Evaluation of Power Grid Enterprises' Digital Projects Investment Effect Based on AHP-Entropy and SVM Method

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Abstract. In order to accurately evaluate the digital project of power grid enterprises, and the characteristics of existing research, a new combined evaluation model organically combines hierarchical analysis, entropy, radar map and support vector machine. First combine the empowerment, then integrate the decision information, then form the expert decision model, and finally build the corresponding evaluation model. It verifies the rationality and feasibility of the proposed model, shows that digital projects have played an important role in the sustainable and healthy development of power grid enterprises, and provides a certain reference value for the investment decision-making of power grid digital projects.

Keywords: Enterprise Digitization · Portfolio Evaluation · Analytic Hierarchy Process · Support Vector Machine

1 Introduction

As the wave of digitization sweeps across the world, digital transformation has increasingly become a focus area and a hot topic. Digital transformation is not only the application of digital technology, but also creates new digital application scenarios, bringing all-round changes to enterprises. Therefore, under the new situation, power grid enterprises need to create favorable conditions for digital transformation, pay attention to the benefits of digital transformation, actively cultivate digital culture under the guidance of the overall strategic system, promote the digital transformation of power grid enterprises, and promote innovation and development. How to scientifically and rationally make decisions on power grid investment and improve the accuracy of project arrangement is crucial to the sustainable development of enterprises [1].

Shao Chunfu believes that Analytic Hierarchy Process (AHP) can be applied to muti-objective comprehensive analysis and theoretical evaluation methods of network systems [2]. Based on support vector machine (SVM), Liu Liyuan proposed a fault diagnosis method which improved AHP combined with DS evidence theory, but increased its computational complexity [3]. SVM can obtain good classification and recognition

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ability in a small number of training samples. If SVM is combined with particle swarm algorithm, it can effectively improve the recognition accuracy of SVM [4]. Meng Qinglan comprehensively used the advantages of AHP and SVM to propose a digital library service quality evaluation method based on AHP-SVM [5]. However, there are still gaps in the study of economic benefits in the field of digitization projects.

To sum up, this paper proposes a combined evaluation model according to the characteristics of the investment evaluation of the digital projects of the State Grid, mainly organically combines the four methods of AHP, SVM, Entropy and Radar Chart, and then evaluates the project. The model can use fewer samples to evaluate digital projects in terms of economic benefits based on the knowledge and experience of experts, which improves the timeliness and quality of multiple evaluations, in addition, the method of combined weights takes into account the local differences between the subjective experience of experts and the index values, and reflects the actual situation more comprehensively. Radar map integration is also introduced, which is less affected by noise and more intuitive than the commonly used linear weighting operator.

2 Index System of Investment Benefit Portfolio Evaluation Model of Power Grid Digital Projects

The digital multi-application scenario of the power grid enterprises is mainly divided into four main scenarios: the power grid production scene, the enterprise operation scene, the customer service scene and the emerging business scene. The power grid production scenarios are subdivided into five sub-scenarios: transmission digitization, substation digitization, distribution digitization, dispatching operation digitization, and load forecasting; the business operation scenarios of the enterprise are subdivided into six sub-scenarios: material resource management, human resource management, financial resource management, information resource management, corporate culture construction and brand marketing; the customer service scenarios are divided into four sub-scenarios: customer portrait, sales management, online customer experience and customer feedback; emerging business scenarios are divided into six sub-scenarios: new energy storage business, virtual power plant business, digital twin business, financial service business, credit reporting business and agency power purchase business.

For different business scenarios, establish the corresponding index system to analyze and evaluate the economy, efficiency, efficiency and fairness of the project. It mainly follows the principle of correlation principle, importance principle, comparability principle and systematic principle, and has established five first-level indicators, and set up a corresponding total of 17 secondary indicators, as shown in Fig. 1. Refer to the previous similar items, 1–10 points, with an average of 5 points, the higher the score, the better the effect; otherwise, the worse the effect.

