou & Xu [13] introduced an iterative optimization algorithm to improve the consistency

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An improved failure mode and effect analysis method for multi-criteria group decision-making in green logistics risk assessment

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ABSTRACT

As one of the powerful systematic reliability management tool, the failure mode and effect analysis (FMEA) method is adopted to investigate and analyze potential failure mode (FM) risks of the cold chain green logistics (CCGL). Since FMEA experts have different professional backgrounds and risk preferences, they may give evaluation from different angle and emphasis; and express different limited rational behavior. Therefore, this study proposes an improved FMEA model which considers the expert group and the bounded rational behavior of experts. Firstly, this paper develops the K-means clustering method to partition FMEA experts. Further, a calculation model of attribute weights that considers different risk attitudes is proposed. Additionally, this study proposes a combination final ranking method based on regret theory (RT) and PROMETHEE II method. A practical case and two simulation experiments are carried out to demonstrate the validity, reliability and superiority performance of the proposed FMEA model. The improved FMEA model can enhance the fairness and reasonableness of the expert evaluation, improve the adaptability and flexibility of FMEA, and enrich the theoretical research of FMEA method. Findings indicated that it is necessary to consider the grouping and risk attitudes of experts in the practical risk assessment.

1. Introduction

With the improvement of living standards, people's health awareness is constantly increasing. People are pursuing safety and quality more when buying and choosing food. However, for many foods, especially perishable and fresh-keeping one, it is difficult to keep them fresh and safe in the traditional transportation, distribution, and sales process. Hence, in order to ensure food quality and safety, improve resource utilization, reduce environmental pollution, and meet the individual needs of the market, retail supermarkets are committed to forming their supporting food cold chain green logistics services. Nevertheless, many risk factors such as personnel, equipment and information communications are hidden in the actual operation process. If they are not properly identified and managed, they will cause quality variation, damage and beyond the shelf life in the logistics process. If these risk factors can be identified early and quality management can be carried out, the loss can be greatly reduced. At the same time, accurate identification of the risks in the cold chain green logistics system and timely quality management of the risks have an important role in improving the transportation quality, food safety, reducing loss costs, etc. Therefore, it is necessary to adopt a powerful reliability management tool to deal with the risk assessment of cold chain green logistics.

Failure mode and effect analysis (FMEA) was developed by NASA in the 1960s [3]. It is a systematic reliability management tool for investigating and analyzing potential failure mode (FM) risks of products and processes. It allows experts uses quantitative assessment of the occurrence (O), severity (S), and detection (D) of FMs, and then generates RPN ($RPN = O * S * D$) to evaluate FMs. Owing to its easy to understand and simple to operate, FMEA has a wide range of applications, such as supplier selection, 3D print selection, portfolio selection, goods transportation, offshore engineering and healthcare management, food cold chain logistics risk assessment, etc [1,5,6,10,12]. Nevertheless, with the continuous change of application environment and the need of realistic decision-making, the classical FMEA has exposed some inherent defects, such as (i) it only evaluates FMs by crisp numbers, which cannot adapt to the fuzzy environment, and is not conducive to the expression of experts' evaluation information; (ii) the weight of FMEA experts is not considered; (iii) the weight of attributes is not considered; (iv) the final ranking method uses a multiplication algorithm, which is too simple and not conducive to determining the ranking, etc.

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A weighting model based on best–worst method and its application for environmental performance evaluation

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ABSTRACT

The analytic hierarchy process (AHP) is widely used as a multi-criteria decision-making method in practical applications. Several researchers have expanded the AHP method to D numbers AHP (D-AHP) to apply AHP to an uncertain decision-making environment. D numbers is an extension of the Dempster–Shafer (D–S) theory, which overcomes the shortcomings of the D–S theory and can effectively express uncertain information. With the deepening of research on the AHP method, the best–worst method (BWM) was proposed as an improvement to the AHP method. The BWM can lower the inconsistency in results and reduce the number of required pairwise comparisons. Although some researchers have extended the BWM method to an uncertain environment and proposed fuzzy BWM methods, these methods cannot handle some special situations, such as when the subjective evaluations of experts are conflicting or altogether missing. To apply the BWM method to these special situations, this study suggests combining the BWM with D numbers and proposes D numbers BWM (D-BWM) weighting model. First of all, we discuss D numbers extended fuzzy preference relations (DNFPRs). Afterwards, we design an algorithm to select the best and worst criteria based on the DNFPRs by calculating the out-degrees and in-degrees. Furthermore, we develop a linear programming model to derive the weights of criteria, and then propose a consistency ratio to check the reliability of the derived results. The experimental results show that the D-BWM method is more suitable for realistic decision-making because of its simplicity and sensitivity to subjective information. Finally, the proposed method is applied to evaluate the environmental performances of 30 provincial administrative regions of China.

