AHP and Fuzzy Evaluation Methods for Improving Cangzhou Honey Date Supplier Performance Management

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***Abstract*—This study focuses on improving supplier performance management within the Cangzhou honey date industry by integrating the Analytic Hierarchy Process (AHP) and fuzzy evaluation methods. Recognizing the limitations of traditional evaluation systems—such as subjectivity and insufficient quantitative analysis—the research aims to build a comprehensive, data-driven evaluation framework. The methodology involves constructing a supplier performance index system based on five key dimensions: quality, cost, delivery, service, and social responsibility. Using the AHP method, expert opinions are quantified to determine the weight of each indicator. Subsequently, fuzzy evaluation is employed to transform qualitative judgments into numerical scores, enabling more objective assessment. Five major suppliers are evaluated empirically, and statistical methods such as ANOVA and cluster analysis are used to identify performance differences and classify suppliers into performance tiers. The results indicate that Supplier A excels in quality and service, Supplier B leads in delivery performance, while Suppliers C and E require significant improvements. Correlation analysis reveals strong links between supplier performance and key operational metrics such as product defect rates, procurement costs, and customer satisfaction. Based on these findings, the study proposes targeted improvement strategies including the adoption of Six Sigma practices, implementation of VMI and JIT models, and enhanced performance-based incentive mechanisms. The research confirms the effectiveness of combining AHP and fuzzy methods in supplier evaluation and provides actionable insights for improving supply chain efficiency, resilience, and competitiveness. It also suggests that future studies should incorporate larger datasets and intelligent algorithms to refine evaluation accuracy and operational decision-making.**

***Keyword*—AHP; fuzzy evaluation method; supplier performance; Cangzhou honey date; supply chain management**

I. Introduction

With the rapid development of the market economy, the importance of supply chain management has become increasingly prominent in various industries [1]. Especially for agricultural products enterprises, the optimization of supplier performance management has become a key factor to enhance competitiveness and ensure product quality [2]. As an agricultural product with local characteristics, Cangzhou honey date is loved by consumers for its unique taste and rich nutritional value, and the market demand continues to grow. However, in the supply chain management of the honey date industry, there are still some management problems, including improper supplier selection, imperfect supplier performance evaluation system, and difficulty in stabilizing product quality. These problems directly affect the overall operational efficiency and market competitiveness of honey date enterprises. In the process of supplier management, how to scientifically and reasonably evaluate the performance of suppliers has become a challenge that enterprise managers must face [3]. Traditional performance evaluation methods mostly rely on qualitative analysis or a single quantitative index, which lacks comprehensiveness and systematicity. To solve this problem, the supplier performance evaluation system based on the hierarchical analysis method (AHP) and fuzzy evaluation method has gradually received attention from both academia and the business community. The AHP method can decompose the complex evaluation problem into multiple levels for quantitative analysis, while the fuzzy evaluation method can deal with the uncertainty and fuzzy information to make up for the shortcomings of the traditional evaluation methods [4]. The combined application of these two methods can more accurately assess the comprehensive performance of suppliers and provide powerful support for corporate decision-making [5]. The purpose of this paper is to construct a supplier performance management evaluation system applicable to the Cangzhou honey date industry by combining the AHP method and fuzzy evaluation method through empirical research [6]. The systematic analysis of the performance of multiple suppliers provides the theoretical basis and practical guidance for enterprises to optimize supplier management and improve the overall efficiency of the supply chain [7]. At the same time, this study also explores how to improve supplier performance management according to the evaluation results, so as to enhance the competitiveness and market share of honey date enterprises.

The structure of this study is as follows: Section II reviews the relevant research results in the field of supplier performance management, focuses on the theoretical basis, evaluation methods, and application status of supplier performance evaluation, and analyzes the application of AHP method and fuzzy evaluation method in supplier management. Section III describes in detail the construction method of the evaluation index system, the weight determination process of the AHP method, and the implementation steps of the fuzzy evaluation method adopted in this study. Section IV presents the performance evaluation results of Cangzhou honey date suppliers through empirical analysis, combines the evaluation data with an in- depth discussion of the advantages and shortcomings of different suppliers, and puts forward relevant management improvement suggestions. Section V summarizes the main conclusions of this study, reviews the limitations of the study, and proposes directions for future research.

II. Synthesis of Research

A. *Progress of Research on Supplier Performance Management*

Supplier performance management is an important part of supply chain management, and its core objective is to select high-quality suppliers through a scientific evaluation system and continuously optimize supplier management to improve the overall operational efficiency of enterprises [8]. Existing research shows that supplier performance management involves multiple dimensions, including quality, cost, delivery capability, service level, and sustainability [9]. Traditional supplier evaluation methods mainly rely on expert experience or financial data analysis, but these methods have limitations in dealing with complex, multi-dimensional data [10]. In recent years, with the application of multi-criteria decision analysis (MCDM) methods, the supplier performance evaluation system has gradually developed towards systematization, quantification, and intelligence [11]. Fig. 1 illustrates the development of supplier performance evaluation methods and lists the main methods in chronological order, along with their characteristics and limitations.