2.1 Economic Benefits

To evaluate the success of a project, economic benefit is also a very important evaluation index. The evaluation of digitization projects should also be based on the digitization of

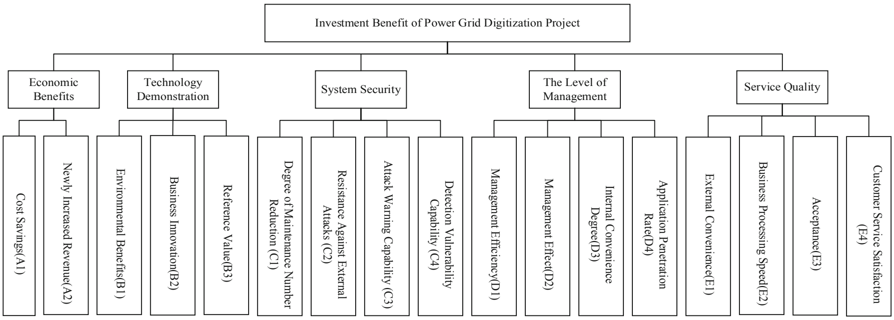

Fig. 1. Invest benefit evaluation index system

benefits. This paper mainly evaluates the economic benefits of digitization projects in terms of cost savings and income newly increased.

1) Cost Savings (A1)
Reflect the benefits before and after the implementation of the digitization project. Determine whether to reduce the costs and costs, and include the actual reduced cost investment into its economic benefits.

2) Newly Increased Revenue (A2)
Reflect the benefits of projects before and after the implementation of digital projects, and judge whether the digital projects can increase their profits by increasing the corresponding income.

2.2 Technology Demonstration

Technology demonstration means that the power grid drives the development of upstream and downstream industries through digital transformation, and has played an important role in demonstrating and guiding other industries. Therefore, this indicator is based on technological innovation, and evaluates the technology demonstration of power grid digitization projects from the perspective of environment, innovation and reference value to other enterprises.

1) Environmental Benefits (B1)
Show the ability of digital to improve environmental protection, and promote the continuous progress of enterprises and society, sustainable economic development, and the increasing improvement of the environment.

2) Business Innovation (B2)
It refers to the creative activities of the enterprise through the development of products in the establishment of market needs and technological changes corresponding to the market economy to realize the sustainable development of the enterprise.

3) Reference Value (B3)
It reflects the innovation ability of digital projects, and focuses on the reference and

demonstration role and driving role played by digital projects for the digitization of other enterprises.

2.3 System Security

System safety is the safety theory and method system developed and studied by people to solve the security problems of the complex system, which is the perfect embodiment of the combination of the system engineering and the safety engineering. From the perspective of system security, digital projects comprehensively evaluate the overall function of the system.

1) Degree of Maintenance Number Reduction (C1)
To judge the security improvement of the overall system by counting the changes before and after the application of the maintenance number of digital projects.

2) Resistance Against External Attacks (C2)
The security of the overall system is observed by statistically changing the number of successful attempts against external attacks.

3) Attack Warning Capability (C3)
The early warning ability of the system is judged by counting the number of early warning times and the speed of its early warning system.

4) Detection Vulnerability Capability (C4)
Through the ability of the system to detect its own vulnerabilities and the number of vulnerabilities detected in advance, to improve the system's active defense ability of the system.

2.4 The Level of Management

The management level of digital projects mainly starts from two dimensions, horizontal and vertical, to judge whether it can solve the problems encountered in actual operation, and how to solve the problems.

1) Management Efficiency (D1)
Reflect the impact of digital projects on the speed of company management. Management efficiency is the evaluation of longitudinal management speed, to judge whether the project can improve the management speed, whether it can provide scientific and effective efficiency analysis methods and ways to improve the management level.

2) Management Effect (D2)
Reflects the digital project's evaluation of management results. The management effect refers to whether the project improves the final and staged results compared with the

expected target status, including the completion of work tasks, the level of work efficiency and the quality of work benefits.

3) Internal Convenience Degree (D3)
Reflect the impact of digital projects on horizontal management. The degree of internal convenience is an evaluation of the horizontal management between various departments, to judge whether the project has improved the way of cooperation between various departments, and improved the efficiency of cooperation.

4) Application Penetration Rate (D4)
Reflects the adoption rate of digital projects across the company. The application penetration rate refers to the popularity and application degree of the project among the employees of the entire company, also considers whether the project has improved the work efficiency of the employees.

2.5 Service Quality

Service quality is the core of service marketing. It is aimed at suppliers and users, respectively, to judge their convenience, popularity, acceptance and service satisfaction, and to comprehensively evaluate the quality of their service.

1) External Convenience (E1)
Services are meaningful to both parties, whether digital projects can improve the entire service process, improve service quality, and provide convenience.

