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Design of Digital Economy Industry Investment Decision Support System Based on Fuzzy Comprehensive Evaluation Method

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This paper presents research on the design and application of an investment decision support system for digital economy industry based on fuzzy comprehensive evaluation method. In view of the rapid changes and high uncertainty of the digital economy industry, we adopt a multi-level fuzzy evaluation system and refine the affiliation intervals in order to deal with subjectivity and ambiguity in the evaluation process more accurately. The study conducted a case study of digital economy enterprises such as Starfleet Technology by constructing an index system containing technological innovation ability, market potential, operational stability, risk control and brand influence. The experimental results show that Starlight Technology has a significant overall affiliation on the "high" and "very high" evaluation scale, indicating its advantages in technological innovation and market potential. We further provide specific investment recommendations, including measures for strategic investment, risk assessment and ongoing monitoring. Compared with state-of-the-art (SOTA) studies, this study demonstrates significant advantages in methodological innovation, deepening of statistical analysis, completeness of indicator system and domain specificity. In conclusion, this study provides new perspectives and practical tools for investment decision-making in the digital economy industry through the application of fuzzy comprehensive evaluation method.

Povzetek: Za podporo investicijskim odločitvam v digitalni ekonomiji je uvedena metoda celovite mehke ocene, ki izboljšuje ocenjevanje tveganji in priložnosti v dinamičnem okolju.

1 Introduction

As an important driving force for modern economic development, the digital economy is affecting the global industrial structure and investment direction at an unprecedented speed and scale. With the continuous advancement of Internet technology, the application of big data, cloud computing, artificial intelligence and other technologies has become increasingly widespread, causing the boundaries of the digital economy to continue to expand, covering multiple fields such as online retail, intelligent manufacturing, and financial technology. The rapid development of these fields not only provides investors with abundant investment opportunities, but also brings complex risk assessment and decision-making challenges. In this context, traditional investment decision-making methods are difficult to accurately capture the dynamics and uncertainty of the digital economy industry due to their rigid and linear limitations. It is particularly urgent to develop a decision support system that can comprehensively evaluate investment risks and opportunities in the digital economy industry. The fuzzy comprehensive evaluation method has been successfully applied in decision support systems in many fields due to its ability to handle uncertainty information. Applying it to investment decisions in the digital economy industry can not only improve the accuracy and efficiency of decision-making, but also provide investors with a new perspective and tools to better adapt to the investment environment in the digital economy era.

In recent years, significant progress has been made in fuzzy comprehensive evaluation methods and related research on the digital economy industry. Ye and Liu [1] discussed how to improve the fuzzy comprehensive evaluation model through fuzzy C-means clustering. Their research emphasized the effectiveness and applicability of fuzzy clustering technology when dealing with fuzzy information and complex system evaluation. Ma and Si [2] discussed optimization methods and improvement strategies based on fuzzy comprehensive evaluation, and their work provided new ideas for improving the accuracy and reliability of the evaluation model.

Especially in the research field of digital economy industry, Quan et al. [3-6] demonstrated the application of fuzzy comprehensive evaluation in missile hydrodynamic shape selection, highlighting the practical value of this method in technical decision-making and evaluation. Cao et al. [7] studied the impact of enterprise digital transformation based on EM algorithm on the green innovation efficiency of enterprise investment, providing empirical evidence for understanding the role of the digital economy in promoting green innovation.

Guo et al. [8] explored the spatial impact of the digital economy on China's energy intensity, emphasizing the importance of how the digital economy affects national energy consumption in the context of achieving sustainable development goals. The research by Liu et al. [9] focused on the relationship between the digital economy and substantive green innovation, providing empirical evidence from Chinese listed companies and supporting the positive contribution of the digital economy to green innovation. In addition, Sun et al. [10] studied the impact of the digital economy on industrial wastewater discharge, and their findings demonstrated the potential benefits of the digital economy in environmental protection. Yang et al. [11] discussed how the digital economy affects the mechanisms and paths of low-carbon inclusive development from the perspective of high-quality development, providing new insights into the relationship between the digital economy and sustainable development.

Exploring the effective support system design for investment decisions in the digital economy industry has significant practical value in guiding the correct flow of capital in a rapidly changing market. With the rapid development of digital technology, the uncertainty faced by investors has increased significantly, and traditional decision-making tools are no longer sufficient to deal with the complex and ever-changing investment environment. Using fuzzy comprehensive evaluation method to build a decision support system can effectively process and analyze uncertain information and improve the scientificity and rationality of investment decisions. This move will not only help narrow the information gap between investors and investment opportunities, but also promote the effective allocation of capital, thereby stimulating the vitality and innovation potential of the digital economy. At the theoretical level, this research enriches the application field of fuzzy comprehensive evaluation method in economic decision-making and provides a new perspective and methodological reference for subsequent research. At a practical level, the research results can provide customized decision support tools for governments, enterprises and individual investors, helping various economic entities seize opportunities, avoid risks and achieve sustainable development in the wave of digital economy [14].

2 Theoretical basis and literature review

2.1 Digital economy

Digital economy, as a product of the deep integration of information technology and economy, marks a new form of economic activity. In this category, the collection, processing and utilization of data resources have become the core driving force for output value growth and competitiveness improvement. With the widespread application of technologies such as the Internet, big data, and artificial intelligence, traditional industries are being redefined, and new business formats and models such as e-commerce, smart manufacturing, and online services have also been given birth to. These changes not only promote a leap in production efficiency and innovation capabilities, but also have a profound impact on social life, including changes in working styles, diversification of consumption patterns, and increased convenience in accessing information. Facing the opportunities and challenges brought by the digital economy, individuals, enterprises and even countries need to adapt to this new economic form and actively participate in the digital economy by strengthening digital technology capabilities, improving relevant laws and regulations, and promoting the construction of digital infrastructure. In development. At the same time, paying attention to data security and privacy protection to ensure the healthy, orderly and sustainable development of the digital economy has become the focus of common concern of all parties.