1. Introduction

Multi-criteria decision-making (MCDM) is the process of evaluating situations and analyzing multiple conflicting assessments to arrive at a decision. It is a significant part of the decision-making theory [1]. Based on the discrete or continuous solution space, MCDM is usually divided into multi-attribute decision-making (MADM) and multi-objective decision-making. In this study, we used MCDM to represent MADM for convenience and practicality. Owing to the evaluation mechanism characteristics of MCDM, it is widely applicable to real decision-making environments such as in management [2], transportation [3], investment [4], and other fields [5,6]. Several MCDM methods have been researched and expanded, such as the analytic hierarchy process (AHP) [7,8] and the technique for order of preference by similarity to ideal solution (TOPSIS) method [9] for different decision situations. Among the MCDM methods, AHP is widely used owing to its applicability and operability in practical applications [10]. AHP, proposed by Saaty [7,8], is based on pairwise comparisons and is widely used in practical management environments such as public transport service development [11], urban planning [12,13] and urban sustainability assessment [14]. Furthermore, to overcome the environmental uncertainty in some practical decisions and the ambiguity of human consciousness, fuzzy sets [15], intuitionistic fuzzy sets [16], Pythagorean fuzzy sets [17], hesitant fuzzy sets [18], interval type-2 hesitant fuzzy sets [19] are proposed. Some researchers have expanded the classical AHP to the fuzzy AHP method with the aid of these fuzzy sets. Fuzzy AHP [20], intuitionistic fuzzy AHP [21], Pythagorean fuzzy AHP [22] and hesitant fuzzy AHP [23] are proposed to solve decision problems in different situations. These fuzzy AHP methods have a better comprehensive structure than the traditional AHP because these methods combine quantitative and qualitative criteria. For example, Zyoud et al. [20] applied the fuzzy AHP to study how to reduce water loss, and Liao and Xu [21] studied the consistency of AHP preference relationships in intuitionistic fuzzy environments. Ilbahar et al. [22] combined risk assessment with fuzzy AHP to evaluate occupational health.

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Normal wiggly hesitant fuzzy linguistic power Hamy mean aggregation operators and their application to multi-attribute decision-making

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ABSTRACT

As a useful tool for information representation, hesitant fuzzy linguistic term sets (HFLTSs) have received extensive attention and in-depth discussion in recent years. However, in real decision making, it is impossible for decision makers to express all preference information only through a few continuous linguistic terms. Much valuable information is hidden in the original evaluation information. Thus, this paper mainly studies how to mine deeper uncertain information from the original hesitant fuzzy linguistic evaluation information. To achieve this goal, we present a new representation tool called the normal wiggly hesitant fuzzy linguistic term set (NWHFLTS). The NWHFLTS not only retains the original evaluation information, but it also delivers and quantifies potential uncertain information. First, we propose some basic theories of NWHFLTS, such as some basic operational rules, score function and distance measures between two NWHFLTSs. Then, based on the distinctive features of the power average (PA) operator and Hamy mean (HAM) operator, we propose two new information aggregation operators, i.e., the normal wiggly hesitant fuzzy linguistic power Hamy mean (NWHFLPHAM) operator and its weighted form (NWHFLPWHAM). Furthermore, based on the NWHFLPWHAM operator, a new method is proposed to address multi-attribute decision-making (MADM) problems. Finally, we use a numerical example to show the specific calculation steps and provide a comparison with other methods to validate the effectiveness and advancement of our proposed method.

