Research on the Investment Decision Model of Power Grid Enterprises Based on Neural Network Method

Chaoyang Li [1st], Guangchao Qian [2nd], Lei Shi [3rd], Yi Gao [4th], Yongli Wang [5th], Bo Yuan [6th] *

[1]State Grid Tianjin Electric Power Company Tianjin, China
[2]State Grid Tianjin Electric Power Company Economic and Technical Research Institute Tianjin, China
[3]State Grid Tianjin Electric Power Company Tianjin, China
[4]State Grid Tianjin Electric Power Company Economic and Technical Research Institute Tianjin, China
[5]School of Economics and Management North China Electric Power University, Changping District Beijing, China
[6]School of Economics and Management North China Electric Power University, Changping District Beijing, China
chaoyang.li@tj.sgcc.com.cn
guangchao.qian@tj.sgcc.com.cn
lei.shi@tj.sgcc.com.cn
yi.gao1@tj.sgcc.com.cn
wyl_2001_ren@126.com
**120212206288@ncepu.edu.cn*

Abstract

In the context of "new infrastructure", in order to enable power grid enterprises to better make investment decisions, this paper proposes a model based on neural network method, which can effectively improve the economic, social and environmental protection benefits of power grid enterprises' investment and encourage power grid enterprises to invest. Based on the consideration of investment capital and output requirements, the grid investment decision model is solved by neural network method to greatly improves the accuracy of the results. The simulation analysis through calculation examples shows that the method can quickly and effectively give quantitative evaluation results for different strategic objectives.

Keywords*-Ower Grid Investment Decision; Project Evaluation; Rural Network Method*

1. INTRODUCTION

Power grid construction is a basic industry of the national economy, which is related to national security and the lifeline of the national economy. The investment benefit of fixed assets of power grid enterprises directly affects the investment effect of China's state-owned assets, thereby affecting the growth of the entire national economy. The dual-carbon target and the new infrastructure strategy have further increased the factors that need to be considered in the project investment of power grid companies, including national and regional policies, environmental and social impacts, economic benefits, etc., which have multiple objectives, uncertainties, nonlinearities and multiple The characteristics of phases, etc., are an uncertain, multi-objective optimization and complex system engineering decision-making problems.

At present, the investment project decision-making of power grid enterprises is mainly divided into the feasibility study before the investment decision and the evaluation after the decision [1]. In terms of the feasibility study before investment decision-making, the feasibility analysis of an investment project is to investigate the development prospects of the market where the project is located and scientifically analyze the company’s own economic strength before investing 2]. The post-decision evaluation is mainly to construct a corresponding evaluation index system. Many individual indicators in the evaluation system have different meanings. When determining the weight of each individual indicator, some important evaluation indicators are quantified and subjective factors are

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eliminated to objectively reflect the importance of each indicator [3]. The project benefit evaluation methods are currently mainly concentrated in the analytic hierarchy process [4], fuzzy comprehensive evaluation method [5], gray correlation analysis method [6] and the comprehensive application of a combination of multiple methods [7].

However, through the above research, we found that the existing investment project feasibility analysis methods are mainly based on expert experience and historical data for analysis, subjective factors are relatively large, which is not conducive to objective analysis of the project. Most of them are aimed at specific investment projects or processes, and it is difficult to consider the significance of the project to policies and macro strategies; and the research of some power investment project evaluation indicators focuses on qualitative research, and the quantitative methods mainly used fuzzy comprehensive evaluation method and gray correlation The quantitative method for evaluation and analysis of indicators is susceptible to the influence of subjective factors of the evaluation subject; the scalability of the model and the ability of automatic data analysis and learning are poor. Neural network has a flexible model structure and learning ability. It can use existing expert opinions as weights for model construction, expand the model under the conditions of mature big data, and provide more objective optimization solutions and decision support for investment project analysis [8].

2. EVALUATION MODEL

2.1. Neural Network and Neuron Model

Artificial neural network, abbreviated as ANN, has the function of imitating the human brain to obtain and process information. It is a complex network connected by a large number of processing units and a system that can perform logical operations. The basic structural unit of a neural network is a neuron, and a neuron is also the information processing unit of a neural network, which is generally called a "processing unit" or "node". The neuron model is a simulation of the neuron cell in biological sciences. The structure of the neural network is determined by the neuron and its interconnection mode. The M-P neuron model proposed by American psychologist Mc Culloch and mathematician W. Pitts in 1943 when they summarized the basic characteristics of neurons is the most influential and earliest neuron model. After continuous improvement, the M-P model is now the most widely used neuron model.