2.2 Investment decisions

Table 1: Factors to consider in investment decisions

Key considerations	Describe	Influence
Market environment	Including macroeconomic conditions, industry trends, market demand	Directly affects the profit prospects and risk level of investment projects.
Industry News	Competition landscape, technological innovation, changes in policies and regulations within the industry	Determines the relative position and growth potential of investment projects in the industry.
Business status	The company's financial status, management team, market share, brand influence	Affect the operational efficiency and market competitiveness of the project.
Financial analysis skills	Including the ability to interpret financial statements, cash flow analysis, valuation techniques	Determine investors' ability to identify investment opportunities and risks.
Data processing capabilities	In the context of the digital age, big data analysis and processing capabilities, such as data mining, pattern recognition	Improving the accuracy and adaptability of investment decisions is particularly important for predicting market trends.

Economic Policy and Regulation	The government's macroeconomic policies and industry-related laws and regulations.	It has a significant impact on the stability of the investment environment and the legal risks of the project.

As shown in Table 1, by in-depth analysis of these factors, investors can more comprehensively evaluate the potential value and risks of investment projects. In the ever-changing market environment, continuous tracking and analysis of these key factors can help investors flexibly adjust investment strategies, seize investment opportunities, and effectively control risks, thereby achieving steady appreciation of assets [17].

2.3 Fuzzy comprehensive evaluation method

The fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics, which is designed to handle and solve evaluation problems characterized by uncertainty and fuzziness. By establishing a fuzzy relationship matrix, this method can comprehensively evaluate multiple factors of the object, and is especially suitable for the evaluation of complex systems that are difficult to describe with precise mathematical models. In practical applications, this method first determines the evaluation index system and quantifies the evaluation indicators into fuzzy sets; then constructs a fuzzy relationship matrix based on expert judgment or actual data; then uses fuzzy operations to synthesize the evaluation results of multiple indicators into one Comprehensive evaluation results. The advantage of this method is that it can make full use of fuzzy information and improve the objectivity and accuracy of the evaluation. The fuzzy comprehensive evaluation method is widely used in economic management, environmental assessment, technical and economic analysis and other fields. It helps decision-makers make more scientific and reasonable choices in complex decision-making environments by providing an effective tool for processing uncertain information. Especially in today's era of information explosion, this method provides a flexible and effective evaluation method for various decisions.

The flexibility and adaptability of the fuzzy comprehensive evaluation method are also important reasons for its widespread adoption. The determination of evaluation indexes and weights has a certain degree of flexibility and can be adjusted according to different research objects and purposes. This flexibility makes the fuzzy comprehensive evaluation method not only able to respond to the current evaluation needs, but also the application of fuzzy comprehensive evaluation method in digital economy decision-making is specifically shown in Table 2.

Table 2: Status of research

Serial number	Author	methodologies	Key findings	limitations
1	Liu, Q. L., et al. [9]	Fuzzy integrated evaluation method combined with hierarchical analysis method (AHP)	In the digital economy industry, the fuzzy comprehensive evaluation method can effectively deal with the uncertainty in the investment decision, and enhance the scientificity and reliability of the decision by constructing a multi-level index system.	AHP subjective weight settings may introduce bias and more empirical data are needed to verify the validity of the model.
2	Sun, X. X., et al. [10]	Fuzzy Petri Nets and Fuzzy Comprehensive Evaluation Methods	An investment decision model integrating fuzzy Petri nets and fuzzy comprehensive evaluation method is proposed, which can better simulate and predict the dynamic changes of the digital economy industry.	Models are complex and require powerful computing resources and specialized staff to maintain and operate.
3	Yang, G. G., et al. [11]	Fuzzy Cluster Analysis and Fuzzy Comprehensive Evaluation Method	The enterprises in the digital economy industry are categorized by fuzzy cluster analysis, and the fuzzy comprehensive evaluation method is used to make investment decisions, which improves the accuracy and applicability of the decisions.	The results of fuzzy clustering are highly influenced by the initial conditions and may lead to unstable classification results.

Serial number	Author	methodologies	Key findings	limitations
4	Zhao, Y., et al. [12]	Fuzzy Logic and Fuzzy Integrated Evaluation Method	Studies have shown that the combination of fuzzy logic and fuzzy comprehensive evaluation method can more accurately assess the risk and return of investment in the digital economy industry, especially for those projects with a high degree of uncertainty.	Limited ability to deal with non-linear relationships and may not be able to capture all complex investment patterns.
5	Li, Y. J., et al. [13]	Fuzzy Neural Network and Fuzzy Comprehensive Evaluation Method	Using fuzzy neural networks for prediction, combined with fuzzy comprehensive evaluation method for decision making, this method shows high accuracy and flexibility in investment decision making in digital economy industry.	Training fuzzy neural networks requires a large amount of historical data and the model may be overfitted.

Although state-of-the-art (State-of-the-Art, SOTA) research has made significant progress in fuzzy integrated evaluation methods in the digital economy, they still show limitations in dealing with highly dynamic and uncertain investment environments. Existing models tend to focus on static analysis and ignore the rapidly changing nature of the digital economy, which results in decision support systems lacking in real-time and adaptability. In addition, the SOTA approach has challenges in integrating multidimensional and heterogeneous data, especially in failing to fully exploit the potential value of big data, which limits the comprehensiveness and depth of decision-making. Further, current technology has limited ability in long-term forecasting and strategic planning, making it difficult to provide forward-looking investment guidance.

In view of this, this work aims to develop a more robust and flexible decision support system that is capable of capturing market dynamics in real time, efficiently integrating multifaceted information, and at the same time possessing strong predictive capabilities to cope with the uncertainties of the digital economy. By bridging the gap of SOTA, we aim to provide investors with a more reliable and comprehensive decision-making tool to help them make more informed investment choices in the digital economy.

