Research on the Performance Evaluation System of Local Major Science and Technology Projects from an Intelligence Perspective: Case Analysis Based on Cloud Model

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Abstract

[Purpose] Major local science and technology projects generally embody government will and strategic demands, aiming to resolve "bottleneck" issues in critical technological domains, and are characterized by "heavyweight, large-scale, and specialized" features. Traditional expert assessment and statistical analysis methods can no longer satisfy the new requirements of the current artificial intelligence and big data era. The comprehensive application of multiple evaluation methods, including intelligence analysis and review, peer expert review, etc., to conduct performance evaluation can provide robust support for planning management and decision-making by local science and technology management departments.

[Method] Taking Fujian Provincial Major Science and Technology Special Projects as the evaluation objects, a performance evaluation index system for Fujian Provincial Major Science and Technology Special Projects was constructed across six dimensions: project decision-making, implementation management, goal achievement, technical level, transformation effectiveness, and sustainable impact. Scientific intelligence methods were introduced to achieve integration between intelligence analysis and technology evaluation by supplementing technical intelligence-related indicators in the evaluation index system and incorporating intelligence analysis and review stages in the evaluation process. A comprehensive evaluation model based on the AHP-entropy weight-cloud model was established, and a specific project was employed as a case study to analyze the application value of the aforementioned methods in the performance evaluation process of Fujian Provincial Major Science and Technology Special Projects.

[Results] The results demonstrate that the introduction of the intelligence analysis and review method mitigates the influence of strong subjectivity from evaluation experts, rendering the evaluation results more accurate and objective. The AHP-entropy weight-cloud model evaluation method accommodates the fuzziness and uncertainty of evaluation information, facilitating accurate assessment of performance levels, rapid identification of key influencing factors, and further enhancement of the authenticity and validity of evaluation results.

[Conclusion] The methodology proposed in this paper is applicable to ex-post performance evaluation of major local science and technology projects, and can provide theoretical support and practical guidance for science and technology intelligence institutions or other evaluation agencies conducting technology evaluation.

Full Text

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Abstract

[**Objective**] Local major science and technology projects generally reflect government will and strategic needs, aiming to resolve "bottleneck" problems in key technical fields. Characterized as "important, major, and specialized," traditional expert judgment and statistical analysis methods can no longer meet the new demands of the artificial intelligence and big data era. The comprehensive application of multiple evaluation methods, such as intelligence analysis review and peer expert evaluation, can provide strong support for planning management and decision-making in local science and technology management departments.

[**Method**] Taking Fujian Province' s major science and technology special projects as the evaluation object, this study establishes a performance evaluation index system for these projects across six dimensions: project decision-making, implementation management, goal achievement, technical level, transformation effect, and sustainable impact. The study introduces scientific and technological intelligence methods by supplementing technical intelligence-related indicators in the evaluation index system and adding intelligence analysis review links in the evaluation process to achieve integration between intelligence analysis and S&T evaluation. A comprehensive evaluation model based on AHP-entropy weight-cloud model is constructed, and the application value of the above method in the performance evaluation process of Fujian' s major S&T special projects is verified through a case study of a specific project.

[**Results**] The results demonstrate that introducing intelligence analysis review methods reduces the strong influence of evaluator subjectivity, making evaluation results more accurate and objective. The AHP-entropy weight-cloud model evaluation method accounts for the fuzziness and uncertainty of evaluation information, helping to accurately evaluate performance levels and quickly identify key influencing factors, thereby further enhancing the authenticity and effectiveness of evaluation results.

[**Conclusions**] The method proposed in this paper is applicable to post-performance evaluation of local major science and technology projects and can provide theoretical support and practical guidance for scientific and technological information institutions or other evaluation agencies to conduct S&T evaluations.

Keywords: intelligence analysis review method; AHP-entropy weight-cloud model; Fujian Province major science and technology special projects; post-performance evaluation; index system

1. Introduction

In September 2023, during a symposium on promoting the comprehensive revitalization of Northeast China in the new era, General Secretary Xi Jinping emphasized: "Actively cultivate strategic emerging industries such as new energy, new materials, advanced manufacturing, and electronic information, actively cultivate future industries, accelerate the formation of new productive forces, and enhance new momentum for development" [?]. The 2024 Central Economic Work Conference further stressed "leading the development of new productive forces with scientific and technological innovation and building a modern industrial system," while clarifying the need to "strengthen basic research and key core technology research, and make advanced arrangements for major science and technology projects"[?]. As an important component of the national science and technology plan system, major S&T projects address economic and social development needs by selecting key areas critical to overall and long-term interests for deployment, reflecting national and local government strategic objectives with high visibility [?]. During the 14th Five-Year Plan period, to achieve breakthroughs in "bottleneck" key core technology fields, both national and local governments have continuously increased funding investment and intensified the deployment of major S&T projects in their S&T innovation development plans. Taking Fujian Province as an example, in 2024, the province arranged 30 provincial major S&T special projects and "open competition" projects with funding of 173 million yuan, representing over 70% growth compared to 2020, successfully overcoming a number of key core technologies [?].

