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Research on Social Benefit Evaluation of Transnational Interconnected Power Grid Project from the Perspective of Recipient Countries

Jinying Li, Yan Di

Department of Economic Management, North China Electric Power University, Baoding, China

Abstract*:* With the implementation of the "One Belt And One Road" strategy, the cooperation between China and countries along the belt and road is getting closer, among which the interconnection of power grids is the focus of cooperation.Transnational interconnected power grid projects have an important impact on the development of national economy and the evaluation of their social benefits has become an important subject. In this paper, from the perspective of recipient countries, the social evaluation index system of transnational network project of power grid construction is established through the gray relative analysis method, and the analytic network process is used to determine the weight of evaluation index. At last, comprehensive evaluation is completed by the matter-element extension evaluation model. This paper shows that the evaluation model is scientific and feasible through an example.

Keywords Gray relative analysis method, Analytic hierarchy process, Matter-element extension evaluation model, Transnational interconnected power grid project, Social benefit evaluation index system.

INTRODUCTION

With the rapid development of social economy, the continuous growth of energy consumption and the use of traditional fossil energy, resource shortage, environmental pollution, climate change and unbalanced development have become the four major challenges facing the global energy industry at the present stage, which seriously threaten the survival and development of mankind.[Song, *et. al.*, 2017] Through the establishment of transnational interconnected power grid, which will promote the development and utilization of renewable energy in different countries and regions, it is helpful to optimize the power structure, increase the proportion of clean electric energy, meet the demand of electric energy, and give full play to the complementarily of energy and electric power development among countries, and promote the sustainable development of world energy. With the implementation of the ”One Belt And One Road strategy”, China and countries along the belt and road have become increasingly close and started cooperation in many fields, among which energy and power is the focus of cooperation. [Yunyan, *et. al.*, 2019]

According to the 13th five-year plan for electric power development released by the national development and reform commission on November 7, 2016, one of the key tasks for the development of China's electric power industry during the 13th five-year plan period is to strengthen international electric power cooperation, promote cross-border grid connectivity according to needs, and encourage electric power enterprises to participate in the construction and operation of overseas electric power projects. [Wei, *et. al.*, 2017]As a result, the number of transnational connected projects will increase greatly in the future. How to evaluate this kind of investment project scientifically and reasonably has become an urgent problem to be analyzed.

At present, it is common to pay more attention to economic and environmental impact assessment and neglect social benefit assessment. [Hao, *et. al.*, 2018] Social benefit refers to the impact on and contribution to the society. [Wang, *et. al.*, 2018] Aiming at this problem and combining with the characteristics of transnational interconnected power grid projects, this paper establishes a social benefit evaluation index system of transnational interconnected power grid projects from the perspective of recipient countries, and screens the indexes through the gray relative analysis method. Then, the analytic network process is used to calculate the weight of evaluation indexes, and the matter-element extension evaluation model is adopted to obtain the final evaluation results.

METHODS

Methods

Gray relative analysis method

Grey relational analysis method is the core method of grey system theory. Its essence is to carry on the quantitative geometric comparison to the change characteristic of each influence factor through the similarity and comparability of the series, to obtain the correlation degree and order between the factors.

Analytic hierarchy process

Network analysis is a new practical decision-making method based on analytic hierarchy process. ANP first divides system elements into two major parts: the first part is called the control factor layer,

including problem objectives and decision criteria. All decision criteria governed only by the target element are considered independent of each other. Control factors can have no decision criteria, but at least one goal. The weight of each criterion in the control layer can be obtained by AHP method. The second part is the network layer, which is composed of all groups of elements dominated by the control layer, and its internal network structure influences each other. Elements depend on and dominate each other, and elements and layers are not independent internally.

On the basis of analytic hierarchy process, ANP takes into account the mutual influences of various factors or adjacent layers, and uses the "supermatrix" to conduct comprehensive analysis on the factors that interact with each other to obtain their mixed weights.

Matter-element extension evaluation model

The basic principle of matter-element extension method is to take the evaluation index system and its characteristic value as matter-element according to the matter-element extension analysis theory, and obtain the classical domain, node domain and correlation degree through the evaluation level and the measured data, so as to establish the quantitative comprehensive evaluation method. The extension model of matter-element is based on the extension theory and the concept of matter-element, which converts the evaluation of multiple targets into the evaluation of a single target, and uses mathematical model to quantify the index data.