3 Research methods and data collection

3.1 Basis for selection of fuzzy comprehensive evaluation method

Table 3: Basis for selection of fuzzy comprehensive evaluation method

Selection basis	Describe	Importance assessment
Dealing with information uncertainty	The fuzzy comprehensive evaluation method can effectively handle uncertainty information in the evaluation process, such as subjective judgment and fuzzy data.	high
The complexity of systematic reviews	It is suitable for comprehensive evaluation of complex systems and can consider multiple evaluation indicators and factors at the same time.	high
Flexibility and adaptability	The method has strong flexibility and adaptability, and the evaluation indicators and weights can be adjusted according to specific circumstances.	middle
Easy to understand and operate	Compared with other complex decision-making methods, the fuzzy comprehensive evaluation method is simple to operate, easy to understand and implement.	middle
Wide range of applications	It has been widely used in decision-making analysis in many fields such as economic management, environmental assessment, and engineering technology.	high

As shown in Table 3, the fuzzy comprehensive evaluation method is an effective tool for dealing with uncertainty problems, and its selection is mainly based on its unique advantages and applicability. The application of this method is particularly important in the design research of investment decision support system for digital economy industry. The characteristics of the digital economy industry include rapid development and change, which bring a large amount of uncertain information, such as rapid changes in market demand, uncertainty in technological innovation. These factors make it difficult for traditional decision-making methods to adapt. The fuzzy comprehensive evaluation method can effectively handle this uncertainty information and provide more accurate decision support.

Investment in the digital economy industry involves multiple levels of factors, including technology, market, policy and other multi-dimensional factors. These factors interact with each other to form a complex system. The fuzzy comprehensive evaluation method can comprehensively consider these multi-dimensional factors and achieve effective evaluation of complex systems by constructing a fuzzy relationship matrix.

The flexibility and adaptability of the fuzzy comprehensive evaluation method are also important reasons for its widespread adoption. The determination of evaluation indicators and weights has a certain degree of flexibility and can be adjusted according to different research objects and purposes. This flexibility enables the fuzzy comprehensive evaluation method to not only respond to current evaluation needs, but also adapt to possible future changes.

3.2 Data collection process and methods

3.2.1 Data collection

Clarify the type and scope of data required for research, including industry trend data, corporate operating data, market competition status, technological development level, to support the application of fuzzy comprehensive evaluation methods. Data sources can be public industry reports, government statistics, professional data service agencies, and raw data directly obtained through questionnaires, interviews.

Table 4: Industry trend data

Indicator name	2021 data	2022 data	2023 data	Unit
Annual growth rate	5.2%	6.1%	6.5%	percentage
Investment amount	120 billion	140 billion	160 billion	billion
The total profit	3×10^{11}	35 billion	40 billion	billion
Investment in technological	20 billion	25 billion	3×10^{11}	billion
Market share	15%	18%	20%	percentage

As shown in Table 4, it shows the key development indicators of the digital economy industry in the past three years, including annual growth rate, investment amount, total profit, technological innovation investment and market share, providing data support for investment decisions. It can be seen from the data that the industry has maintained a stable growth momentum, and the annual growth rate has increased year by year, reflecting the continued increase in market demand and the good development prospects of the industry. The year-by-year increase in investment and technological innovation investment shows that companies in the industry are increasing investment, especially in technological innovation, which is crucial to maintaining industrial competitiveness and promoting long-term development. The growth in total profits also shows a good return on investment, attracting more investors to pay attention and enter the industry. In addition, the gradual increase in market share indicates that the influence of major enterprises in the market has increased, which is conducive to the formation of a more stable competitive landscape.

Table 5: 2023 Operating data of major enterprises in the digital economy industry

Index	Xinghui technology	Future network	Smart cloud services	Unit	Comment
Operating income	50 billion	45 billion	55 billion	billion	-
Net profit	10 billion	8 billion	12 billion	billion	-
R&D investment ratio	10%	12%	15%	percentage	R&Dinvestment as a proportion of operating income
Market share	20%	18%	twenty-two%	percentage	-
Employee satisfaction index	85	88	90	points (out of 100 points)	Obtained through employee surveys

As shown in Table 5, Xinghui Technology, Future Network, and Smart Cloud Services, as leaders in the digital economy industry, have demonstrated strong operating performance in 2023. It can be seen from the data in the table that smart cloud services lead the way with operating revenue of 55 billion, showing that it has strong business expansion capabilities and market occupation speed in the market. In terms of net profit, all three companies have achieved good profitability levels. Among them, smart cloud services performed best with a net profit of 12 billion, indicating that they not only have strong sales capabilities, but also have high profitability efficiency.

In terms of the proportion of R&D investment, all companies exceed 10%, reflecting the importance that the digital economy industry attaches to technological innovation. The proportion of R&D investment in smart cloud services is the highest, reaching 15%, which shows that the company emphasizes technology-driven and product innovation, laying a solid foundation for its long-term development. Market share is a key indicator to measure the competitiveness of enterprises. Smart Cloud Services occupies the leading position in the industry with a share of 22%, while Xinghui Technology and Future Networks also maintain market shares of 20% and 18% respectively. The three companies jointly promote the overall market share. Development of the industry. The employee satisfaction index reflects the effectiveness of the company's internal management and employees' work happiness. The indexes of the three companies are all high, especially the smart cloud service reaching 90 points, indicating that they have a good corporate culture and a high degree of employee identity.