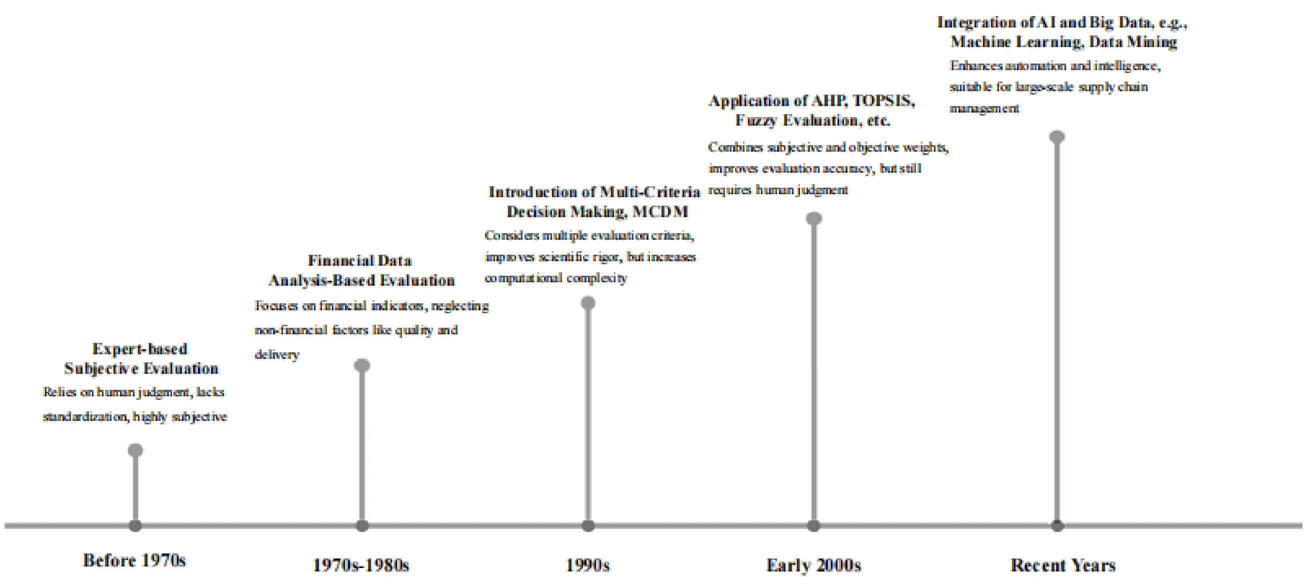

Fig. 1. Development of supplier performance evaluation methods.

B. *Application of AHP Method in Supplier Performance Evaluation*

The hierarchical analysis method (AHP) is a decision analysis method proposed by Saaty in the 1970s, which is widely used in the field of supplier selection and performance evaluation [12]. The AHP method decomposes a complex decision problem into different levels of criteria by constructing a hierarchical structural model, constructs judgment matrices by using the expert scoring method, and ultimately calculates the weights of each index [13]. This method can effectively quantify expert judgment and improve the scientificity of the evaluation system. It has been shown that the application of the AHP method in the supply chain management of agricultural products has strong feasibility and can help enterprises assess the comprehensive ability of suppliers from multiple angles [14]. However, the AHP method has some limitations in dealing with ambiguity and uncertain information, especially in the expert scoring process, where subjective judgment may lead to biased evaluation results.

C. *Application of Fuzzy Evaluation Method in Supplier Management*

The fuzzy evaluation method is a decision analysis method based on fuzzy mathematical principles, which is suitable for dealing with problems with high uncertainty [15]. In supplier performance management, many evaluation indexes are difficult to express by precise numerical values, such as "product quality stability" or "delivery reliability", which usually need to be evaluated by fuzzy linguistic variables (such as "excellent", "good", "fair"). The fuzzy evaluation method can transform expert opinions into fuzzy numbers and quantitatively analyze them through the affiliation function, thus reducing the influence of subjective factors and improving the reliability of evaluation results [16]. In recent years, the fuzzy evaluation method has been widely used in the supply chain of agricultural products, manufacturing, and retail industry supplier management as shown in Fig. 2.