1. Introduction

In multi-attribute decision-making (MADM) problems, people need to evaluate alternatives based on predetermined attributes and then make decisions based on reasoning or decision-making methods. In fact, due to the ambiguity and complexity of evaluation problems, some decision-making problems cannot be quantitatively evaluated by one or several specific numerical values. In contrast, they can be described by intuitively qualitative evaluations. Thus, the fuzzy linguistic evaluation method based on linguistic variables proposed by Zadeh (1975) has been favored by many scholars, and it has gradually become a suitable tool for the evaluation of qualitative information. However, the traditional fuzzy linguistic method can only allow decision makers (DMs) to describe the characteristics of alternatives by a single linguistic term, which sometimes does not accurately reflect the true perception of DMs. Based on such theoretical defects, in the continuous exploration and improvement of fuzzy linguistic methods, various new fuzzy linguistic methods have been proposed, such as uncertain linguistic variables (Xu, 2006), intuitionistic uncertain linguistic variables (Liu & Jin, 2012), linguistic intuitionistic fuzzy numbers (Chen & Liu, 2015) and the 2-tuple fuzzy linguistic representation model (Herrera & Martínez, 2000). However, these models are still very limited for comprehensively characterizing complex qualitative information. In particular, when the DM hesitates among several different linguistic terms, he/she needs to use more complex linguistic terms to express his/her cognitive preferences. Obviously, none of the above linguistic expression models can handle this situation. Inspired by the hesitant fuzzy sets (HFSs) proposed by Torra (2010), Rodríguez, Martínez, and Herrera (2012) proposed the concepts of hesitant fuzzy linguistic term sets (HFLTSs) and the hesitant fuzzy linguistic term element (HFLTE). HFLTS combine the advantages of the hesitant fuzzy set and linguistic variables, thus allowing DMs to qualitatively express their evaluation values as an alternative to the orderly and continuous subset of the linguistic term set (LTS).

Since HFLTS were proposed, the theory, method and application of HFLTS have been deeply studied and developed (Farhadinia & Herrera-Viedma, 2018; Liao et al., 2019; Tang & Liao, 2019; Wei, Rodríguez, & Martínez, 2018). Liao, Xu, Herrera-Viedma, and Herrera (2018)

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Decisions and coordination of green e-commerce supply chain considering green manufacturer's fairness concerns

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With the rapid development of the cyber economy and green consumption demand, more and more consumers choose to purchase green products through e-commerce platforms. Considering the product green degree and the e-commerce platform's service, the paper studies the decisions and coordination of green e-commerce supply chain under green manufactures' fairness concerns. The centralised model and the decentralised models with and without fairness concern are constructed and analysed with consideration of product green degree and service level. Then, the 'cost-sharing joint commission' contract is proposed to realise system coordination. Finally, propositions and conclusions are verified by numerical simulation. The results indicate that unlike traditional offline and dual-channel supply chains, the manufacturer's behaviour in response to fairness concerns can result in the decline both in product green degree and system efficiency but has no impact on service level. Under the centralised model, the product green degree is not the highest but is more affected by consumers' green preferences. In addition, the product price and the service level will reach the highest under the centralised model. The increase in green technology investments can downsize the feasible interval of the contract, and the consumers' green preferences can extend the feasible interval.

Keywords: Green supply chain; e-commerce; fairness concerns; network service level

1. Introduction

Currently, the economic and social impacts of the reuse of resources have gradually emerged as an issue of public concern. Many companies have undertaken green initiatives to take collective responsibility and establish a good corporate image (Du, Liu, and Li 2017). For instance, Panasonic held the Panasonic Green Creative Forum 2010 at his headquarters in 2010, viewing environmental protection and green as the company's primary innovation goals; In 2011, Haier held an end-of-the-year product sampling meeting in Beijing, and expressed his willingness to take the lead in environmental responsibility and promotion of green products. In the pursuit of green production, enterprises inevitably increase their investments in green technology, resulting in an increase in production costs. Considering that, companies are seeking more cost-effective ways of operating. On one hand, the e-commerce platforms (as e-platform) feature with the large customer flow and standardised low-cost sales services, which provide new sales opportunities for green manufacturers. Product display and sales through e-platforms can effectively reduce operating costs and relieve production pressure from manufacturers. On the other hand, consumers' consumption habits have changed in favour of green products. Consumers not only prefer green products (Liu, Anderson, and Cruz 2012) but also increasingly rely on online shopping (Wang, Malthouse, and Krishnamurthi 2015). As a result, manufacturers are shifting sales of green products from offline to online, and the e-commerce supply chain (ECSC), combining green product manufacturers and e-platforms, is also gradually emerging.