2) Business Processing Speed (E2)
Compare the current and the previous single service time, to improve the efficiency to improve the speed of business processing, and then improve the service quality.

3) Acceptance (E3)
It reflects the acceptance degree and acceptance speed of digital projects of suppliers and users, so as to judge the reasonable degree and invest-ability of the project.

4) Customer Service Satisfaction (E4)
By counting the customer service satisfaction of users, to judge the improvement of the overall service level, and then to evaluate their own service quality.

3 Model Establishment

3.1 Radar Chart-Based Information Integration

The purpose of adding SVM to the investment performance portfolio evaluation model is to improve its timeliness in the evaluation of similar problems. As far as the evaluation of the investment effect of a single digital project is concerned, the input part of the training sample is the quantity matrix scored by experts, and the output part is the comprehensive evaluation vector obtained by integrating the quantity matrix through a

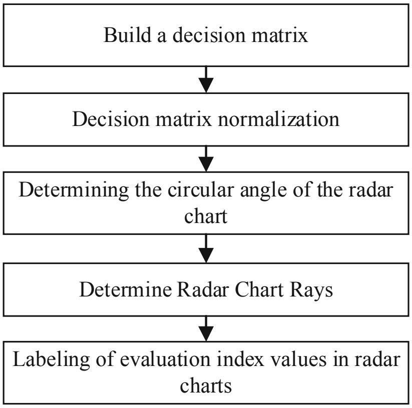

Fig. 2. Radar diagram implementation steps

certain set of counters. The input part does not need special treatment, the key lies in the selection of the integration operator in the output part. In view of the above problems, this topic chooses the radar chart to implement the integration of the input quantity matrix. The specific steps are shown in Fig. 2.

Repeat the above process to label all the investment results of the evaluation objects in the scheme set V on the same two-dimensional radar map.

3.2 Combination Empowerment Based on AHP-Entropy

As an important part of the comprehensive evaluation, the weight is directly related to the success or failure of the model. According to different principles, weighting methods can be divided into two categories: subjective empowerment law and objective empowerment law. In the evaluation of investment benefits of digital projects, the index set is a hierarchical structure, and the scale of the index set is often smaller than the scale of the scheme set, so the use of AHP has certain advantages. As the most widely used objective weighting method, the entropy method is similar to the AHP method, it is easier to operate. Therefore, the combined weighting method of AHP and entropy integration is selected, taking into account both subjective and objective aspects, in order to reflect the actual situation of the problem more truly and comprehensively. The specific calculation steps of the AHP - Entropy combination assignment are as follows:

Subjective weight of AHP:

$$W' = (w'_1, w'_2, \ldots, w'_m) \tag{1}$$

$$0 < w'_i < 1 \tag{2}$$

$$\sum_{i=1}^{m} w'_i = 1, i = 1, 2, \ldots, m \tag{3}$$

Objective weight of the entropy weight:

$$W'' = (w_1'', w_2'', \ldots, w_m'') \tag{4}$$

$$0 < w_i'' < 1 \tag{5}$$

$$\sum_{i=1}^{m} w_i'' = 1, i = 1, 2, \ldots, m \tag{6}$$

Combination weights of competency indicators obtained by linear weighted summation method.

$$W = (w_1, w_2, \ldots, w_m) \tag{7}$$

$$w_i = t * w_i' = (1 - t) * w_i'' \tag{8}$$

$$0 \le t \le 1 \tag{9}$$

Among $w_i = t * w_i\prime = (1 - t) * w_i^{''}, 0 \le t \le 1, t$ and $(1 - t)$ the relative importance of the subjective and objective weight.

$$0 < w_i < 1 \tag{10}$$

$$\sum_{i=1}^{m} w_i = 1, i = 1, 2, \ldots, m \tag{11}$$

3.3 Expert Decision-Making Model Based on the SVM

As a new technology of data mining, SVM takes the structural risk minimization as the principle, transforms nonlinear separable problem into linear separable problem through kernel function, and finally obtains the global optimal and unique solution. Compared with BP neural network, it has unique advantages in solving small-sample and nonlinear identification problems, and can avoid the defects of over-learning and easy to fall into local minimum of BP neural network. The combined evaluation model proposed in this subject integrates the data matrix through the radar chart, which is a typical nonlinear integration method. The specific implementation steps are shown in Fig. 3:

4 Simulation Results

Aiming at the digital project investment effectiveness model constructed in Sect. 2, the simulation calculation is carried out according to the processing flow of the combined evaluation model proposed in this paper. The combination weight of the investment effectiveness evaluation index is determined by the combination of the AHP method and

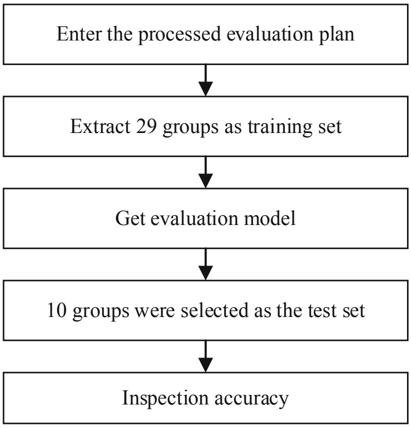

Fig. 3. SVM training process

the entropy value method; then, the determined combination weight and the corresponding index value are integrated with the help of the radar chart to obtain a comprehensive evaluation of the investment effectiveness of each digital project. Finally, the index data matrix of the investment effect of the digital project is used as the input variable, and the comprehensive evaluation value obtained from the integration of radar charts is the output variable, which is brought into the SVM for training, and the knowledge and experience of experts are fixed in the trained SVM. Inside the model, SVM will respond in time when evaluating objects other than the sample pattern. The specific process is shown in Fig. 4.

This paper mainly selects a total of 39 items from 21 sub-scenarios in the four main scenarios. Among them, 29 items were randomly selected as the subject data group for machine training; the remaining 10 groups were used as the detection group to test the accuracy of machine learning. The digitization project mentioned in this article belongs to the digitization of dispatching operation in the power grid production scenario.

The digitization project mentioned in this article belongs to the dispatching operation digitization in the power grid production scenario. According to the previous investment standards, it is estimated whether the project is worth investing in.

According to the combined weights of the investment effectiveness evaluation models of related digital projects, three groups were randomly selected from the 29 groups of test data for the description of the radar chart, as shown in Fig. 5. Figure 6 shows the comparison of the training evaluation values of AHP-Entropy combined weighting and SVM on 29 groups of test data, showing a good fitting effect between the training evaluation values and the real values. Figure 7 shows the relative error of the 29 groups of subjects' data for AHP-Entropy combined weighting and SVM training evaluation results. The maximum value is 2.59%, and the minimum value is 0.09%. The degree of dispersion is small, and there are fewer points with large error values.

The other 10 groups were tested according to the trained method. The tested groups were named V1–V10. The difference between the expected output and the actual result was tested to determine whether the result was acceptable. According to the specific data

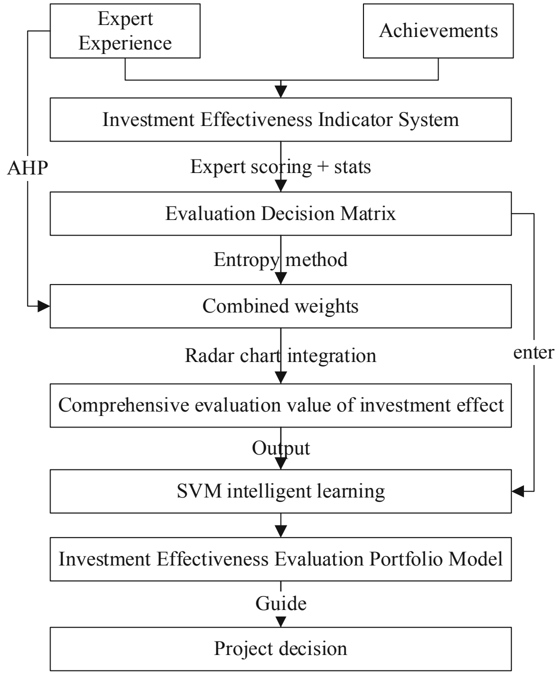

Fig. 4. Flow chart of the combined evaluation of digital projects

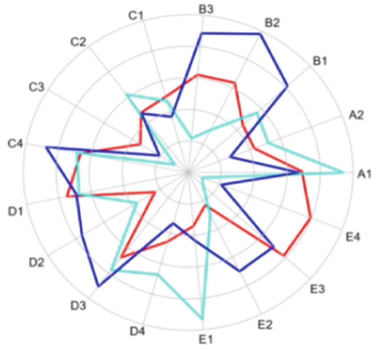

Fig. 5. Combined evaluation radar map of the data from the three groups of subjects

in Table 1, the maximum relative error between the expected output of the model and the test result is 2.61%. According to historical experience, the result is acceptable.