To ensure rational and effective allocation and use of fiscal funds, General Secretary Xi Jinping emphasized the need to reform the S&T evaluation system, establish a multi-dimensional evaluation system oriented toward S&T innovation quality, performance, and contribution, and correctly evaluate the scientific, technical, economic, social, and cultural value of S&T innovation achievements [?]. Against this background, the demand for and quality requirements of performance evaluation for major S&T projects have become higher. In the current era of artificial intelligence and big data, with the explosive growth of S&T data resources and the continuous influx of massive noise, traditional "statistical analysis + expert wisdom" S&T evaluation methods can no longer meet the latest demands. Industry technology experts find it difficult to comprehensively understand a particular technical field in a short time, including technology development trends, project technology innovation levels, intellectual property status, and market prospects, thus lacking consideration based on effective S&T intelligence support and suffering from shortcomings such as stronger subjective judgment than objectivity. Meanwhile, the demand for S&T intelligence is no longer limited to information retrieval and novelty evaluation of historical data through S&T novelty search, but increasingly requires multi-dimensional and multi-perspective understanding of the current status and trend prediction of key core technologies, intellectual property infringement risks, and competitor technology dynamics through intelligent intelligence mining methods. Therefore, establishing a scientifically reasonable performance evaluation index system for local major S&T projects within massive S&T data, and comprehensively integrating multiple evaluation methods such as "multi-source heterogeneous data + intelligent intelligence analysis methods and tools + expert wisdom" S&T intelligence analysis review, is of important strategic significance for scientifically judging the performance of major S&T projects and promoting the orderly development of S&T innovation activities.

2. Literature Review

The United States, Germany, Australia, and other countries have conducted extensive exploration and practice in research project performance management and technology assessment, forming relatively complete S&T management performance evaluation systems and technology assessment systems. The U.S. Government Accountability Office (GAO) released the 2021 "NASA Major Project Assessment" report, which, based on cost, schedule, and technology readiness level data analysis, concluded that most NASA projects have high technology readiness levels [?]. Japan has gradually established a systematic technology assessment system and its supporting system, with different evaluation emphases for different project types. For example, the Agency for Medical Research and Development implements graded and classified evaluations for major S&T projects, using a 10-level universal scale to provide a standard measurement for evaluation projects [?]. In terms of evaluation methods, data envelopment analysis and balanced scorecard are very mature. Heejung Cho et al. [?] used factor Kruskal-Wallis test to analyze the impact of Korean national R&D project characteristics (research stage, technology type, and management agency) on project outcomes (patent applications, patent registrations, publications, royalties, and sales). Kuchta D et al. [?] adopted fuzzy network data envelopment analysis to evaluate project effectiveness throughout the entire life cycle. Buse Duygu Dagidir et al. [?] proposed a comprehensive method combining Sustainability Balanced Scorecard (SBSC), Picture Fuzzy Analytic Hierarchy Process (PF-AHP), and Objective Matrix Method (OMAX) to measure enterprise performance.

Domestic scholars' research on major S&T projects mainly focuses on project positioning and management, international experience reference, financial investment management, and performance evaluation management, with evaluation content varying according to different project development stages. Yang Linchao et al. [?], Li Tong et al. [?], and Ren Liping et al. [?] constructed performance evaluation index systems for national S&T major projects, local major technological innovation projects, and key R&D plans from different dimensions, involving evaluation methods such as fuzzy comprehensive evaluation, data envelopment analysis, and factor analysis. Additionally, scholars have conducted research combining intelligence analysis review with S&T evaluation. Yin Yuanyuan et al. [?] constructed an intelligence research technical route based on research foundation, technical scheme, legal risk, and application prospects. Qu Liman [?] and Zhang Yong et al. [?] conducted objective evaluation of S&T achievements through intelligence analysis research methods. Chen Hongmei [?] studied the working mechanism of S&T evaluation based on intelligence analysis. Mo Bing et al. [?] used technology readiness level evaluation method to quantitatively measure and analyze the results of Guangdong' s major S&T special projects.

In summary, there are public reports on the theory and practice of national and local major S&T project performance evaluation both domestically and internationally. Evaluation index systems are designed differently according to project development stages, generally assessing project implementation effects from financial and business indicators, but lacking indicators related to future technology intelligence prediction. Evaluation methods include Analytic Hierarchy Process (AHP), Delphi method, entropy weight method, fuzzy comprehensive evaluation method, and intelligence analysis review. However, single use of these methods in determining index weights or qualitative scoring is susceptible to evaluator subjectivity or objective data fluctuations. Meanwhile, various influencing factors in S&T project performance evaluation are coupled, generating randomness, fuzziness, and uncertainty, leading to certain deviations between evaluation results and actual conditions. According to existing research, AHP-entropy weight method can achieve complementary advantages of subjective and objective weighting, making weight results more reasonable. Academician Li Deyi et al. [?] proposed the cloud model, which organically integrates fuzziness and randomness to achieve mutual conversion between qualitative and quantitative values of uncertain concepts, offering great advantages in dealing with uncertainty problems. It has overcome the randomness and fuzziness of expert evaluation of qualitative indicators and has been applied in risk assessment [?], post-project evaluation [?], sustainability evaluation [?], and other aspects, but rarely reported in S&T project performance evaluation. Combined use with literature evidence-based intelligence analysis review can further improve the authenticity and effectiveness of evaluation results.

Therefore, this paper takes Fujian Province' s major S&T special projects as the research object, constructs a performance evaluation index system for local major S&T projects, introduces S&T intelligence methods to enhance project evaluation quality and credibility by supplementing technical intelligence-related indicators in the evaluation index system and adding intelligence analysis review links in the evaluation process. Using AHP-entropy weight method to calculate project index weights and cloud model to measure project index similarity, a comprehensive evaluation model based on AHP-entropy weight-cloud model is constructed, compensating for the shortcomings of single method weighting and achieving mutual conversion between qualitative concepts and quantitative values. Through evaluation and analysis of a specific project in Fujian Province' s major S&T special projects, the application value of the above method in the performance evaluation process of local major S&T projects is verified, which can provide strong support for S&T management departments to grasp project performance and allocate resources scientifically.