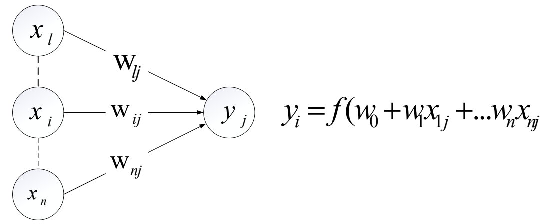

Figure 1. Neuron model

As shown in Figure 1, the inputs of the neuron are denoted by $x_1, ...x_i, ...x_n$, and each input corresponds to a weight $w_{1j}, ...w_{ij}, ...w_{nj}$, which is taken according to a specific function. The output of the neuron is y, see Equation 1.

$$y_i = f(w_0 + w_1 x_{1j} + ...w_n x_{nj} \tag{1}$$

2.2. Data Structure

Power grid investment projects are different from other separate production and marketing projects. Their essence is to ensure the long-term benefits of overall investment and efficient power production and services through a combination of different investment projects. Different types of power grid investment projects have different emphasis on economy and reliability, as well as comprehensive benefit evaluation indicators and evaluation methods. Under different strategic objective conditions, the weight of each indicator is not the same. The conceptual structure of the investment model is shown in Figure 2. Assuming that the investment plan is, there are s investment projects. Due to the constraints of constraints, each plan contains several investment projects, and each project contains several evaluation indicators. Evaluation indicators have different contribution values to different strategic objectives.

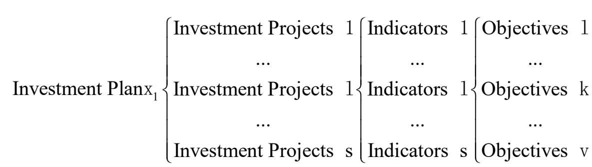

Figure 2. Data hierarchy of the evaluation model

2.3. Evaluation Process

The investment evaluation network model of power grid enterprises is shown in Figure 3. By inputting the project plan (including investment constraints, investment project library), relevant data and its parameters, the final evaluation result is obtained.

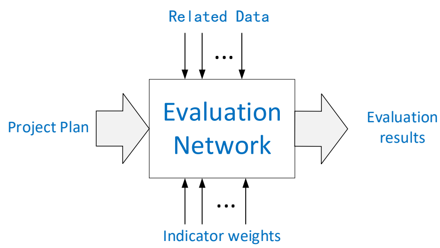

Figure 3. Data hierarchy of the evaluation model

The specific evaluation process is as follows: First, determine the investment constraints and project options. Second, determine the output target vector, and the neurons in the output layer get the final evaluation result with different target weights. Third, determine the network level. This model is determined as a five-layer network based on actual applications, namely the input layer, multi-level indicator mapping layer (project layer, indicator layer, target layer) and output layer. The multi-level indicator layer can be expanded according to actual problems. Fourth, input data for network evaluation. The data includes planned items, and the weight ratios of indicators at all levels are input as parameters. The weight ratios of the indicators can be obtained by expert evaluation methods or other machine learning algorithms. Fifth, complete the current round of project evaluation, get the evaluation result, and obtain the actual data of the completed project as the subsequent machine learning training data.

2.4. Multi-Level Metrics Mapping Network

The investment plan contains multiple investment projects. In the case of limited investment funds, the final investment decision needs to be formed according to certain standards to ensure that the expected strategic goals can be achieved with the greatest probability.

2.4.1. Restrictions

According to the investment capital and output requirements, design the constraints of the investment plan. The capital constraints of the grid enterprise project investment portfolio to be studied in this paper mainly consider two aspects of capital constraints. First of all, ensure that the total investment in projects in all fields is within the total planned investment quota of the power grid company. Secondly, for each professional field, considering the balanced development of the enterprise, there may be upper and lower constraints on the project investment in each professional field. If l_{ij} represents the investment amount of the j-th project in the i-th professional field, I represents the total investment in the grid company's annual power grid project, and a_i and b_i represent the lower and upper limits of the annual investment in the i-th professional field, then the corresponding total investment Constraints and professional investment constraints can be expressed by the following formula:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} I_{ij} \times X_{ij} \tag{2}$$

$$b_i \geq \sum_{j=1}^{m} I_{ij} \times X_{ij} \geq a_i \tag{3}$$

In addition, if there are some investment linkages between projects in different professional fields, then in the specific project investment decision-making process, a specific analysis of the constraint relationship between each field is required. This part of the work can also be reflected in the weight of the first-tier investment project in the data hierarchy.

2.4.2. Indicator mapping

According to the constraints, the investment plan is divided into a number of investment project portfolios, and the investment plan is divided into three levels according to priority for data structure processing:

Investment project layer. Set the weights of the corresponding projects according to the constraints: $f_l = 0$ or 1, indicating whether the investment decision is to invest in the lth investment project, with 1 indicating investment and 0 indicating no investment.