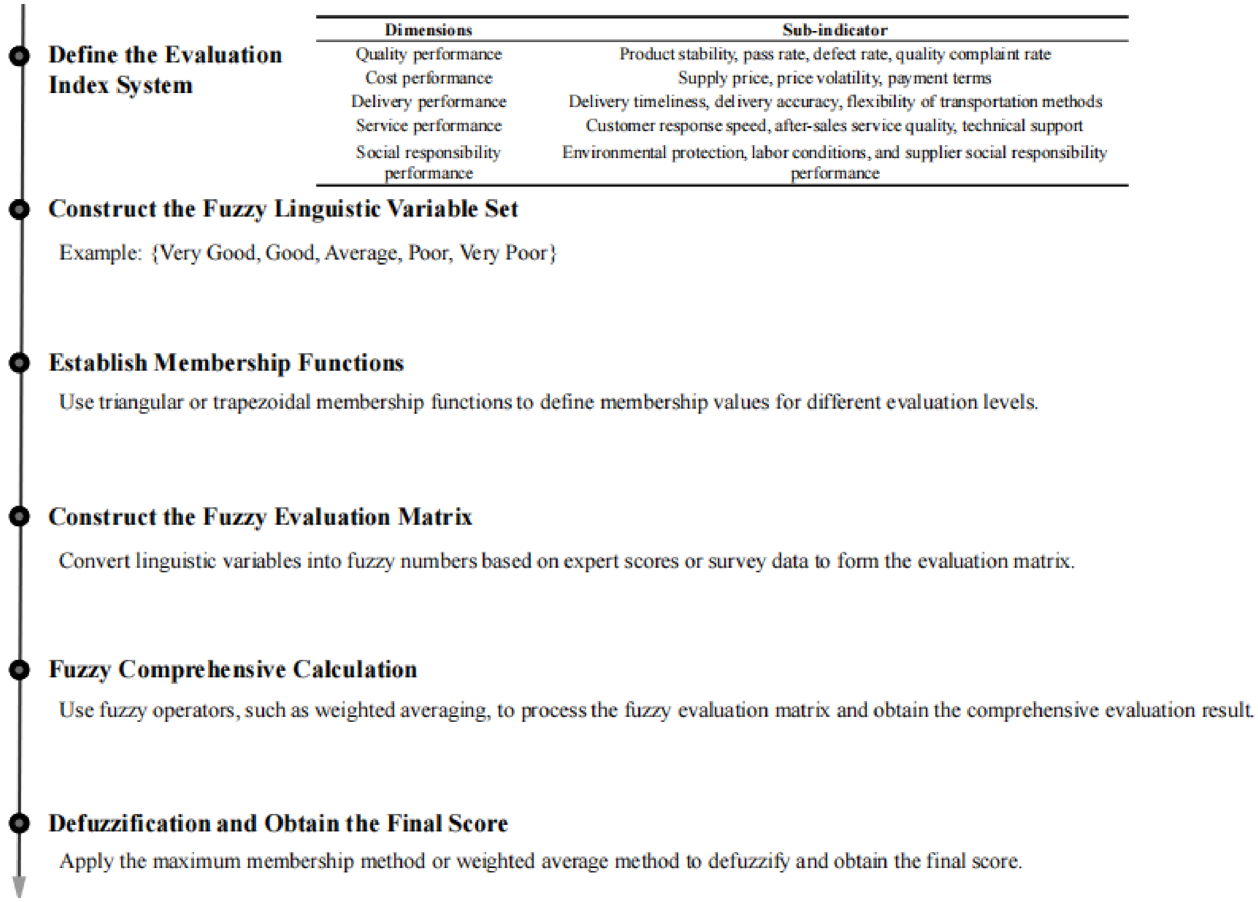

Fig. 2. Basic principle of the fuzzy evaluation method.

D. Combination of AHP and Fuzzy Evaluation Method and its Advantages

To make up for the shortcomings of a single method, academics have proposed a combination of the AHP and fuzzy evaluation method, in which the AHP method is utilized to determine the weights of each evaluation index, and then the fuzzy evaluation method is used to provide a comprehensive score of the supplier's performance[17]. The main advantages of this method are:

- Clear hierarchical structure: The AHP method can effectively decompose complex problems and ensure the rationality of the evaluation index system.
- Reduction of subjective bias: the fuzzy evaluation method can quantify the fuzzy judgment of experts and improve the objectivity and accuracy of evaluation results.
- Applicable to the uncertain environment: especially in the agricultural supply chain, market demand fluctuates greatly, and supplier performance is affected by many uncertain factors, the combination of the AHP-fuzzy evaluation method can better deal with the complex environment.

It has been shown that the AHP-fuzzy evaluation method has been successfully applied in several fields, including manufacturing, the food supply chain, and the medical industry [18]. However, the current research on the supply chain of local speciality agricultural products is still relatively limited, especially for the Cangzhou honey date industry [19]. Therefore, this paper will build an evaluation system applicable to the performance management of Cangzhou honey date suppliers based on existing research, and verify its effectiveness through empirical analysis [20]. Fig. 3 below shows the combination process of AHP (hierarchical analysis method) and fuzzy evaluation method, especially the whole process from problem decomposition to final comprehensive evaluation.