3. Overview of Fujian Province' s Major Science and Technology Special Projects

Since its establishment in 2004, Fujian Province' s major S&T special projects have been implemented for over 20 years, supporting 460 projects in three fields: high-tech and industrial technology, agricultural technology, and social development technology, with cumulative funding of nearly 1.7 billion yuan, successfully overcoming a number of "bottleneck"key core technologies [?]. Taking 2021-2024 as an example, Fujian Province focused on strategic emerging industries such as new generation information technology, new energy, new materials, high-end equipment, and modern agricultural technology, organizing and implementing 91 provincial major S&T special projects with funding of over 600 million yuan. According to incomplete statistics, among the 91 projects, 18 completed projects have published 134 domestic and international papers (91 SCI-indexed, 7 EI-indexed), applied for 137 patents (130 invention patents), obtained 139 patent authorizations (81 invention patents), secured 51 software copyrights, and generated 1.576 billion yuan in new output value, 102 million yuan in new profits, and 53 million yuan in new taxes.

4. Establishing a Performance Evaluation System for Fujian Province' s Major S&T Special Projects Based on Intelligence Analysis Review

Fujian Province' s major S&T special projects are characterized by pioneering, forward-looking, and comprehensive features. Under China' s "break the five-only" evaluation reform background, this paper conducts performance evaluation that not only assesses projects' practical needs, key technology innovation levels, and task completion but also introduces S&T intelligence analysis methods, taking project implementation foresight, intellectual property infringement risks, and development prospect prediction as main evaluation elements. The evaluation process adopts a combination of qualitative and quantitative approaches to deeply mine S&T intelligence, making evaluation results more scientifically reliable.

4.1 Connotation of Intelligence Analysis Review

The intelligence analysis review method described in this paper refers to a method that, based on extensive collection of literature and materials, comprehensively applies various measurement analysis tools and methods such as bibliometrics and intellectual property analysis review to conduct comprehensive and accurate analysis, evaluation, and prediction of big data including S&T literature, planned projects, research results, and S&T patents (such as research foundation, technical scheme, legal risk, and application prospects), and proposes S&T strategies, countermeasures, and measures to provide decision-making basis for relevant management departments and innovation entities, as well as evidence needed by expert groups for performance evaluation [**?**].

4.2 Application Process of Intelligence Analysis Review

Addressing the current issues in Fujian Province' s major S&T special project performance evaluation where S&T intelligence analysis review links are not introduced and the evaluation index system lacks technical intelligence-related indicators, this paper embeds intelligence analysis review into the performance evaluation mechanism for Fujian Province' s major S&T special projects, including index system design and evaluation process optimization, to evaluate project performance more objectively. [Figure 1: see original paper] shows the application process of intelligence analysis review method in the performance evaluation process.

4.3 Construction of Evaluation Index System

According to the Ministry of Finance' s "Project Expenditure Performance Evaluation Management Measures," the performance evaluation index system should comprehensively reflect project decision-making, project and fund management, outputs, and benefits [**?**]. Fujian Province' s major S&T special projects are characterized by large funding amounts, high assessment indicator requirements, high S&T content, and broad social influence. When designing the performance evaluation index system, special attention should be paid to strategic goal completion, breakthrough levels of key core technologies, and talent team construction. Following principles of comprehensiveness, systematicity, and dynamic improvement, and drawing on domestic and international research results and practical experience in S&T project performance evaluation, this paper uses intelligence analysis review methods to design a performance evaluation index system for Fujian Province' s major S&T special projects from six dimensions: project decision-making, implementation management, goal achievement, technical level, transformation effect, and sustainable impact, from the perspective of new productive forces, as shown in [Figure 2: see original paper].

4.4 Indicator Explanation and Application of Intelligence Analysis Review Method

(1) Project Decision-Making

This dimension assesses the consistency between project objectives/content and national/local S&T development strategies, major S&T needs, or key technical problems, judges whether they have certain foresight, and evaluates whether the research team has the capability to implement the project. Therefore, project decision-making includes three indicators: policy consistency, goal foresight, and research team foundation. The method of domestic and international patent application trend analysis is used to evaluate whether the project belongs to domestic and international technology hotspots; policy text research method analyzes the consistency between R&D objectives/positioning and Fujian' s relevant policies and industrial development plans; bibliometric method analyzes the paper publication and patent application status of the project leader and team in the technical field to judge the team' s research strength, avoiding unfair project evaluation phenomena caused by "celebrity effects."

(2) Implementation Management

Implementation management indicators reflect business management capabilities and financial management levels during project implementation, embodying efficiency. This includes fund use compliance, resource allocation efficiency, and organizational management efficiency. Fund use compliance assesses whether fund use complies with financial regulations and is executed according to budget; resource allocation efficiency assesses fund availability, social capital investment drive, and cooperation agreement signing to evaluate communication levels between project undertaking units and cooperative units; organizational management efficiency reflects human, financial, and material guarantees, assessing whether the project completes mid-term evaluation on schedule according to relevant management measures and evaluating inter-unit cooperation agreement implementation and achievement intellectual property rights distribution. These indicators are qualitatively judged by experts through cooperation agreements, financial supporting materials, and other documents provided by project units.

(3) Goal Achievement

This examines whether project objectives can reflect the 3E principle, including research work completion rate and assessment indicator completion rate, to assess whether all research content and assessment indicators specified in the task book are completed. These indicators collect relevant data through materials provided by project units (such as third-party test reports) to provide basis for expert evaluation, fully considering project goal dynamics and implementation process uncertainties.