Evaluation index layer. Determine the evaluation index matrix of each investment project, taking into account the actual construction needs and expected goals of the investment project, the index system of the investment project can be sorted in terms of economic benefits, technical reliability and social environmental benefits. Formulate the evaluation index set and contribution weight of each project. The contribution weight can be given by the expert evaluation method or calculated by other data modules. The weight measurement of each indicator is the solution of the equation, weighted according to the investment project, as shown in the following formula.

$$p_u = \sum_{i=1}^{s} f_l p_{lu} \tag{4}$$

Among them, μ=1, 2, …, S represents the type of evaluation index; is the weight of the u-th evaluation index for the l-th investment project; a represents the contribution value of all investment projects included in the investment plan to the evaluation index u.

Strategic Objective Layer. Determine the contribution values of all the investment projects included in this investment plan to the strategic objectives. Consider the contribution weights of indicators to different strategic objectives and develop the set of evaluation indicators and contribution weights included in each strategic objective, again using expert evaluation methods or the output of external data modules as input.

$$v_k = \sum_{u=1}^{z} p_u v_{uk} \quad (5)$$

Among them, k = 1, 2, ..., v denotes the strategic objective, v_k is the score of the kth strategic objective of the investment plan, indicating its contribution to the strategic objective k.

2.4.3. Model output

Finally each matrix and the whole hierarchy are analyzed for consistency, the expert evaluation method or the output of the external data module is used to prioritize v_k and give the corresponding weight w_k. Finally, the quantitative results of the evaluation of the investment plan y are obtained, as in Equation (6)

$$y = \sum_{k=1}^{v}\sum_{u=1}^{z}\sum_{l=1}^{s} f_1 p_{lu} v_{uk} w_k \quad (6)$$

2.5. Evaluate the Network Level of the Model

According to the multi-level mapping evaluation analysis of the investment plan, a neural network model with multiple hidden layers can be constructed to realize the evaluation model. Corresponding to the above three levels, plus the input and output layers, a five-layer power investment project evaluation network including the input layer, project layer, indicator layer, target layer and output layer is constructed, as shown in Figure 4.

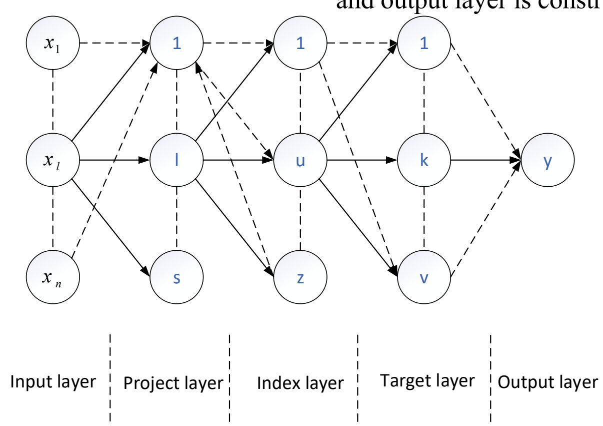

Figure 4. Neural network-based network model for project evaluation

The input layer refers to the investment plan. Grid companies develop investment plans based on the strategic objectives of the state and the company, including a detailed pool of investment projects and total investments. The evaluation network mainly contains a project layer, an indicator layer and a target layer. The project layer contains multiple investment projects, each different type of investment project corresponds to a different evaluation index system, and different strategic objectives may have different focus on each evaluation index. Therefore, the last layer is the target layer. With different focus on strategic objectives, different evaluation results of investment decisions may be obtained under the same investment plan. The results are given through the output layer.

3. CASE STUDY

The post-project evaluation survey data of nine power grid investment projects of a local power grid enterprise from 2015-2020 are used as experimental data, and the data are hierarchically structured and input into the model to obtain the evaluation results. For the confidentiality of the project experimental report, only the final experimental results are given, and the regions are fuzzy processed.

3.1. Indicator System

As an independent project, each investment project has a total of 9; the indicator layer has 2 layers, the first layer has 28 basic indicators, and the second layer has 7 comprehensive indicators; the target layer has 3 in total.

TABLE I. INDICATOR SYSTEM

Indicator 1 layer	Indicator 2 layers	Indicator 3 layers
Annual investment scale	1.1 Evaluation of socio-economic development coordination	1.Comprehensive coordination
Average customer outage time		
Comprehensive voltage qualification rate		
Electricity supply		
Maximum power supply load		
Household electricity connection rate		
GDP per capita		
. Total retail sales of consumer goods		
Fiscal Budget Income		
Per capita disposable income		
Grid capacity-load ratio (110kV, 35kV)	1.2 Evaluation of power system coordination	
Average load ratio of power grid (110kV, 35kV)		
10kV outgoing interval utilization rate		
Ratio of heavy, overloaded and lightly loaded 10kV grid		
Ratio of 10kV light, heavy and overloaded lines	2.1 Grid operation capacity	2.Grid Effectiveness
Ratio of 10kV light, heavy and overloaded distribution substation		
Main Transformer Load Ratio, Line Load Ratio		
Capacity-load ratio		
Inter-substation contact ratio	2.2 Grid structure	
All 10kV lines can be transferred to supply rate		
Ratio of high loss transformers	2.3 Energy saving and consumption reduction	
Line Loss Ratio		
Internal rate of return	3.1 Financial benefits	3.Grid effectiveness
Net present value of unit investment		
Annual operation and maintenance cost rate		
Input-output ratio	3.2 Investment efficiency	
Unit investment in additional power		