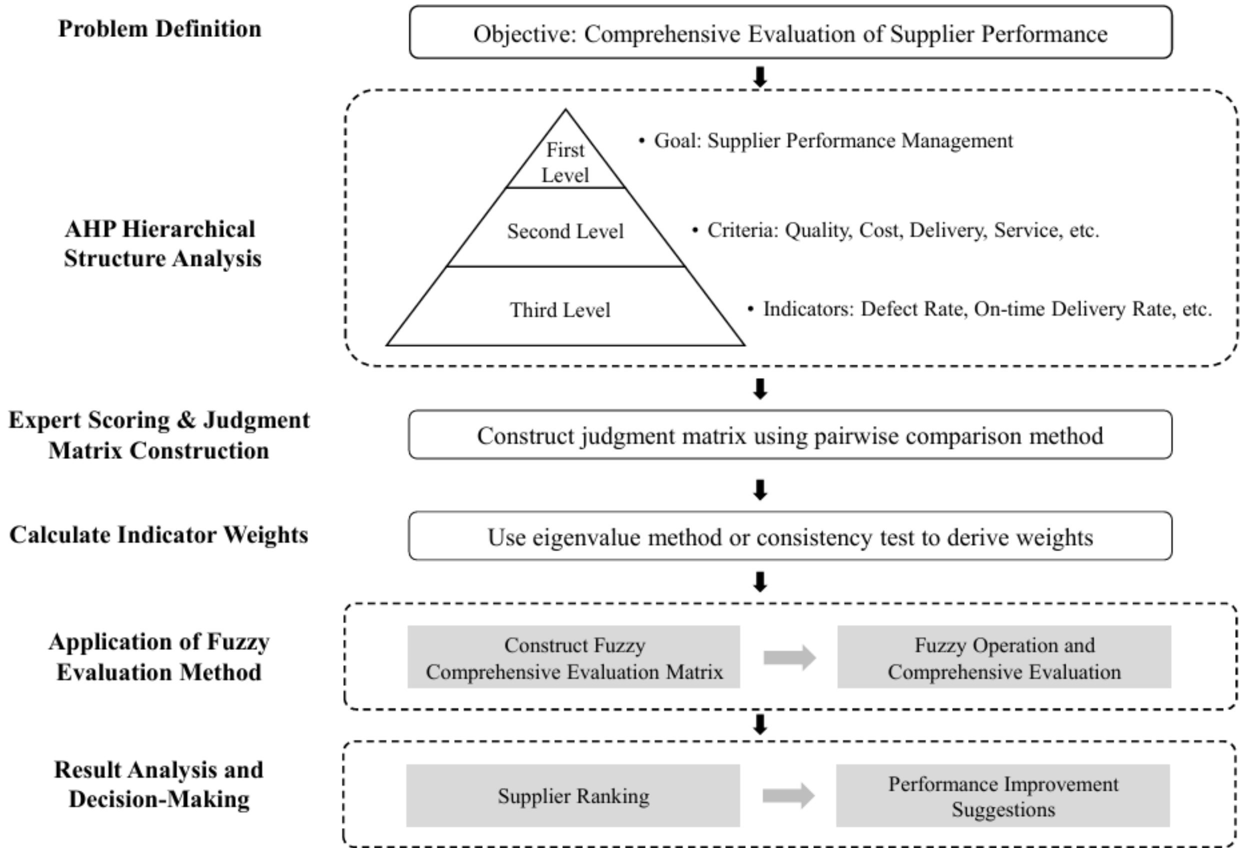

Fig. 3. Analytical framework diagram of the combined AHP-fuzzy evaluation method.

III. Methodology

This study aims to construct a supplier performance management improvement system based on the hierarchical analysis method (AHP) and fuzzy evaluation method, focusing on the supplier performance evaluation of the Cangzhou honey date industry [21]. To achieve this goal, this study first carries out a detailed design of the construction process of the supplier performance evaluation system, and then empirically analyzes Cangzhou honey date suppliers using the AHP method and fuzzy evaluation method [22]. The research method mainly includes the following steps: constructing the evaluation index system, determining the weights of evaluation indexes, fuzzy processing supplier evaluation data, comprehensive evaluation, and result analysis.

A. Construction of the Evaluation Indicator System

The core of supplier performance evaluation lies in the selection of appropriate evaluation indexes. Based on the characteristics of the Cangzhou honey date industry, combined with the classic theories of supply chain management and existing literature, this study constructs a supplier performance evaluation index system that includes five main dimensions, specifically: quality performance, cost performance, delivery performance, service performance and social responsibility performance [23]. Under each dimension, there are several sub-indicators, which can comprehensively reflect the supplier's comprehensive ability in different aspects [24]. The specific sub-indicators are shown in Table I. To ensure the scientificity and comprehensiveness of the evaluation index system, this study refers to several kinds of literature on supplier performance evaluation conducts interviews with several industry experts, and ultimately forms an evaluation framework applicable to the Cangzhou honey date industry.

TABLE I SUPPLIER PERFORMANCE EVALUATION INDICATOR SYSTEM

Dimension (Math.)	Subindex
Quality performance	Product stability, pass rate, defect rate, quality complaint rate
Cost performance	Supply prices, price volatility, payment terms
Delivery performance	Timeliness of delivery, accuracy of delivery, flexibility of mode of transportation
Service performance	Customer responsiveness, after-sales service quality, technical support
Social responsibility performance	Environmental protection, labor conditions, fulfillment of suppliers' social responsibility

B. Determination of Weights of Evaluation Indicators

After determining the evaluation indicator system, the next step is to determine the weight of each evaluation indicator. Since the importance of each indicator varies in practical application, it is necessary to determine the weights of dimensions and sub-indicators by expert scoring method. In this study, the hierarchical analysis method (AHP) is used to determine the weights [25]. Fig. 4 shows in detail the hierarchical relationship of the AHP method in supplier performance evaluation, covering the target level (Top Level), criterion level (Criteria Level), and sub-criteria level (Sub-criteria Level) to reflect the hierarchical relationship of each evaluation factor. The following is a textual description of the steps of the AHP method: constructing a hierarchical model, expert judgment, constructing a judgment matrix, and calculating weights [26]. The specific process is as follows:

- Constructing a hierarchical model: Based on the research objectives and evaluation system, the overall objective (supplier performance evaluation) is first placed at the top level [27]. Then, five dimensions are taken as the factors in the second level, and each dimension is further subdivided into several sub-indicators under each dimension.

- Expert judgment and judgment matrix construction: through interviews with experts in the fields of supply chain management, procurement, quality management, etc., collect expert ratings on the relative importance of each dimension and sub-indicator [28]. The experts use a scale from 1 to 9 (e.g. 1 means that two factors are equally important, and 9 means that a factor is important).

- Calculation of weights: By constructing a judgment matrix and conducting consistency tests, the weights of each dimension and sub-indicator are finally calculated. The calculation methods of specific weights include the characteristic root method or the approximation method. To ensure the reasonableness of the calculation results, this study chose the weighted average method for data processing, and the results of the weights were strictly analyzed statistically [29]. After determining the index weights, we can quantitatively score the performance of each supplier in different dimensions.

C. Application of the Fuzzy Evaluation Method

In the actual evaluation process, supplier performance is often affected by a variety of uncertainties, such as market fluctuations, supply chain disruptions, and other factors, which make some evaluation indexes difficult to express through precise numerical values [30]. To deal with these uncertainties, this study adopts the fuzzy evaluation method to further process the scoring results obtained by the AHP method [31]. The main steps of the fuzzy evaluation method include:

- Fuzzy scoring: Since experts often use fuzzy language, such as "excellent", "good", "fair", "poor", etc., when evaluating supplier performance, this study translates linguistic evaluations into corresponding fuzzy numbers. The fuzzy number of each evaluation index can be expressed by a triangular fuzzy number or trapezoidal fuzzy number, for example, the corresponding fuzzy number of "excellent" is (8, 9, 9), which means that experts believe that the supplier's performance in this index is extremely excellent.