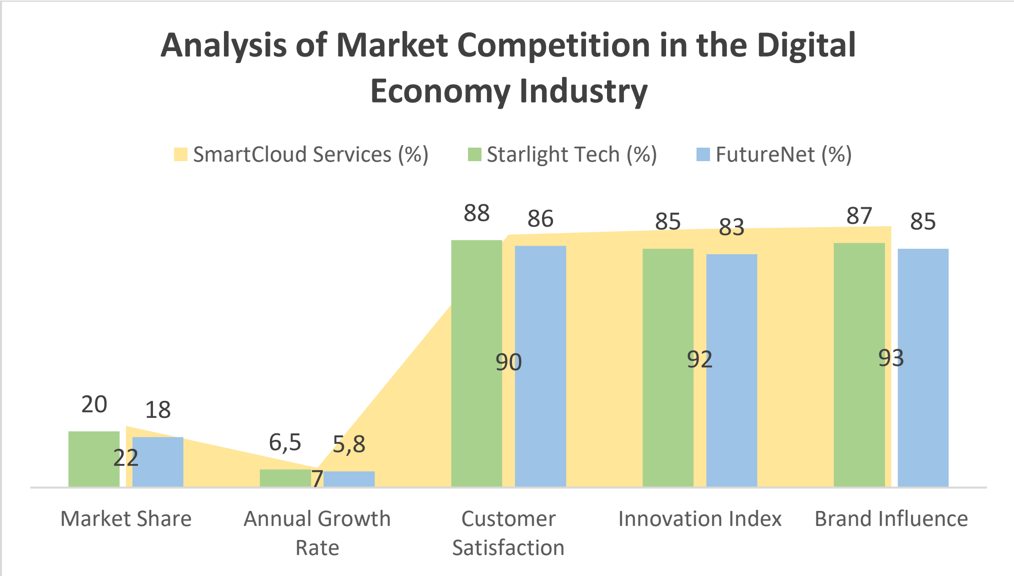

Figure 1: Digital economy industry market competition analysis table

As shown in Figure 1 above, from the perspective of market share, smart cloud services occupy a leading position with a proportion of 22%, showing that it has strong control and influence in the market. In terms of annual growth rate, smart cloud services also led the way at 7.0%, reflecting its business expansion speed and market acceptance. Customer satisfaction is an important indicator for measuring enterprise service quality and customer loyalty. All three companies performed well. Among them, Smart Cloud Service ranked first with 90% customer satisfaction, indicating that it has done a relatively good job in providing services and user experience. The two indicators of technological innovation index and brand influence are also important aspects to evaluate the competitiveness of enterprises. The performance of smart cloud services in both aspects is also very strong, with a technological innovation index reaching 92% and a brand influence reaching 93%, which reflects its leading position in technology research and development and marketing.

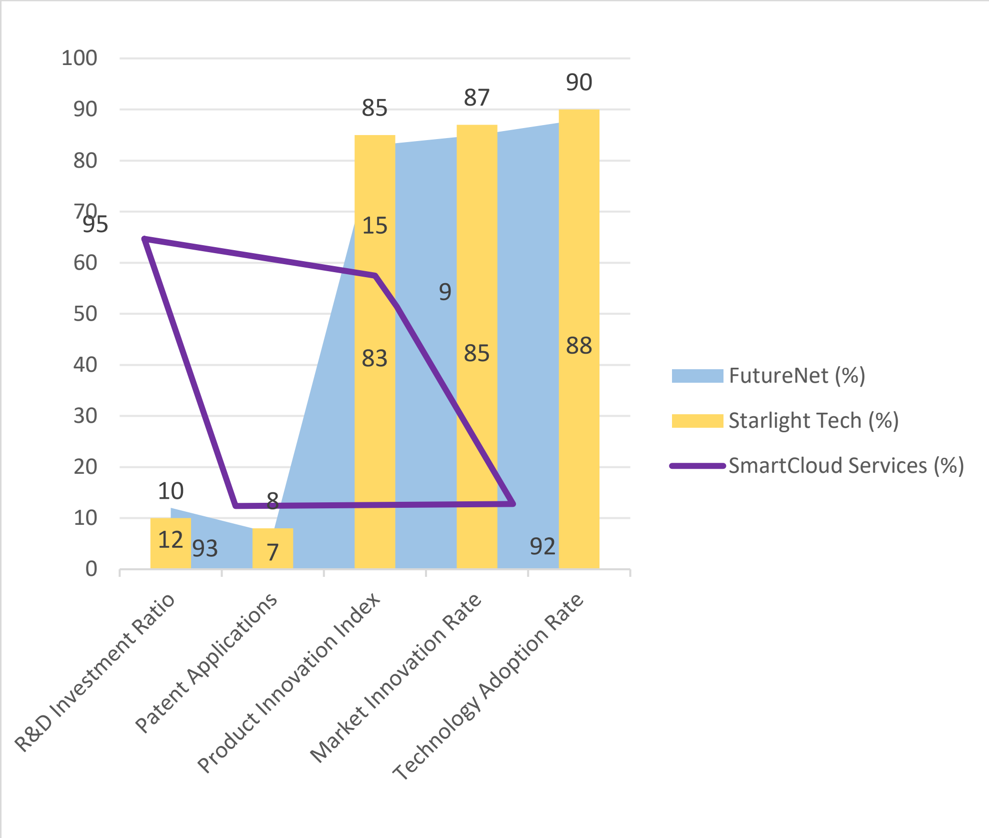

Figure 2: Analysis of technology development level of digital economy industry

As shown in Figure 2 above, the technological progress and innovation efforts of Starlight Technology, Future Network and Intelligent Cloud Services in the field of digital economy. The R&D investment ratio is a key metric that shows how much each company invests in R&D, with SmartCloud Services leading the way with 15%. This investment is critical to sustaining long-term growth and innovation. Patent applications, as a proxy for technological creativity and potential future innovation, also highlight competitive advantages between companies. Intelligent cloud services have the highest number of applications, demonstrating a strong focus on ensuring their technological advancement. The Product Innovation Index and Market Innovation Rate further describe each company's ability to not only develop new products, but also successfully introduce them to the market. SmartCloud Services performs well on both metrics, indicating that its product is both innovative and well-received by the market. Technology adoption measures how quickly and efficiently each company integrates new technologies into its operations and products. The SmartCloud service once again leads the way with an adoption rate of 95%, illustrating its agility and openness to innovation.

Collect data using appropriate tools and methods based on identified data needs and sources. For publicly available data, you can directly download or purchase it; for original data, you need to design a questionnaire or interview outline and conduct on-site or online surveys. Data preprocessing includes data cleaning (removing duplicate and erroneous data), data conversion (unifying data formats and units), and data normalization to prepare for subsequent analysis.

3.2.2 Collection method

Literature review: Systematically collect and analyze existing research literature to obtain macro-level data such as industry background and development trends.

Questionnaire surveys and interviews: Design targeted questionnaires and interview outlines to collect data from different perspectives such as business managers, industry experts, and consumers to obtain more in-depth and detailed information.

3.3 Construction of evaluation index system

3.3.1 Indicator selection principles

Relevance: The selected indicators should be closely related to investment decisions in the digital economy industry and be able to fully reflect the multifaceted needs and characteristics of investment decisions.