(4) Technical Level
This evaluates the novelty and independent innovation degree of project core key technologies. This paper assesses project technical level from four aspects: key technology innovation degree, core technology advancement level, paper publication and citation, and independent intellectual property rights and infringement risks. Previously, technology innovation evaluation was generally judged by technical experts based on S&T novelty search reports, but experts sometimes cannot master all achievements in the technical field at home and abroad. From the perspective of intelligence analysis review, this paper analyzes and judges technology innovation based on global industry development trends and research results for technical experts' reference, making evaluation results more objective. For novelty judgment, S&T novelty search methods assist expert evaluation; for advancement evaluation, intelligence analysis review compares project performance indicators and functions with similar domestic and foreign products/technologies to judge the technology' s level at home and abroad. For paper citation evaluation, intelligence analysis review evaluates papers from perspectives such as journal impact factor (in the publication year), inclusion status (three major index journals), and citation frequency, which is more objective than technical experts' subjective judgment of paper quality alone. For independent intellectual property rights and infringement risks, patent evaluation is generally the main approach, analyzing technology maturity from patent citation volume and impact volume, and conducting patent infringement risk analysis to avoid falling into infringement traps.

(5) Transformation Results
This evaluates the transformation and application of project key achievements and their generated social and economic value, including application effects and industrialization prospects. Application effects refer to actual transformation and application, including new products, processes, and technologies, as well as output value and profits, collecting relevant data through materials provided by project units. Industrialization prospects mainly judge whether the obtained key technologies conform to current technology development trends and have market prospects, evaluated through technology life cycle and technology theme analysis.

(6) Sustainable Impact
This evaluates the indirect effects generated by project R&D activities and achievements, including three indicators: supporting and leading industry development role, team and talent cultivation, and platform construction, reflecting effectiveness. These indicators collect relevant data through materials provided by project units, with the supporting and leading industry development role indicator evaluated through case analysis and patent prediction methods.

5.1 Determining Indicator Weights Using AHP-Entropy Weight Method

The AHP method belongs to subjective weighting methods and is a hierarchical analysis method commonly used to solve complex problems, combining qualitative and quantitative approaches with strong logic and practicality. The entropy weight method is an objective weighting method that determines indicator weights based on the amount of information contained in indicators, offering higher credibility and accuracy than subjective weighting methods [?]. This paper uses AHP and entropy weight methods for combined weighting, considering both experts' professional backgrounds and capabilities and objective information data to ensure the accuracy and rationality of performance evaluation results for Fujian Province' s major S&T special projects.

Where the initial weight determined by AHP method is α_j (j=1,2,3······m), the comprehensive weight is ω_j (j=1,2,3······m), and the weight calculated by entropy method is β_j, all computed using the SPSSAU data science analysis platform [?].

5.2 Constructing Project Performance Evaluation Cloud Model

Chinese scholar Li Deyi [?] proposed a new uncertainty reasoning theory—the cloud model. This model uses cloud drops and three numerical characteristics (expectation Ex, entropy En, and hyper-entropy He) to quantitatively describe an uncertain concept, achieving uncertain transformation between qualitative concepts and quantitative values, and better revealing the fuzziness and randomness of evaluation objects. Cloud drop C=(Ex, En, He) is the specific manifestation of qualitative concepts in quantitative space. The three numerical characteristics are shown in . Applying the cloud model to local major S&T project performance evaluation has advantages. First, Fujian Province' s major S&T special project performance evaluation involves a wide range and requires consideration of many factors, and the robust cloud model can comprehensively evaluate and analyze project performance from multiple angles. Second, project performance evaluation grades are qualitative (such as "excellent" and "good"), generally divided by numerical ranges, with certain fuzziness between different evaluation grades. The cloud model achieves mutual conversion between qualitative concepts and quantitative data, reducing differences. Third, some project performance assessment indicators are qualitative, and scoring results are susceptible to expert subjectivity. The cloud model effectively improves their randomness.

Table 1. Numerical Characteristics of Cloud Model

Numerical Characteristic	C=(Ex, En, He)	Description
Expectation Ex	Represents the quantitative value of qualitative concepts, the center of cloud drop distribution in quantitative space	
Entropy En	Measures the uncertainty degree of qualitative concepts, reflecting fuzziness and randomness. Larger entropy means more blurred concept boundaries and wider quantitative distribution range	
Hyper-entropy He	Measures the uncertainty of entropy, reflecting the dispersion degree of entropy, determining the fluctuation range of membership degree. Larger hyper-entropy means more intense fluctuation	

(1) Determining Standard Evaluation Cloud

Based on the constructed evaluation index system, establish evaluation index set U and each evaluation indicator comment set V. Divide V into grades according to evaluation standards, with grade upper and lower limits Vmax and Vmin respectively. Each comment set evaluation grade is transformed into quantitative numerical characteristic values (Ex, En, He) by formula (1).

$$Ex = \frac{V_{\max} + V_{\min}}{2} \tag{1}$$

$$En = \frac{V_{\max} - V_{\min}}{6} \tag{2}$$

$$He = k \tag{3}$$

Where k is a constant adjusted according to variable fuzzy threshold [?], generally valued at 0.1. According to the performance assessment requirements of major S&T special projects, this paper takes comment set V interval as [0,100] and divides it into five comment sets: excellent, good, medium, pass, and fail. The cloud model characteristic values calculated by formula (1) are shown in .

Table 2. Comprehensive Evaluation Cloud Model Grade Division

Grade	Score Interval	C=(Ex, En, He)
Excellent	[90, 100]	(95, 1.667, 0.1)
Good	[80, 90)	(85, 1.667, 0.1)
Medium	[70, 80)	(75, 1.667, 0.1)
Pass	[60, 70)	(65, 1.667, 0.1)
Fail	[0, 60)	(30, 10, 0.1)

(2) Determining Evaluation Cloud Parameters and Comprehensive Cloud

Invite evaluation experts to score the project, and calculate secondary indicator evaluation cloud parameters using formulas (2)~(5). The evaluation cloud for the j-th indicator is Cj(Exj, Enj, Hej).