Compared with other evaluation methods, this method has advantages in the research field of social benefit evaluation of transnational interconnected power grid project.

ESTABLISHMENT OF SOCIAL EVALUATION INDEX SYSTEM

Social benefit evaluation index database

The construction and transformation of transnational interconnected power grid project will bring corresponding social benefits while the power grid structure is improved. To evaluate the social benefits of transnational interconnected power grid project from the perspective of recipient countries, it is necessary to look at the contribution of the project to the social development and people's welfare of the region. [4]P786 Therefore, the establishment of a relatively comprehensive evaluation index system needs to be considered from various aspects. The evaluation index system of social benefits of transnational interconnected power grid project is a multi-angle and multi-level system, which can be measured from three aspects: the impact on regional economy, the impact on residents and the impact on national relations

(1) Impact on regional economy

To measure the contribution of the project to the social benefits of the region, the first step is to measure the economic benefits brought to the region. The impact on the region's economy is measured mainly from the perspective of stimulating economic growth and promoting employment. [5]P174

(2) Influence on relevant interest groups

This part mainly refers to the impact on residents. Consider the improvement of local power supply reliability and the happiness of the residents due to the project.

(3) The impact on the relationship between the two countries

Transnational projects will bring about trade exchanges between the sending and receiving countries, which will also affect the relations between the two countries to some extent.

Combined with the above aspects, social benefit evaluation index database is established, which is showed below.

Table 1. Social benefit evaluation index database of transnational networked engineering projects

First-level indicators	Second-level indicators	Third-level indicators	Character
Social benefit evaluation index (A)	Socio-economic indicators （A1）	A11 Regional economic contribution value	positive dimensions
		A12 Employment effects	positive dimensions
	Social environmental indicators （A2）	A21 Per capita electricity increase	positive dimensions
		A22 Electric reliability	positive dimensions
		A23 gross national happiness index	positive dimensions
	Indicators of bilateral relations （A3）	A31 Bilateral economic relations	positive dimensions
		A32 Bilateral political relations	positive dimensions
		A33 Bilateral cultural exchange	positive dimensions

Interpretation of the indicators

Socio-economic indicators

(1) Regional economic contribution value

The value of regional economic contribution can be measured by the regional GDP growth of the recipient countries due to the increase of power generated by transnational interconnected power grid project. [6]P16-26

$$GDP_{\mathrm{e}} = \frac{C_{\mathrm{new}}}{C_{\mathrm{all}}} \times GDP$$

Where GDP_{e} represents the increment of GDP because of the power growth, C_{new} is the increase of electricity consumption in the whole society, C_{all} refers the total electricity consumption, GDP is the total GDP of the region.

(2) Employment effects

The construction and operation of projects can bring direct or indirect employment. The construction and operation of the project involves various industries such as design, machinery manufacturing, civil engineering construction and maintenance. All these provide direct or indirect employment opportunities for the society. According to the statistics of the new energy office, the installation of 1MW will directly add 5 jobs. The employment effect index is expressed by the number of people directly employed. [8] p44-45

Social environmental indicators

(1) Per capita electricity increase

The increase of per capita electricity consumption indicates that China's economy is developing healthily and stably and people's living standard is gradually improving. The per capita increase in electricity use is the ratio of the total increase in electricity use by the whole society to the average annual resident population.

(2) Electric reliability

The practical purpose of transnational interconnected power grid project is to build an efficient, safe and stable transmission and distribution network across countries or regions, and to realize the interconnection of power grids between different countries or regions. Electric reliability refers to the continuous power supply capacity of the power supply system, which is an important indicator to evaluate the power quality of the power supply system, and reflects the degree of satisfaction of the power industry to the power demand of the national economy, and has become one of the standards to measure the economic development of a country.

(3) Gross national happiness index

The establishment of transnational interconnected power grid project will correspondingly improve the economic level of the region and improve the happiness of residents to a certain extent. This index is a qualitative index, and relevant data are obtained by questionnaire survey in the actual evaluation.

Social relation indicators

(1) Bilateral economic relations

The establishment of the project will bring a certain degree of change to the economic and trade relations between the two countries.