supply		
Unit investment to increase supply load		

3.2. List of results

TABLE II. OVERALL EVALUATION SCORE OF INVESTMENT PROJECTS

Evaluation Indicators	2015	2016	2017	2018	2019	2020	Weights
Coherence Indicators	76.8	82.43	85.28	87.19	88.6	88.75	0.3
Process evaluation	90	87	85	90	88	92	0.3
Effectiveness evaluation	77.84	79.14	80.42	81.37	82.6	82.68	0.4
Overall Score	81.17	82.48	83.25	85.71	86.02	87.3	1

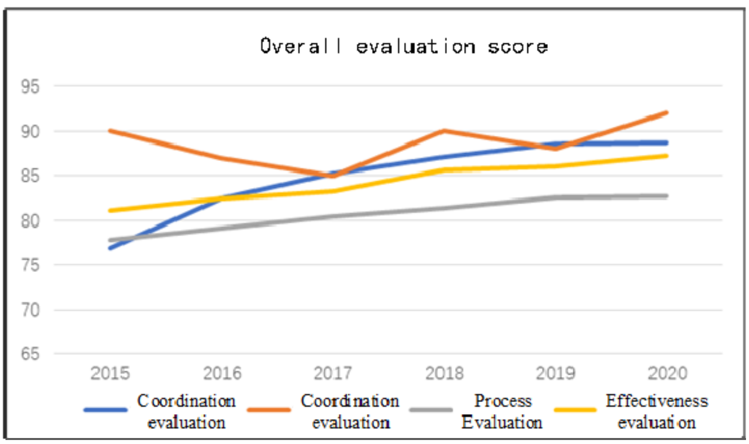

Figure 5. Overall investment project score line graph

TABLE III. INVESTMENT PROJECT EVALUATION SCORES BY REGION

Evaluation Indicators	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Coherence Indicators	83.83	89.76	87.13	82.3	86.47	84.7	83.93	85.63	79.8
Process evaluation	81	92	90	92	89	94	97	85	77
Effectiveness evaluation	83.45	85.8	79.41	70.68	81.4	70.55	78.84	81.47	80.75
Score	82.83	88.85	84.90	80.56	85.2	81.83	85.81	83.77	79.34

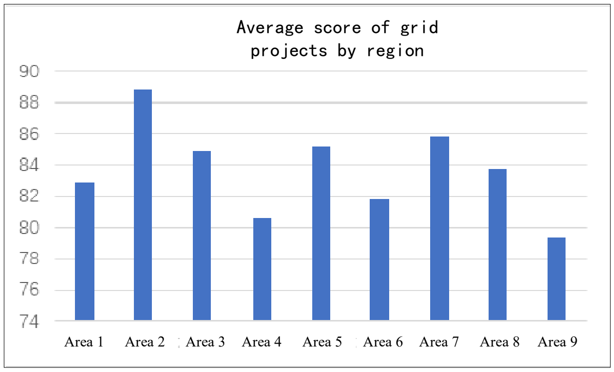

Figure 6. Comparison of investment project scores by region

From Table 2, Table 3, Figure 5 and Figure 6, it can be seen that the scores of power grid investment projects in this region have been on the rise year by year, reaching 87.29 by 2020, indicating that the goal of county power grid construction in this region has been better achieved and some success has been achieved. But there is still room for improvement. Judging from the overall scores of the regional bureaus, the grid construction situation in each region is relatively ideal, and the goals have been achieved, with the highest score of region 2 being 88.85 points, and region 9 having the lowest score of 79.34 points. Reflects the gap in the relative level of power grid investment and construction in various regions in recent years.

Therefore, the proposed method has been applied in a special research project of power planning of a Southwest Power Grid Corporation. Compared with the existing research reports and experimental results, it shows that the method can quickly and effectively give quantitative evaluation results for different strategic objectives.

4. CONCLUSION

This paper constructs a power grid investment decision-making model for power grid enterprise investment under the background of new infrastructure construction, proposes an algorithm based on neural network method to solve it, and analyzes its practicability through calculation examples. The research results show that the solution method based on the neural network method has flexible model structure and learning ability, and expert opinions can be added to the model construction, so that the model can be expanded under the condition of mature big data and provide more objective optimization solutions and decision support for investment project analysis.

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