Quantifiable: Indicators should have clear quantitative standards to facilitate data collection and subsequent analysis and calculation.

Objectivity: Try to choose objective data as evaluation indicators to reduce the interference of subjective judgment and improve the fairness and accuracy of evaluation.

Comprehensiveness: Evaluation indicators should cover all aspects of digital economy industry investment, including economic benefits, technological innovation, market potential

Dynamic: Considering the rapid changes in the digital economy industry, the selected indicators should be able to reflect the development trends and dynamic changes of the industry.

3.3.2 Structure of the indicator system

The first layer: the overall goal layer, which is the overall goal of comprehensive evaluation of investment decisions in the digital economy industry.

The second layer: the criterion layer, including several major criteria such as economic benefits, technological innovation, market competitiveness, and risk control.

The third layer: indicator layer. Each criterion has multiple specific evaluation indicators, such as return on investment, proportion of R&D investment, market share, customer satisfaction

Quantitative methods of indicators

For each specific indicator, the following formula is used for quantification:

Investment return rate (IRR) calculation formula (1):

$$IRR = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - InitialInvestment \quad (1)$$

Among them, (CFt) represents (t) the cash flow in the first year, (r) represents the discount rate, and ($InitialInvestment$) represents the initial investment amount.

R&D investment ratio（$R\ Ratio$）calculation formula (2):

$$R\&DRatio = R\&DInvestment / TotalSales \times 100\% \quad (2)$$

Among them, (R) represents the amount of R&D investment and ($TotalSales$) represents the total sales.

Market share ($Market\ Share$) calculation formula (3):

$$MarketShare = \frac{CompanySales}{TotalMarketSales} \times 100\%$$

(3)

Among them, ($CompanySales$) represents the company's sales and ($TotalMarketSales$) represents the total market sales. The evaluation index system constructed through the above method can not only comprehensively and objectively evaluate investment decisions in the digital economy industry, but also adapt to the dynamic changes in industry development and provide scientific and accurate support for investment decisions. The pseudo-code is shown in Table 6.

Table 6: Algorithm pseudo-code

```
function FuzzyComprehensiveEvaluation () {
  // Define the system of evaluation indicators
  let criteria = ["EconomicBenefits", "TechnologyInnovation", "MarketCompetitiveness", "RiskControl"];
  let subCriteria = {
    EconomicBenefits: ["InvestmentReturnRate", "NetPresentValue"],
    TechnologyInnovation: ["ResearchDevelopmentRatio", "PatentCount"],
    MarketCompetitiveness: ["MarketShare", "BrandInfluence"],
    RiskControl: ["MarketRisk", "FinancialRisk", "LegalRisk"]
  };
  // Data collection
  let data = collectData(subCriteria);
  // Standardized data
  let standardizedData = standardizeData(data);
  // Construction of a fuzzy evaluation matrix
  let fuzzyMatrix = buildFuzzyMatrix(standardizedData);
  // Determine the weight vector
  let weights = determineWeights(criteria);
  // Fuzzy integrated evaluation
  let evaluationResult = fuzzySynthesis (fuzzyMatrix, weights);
  // Result defuzzification
  let clearResult = defuzzify(evaluationResult);
  // Output decision-making recommendations
  outputDecision(clearResult).
}
```

Fuzzy comprehensive evaluation method is a method that applies fuzzy mathematical theory to comprehensive evaluation, which is used to deal with those evaluation problems with vagueness and uncertainty. When conducting fuzzy comprehensive evaluation, we first need to construct a fuzzy evaluation model, and then obtain the final comprehensive evaluation results through a series of mathematical operations.

The first step is to define the fuzzy set and the degree of affiliation. For the evaluation object X, we define the fuzzy set $U = \{u_1, u_2, ..., u_n\}$, where each represents an evaluation level, such as "poor", "average", "good", etc. For each evaluation index x_j, we define the affiliation function to represent the degree that the evaluation object X belongs to the fuzzy set. For each evaluation index x_j, we define the affiliation function $\mu_{ij}(x_j)$ to represent the degree that the evaluation object X belongs to the fuzzy set.

The second step is to construct the fuzzy evaluation matrix. Based on expert assessment or historical data, we construct the fuzzy evaluation matrix R, where each element r_{ij} denotes the degree of affiliation of the jth evaluation indicator x_j belonging to the fuzzy set u_i . The matrix R can be expressed as:

$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$. Where m is the number of evaluation indicators and n is the size of the fuzzy set.

The third step is to determine the indicator weights. We also need to determine the importance of each evaluation indicator, i.e., the weight vector $W=[w_1,w_2,...,w_m]$, where w_j is the weight of the jth indicator.

The fourth step is fuzzy comprehensive evaluation. Use fuzzy operators (e.g. fuzzy weighted average) to operate on the fuzzy evaluation matrix R and the weight vector W to get the comprehensive evaluation vector B. Common fuzzy operators include maximum-minimum operation, algebraic multiplication, and algebraic addition. Here we use the fuzzy weighted average method with the formula:

Where c denotes the fuzzy operator, b_i is the ith element of the fuzzy comprehensive evaluation vector, which indicates the comprehensive affiliation degree of the evaluation object X belonging to the fuzzy set u_i after considering all the indicators together. $B=W^\circ R=[b_1,b_2,...,b_n]$ The fifth step is defuzzification. We need to convert the fuzzy comprehensive evaluation result B into a clear value or grade, and this process is called defuzzification. Commonly used methods include the center of gravity method, the maximum affiliation method, and so on. Taking the center of gravity method as an example, assuming that the domain of the fuzzy set U is a continuous range of values [a, b], the result V after defuzzification can be expressed as: $V=\frac{\int_a^b x\cdot\mu_B(x)dx}{\int_a^b \mu_B(x)dx}$ where $\mu_B(x)$ is the affiliation function of the integrated evaluation vector B and x is a variable on the domain.

4 Data analysis

4.1 Application of fuzzy comprehensive evaluation method

Applying the fuzzy comprehensive evaluation method to "Research on the Design of Digital Economy Industry Investment Decision Support System Based on the Fuzzy Comprehensive Evaluation Method", we take the "technological development level" discussed previously as an example to specifically demonstrate how to construct a fuzzy relationship matrix. This process needs to be explained with specific table data.