- Establishment of affiliation function: The key to the fuzzy evaluation method is how to convert the fuzzy numbers into specific affiliation values [32]. By constructing an affiliation function suitable for this study, the fuzzy scores can be converted into specific values, which makes it possible to further compare the performance scores of suppliers.

- Weighted Fuzzy Comprehensive Evaluation: The weights determined by the AHP method are combined with the fuzzy scores, and the final supplier performance score is calculated through the weighted average method. In this way, the problem of uncertainty that cannot be handled in the traditional scoring method can be effectively solved. In the process of fuzzy evaluation, the weights of the dimensions and sub-indicators are combined to finally arrive at the comprehensive performance score of each supplier as shown in Table II.

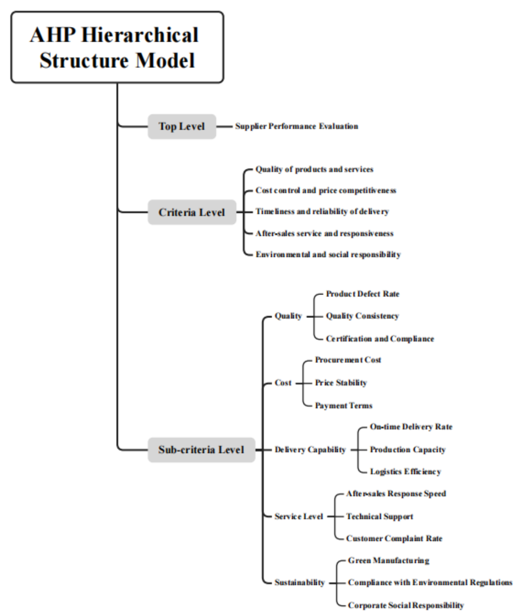

Fig. 4. Hierarchy diagram of the AHP method.

TABLE II EXAMPLE OF FUZZY EVALUATION MATRIX

Provider	Quality performance	Cost performance	Delivery performance	Service performance	Social responsibility performance
Supplier A	(8, 9, 9)	(7, 8, 9)	(6, 7, 8)	(7, 8, 8)	(6, 7, 8)
Supplier B	(7, 8, 9)	(6, 7, 8)	(7, 8, 9)	(6, 7, 8)	(7, 8, 9)

D. Data Collection and Analysis

To ensure the scientificity and reliability of the study, five major suppliers in the Cangzhou honey date industry were selected as samples for this study, covering suppliers of different sizes and geographic regions. The performance data of these suppliers come from public industry reports, enterprise interviews, and expert ratings [33]. By scoring each supplier's indicators and combining the expert's weighting judgment, this study has come up with comprehensive evaluation results of the suppliers [34]. The data analysis process was carried out using SPSS and Excel to ensure the statistical soundness of the data, and a series of reliability and validity tests were conducted to ensure the validity of the final evaluation results.

E. Analysis of Results and Improvement Measures

The performance scores of each supplier obtained through AHP and the fuzzy evaluation method will provide a scientific basis for the supplier management of the Cangzhou honey date industry. Combined with the resulting supplier performance scores, enterprises can formulate improvement measures for poorly performing suppliers to further optimize supply chain management. At the same time, this study will also provide enterprises with a supplier performance management improvement framework based on AHP and fuzzy evaluation method, which will help enterprises to effectively improve the level of supplier management in actual operation.

IV. Results and Discussion

A. Results of Supplier Performance Evaluation

Based on the evaluation system and analysis method established in the previous section, this study used the hierarchical analysis method (AHP) to determine the weights of each evaluation dimension and combined it with the fuzzy evaluation method to score the performance of five major suppliers. The performance scores of each supplier are analyzed in detail below.

1) Statistical analysis of supplier performance scores: To ensure the robustness and reliability of the supplier performance evaluation results, this study statistically analyzed the obtained rating data. The mean, standard deviation, and coefficient of variation of each supplier on different performance dimensions were calculated to measure the stability and consistency of each supplier's performance [35]. Suppliers with lower standard deviations indicate more consistent performance, while suppliers with higher standard deviations may need further optimization. In addition, this study conducted an analysis of variance (ANOVA) on the performance scores of each supplier to test whether there is a significant difference in the scores of different suppliers on each performance dimension [36]. When the significance level (p- value) is less than 0.05, it indicates that at least one supplier's performance is statistically significantly different from other suppliers. For significant differences, the Tukey HSD post hoc test was further used in this study to clarify the comparative results between suppliers where the specific differences lie.

TABLE III DESCRIPTIVE STATISTICS AND ANOVA RESULTS FOR SUPPLIER PERFORMANCE SCORES

Performance dimensions	Provider	Mean	Standard Deviation (SD)	Coefficient of variation (CV)	F-value	p-value	Significant difference (Tukey HSD)
Quality performance	A	8.5	0.42	4.94%	6.87	0.002	A > C, E
	B	7.9	0.51	6.46%			
	C	6.8	0.65	9.56%			
	D	7.7	0.49	6.36%			
	E	6.5	0.72	11.08%			
Cost performance	A	7.2	0.55	7.64%	3.92	0.027	No significant difference
	B	7.5	0.47	6.27%			
	C	6.9	0.61	8.84%			
	D	7	0.52	7.43%			
	E	6.7	0.66	9.85%			
Delivery performance	A	8.2	0.4	4.88%	9.25	<0.001	B > C, D, E
	B	8.6	0.35	4.07%			
	C	7.1	0.6	8.45%			
	D	7.3	0.58	7.95%			
	E	6.8	0.67	9.85%			
Service performance	A	8.3	0.38	4.58%	7.88	0.001	A > C, E