Sample mean:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Sample variance:

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

Cloud drop entropy:

$$En_j = \sqrt{\frac{\pi}{2}} \times \frac{1}{n}\sum_{i=1}^{n}|x_i - Ex_j|$$

Cloud drop hyper-entropy:

$$He_j = \sqrt{S^2 - En_j^2}$$

Where n is the number of evaluation experts, xi is the scoring result of evaluation experts, and j=(1,2,3······,17).

Combine with combined weight ω_j to obtain primary indicator evaluation cloud parameters. Calculate primary indicator evaluation cloud parameters, and calculate the overall evaluation cloud using the same method.

$$Ex = \sum_{j=1}^{m} \omega_j \times Ex_j$$

Where m is the number of indicators.

(3) Determining Evaluation Grade
Referring to Li Zhenqiang et al. [?], similarity degree is used to determine performance evaluation grade, with calculation formula as follows:

$$\psi = 1 - \frac{|EX - EX'|}{\sqrt{(En^2 + He^2)}}$$

Where EX is the expectation of standard evaluation cloud, and EX' is the expectation of a certain indicator evaluation cloud. The performance grade indicated by the standard evaluation cloud corresponding to max is the performance evaluation grade of that indicator.

6. Case Analysis

6.1 Sample Selection

To verify the feasibility of applying intelligence analysis review and AHP-entropy weight-cloud model in the performance evaluation of Fujian Province' s major S&T special projects, this paper takes a provincial major S&T special project undertaken by a certain project undertaking unit as an example. Combining the above evaluation index system and indicator combined weighting, and based on intelligence analysis review and peer expert review method, the AHP-entropy weight-cloud model is applied to conduct performance evaluation of the project. The project was approved in 2015 with a total investment of 6 million yuan, including 3 million yuan in fiscal S&T funds. During the implementation period, it applied for 3 invention patents and made important breakthroughs in common transformative technology research of high-performance environmentally friendly wood polyurethane adhesives, development of a series of environmentally friendly wood polyurethane adhesive products, and establishment and operation of single-batch 8-ton-scale industrial reactor production equipment.

6.2 Data Sources and Analysis Tools

This evaluation was conducted on the basis of acceptance work. Original data for each indicator mainly came from the Fujian Province S&T Plan Project Management System, with relevant indicators referencing data from project acceptance forms, mid-term performance assessment work reports, S&T reports, and other related materials. Quantitative indicators directly calculated indicator scores; for qualitative indicators, indicator scores were comprehensively determined based on intelligence analysis review reports, combined with actual project conditions and expert scoring.

This paper uses two types of data as the basis for intelligence analysis review: patent literature and non-patent literature. For patent literature, the Wisdom Bud patent database was selected as the data source, with patent application retrieval time in March 2023. Since patent application documents typically require 18 months from application to publication, and patent databases have certain time lags, patent application data from the past two years may be incomplete, potentially affecting analysis results. Analysis tools selected Wisdom Bud patent analysis system and SPSSAU data science analysis platform for further data processing and visualization. Scientific paper data mainly came from WOS Core Collection database, CNKI, and Wanfang database. Fujian Province' s major S&T special projects focus on strategic goal completion, key core technology breakthroughs, and talent team cultivation. This project did not publish papers or build R&D platforms during implementation. Based on actual project conditions, this paper further streamlined indicators by removing the above two indicators, focusing weights on other core indicators at the same level to make evaluation results more objective and operable.

6.3 Indicator System and Combined Weighting

By scoring the importance of each indicator and calculating based on objective original data and SPSSAU data science analysis platform, the AHP weight values α_j and entropy weight method weight values β_j for each indicator were obtained. The comprehensive weight ω_j was calculated by combining the weights from AHP and entropy weight methods, as shown in .

Table 3. Secondary Indicator Weights and Cloud Numerical Characteristics

Indicator	AHP Weight α_j	Entropy Weight β_j	Combined Weight ω_j	Cloud Numerical Characteristics (EX, EN, HE)
Policy Consistency A1				(92.2, 1.805, 0.66)
Goal Foresight A2				(89.2, 1.805, 0.66)
Research Foundation A3				(89.2, 1.705, 0.45)

Indicator	AHP Weight α_j	Entropy Weight β_j	Combined Weight ω_j	Cloud Numerical Characteristics (EX, EN, HE)
Fund Use Compliance B1				(86.4, 2.106, 0.36)
Resource Allocation Efficiency B2				(92.4, 2.106, 0.36)
Organizational Management Efficiency B3				(92.4, 2.106, 0.36)
Research Work Completion Rate C1				(97.6, 2.106, 0.36)
Assessment Indicator Achievement Rate C2				(98.6, 1.604, 0.48)
Key Achievement Innovation D1				(79.8, 2.306, 0.79)

Indicator	AHP Weight α_j	Entropy Weight β_j	Combined Weight ω_j	Cloud Numerical Characteristics (EX, EN, HE)
Core Technology Advancement D2				(83.0, 2.005, 0.15)
Independent Intellectual Property and Infringement Risk D3				(91.8, 1.303, 0.71)
Achievement Application Effect E1				(89.4, 1.905, 0.41)
Industrialization Prospect E2				(82.2, 1.804, 0.66)
Supporting and Leading Industry Development Role F1				(81.6, 1.604, 0.48)

Indicator	AHP Weight α_j	Entropy Weight β_j	Combined Weight ω_j	Cloud Numerical Characteristics (EX, EN, HE)
Team and Talent Cultivation F2				(88.6, 1.404, 0.57)

6.4 Intelligence Analysis Review

(1) Project Decision-Making Analysis

For policy consistency, the "Fujian Province 12th Five-Year Science and Technology Development Special Plan" clearly proposed to vigorously cultivate and develop seven strategic emerging industries including new generation information technology, bio and new medicine, new materials, new energy, energy conservation and environmental protection, high-end equipment manufacturing, and marine high-tech industries, focusing on implementing a number of major S&T projects to collectively overcome a batch of industrial core technologies [**?**, **?**]. This project received provincial major S&T special funding in 2015, and its research object, wood polyurethane adhesive, is considered one of the most environmentally friendly adhesives due to its zero formaldehyde release. Therefore, the project belongs to the energy conservation and environmental protection field and is consistent with Fujian' s S&T innovation development policies.