However, some new problems have arisen in the green e-commerce supply chain (GECSC). First, unlike traditional supply chains dominated by manufacturers, e-platforms have a distinct advantage due to their significant impact on product sales in GECSC, which causes some e-platforms to gain more profits by infringing upon the rights of green manufacturers. For example, JD (www.JD.com) forced coordinating manufacturers to participate at a '618 venue', locked inventory and prices, and forced promotion.[1] During the '11.11' and '618' online shopping events, Tmall (www.tmall.com) required manufacturers to make a choice between Tmall and JD, otherwise, manufacturer traffic would be stopped.[2] Second, the

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电商闭环供应链中的“让利”公平关切回收决策研究

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摘　要:针对单一再造商和单一电商平台构成的两阶段电商闭环供应链,本文研究了电商闭环供应链的三种回收决策模型:再造商无公平关切的分散决策模型、再造商让利公平关切的分散决策模型以及联合决策模型。然后,求解分析模型,给出每种模式的最优回收策略,并对三种模式的最优决策进行比较分析。在此基础之上,进一步设计电商闭环供应链的“回收成本共担联合收益共享”契约,实现系统的协调。最后,采用数值分析对模型结论进行验证。研究发现:(1)再造商的公平关切行为是一种“让利”行为:虽然对自身收益不利,但是对电商平台和消费者都有利,当让利公平关切程度不高于 0.5 时,对系统利润起到促进作用,但是当让利程度超高 0.5 时,会造成系统利润下降。因此再造商往往迫于一定的压力实施让利公平关切,并且让利程度有限,一般不超过 0.5。从长远来看,再造商的让利公平关切能够稳固 EC－CLSC 的稳定运行。(2)联合决策下,废旧品回收价格达到最高,电商平台佣金最低,系统利润最优,采用文章设计的“回收成本共担联合收益共享”契约可以实现系统协调。(3)在协调机制中,再造商分担电商平台的成本比例恰好等于分得的系统利润比例。而且随着佣金的降低,再造商分担电商平台服务成本的比例和电商平台分享再造商收益的比例均会增加。这些结论丰富完善了电商闭环供应链的理论基础,为电商闭环供应链成员的决策提供一定的理论参考。

关键词:电商平台;让利公平关切;电商闭环供应链;协调机制
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1　引言

随着人们环保意识的增强以及对可持续发展认识的深入,废旧产品的回收利用得到了企业的重视,越来越多的企业将废旧品的回收利用作为企业的一项发展战略。通过电商平台从客户手中回收废旧产品并进行处置或者再利用,能够降低回收成本,提高交易效率,优化社会资源配置。这种将电子商务与闭环供应链相结合的运作模式就是电商闭环供应链(E－commerce Closed－loop Supply Chain,简称 EC－CLSC)。在 EC－CLSC 中,电商平台作为一个企业推广销售产品和回收废旧品的新渠道,将有关废旧品的回收以及再造品的销售等重要信息进行整合,使的供应链成员能够高效沟通和有效合作。目前,国内开展产品回收业务的电商平台有很多,例如,乐回收、爱回收、淘绿网等。

学术界关于再制造闭环供应链的研究已经取得了丰硕的成果。Hong Xianpei 等[1]建立了闭环供应链中制造商、零售商和第三方回收商分别负责回收的三种模型,研究了系统的协调策略。针对建筑行业,Yi Pengxing 等[2]研究了零售商和第三方回收商同时负责回收的建筑机械行业闭环供应链的绩效问题。后来,Liu Liwen 等[3]进一步深入研究了闭环供应链的双重回收渠道选择问题。Huang Yanting 和 Wang Zongjun[4]分析了制造商再造、制造商和零售商再造、制造商和第三方回收商负责再造三种模式下的闭环供应链定价策略。Masoudipour 等[5]则根据回收产品的质量研究了纺织行业的闭环供应链的定价问题。陈军和田大钢[6]研究了由再造商、零售商、消费者组成的闭环供应链的回收模式选择问题。针对电器电子产品回收再制造问题,王文宾等[7]探讨了在双重信息