	B	7.8	0.49	6.28%			
	C	6.9	0.57	8.26%			
	D	7.5	0.5	6.67%			
	E	6.6	0.71	10.76%			
Social responsibility	A	7.9	0.47	5.95%	4.63	0.013	No significant difference
	B	7.6	0.5	6.58%			
	C	7	0.59	8.43%			
	D	7.8	0.48	6.15%			
	E	6.9	0.63	9.13%			
Consolidated performance	A	8.1	0.4	4.94%	8.76	<0.001	A > C, E
	B	7.8	0.45	5.77%			
	C	7	0.58	8.29%			
	D	7.5	0.52	6.93%			
	E	6.7	0.69	10.30%			

As can be seen in Table III, Supplier A excels in most of the performance dimensions, with the highest or near-highest means in Quality Performance, Delivery Performance, and Service Performance, and a small standard deviation, which suggests that its performance is relatively stable. Supplier B has the highest score in Delivery Performance (mean 8.6), indicating a significant advantage in On-Time Delivery and Supply Chain Management. In contrast, Supplier C and Supplier E have low scores in several dimensions, especially in quality performance and delivery performance, with large standard deviations, indicating that their performance is less stable and there is more room for improvement. The results of the analysis of variance (ANOVA) showed that there were significant differences ($p < 0.05$) among different suppliers on the quality, delivery, service, and overall performance dimensions. Among them, the highest F-value ($F = 9.25$, $p < 0.001$) was found in the delivery performance dimension, indicating that the most significant differences between suppliers were found in delivery capability. Tukey HSD post hoc tests further showed that both supplier A and supplier B were significantly better than suppliers C and E in quality, delivery, and service performance, while in the cost performance and social responsibility performance dimensions, no significant differences were found between suppliers did not show any significant difference between them ($p > 0.05$). The results further validate the variability of suppliers in different performance dimensions and provide a quantitative basis for supplier performance management [37]. Enterprises can optimize their supplier selection strategy accordingly, focusing on strengthening the management and support of suppliers C and E. Meanwhile, suppliers A and B are encouraged to further improve their performance based on their existing strengths to promote the overall optimization of the supply chain.

2) Cluster analysis of supplier performance: To further explore the similarities and differences among suppliers, this study uses a systematic cluster analysis approach to categorize suppliers based on their performance scores. The results of cluster analysis can identify suppliers with similar characteristics and provide deep insights into their strengths and weaknesses [38]. In this study, Euclidean distance was used as the similarity measure, and Ward's minimum variance method was used as the clustering algorithm to ensure the rationality of the classification. Finally, the suppliers were categorized into three categories: "High-performing suppliers", "Medium- performing suppliers", and "Low-performing suppliers". High-performing suppliers excel in several dimensions, while low-performing suppliers score low in several dimensions. Fig. 5 below shows a clustered dendrogram of supplier performance, demonstrating the similarity of relationships between different suppliers [39]. The figure shows that suppliers A and B are first clustered into one category, indicating that they are very similar in terms of performance. Suppliers C and E are also clustered into one category, showing that they are similar in performance. Supplier D is clustered in a separate category, indicating that its performance is quite different from the other suppliers.

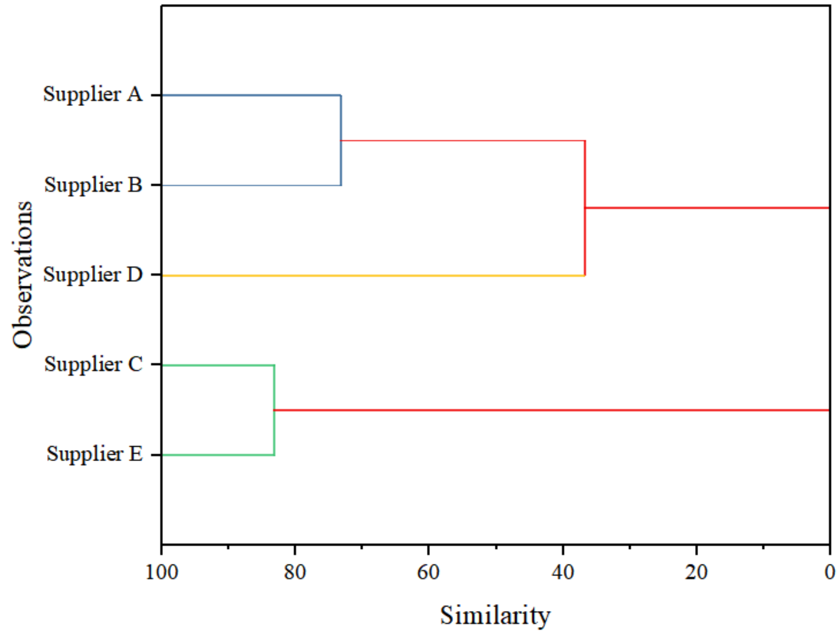

Fig. 5. Tree diagram of supplier performance clustering.

B. Discussion of Results

1) Trend analysis of performance scores: This study further analyzes the time series of suppliers' performance scores, and Fig. 6 below exhibits a time series line graph of suppliers' performance scores to examine the trend of their performance changes over the ten evaluation cycles. The line graphs are used to show the changes in the scores of different suppliers in each dimension to determine whether the performance of suppliers shows a steady upward or downward trend [40]. The analysis results show that the overall performance scores of Supplier A and Supplier B show an upward trend over time, indicating continuous optimization in quality control, delivery capability, and service level. The performance scores of Supplier C and Supplier E are more volatile, indicating possible instability in their production and logistics management.