We selected the following set of evaluation indicators (U): R&D investment ratio (R&D), product innovation index (PI), market innovation rate (MI), technology adoption rate (TA), and brand influence (BI). At the same time, we define the evaluation result set \(V\): very low (VL), low (L), medium (M), high (H), and very high (VH).

For each evaluation indicator, we assign a membership degree to each enterprise based on industry data, historical performance and expert experience. Examples are as follows:

The membership degree distribution of R&D investment proportion is: ($\{VL: 0\%,\ L: 10\%,\ M: 40\%,\ H: 40\%,\ VH: 10\%\}$).

The membership degree distribution of product innovation index (PI) is ($\{VL: 0\%,\ L: 5\%,\ M: 35\%,\ H: 50\%,\ VH: 10\%\}$).

(Note: Other indicators are allocated in a similar manner)

Based on these membership degrees, we can construct a fuzzy relationship matrix for each enterprise (R), expressed as formula (4):

$$R=\begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} \end{bmatrix} \quad (4)$$

Among them, $(r\{ij\})$ represents (i) the membership degree of the th evaluation index corresponding to the th evaluation result. (j) For example, $(r\{11\})$ it represents the degree of membership of the R&D investment ratio to the "very low" evaluation result.

For a given weight vector (W) (the importance of each indicator has been given), we can $(B=W^\circ R)$ calculate the comprehensive evaluation vector through the fuzzy comprehensive evaluation formula (B), where " $(^\circ)$ " represents the fuzzy comprehensive operation, which can be realized through matrix multiplication formula (5):

$$B=\begin{bmatrix} w_1 & w_2 & w_3 & w_4 & w_5 \end{bmatrix}^\circ R \quad (5)$$

This (B) will provide a comprehensive view that reflects the degree of membership corresponding to each evaluation result, based on which the company's technological development level can be evaluated.

For simplicity, we only consider one enterprise, and its corresponding fuzzy relationship matrix (R), based on the membership degree of the evaluation index to the evaluation result, is as follows formula (6):

$$R=\begin{bmatrix} 0 & 0.1 & 0.4 & 0.4 & 0.1 \\ 0 & 0.05 & 0.35 & 0.5 & 0.1 \\ 0 & 0.1 & 0.3 & 0.5 & 0.1 \end{bmatrix} \quad (6)$$

Calculate the comprehensive evaluation vector (B): The comprehensive evaluation vector (B) is calculated through the fuzzy comprehensive evaluation formula of the weight vector (W) and fuzzy relationship matrix : (R), as shown in formula (7):

$$B = W \circ R = \begin{bmatrix} 0.4 & 0.3 & 0.3 \end{bmatrix} \circ \begin{bmatrix} 0 & 0.1 & 0.4 & 0.4 & 0.1 \\ 0 & 0.05 & 0.35 & 0.5 & 0.1 \\ 0 & 0.1 & 0.3 & 0.5 & 0.1 \end{bmatrix} \quad (7)$$

By performing matrix multiplication, we can get (B), which is a vector with five elements, each element representing the membership degree of the corresponding evaluation result.

After calculation (B), $(\begin{bmatrix} 0 & 0.08 & 0.35 & 0.47 & 0.1 \end{bmatrix})$ this means that the degree of membership of the enterprise for the evaluation results of "medium", "high" and "very high" are 0.35, 0.47 and 0.1 respectively. From this vector, we can see that "High" (H) has the highest degree of membership (0.47), which indicates that the overall performance of the enterprise in terms of the level of technological development is evaluated as "High" according to the selected indicators and weights.

This result provides investors with a quantitative tool to help them understand the technological development status of specific companies in the digital economy industry. Through similar methods, investors can evaluate the technological development levels of different companies and then make more informed investment decisions.

In order to verify the validity and accuracy of the comprehensive evaluation vector (B), the evaluation results predicted by the model can be compared with the actual market performance, technical achievements or other quantifiable performance indicators of the enterprise. This verification helps adjust model parameters, such as adjusting weights (W) or improving membership assignments, to improve the accuracy and practicality of the evaluation model.

4.2 Investment decision analysis

In "Research on Design of Digital Economy Industry Investment Decision Support System Based on Fuzzy Comprehensive Evaluation Method", investment decision analysis uses the built evaluation model and collected data to conduct in-depth analysis of potential investment opportunities. This process involves not only comprehensive analysis of data, but also interpretation of results and optimization of the decision-making process. Through the fuzzy comprehensive evaluation method, analysts can conduct a comprehensive evaluation of different companies or projects within the digital economy industry. This assessment is based on a series of pre-defined indicators, such as technological innovation capabilities, market potential, operational stability, risk control. Each indicator is assigned a corresponding weight, reflecting its importance in investment decisions. By calculating the weighted membership of each indicator, a comprehensive score for each investment opportunity can be obtained, and then prioritized.