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Multiple-Attribute Decision-Making Based on Archimedean Bonferroni Operators of q-Rung Orthopair Fuzzy Numbers

Peide Liu and Peng Wang

***Abstract*—The theory of q-rung orthopair fuzzy sets (q-ROFSs) proposed by Yager effectively describes fuzzy information in the real world. Because q-ROFSs contain the parameter q and can adjust the range of expressed fuzzy information, they are superior to both intuitionistic and Pythagorean fuzzy sets. Archimedean T-norm and T-conorm (ATT) is an important tool used to generate operational rules based on the q-rung orthopair fuzzy numbers (q-ROFNs). In comparison, the Bonferroni mean (BM) operator has an advantage because it considers the interrelationships between the different attributes. Therefore, it is an important and meaningful innovation to extend the BM operator to the q-ROFNs based upon the ATT. In this paper, we first discuss q-rung orthopair fuzzy operational rules by using ATT. Furthermore, we extend BM operator to the q-ROFNs and propose the q-rung orthopair fuzzy Archimedean BM (q-*ROFABM*) operator and the q-rung orthopair fuzzy weighted Archimedean BM (q-*ROFWABM*) operator and study their desirable properties. Then, a new multiple-attribute decision-making (MADM) method is developed based on q-*ROFWABM* operator. Finally, we use a practical example to verify effectiveness and superiority by comparing to other existing methods.**

***Index Terms*—Archimedean T-norm and T-conorm (ATT), Bonferroni mean (BM), multiple-attribute decision-making (MADM), q-rung orthopair fuzzy sets (q-ROFSs).**

I. Introduction

MULTIPLE-ATTRIBUTE decision-making (MADM) is a process that can give the ranking results for the finite alternatives according to the attribute values of different alternatives. In recent years, some hot decision problems, such as the strategic choice of enterprises and the behavior of government procurement, are all related to the MADM. In a real decision process, the first question is how to effectively and accurately express the attribute value of uncertain decision information. Because of the complexity of human cognition and decision-making environment, exact values are not enough to express fuzzy information. Therefore, many fuzzy information expression tools came into being [6], [15], [19]. The intuitionistic fuzzy set (IFS), first presented by Atanassov [1], [2], is improved from fuzzy sets (FSs) by Zadeh [45], and it has a membership degree (MD), a nonmembership degree (NMD), and a hesitancy degree, which can express the degree of satisfaction, the degree of dissatisfaction, and the degree of hesitancy, respectively. IFS is a very valuable tool, so it is widely applied to describe fuzzy decision information and studied by a large number of experts and scholars. These researches mainly include the following aspects: 1) the basic theory research, such as operational laws of intuitionistic fuzzy numbers (IFNs) [8], distance measures between IFNs [7], [34], similarity measures between IFNs [5], information entropy of IFNs [14], etc.; 2) some extended MADM methods for IFNs, such as the application of government E-tendering based on the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method [36], the application of optimizing multiresponse problems in IFS based on the VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method [29], the supplier selection of a supply chain based on the Elimination Et Choice Translation Reality III (ELECTRE III) method [27], the distributor evaluation and selection problem based on the TODIM (an acronym in Portuguese of interactive and multicriteria decision making) method [20], and so on. (3) The intuitionistic fuzzy aggregation operators (AOs), for example, Xu [39] and Xu and Yager [40] presented some basic weighted averaging operator and the weighted geometric operator for IFNs, respectively. Liu [22] and Zhang *et al*. [46] presented some extended AOs based on the special Hamacher operation rules and Frank operation rules, respectively, and they are more superior by using a flexible parameter. Xu and Yager [41] proposed the BM operator whose prominent feature is that the interrelationships between different attributes can be taken into account.