(2) Bilateral political relations

In the context of global energy interconnection development, with the development of transnational power grid interconnection and power trade, energy geopolitics will also face a new round of big reshuffle. Cross-border electricity trade cooperation has promoted the growth of bilateral common interests and provided a solid material basis for the development of bilateral political relations. The establishment of the transnational networking project will help increase the international friendly relations between the two countries and promote the long-term cooperation between the two countries in the fields of economy, science and technology. Bilateral political relations index is a qualitative index, which is obtained by expert evaluation in practical evaluation. [9] p94-96

(3) Bilateral cultural exchange

The degree of cultural exchange is shown by the degree of cultural acceptance between the two countries, the degree of local people's needs, and the degree of support from relevant interest groups (the government, the public, electricity enterprises). This index is a qualitative index. In the actual evaluation, people's attitudes towards festivals, films, music, food and language in countries with interconnected power grids can be obtained through questionnaire survey, as well as the change of attitudes after the establishment of transnational networking project.

Indicator selection based on grey correlation analysis

Indicators are now filtered through data from 15 simulated projects by gray relative analysis method. The gray correlation degree of indicators is shown below.

Table 2.Weights of the indicators

	Indicators	gray correlation coefficient
A11	Regional economic contribution value	0.6995
A12	Employment effects	0.7385
A21	Per capita electricity increase	0.5466
A22	Electric reliability	0.7100
A23	Gross national happiness index	0.7013
A31	Bilateral economic relations	0.7418
A32	Bilateral political relations	0.7033
A33	Bilateral cultural exchange	0.6978

The indexes arranged in the order of correlation are shown as below: Bilateral economic relations> Employment effects> Electric reliability> Bilateral political relations> Gross national happiness index> Regional economic contribution value> Bilateral cultural exchange> Per capita electricity increase

Because the gray correlation coefficient of per capita electricity increase is very low, it is deleted in this link.

EMPIRICAL ANALYSIS

To verify the applicability and scientific validity of the evaluation model, this paper takes Mongolia - Shandong/dc transmission project as an example.

The Mongolia - Shandong/dc transmission project will send solar power from southern Mongolia and wind power from eastern Mongolia to northern China. The project plans to use 800 kilovolts of direct current with a capacity of 8 million kilowatts. The length of the two projects is 1,700 and 1,900 kilometers respectively, and the project is planned to be completed in 2035 and 2050 respectively.

The social benefits of recipient countries will be studied below.

Determination of weights of evaluation indexes

Firstly, the weights of evaluation are needed. In order to obtain the weights, this paper use ANP method. The software used is" super decision".

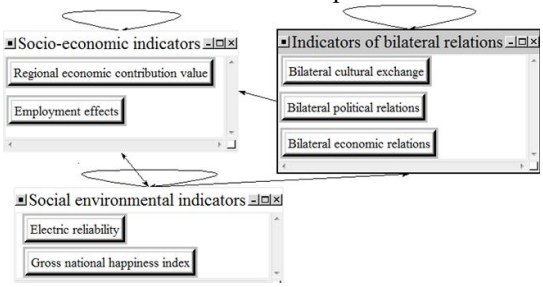

Figure 1.Indicators diagram

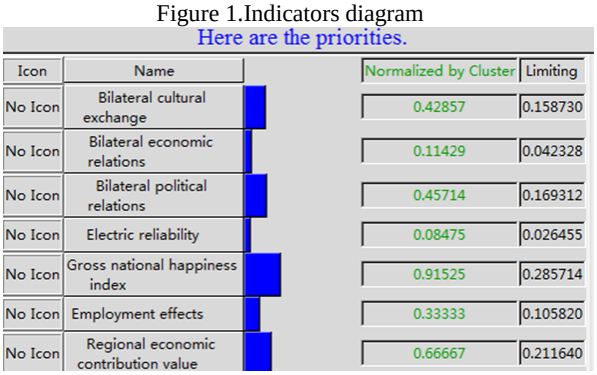

Figure2.Weight Map

The weights of evaluation indexes calculated by analytic network process are shown in the following table.

Table 3.Weights of the indicators

	Indicators	Weights
A11	Regional economic contribution value	0.211640
A12	Employment effects	0.105820
A21	Electric reliability	0.026455
A22	Gross national happiness index	0.285714
A31	Bilateral economic relations	0.042328
A32	Bilateral political relations	0.169312
A33	Bilateral cultural exchange	0.158730

Measurement and normalization of index data

Data of quantitative indicators of the project in this section come from China statistical yearbook. Some of the indicators are qualitative indicators, mainly obtained through questionnaire survey and expert scoring. Through the calculation of index data in the background of Mongolia-Shandong/dc transmission project, the expert scoring method is adopted to normalize the index data. The comprehensive evaluation index data calculation and normalization results of this transnational network project are shown in the following table.