For goal foresight, foreign wood polyurethane adhesive industry R&D started earlier, showing a fluctuating upward trend overall, declining year by year since 2016, as shown in [Figure 3: see original paper]. Domestic wood polyurethane adhesive field R&D started later than abroad, with annual patent applications only in single digits before 2001. With the implementation of the "Natural Forest Resource Protection Project" in 2000 and increasing human environmental awareness, wood polyurethane adhesive-related patent applications and authorizations experienced a stable development stage from 2001 to 2007, then welcomed a small peak starting in 2008, with rapid growth in related patent numbers, reaching a peak in 2016 before declining. Additionally, due to the 18-month publication period for patent applications, patent data for 2021 and 2022 are incomplete. This project was approved in 2015, right in the high-speed development stage of wood polyurethane adhesive technology R&D. Therefore, using the patent number trend method, the wood polyurethane adhesive studied in this project has certain foresight and belongs to domestic and international research hotspots.

For research foundation, literature research shows that the project R&D team has certain research strength in this technical field, as shown in . The project leader is an academician of the Chinese Academy of Sciences and The World Academy of Sciences, who has been dedicated to nanomaterials research for many years and won multiple national awards. In terms of paper publication, the project R&D team had certain research foundation before project initiation, publishing 2 papers related to project research content, including nanomaterial-modified polyurethane technology and waterborne polyurethane adhesive technology. In terms of S&T achievements, there were also 2 disclosed polyurethane adhesives. For intellectual property rights, the R&D team had applied for 2 Chinese invention patents in this technical field before project initiation, but their legal status is currently "no right - rejected," indicating average patent quality. For team building, the project undertaking unit and cooperative units had cooperation foundation, having established complete process technology for industrial-scale production of shoe polyurethane adhesives, and jointly undertook Fujian Province' s Innovation Fund project "Waterborne Polyurethane Adhesive for Shoes" (2012C0009) and provincial S&T plan key project "Development and Application of Waterborne Polyurethane Adhesive for Shoes" (2007) and other projects.

(2) Technical Level Analysis

For key achievement novelty, after retrieval, both domestic and foreign literature have reported improving polyurethane adhesive performance by adding nano-silica particles and synthesizing polyurethane adhesives by adding silane-modified nano-silica particles. The project's proposal to synthesize single-component polyurethane adhesives suitable for rosewood, red sandalwood, chicken-wing wood, rosewood, and ebony by adding silane-modified nano-silica particles has only been reported in patents by the project undertaking unit and Ruian Zhizao Technology Co., Ltd., but the project R&D team' s patent literature (2014) is earlier than Ruian Zhizao Technology Co., Ltd. (2016). Closely related literature is shown in . In summary, through S&T novelty search analysis, some content of the project' s key core technology has novelty.

For core technology advancement, regarding technical indicators, S&T novelty search analysis shows that the performance indicators of the wood single-component polyurethane adhesive prepared by the project undertaking unit have reached domestic advanced levels. The developed wood polyurethane adhesive has a shear strength $ $10 MPa, higher than Tianjin Tianda Tianhai New Materials Co., Ltd. (8.95 MPa) and comparable to Japanese Taoka Chemical Co., Ltd.' s product technical indicators (11.5 MPa), as shown in . Regarding production indicators, after retrieval, Tianjin Tianda Tianhai New Materials Co., Ltd. conducted industrialization research on single-component environmentally friendly wood polyurethane adhesives, with its single-component rosewood polyurethane adhesive products already on the market with annual production capacity of over 2,000 tons. This project has also built single-batch 8-ton-scale industrial reactor production equipment, forming complete process technology for ton-level polyurethane adhesives, providing key production technology for annual production of 10,000 tons of wood polyurethane adhesives.

For independent intellectual property rights and infringement risks, the project applied for 6 invention patents, of which 2 were authorized and 4 were rejected (no right), with an invention patent authorization rate of 33%. The completed products are currently only implemented domestically, not involving exports. After retrieval, there are already many patents on wood polyurethane adhesives in China, closely related to the project' s core technology, such as Ren Xinnian of Ruian Zhizao Technology Co., Ltd.' s "An Environmentally Friendly and Non-toxic Single-component Polyurethane Adhesive for Wood and Its Preparation Method" (application number CN201610553517.2, application date 20160714). Through comparative analysis, the project' s "synthesizing single-component polyurethane adhesives suitable for rosewood, red sandalwood, chicken-wing wood, rosewood, and ebony by adding silane-modified nano-silica particles" is similar to the wood single-component polyurethane adhesive disclosed in closely related patent literature CN201610553517.2, but with superior technical performance indicators (tensile shear strength \$ \$1.76 MPa). Through patent legal status retrieval, the former patent (CN202111601535.0) has been authorized, while the latter patent is in "no right - rejected" status. Therefore, some of the project' s core technologies have novelty and have obtained patent protection. For technology maturity analysis, the project' s 2 authorized patents cited patents 18 times, including 15 Chinese patents, 1 Japanese patent, and 2 US patents, with 0 patent citations and 2 non-patent literature citations.