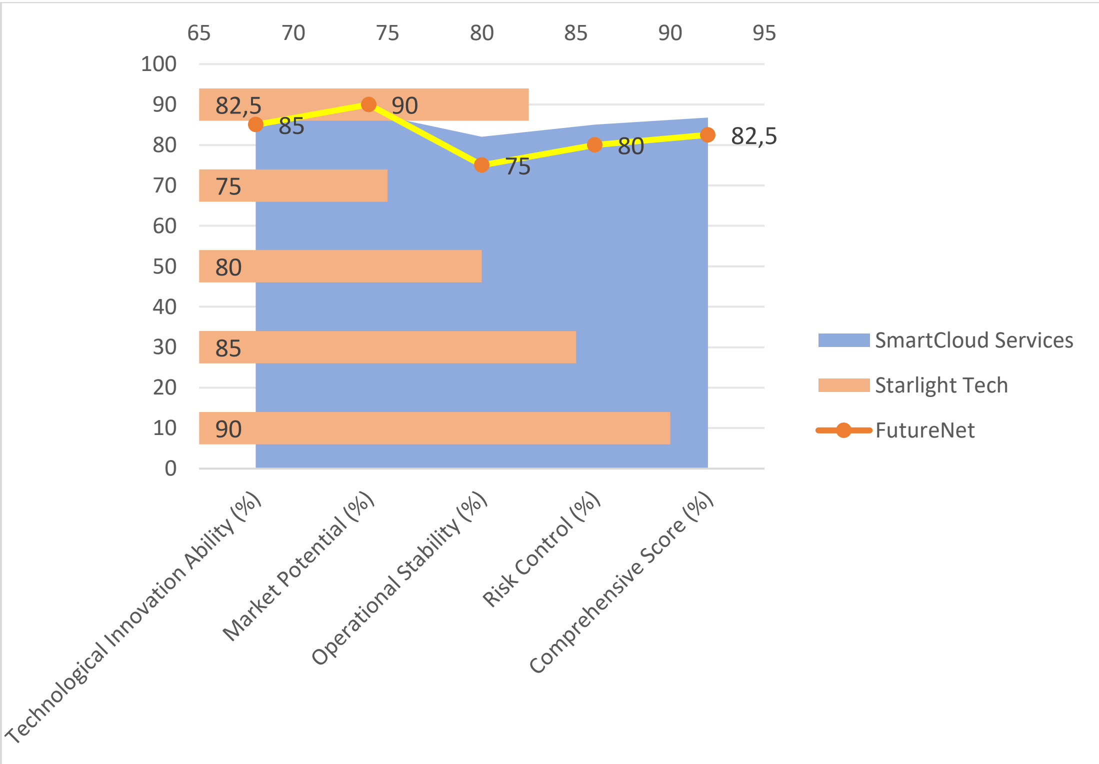

Figure 3: Comprehensive score of investment opportunities in the digital economy industry

As shown in Figure 3 above, by comprehensively scoring three different investment opportunities, the investment decision analysis process based on the fuzzy comprehensive evaluation method is demonstrated. The performance of each investment opportunity on four key indicators of technological innovation capability, market potential, operational stability and risk control is quantified, and combined with the corresponding weights to calculate a comprehensive score. It can be seen from the table data that although the overall scores of "Xinghui Technology" and "Future Network" are the same, there are differences in specific indicators, reflecting their respective advantages and disadvantages. "Smart Cloud Service" performed well on all evaluation indicators and therefore received the highest overall score, indicating that it is the most attractive investment opportunity under the current evaluation system.

Investment opportunities with high overall scores are generally viewed as more attractive because they perform well across multiple key metrics. However, interpretation of these results also needs to take into account market conditions, competitive dynamics and potential macroeconomic risks. For example, an emerging enterprise with a very high technological innovation index may have greater room for growth in market competition, but may also face higher market acceptance and commercialization risks.

Table 7: Investment opportunity evaluation indicators and weights

Norm	Weight (%)	Affiliation interval	Evaluation criteria
Technological innovation capacity	30	VL-L-M-H-VH	Number of patents
market potential	20	VL-L-M-H-VH	growth rate (esp. in economics)
Operational Stability	25	VL-L-M-H-VH	financial ratio
risk control	15	VL-L-M-H-VH	fluctuation
Brand Impact	10	VL-L-M-H-VH	media exposure

Table 7 is a table of indicators and weights for the evaluation of investment opportunities, which provides investors with a framework for assessing potential investment projects. The table lists five key evaluation indicators, each of which is assigned a corresponding weight to reflect its importance in the overall evaluation. The weights are assigned from 0% to 30%, indicating that technological innovation capability is the most important evaluation factor, while brand influence is relatively less important. Affiliation intervals (VL-very low, L-low, M-medium, H-high, VH-very high) were also assigned after each indicator, as well as specific evaluation criteria used to assess the indicator, such as the number of patents used to measure technological innovation capacity.

Table 8: Detailed analysis of starburst's metrics affiliation

Evaluation indicators	VL	L	M	H	VH	Average affiliation
Technological innovation capacity	0	0	0	0.6	0.4	0.5
market potential	0	0	0	0.7	0.3	0.6
Operational Stability	0	0	0.2	0.6	0.2	0.4
risk control	0	0.1	0.3	0.5	0.1	0.35
Brand Impact	0	0	0	0.8	0.2	0.6

Table 8 analyzes in detail the affiliation of Starfleet Technology on each of the evaluation metrics, providing investors with an indication of the company's specific performance on each of the dimensions. For each evaluation metric, Table 2 gives specific values for each of the five affiliation intervals, which indicate the extent to which Starfleet Technology falls within each interval on that metric. By calculating the average affiliation, a composite score can be obtained, which reflects Starfleet's overall performance in terms of technological innovation, market potential, operational stability, risk control, and brand influence. This data helps investors quantify the company's strengths and weaknesses.

Table 9: Comprehensive evaluation vector and weighted affiliation for Starfleet technology

Evaluation results	Affiliation (%)	Weighted affiliation	(Statistics) standard deviation	Z-score
VL	0	0	0	-3
L	0.02	0.006	0.005	-2
M	0.12	0.03	0.02	-1
H	0.52	0.156	0.03	0
VH	0.34	0.102	0.02	1

Table 9 is a comprehensive evaluation vector and weighted affiliation table for Starfleet, which combines the affiliation analysis in Table 2 with the weights in Table 1 to calculate the weighted affiliation, thus providing a quantitative evaluation of Starfleet's overall performance. The table lists the affiliation and weighted affiliation for different evaluation levels (VL to VH). The weighted affiliation takes into account the weights of each evaluation index and therefore better reflects the overall strength of the company. The standard deviation and Z-score provide a statistical analysis of the evaluation results. The standard deviation shows the degree of dispersion of the evaluation distribution, while the Z-score indicates the relative position of each evaluation grade with respect to the average, which helps investors understand the statistical significance of the evaluation results.

Investment decisions should not be based solely on current data and model outputs. Investors and decision makers also need to consider factors such as the future growth potential of a company or project, industry trends, changes in the policy environment, etc., which may involve adjusting and updating models to reflect new market information and investment logic. The effectiveness of investment decision analysis depends to a large extent on the accuracy of the models used and the quality of the data. Continuous collection and analysis of market data, as well as regular review and updating of the evaluation models and indicator systems, are essential to maintain the effectiveness of the decision support system.