However, the application range of IFSs is narrow because it has a condition that the sum of MD u and NMD v is equal to or less than 1, i.e., $u + v \leq 1$. In this case, some decision evaluation values cannot be effectively expressed by IFSs because some decision makers may give some data that the sum of MD and NMD is greater than 1. For example, a decision maker give the MD of 0.8 of NMD of 0.6. It is obvious that the IFNs cannot express this result. Therefore, in order to solve this problem, Yager [42] proposed a new concept of the Pythagorean fuzzy set (PFS), which eminent characteristic is that the square sum of MD and NMD is less than or equal to 1, i.e., $u^2 + v^2 \leq 1$. So, the PFS can describe a lot of fuzzy information that the IFS cannot describe in some practical problems. Based on this theory, some extensive researches have been carried out. For example, Yager and Abbasov [44] studied the relationship between the Pythagorean fuzzy numbers (PFNs) and the complex numbers. Yager [42] proposed some new Pythagorean fuzzy weighted average opera-

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An extended MULTIMOORA method for probabilistic linguistic multi-criteria group decision-making based on prospect theory

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ABSTRACT

The development of social economy has rendered the decision-making environment more complex. To better adapt to the environment and solve practical decision-making problems, this study uses the probabilistic linguistic terms set (PLTS) to describe qualitative information, which can not only provide every possible evaluation value, but can also yield the weight or proportion of these values. Based on the PLTS, we propose a probabilistic linguistic-dependent weighted average (PLDWA) operator; then, we establish the prospect theory-based multi-objective optimization by ratio analysis plus the full multiplicative form (MULTIMOORA) method (PT-MULTIMOORA) and extend it to the probabilistic linguistic information (PLI) environment. Moreover, we propose a final value determination method for the PT-MULTIMOORA method. Based on the combination of the PLDWA operator and the PT-MULTIMOORA method, we develop a novel approach to solve multiple criteria group decision making (MCGDM) problems with PLI. Two practical cases are demonstrated to verify the feasibility and superiority of the proposed method.

1. Introduction

In recent years, with the development of Web 2.0 and the emergence of various e-commerce websites, people are continuously choosing to adopt the consumption mode of online shopping. Meanwhile, people are more willing to provide feedback on their consumption experience through online reviews. Furthermore, with the development of mobile internet and "Internet+", the sharing economy that is based on mobile internet and the "Internet + industry" model has made significant progress. With such new economic developments, it is both an opportunity and a challenge for us. Employing this new development trend in decision making is an important research topic; more specifically, we need to consider how to describe and express the decision information and how to construct a more accurate decision-making method so that a reasonable decision result can be obtained.

In describing and expressing the decision information, owing to the complexity and vagueness of the decision-making environment, it is occasionally difficult to handle the realistic decision-making problems (DMPs) in terms of crisp numbers. On account of the ambiguity of human thinking, it may be occasionally convenient for decision makers (DMs) to evaluate the alternatives with qualitative description; thus, the concept of linguistic variables (LVs) (Zadeh, 1975a, 1975b, 1975c) was proposed to deal with the qualitative information. However, LVs only allow the DMs to express the evaluation information by single and very simple linguistic terms (LTs). However, in most cases, DMs prefer to provide all possible evaluation results at once, so as to better and conveniently express the decision-making information. Rodriguez et al. (Rodriguez, Martinez, & Herrera, 2012) proposed the hesitant fuzzy LTs set (HFLTS), which could cater to the needs of the DMs; since then, it has been extensively researched by scholars. Regarding the basic theory of the HFLTS, based on the operations proposed by the Rodriguez et al. (2012), Liu, Cai, and Jiang (2014) further developed the new operations of the HFLTS. Meanwhile, the information-aggregation operators regarding the HFLTS have also been researched by Rodriguez et al. (2012) and Wei, Zhao, and Tang (2014). Beg and Rashid (2013) proposed the HFLTS–TOPSIS method; Liao, Xu, and Zeng (2015) extended the VIKOR method to the HFLTS environment. Although HFLTS can well describe the decision information in the case where the weight or proportion of each possible LT is the same, it has been found that the DMs typically have different preferences for each possible LT; this implies that the weight or proportion of each possible LT value is different. In other words, the probabilities of the LTs are not equal. Under such conditions, based on the concept of HFLTS, the probabilistic LTs set (PLTS) was proposed by Pang, Xu, and Wang (2016). The PLTS can express every possible LT provided by DMs, as well as its probability. Compared with other forms of linguistic information, it can express

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