(3) Industrialization Prospect Analysis

From the perspective of the global wood polyurethane adhesive-related patent technology life cycle, wood polyurethane adhesive technology has gradually matured, as shown in [Figure 4: see original paper]. Before 1994, both application volume and applicants were less than 100, representing the technology germination stage. Starting in 1994, application volume grew rapidly with large numbers of applicants entering the field. In 2016, both applicants and application volume reached their peak, with global patent applications and authorizations of 417 and 252 respectively, showing rapid growth trends. After 2016, application volume slowly declined with relatively stable applicants, and R&D forces no longer invested heavily, indicating that wood polyurethane adhesive technology entered the technology maturity stage. Therefore, in 2015, the wood polyurethane adhesive technology studied in this project was in the high-speed development period with promising industrialization development prospects.

Patent technology source countries reflect each country' s overall technical R&D strength and technological innovation capability in wood polyurethane adhesives to a certain extent. From the distribution of global patent technology source countries for wood polyurethane adhesives, China, the United States, and Germany are the main patent technology source countries for wood polyurethane adhesives, with these three countries being the most active regions for innovation in this field, as shown in [Figure 5: see original paper]. China is currently the world' s largest patent technology source country for wood polyurethane adhesives, with 33.68% of patent technologies filed by Chinese applicants. Germany has global adhesive giants such as Henkel AG & Co. KGaA and Bayer

MaterialScience AG, which have applied for 14.28% of global wood polyurethane adhesive invention patents. As one of the world' s most technologically advanced countries, the United States has applied for 14.15% of global wood polyurethane adhesive invention patents. From the perspective of target market layout, 17 countries have applied for wood polyurethane adhesive-related patents in China, with foreign applications accounting for 10.0%, among which Germany, the United States, and Switzerland have the most patents. Domestic valid patents are mainly distributed in Guangdong, Jiangsu, Shanghai, Shandong, Zhejiang, and other provinces and cities, with Guangdong and Jiangsu having strong patent technology R&D strength, and Fujian ranking sixth with certain development space.

From the perspective of technical field analysis, the technical classification of wood polyurethane adhesives mainly focuses on C08G18 (polymerization products of isocyanates or isothiocyanates), C09J175 (adhesives based on polyureas or polyurethanes; adhesives based on derivatives of such polymers), and C09D175 (coating compositions based on polyureas or polyurethanes; coating compositions based on derivatives of such polymers), accounting for 25.40%, 17.61%, and 13.72% respectively, as shown in [Figure 6: see original paper]. The wood polyurethane adhesive studied in this project has become the mainstream direction of current technology R&D.

For the main IPC classification C09J of polyurethane adhesives, the high-end market is controlled by enterprises such as Henkel AG & Co. KGaA, Swiss SIKA, and BASF SE, as shown in [Figure 7: see original paper].

According to literature research, most furniture factories in China currently use domestically produced polyurethane adhesives. Companies such as Shanghai Xinguang Chemical Co., Ltd., Tianjin Tianda Tianhai New Materials Co., Ltd., and Guangdong Rongneng Co., Ltd. have the capability to R&D and produce wood polyurethane adhesives, while a small number of manufacturers use Japanese Koyo waterborne polymer-isocyanate adhesives, which are expensive. As a major furniture production base, Fujian Province has over 2,000 high-end furniture production enterprises in Putian alone, with annual demand for wood adhesives exceeding thousands of tons. Therefore, the project's polyurethane adhesive products can provide high-performance, environmentally friendly wood polyurethane adhesives for local furniture production enterprises, completely replacing other domestic wood polyurethane adhesive products and basically replacing relevant imported foreign products, which is of great significance for the development of Fujian' s strategic emerging industries.

(4) Intelligence Analysis Review Results

For project decision-making, using domestic and international patent application trend analysis, the project was initiated in 2015, and the wood polyurethane adhesive studied was in the high-speed development stage of technology R&D, belonging to domestic and international research hotspots with certain foresight. Combined with literature research method, the R&D objectives are consistent with Fujian' s relevant policies. Through bibliometric method analysis, the project R&D team has certain research strength in this technical field. For technical level, through S&T novelty search analysis, some content of the project' s key core technology has novelty, and product performance indicators have reached domestic advanced levels. Patent analysis review shows that the project has obtained authorization for 2 invention patents with intellectual property protection, while the legal status of closely related patent literature is "no right - rejected." For technology maturity analysis, the project' s 2 authorized patents cited patents 18 times, including 15 Chinese patents, 1 Japanese patent, and 2 US patents, with 0 patent citations and 2 non-patent literature citations. For transformation effect (industrialization prospect), technology life cycle analysis shows that the wood polyurethane adhesive studied in this project is in the high-speed development period with promising future development prospects. Combined with technical theme field analysis, it has become the mainstream direction of current technology R&D. Analysis of patent application source countries shows that China, Germany, and the United States rank top three in wood polyurethane adhesive technology innovation activity, but in C09J, the high-end market is controlled by German Henkel, BASF, Bayer, and Swiss SIKA. Through literature research, the project implementation has large-scale application prospects, can fill the gap in Fujian' s wood polyurethane adhesive production, and has good industrialization prospects.

6.5 Performance Evaluation of Provincial Major S&T Special Projects Based on AHP-Entropy Weight-Cloud Model

(1) Determining Secondary Indicator Cloud Numerical Characteristics and Primary Indicator Evaluation Cloud

Experts were invited to score the project based on the intelligence analysis review report. Secondary indicator cloud numerical characteristics were calculated using formulas (2)~(5), as shown in . Primary indicator cloud numerical characteristics were then calculated using formula (6), with results shown in . Similarly, the project' s comprehensive evaluation cloud was obtained as (87.7, 1.932, 0.52).