Finally, the portfolio evaluation model is applied to the digital project, and the investment effectiveness is evaluated. The obtained indicators are shown in Table 2. The final total score of machine learning was 5.05254, and the results showed that with reference to the previous project investment standards, the digital project was worth investing in.

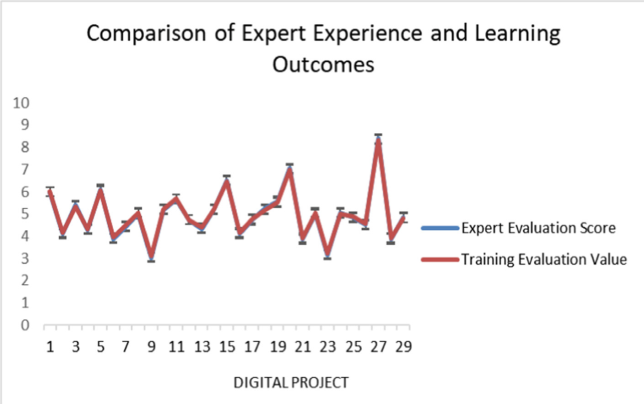

Fig. 6. Comparison of expert experience and SVM learning results

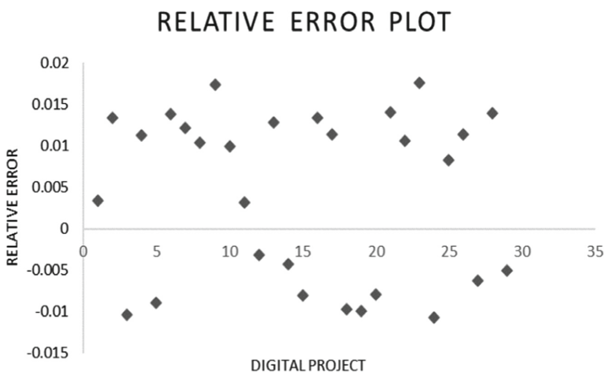

Fig. 7. Expert experience and SVM relative error plots for learning

Table 1. Outputs the results

Project	V1	V2	V3	V4	V5
test result	5.276	4.889	4.090	3.996	4.684
desired output	5.153	4.894	4.195	4.025	4.608
fractional error	2.33%	0.09%	2.59%	0.73%	1.62%
Project	V6	V7	V8	V9	V10
test result	4.908	5.284	6.232	5.533	5.476
desired output	4.971	5.166	6.220	5.389	5.427
fractional error	1.28%	2.22%	0.19%	2.61%	0.90%

Table 2. Test results of each index of the digital project

metric	A1	A2	B1	B2	B3	C1	C2	C3
score	9.50	7.17	3.39	2.95	2.15	7.32	1.23	5.17
C4	D1	D2	D3	D4	E1	E2	E3	E4
9.78	9.67	1.55	2.14	4.06	8.43	5.25	4.52	2.85

5 Conclusions

The combined evaluation model proposed in this paper effectively evaluates and predicts the development prospects of digital projects, proves the economy of digital projects, and also proves the effectiveness of the combined evaluation model.

(1) The combined evaluation model proposed in this paper can achieve higher accuracy by using fewer samples, and improve the timeliness and quality of multiple evaluations. And combining the advantages of the four methods, taking into account the subjective experience of experts and the actual situation of the project, it is less affected by noise and more intuitive, and is more suitable for the evaluation of digital projects.
(2) The feasibility of the model is verified through a numerical example, which can guarantee the rationality and effectiveness of the investment. According to the test results, it is indicated that enterprises should increase their efforts to invest in projects under the sub-scenarios of digital operation and new energy storage business. The further development of the digital project points out the direction, and points out the direction for the economic benefit evaluation of the digital project of the power grid enterprises.
(3) It is suggested that the digital projects of power grid enterprises should integrate and penetrate with traditional industries, break through the original development model, accelerate the optimization and upgrading of industrial structure, and inject new power into the development of enterprises.

Finally, this article is only a preliminary exploration, there are still many questions, such as whether the evaluation system of this project can be applied to other enterprises, the interaction mechanism between digital projects and enterprise growth, etc., which requires further discussion and research in the future.

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