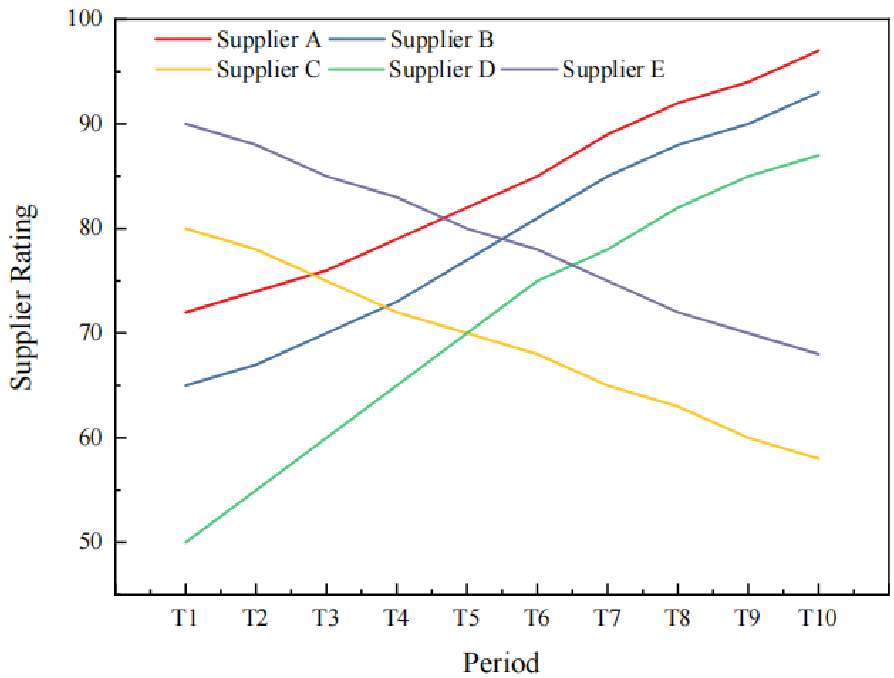

Fig. 6. Time-series line graph of supplier performance ratings.

2) Impact of supplier performance on business operations: Supplier performance has a direct impact on the production efficiency, cost control, and customer satisfaction of an enterprise. In this study, Pearson correlation analysis was used to measure the correlation coefficients between suppliers' performance dimensions and the key operation indexes of the enterprise, and the specific data. From Table IV, the analysis results show that there are various significant correlations between suppliers' performance dimensions and the operation indexes of the enterprise. Among them, quality performance has a significant negative correlation with product defect rate ($r = -0.82$, $p < 0.01$), which indicates that suppliers' excellent performance in quality control can effectively reduce the defect rate of the enterprise's products and thus improve the overall production efficiency ($r = 0.80$, $p < 0.01$). In addition, delivery performance is significantly positively correlated with on-time order fulfillment ($r = 0.76$, $p < 0.05$), suggesting that suppliers' delivery capability directly affects on-time order fulfillment, which in turn affects firms' supply chain stability. In terms of cost control, cost performance is negatively correlated with overall purchasing cost ($r = -0.69$, $p < 0.05$), suggesting that suppliers with good cost management capabilities help to reduce firms' purchasing costs. However, the correlation between cost performance and other operational indicators (e.g., productivity and customer satisfaction) is not significant, which may imply that a low-cost strategy does not necessarily directly improve a firm's operational efficiency [41]. In contrast, service performance had the highest correlation with customer satisfaction ($r = 0.81$, $p < 0.01$), reflecting that suppliers' service quality has a key impact on customer experience and also contributes positively to production efficiency ($r = 0.70$, $p < 0.01$). In addition, social responsibility performance is positively correlated with customer satisfaction ($r = 0.67$, $p < 0.05$) and productivity ($r = 0.55$, $p > 0.05$), but the correlation is relatively low, suggesting that despite the impact of social responsibility factors in terms of corporate image and sustainability, they have a limited role to play in the short-term improvement of operational efficiency.

TABLE IV CORRELATION MATRIX OF SUPPLIER PERFORMANCE DIMENSIONS WITH BUSINESS OPERATING INDICATORS

Performance Dimensions	Product Defect Rate	Orders on Time Compliance Rate	Overall Procurement Costs	Customer Satisfaction	Production Efficiency
Quality performance	-0.82**	0.64*	-0.45	0.78**	0.80**
Delivery performance	-0.59*	0.76*	-0.38	0.72**	0.68*
Cost performance	0.40	-0.35	-0.69*	-0.42	-0.37
Service performance	-0.50	0.58*	-0.32	0.81**	0.70**
Social responsibility	-0.36	0.42	-0.27	0.67*	0.55

Note: * $p < 0.05$, ** $p < 0.01$, Negative correlation coefficients indicate the inhibitory effect of the performance dimension on the operational indicators, and positive correlation coefficients indicate the facilitating effect.