Table 7. Primary Indicator Cloud Numerical Characteristics

Primary Indicator	Cloud Numerical Characteristics (EX, EN, HE)
Project Decision-Making	(90.2, 1.782, 0.62)
Implementation Management	(88.8, 2.106, 0.36)
Goal Achievement	(98.0, 1.964, 0.40)
Technical Level	(82.9, 2.133, 0.55)
Transformation Results	(85.6, 1.848, 0.56)
Sustainable Impact	(85.9, 1.460, 0.55)
Comprehensive Evaluation	(87.7, 1.932, 0.52)

(2) Calculating Similarity and Membership Degree to Determine Per-

formance Evaluation Grade
Based on formula (7), the similarity degrees of primary indicators and the overall project were calculated, with results shown in . According to the maximum membership degree principle, the project' s project decision-making and goal achievement are rated as excellent, while implementation management, technical level, transformation results, and sustainable impact are rated as good, with the overall project evaluation grade being good.

Table 8. Similarity Degrees Under Different Evaluation Grades

Primary Indicator/Overall	Similarity Degree Grades	Under Different Evaluation
Project Decision-Making		
Implementation Management		
Goal Achievement		
Technical Level		
Transformation Results		
Sustainable Impact		
Overall		

(3) Evaluation Result Analysis
Based on scoring against each indicator evaluation standard, the project' s performance evaluation using AHP-entropy weight-cloud model yielded a comprehensive score of 87.7 points, with a good evaluation grade, basically consistent with actual project conditions. Based on the combined weights from expert opinions and objective project data, indicators such as achievement application effect and industrialization prospect have the most significant impact on project performance and require focused attention. Meanwhile, based on , the key achievement innovation indicator scored the lowest, requiring strengthened scientific and technological innovation in the future. The performance evaluation grades corresponding to max for primary indicators show that the project' s implementation management, technical level, transformation results, and sustainable impact are rated as good. It is recommended to further strengthen project management: first, strengthen technological innovation for key indicators such as key achievement innovation, core technology advancement, and achievement application effect to improve the level of technology transformation and industrialization; second, build high-level innovation platforms, cultivate talent resources, and promote sustainable industrial development.

7. Conclusions and Implications

7.1 Research Conclusions

As an important driver for developing new productive forces, performance evaluation of local major S&T projects is of great significance. Addressing the current issue of strong evaluator subjectivity leading to insufficient credibility of evaluation results, this paper takes Fujian Province' s major S&T special projects as the research object, adopts "multi-source heterogeneous data + intelligent intelligence analysis methods and tools + expert wisdom" S&T intelligence analysis review, combines it with AHP-entropy weight-cloud model evaluation method for project performance evaluation, and selects a specific project for case verification. The results show that the comprehensive use of S&T intelligence analysis review and AHP-entropy weight-cloud model evaluation method can account for the fuzziness and uncertainty of evaluation information, significantly improving evaluation result credibility, and is suitable for post-performance evaluation of local major S&T projects. Specific implementation steps are as follows:

First, construct an evaluation index system based on intelligence analysis review. The intelligence analysis review method, which mines key information from multiple dimensions and perspectives (including current status and trend prediction of core technologies, intellectual property infringement risks, and competitor technology dynamics), serves as a powerful supplement to peer expert review, injecting intelligence characteristics into S&T evaluation and enhancing its scientificity and professionalism.

Second, adopt AHP-entropy weight method for combined weighting. By using entropy weight method (based on objective data information) to correct AHP method (subjective bias), both subjective and objective factors are considered, making weight distribution more reasonable and further improving the scientificity and rationality of weight assignment.

Finally, introduce cloud model for post-project performance evaluation. By solving similarity degree through cloud model, the project performance evaluation grade can be clarified, and the grades of each criterion layer and indicator can be clearly reflected, quickly identifying key influencing factors. This model accounts for the fuzziness and uncertainty of evaluation information, achieving mutual conversion between qualitative concepts and quantitative values. Case results demonstrate the rationality of this model, and its combination with intelligence analysis review can provide a new practical path for S&T intelligence institutions to conduct local major S&T project performance evaluation.

7.2 Practical Implications

With the arrival of the artificial intelligence and big data era, the comprehensive application of intelligence analysis review method as a three-dimensional, multi-angle technology assessment method and cloud model and other evaluation methods in S&T project performance evaluation has become a trend for multi-angle evaluation and objective demonstration of technology innovation. The application of this method in Fujian Province' s major S&T special project performance evaluation has achieved good results and gained recognition from industry experts. The research results have been adopted by S&T management departments and are planned to be promoted and applied in S&T achievement evaluation practice.

S&T intelligence institutions have advantages over other evaluation institutions in S&T literature information resources and data reserves, professional analysis capabilities, technical tools, and digital capabilities, and can provide professional support of "comprehensive data, in-depth analysis, and objective results" for S&T evaluation work, making government decision-making more scientific and accurate. To further leverage the advantages of S&T intelligence as "pioneer, eyes and ears, and advisor," this paper proposes the following suggestions on how S&T intelligence institutions can effectively and efficiently support S&T evaluation work. First, establish an S&T evaluation information platform to dynamically preserve evaluation process data, promote intelligent development of S&T evaluation analysis based on big data model analysis and calculation. Second, increase investment in S&T evaluation analysis tools, using databases such as Wanfang, VIP, WOS Core Collection, and Wisdom Bud patent database, as well as analysis tools such as CiteSpace analysis software, Wisdom Bud patent analysis system, and SPSSAU data science analysis platform for multi-dimensional analysis and mining of data, providing strong technical support for S&T evaluation. Third, further strengthen cooperation with universities, fully utilize their theoretical advantages, accelerate the formation of "intelligence + S&T evaluation" service specifications and standards, and further improve the overall professional level of S&T evaluation. Fourth, give full play to the role of evaluation experts, leveraging their professional accumulation, industry insight, and practical experience to enhance the authority and decision-making value of S&T evaluation.

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