Table 4.The original date and normalization of the indicators

Indicators	Original date	normalization
Regional economic contribution value	494.6 Billion Yuan	0.91
Employment effects	535people	0.76
Electric reliability	81	0.81
Gross national happiness index	85	0.85
Bilateral economic relations	89	0.89
Bilateral political relations	93	0.93
Bilateral cultural exchange	78	0.78

Process of matter element extension evaluation

Evaluation criteria are the premise of quantitative evaluation. In this study, social evaluation indicators are divided into 5 grade criteria.

Table 5.Classical domain division of evaluation indicators

	N1	N2	N3	N4	N5
A11	(0,0.2)	(0.2,0.4)	(0.4,0.6)	(0.6,0.8)	(0.8,1)
A12	(0,0.2)	(0.2,0.4)	(0.4,0.6)	(0.6,0.8)	(0.8,1)
A21	(0,0.6)	(0.6,0.7)	(0.7,0.8)	(0.8,0.9)	(0.9,1)
A22	(0,0.6)	(0.6,0.7)	(0.7,0.8)	(0.8,0.9)	(0.9,1)
A31	(0,0.2)	(0.2,0.4)	(0.4,0.6)	(0.6,0.8)	(0.8,1)
A32	(0,0.2)	(0.2,0.4)	(0.4,0.6)	(0.6,0.8)	(0.8,1)
A33	(0,0.2)	(0.2,0.4)	(0.4,0.6)	(0.6,0.8)	(0.8,1)

By calculation, we get the distance between the indexes data of the matter elements to be evaluated and the classical domain.

Table 6. Distance between the indexes data of matter elements to be evaluated and the classical domain

	N1	N2	N3	N4	N5
A11	0.71	0.51	0.31	0.11	-0.09
A12	0.56	0.36	0.16	-0.04	0.04
A21	0.21	0.11	0.01	-0.01	0.09
A22	0.25	0.15	0.05	-0.05	0.05
A31	0.69	0.49	0.29	0.09	-0.09
A32	0.73	0.53	0.33	0.13	-0.07
A33	0.58	0.38	0.18	-0.02	0.02

The results of assessment and analysis

Table 7. Comprehensively evaluate the correlation degree of grade

K1	K2	K3	K4	K5
0.47	0.64	0.81	0.97	1.01

From the distance of the classical domain of social benefit indicators, the regional economic contribution value, bilateral economic relations and bilateral political relations are closer to N5, while the employment effect, electric reliability, gross national happiness index and bilateral cultural exchange are similar to N4.The overall index is within the range of

N4 and N5. So the social benefits of this transnational networking project are good.

From the overall evaluation results, the social benefits of this transnational networking project are good.

CONCLUSION AND RECONMMENDATION

This paper studies the index system of social benefit evaluation of transnational interconnected power grid project and establishes the index system of social benefit evaluation. Based on the existing social evaluation theory and matter-element extension evaluation model, a social evaluation method model for power grid construction projects is proposed. It provides new ideas and methods for practical application in the future. In terms of empirical research, the feasibility and effectiveness of the evaluation model are verified through analysis and calculation, and a more reasonable and reliable conclusion of project social benefit evaluation is obtained.

On the other hand, the following Suggestions are proposed for the social benefits of transnational interconnected power grid projects from the perspective of recipient countries.

(1) Recipient countries shall adopt reasonable ways to reduce operating costs. The formulation of the plan of online power transmission should proceed from the overall situation to realize the overall optimal allocation of resources.

(2) In order to obtain greater off-peak benefit, load prediction should be done well. Starting from the overall benefit of the interconnection power grid, reasonable arrangement of unit maintenance should be made to create conditions for obtaining greater off-peak benefit. [10]

(3) Power grid operation enterprises shall strengthen the operation management and maintenance of lines and equipment, promote the employment of equipment operation management and maintenance personnel, improve the operation level, ensure the reliability of power transmission, reduce losses caused by line failures, and increase the reliability rate of power supply to get more earnings.

(4) The government should make full use of the new capacity of power grid interconnection, attach importance to the exchanges of trade and culture between the two countries, and make the transnational network project play a real role in enhancing the relationship between the two countries. At the same time, it is necessary to do a good job in the investigation of whether the transnational networking project matches the current industry and is consistent with the current development strategy, so as to maximize the social benefits of the project.

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