4.3 Discussion

In order to assess the contribution and uniqueness of this study, we compare its results with the most recent research in the field (SOTA). In particular, we focus on the relevant literature in the area of fuzzy comprehensive evaluation method applied to investment decisions in digital economy industries. Table 10 summarizes the key differences and innovations:

Table 10: Comparison of results

Characteristics/methodology	this study	SOTA study
Methodological innovations	A multi-level fuzzy evaluation system was introduced to refine the affiliation intervals	Most studies are limited to basic fuzzy evaluations and do not adequately break down the evaluation levels
Deepening statistical analysis	Advanced statistical metrics including standard deviation and Z-score	Conventional studies are limited to the calculation of affiliation and weighted affiliation degrees
Completeness of the indicator system	Covering technological innovation, market potential, operational stability, risk control and brand influence	Many studies lack a comprehensive system of indicators and neglect certain key investment factors
Practical Application Guidance	Detailed implementation steps and case studies are provided for practical operation	Most of the literature focuses on theoretical elaboration and lacks specific operational guidelines
Domain-specific	Specifically targeting the digital economy industry and adapting to its rapid growth and innovative nature	Many research methods are generic and fail to adequately take into account the uniqueness of the digital economy

The innovation of this study is that it improves the precision and applicability of the evaluation by refining the affiliation intervals and introducing a multi-level fuzzy evaluation system, which reflects a deep understanding of the characteristics of investment decision-making in the digital economy industry. The use of statistical indicators reveals the performance stability and relative position of the investment targets on various indicators, which is crucial for investors to identify risks and opportunities. The comprehensive indicator system covers key aspects of investment decisions, avoiding the bias brought by single indicator evaluation and providing a more balanced decision-making perspective. Specific operational guidelines and case studies help decision makers quickly master the fuzzy comprehensive evaluation method, which enhances the practical value of the study. Considering the characteristics of the digital economy industry, the solution of this study is more in line with the actual needs and is expected to promote the scientific and intelligent investment decision-making in this field.

The methods and solutions proposed in this study not only theoretically enrich the application scenarios of the fuzzy comprehensive evaluation method, but also provide concrete and effective guidance for investment decision-making in the digital economy industry in practice. By comparing with the SOTA study, we demonstrate the innovation and practicality of this study, as well as its contribution to promoting the scientific process of investment decision-making in the digital economy.

In summary, this study shows significant superiority in methodological innovation, deepening of statistical analysis, completeness of indicator system, practical application guidance and domain relevance, etc. These innovative points not only fill the gaps of existing research, but also provide a more precise and practical tool for investment decision-making in the digital economy industry.

Through detailed statistical analysis and the application of fuzzy comprehensive evaluation method, this study provides investors and decision makers with in-depth insights into investment decisions in the digital economy industry. Specifically, our case study of Starlight Technology reveals the company’s overall performance in terms of technological innovation, market potential, operational stability, risk control and brand influence. The findings show that Starfleet has a high overall affiliation on the “High” and “Very High” rating scales, demonstrating its strength and investment potential in the digital economy. In view of Starlight’s outstanding performance in key indicators such as technological innovation, market potential, operational stability, risk control and brand influence, investors should consider it as a priority strategic investment target in the digital economy sector. In particular, Starfleet’s excellent performance makes it an attractive option when building a long-term growth and innovation-driven portfolio. However, investors should also be aware that despite Starfleet’s outperformance on most metrics, market volatility and potential risks need to be regularly assessed to ensure the robustness and adaptability of the investment strategy. Given the fast-changing nature of the digital economy industry, continuous monitoring of Starfleet’s market performance and technological innovation dynamics, and timely adjustments to its investment strategy are critical to capitalizing on market opportunities and avoiding risks.

This study provides an in-depth analysis of investment decisions in the digital economy industry by applying the fuzzy comprehensive evaluation method, which provides valuable references for investors and decision makers. The results of the study not only demonstrate the attractiveness of Starfleet as an investment target, but also reveal the potential of the fuzzy comprehensive evaluation method in dealing with complex decision-making problems.

5 Conclusion

In this study, the fuzzy comprehensive evaluation method is used to explore the investment decision-making problems in the digital economy industry, and the potential of the method in dealing with complex investment decisions is revealed by using Starlight Technology as a case study. The findings show that Starlight Technology performs well on key indicators such as technological innovation, market potential, operational stability, risk control and brand influence, especially on the “high” and “very high” evaluation levels, indicating its strong investment attractiveness. Strong investment attractiveness. This finding not only provides investors with specific investment targets, but also emphasizes the importance of adopting a multilevel fuzzy evaluation system in investment decisions in the digital economy. The innovation of this study is that it improves the precision and applicability of the evaluation by refining the affiliation interval and introducing a multi-level fuzzy evaluation system, which reflects a deep understanding of the characteristics of investment decision-making in the digital economy industry. The use of statistical indicators reveals the performance stability and relative position of the investment targets on various indicators, which is crucial for investors to identify risks and opportunities. The comprehensive indicator system covers key aspects of investment decisions, avoiding the bias associated with single-indicator evaluations and providing a more balanced decision-making perspective. Although this study provides in-depth insights and practical guidance, its limitations cannot be ignored. The application of the fuzzy comprehensive evaluation method relies on expert opinions and historical data, which may introduce subjective bias and uncertainty in data quality. In addition, the study focuses on Starburst as a case study, and its results may not be sufficiently comprehensive to reflect the investment status of the entire digital economy industry. To overcome these limitations, future research should aim to improve the accuracy of data collection and analysis and explore more complex and precise fuzzy logic models to enhance the objectivity and accuracy of the evaluation system. At the same time, the universality and representativeness of the research findings can be improved by expanding the research sample and conducting comprehensive evaluations of multiple companies or projects. Constructing a dynamic evaluation mechanism to monitor and adjust evaluation indicators and weights in real time will help decision makers better adapt to the constant changes in the digital economy industry and ensure the foresight and flexibility of investment decisions.

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