C. Recommendations for Improvement in Performance Management

This study draws on the supplier management practices of leading international companies to explore feasible performance optimization strategies. Table V shows the comparison between the supplier management strategies of leading enterprises and those of this study. In terms of quality management systems, leading enterprises such as Toyota enhance product consistency through data-driven methods such as Six Sigma, while this study's enterprises mainly rely on self- inspection by suppliers and lack a systematic quality optimization mechanism, which suggests that there is still room for improvement in their quality management approach. In terms of supply chain coordination mechanism, Apple and other enterprises adopt Vendor Managed Inventory (VMI) and Just-In-Time (JIT) models to make the supply chain response more efficient, whereas this research enterprise still carries out inventory management in the traditional way, which leads to a lower degree of supply chain coordination and higher inventory costs. In addition, in terms of supplier incentives, leading companies such as Bosch have established a performance- based long-term cooperation mechanism to ensure that high-quality suppliers get long-term cooperation opportunities, while the supplier performance evaluation mechanism of this research enterprise is not perfect and the incentive is insufficient, making it difficult to fully mobilize the enthusiasm of suppliers [42]. In terms of technology and innovation support, enterprises such as Siemens improve the technology level of the overall supply chain through joint research and development of innovation projects with suppliers, while the suppliers of this research enterprise have weak innovation capabilities. Finally, in terms of sustainability and social responsibility, enterprises such as Starbucks have set up strict ethical sourcing standards for their suppliers, while this study's enterprises are more lax in assessing the social responsibility of their suppliers and have not yet established specific evaluation criteria [42]. This study proposes the following optimization suggestions in conjunction with the case study: introducing Six Sigma management methodology to improve product consistency through data-driven quality optimization strategies to strengthen the supplier quality management system; adopting the VMI and JIT models to improve supply chain responsiveness and reduce inventory costs in order to optimize the supply chain synergy mechanism; At the same time, strengthen the supplier incentive mechanism, the establishment of performance-based supplier rating and incentive mechanism, to ensure that high-quality suppliers to obtain long-term cooperation opportunities, to enhance the overall supplier quality level.

TABLE V COMPARISON OF SUPPLIER MANAGEMENT STRATEGIES OF LEADING COMPANIES AND COMPANIES IN THIS STUDY

Supply Chain Management Strategy	Leading Enterprise Practices	Current status of this research enterprise	Gap analysis
Quality Management System	Toyota Adopts Six Sigma for Data-Driven Quality Optimization	Quality management relies heavily on supplier led self-inspection and lacks data analysis	Lack of systematic quality management system, need to introduce data analysis tools
Supply chain synergies	Apple Applies VMI and JIT Models to Optimize Supply Chain	Supplier inventory management is more traditional and supply chain synergy is low	Lower supply chain integration and higher inventory costs
Supplier incentives	Bosch adopts performance-based long-term cooperation mechanisms	Inadequate supplier performance appraisal mechanisms and insufficient incentives	Lack of systematic assessment and incentives, insufficient motivation of suppliers
Technology and innovation support	Siemens develops joint innovation programs with suppliers	Weak supplier innovation and less collaborative R&D	Insufficient supplier innovation support to drive long-term improvements
Sustainable development and social responsibility	Starbucks sets ethical sourcing standards for suppliers	Social responsibility assessment is more lenient and no specific criteria have been set	Supplier social responsibility assessment system has not yet been established

V. CONCLUSION

Based on the AHP and fuzzy evaluation method, this study constructs an evaluation system for supplier performance management of Cangzhou honey dates, systematically evaluates the performance of major suppliers, and proposes corresponding improvement strategies. The results of the study show that Supplier A has the best performance in quality and service performance, Supplier B has obvious advantages in delivery performance, while Supplier C and Supplier E have relatively low scores in several dimensions, and there is a large room for improvement. Supplier D is more balanced in terms of quality and social responsibility performance, but there is still room for optimization in terms of cost control and delivery stability. Overall, the performance management system constructed in this study can provide empirical support for supplier selection and management in the Cangzhou honey date industry, which helps enterprises make scientific supply chain decisions in actual operation and improves the efficiency and stability of the overall supply chain. The study further shows that the combination of AHP and fuzzy evaluation method has strong applicability in supplier performance evaluation, which can synthesize multi-dimensional performance indicators and provide more comprehensive and accurate evaluation results for enterprises. In addition, the study reveals the relationship between supplier performance and key indicators of enterprise operation through correlation analysis, which further verifies the important impact of supplier quality, delivery capability, and cost control on enterprise supply chain performance. These findings not only provide a theoretical basis for the supplier management of the Cangzhou honey date industry but also provide valuable reference for the supply chain management of other agricultural products. Based on the performance evaluation results, this paper puts forward the following management improvement suggestions: optimize the supplier evaluation and selection mechanism, establish a dynamic evaluation system, combined with data monitoring and real- time feedback, to improve the timeliness of performance evaluation; strengthen the supply chain collaborative management, enhance the information sharing and collaborative operation efficiency between the enterprise and the supplier, in order to reduce the delivery risk and the inventory cost; introduce the performance incentive mechanism, and through the contract incentive, Long-term cooperation mechanism, etc., to improve the service quality and delivery capability of suppliers; strengthen the management of supplier social responsibility, and promote the improvement of suppliers in sustainable development, environmental protection and labor rights and interests, so as to enhance the sustainable competitiveness of the overall supply chain.

Although this study has achieved certain results, there are still some limitations. First, this study only analyzes the data based on five suppliers, and the sample size is relatively small. Future studies can further expand the sample scope and introduce more different types of suppliers for comparative analysis to improve the generalizability of the findings. Second, this study mainly adopts AHP and fuzzy evaluation methods for supplier performance assessment, although these two methods can effectively synthesize qualitative and quantitative factors, there may be some computational complexity limitations when dealing with large-scale supply chain data. Future research can combine machine learning, data mining, and other intelligent analysis techniques to improve the automation level and accuracy of supplier performance assessment. In addition, future research can further explore the in-depth integration of supplier performance evaluation with supply chain risk management, supplier cooperation mechanism, etc., to build a more complete supply chain optimization strategy and provide enterprises with more practical value of decision support. The conclusions of this study are not only applicable to the supplier management of the Cangzhou honey date industry but also can provide theoretical guidance and practical references for other agricultural supply chains and even the broader manufacturing and retail industries. In the future, with the development of digitalization and intelligence in supply chain management, supplier performance management methods will also be further innovated and optimized to adapt to the complex and changing market environment.

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