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Effectiveness Evaluation of Financing Platform Operation of Buildings Energy Saving Transformation Using ANP-Fuzzy in China: An Empirical Study

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Abstract: Building energy saving transformation is an inevitable requirement to achieve sustainable development, which can bring considerable economic, environmental, and social benefits. The key to healthy development of the market lies in the orderly operation of the financing platform. The effectiveness of the financing platform depends on scientific evaluation. Therefore, it is necessary to design a set of systematic and practical evaluation indicators for operational effectiveness of the buildings energy saving transformation financing platform, so as to provide reference for the effective operation of the financing platform, and provide measurement means for scholars to conduct quantitative research on the financing platform. This paper analyzes the effectiveness evaluation content for the financing platform operation of buildings energy saving transformation from the two levels of operation mechanism and operation subject behavior. Combined with the particularity of the financing platform of building energy saving transformation, the operational effectiveness evaluation index system of the financing platform is designed from three levels. The Analytic Network Process (ANP) method is applied to construct network structure, to describe element correlation, and to calculate index weight. The fuzzy comprehensive evaluation (Fuzzy) method was used to carry out quantitative evaluation of qualitative indicators. The Energy Performance Contracting (EPC) financing platform in Beijing was taken as an example to make an empirical analysis. The results show that the operational effectiveness evaluation system of the financing platform of buildings energy saving transformation constructed in this paper has certain practicability. In this evaluation system, scores of target consistency, the degree of information sharing among departments and coordination of operation mechanism are low. Finally, some policy suggestions are put forward to optimize financing platform of buildings energy saving transformation in China.

Keywords: buildings energy saving; transformation; financing platform; ANP; fuzzy comprehensive evaluation; policy optimization

1. Introduction

Nowadays, the world is facing environmental challenges due to excessive energy consumption, a sharp increase of carbon emissions, and climate warming, and low carbon economy has become the hot topic of global concern. As an artificial environment, buildings are an important part of meeting human beings' material and spiritual needs. However, the excessive pursuit of sensory enjoyment and uncontrolled development and construction of modern buildings not only alienates the natural connection and communication between humans and nature, but also brings a heavy burden to the environment and resources. According to statistics, more than 50% of materials obtained by humans from nature are used to construct various kinds of buildings and ancillary facilities, which consume about 50% of the global energy in the process of construction and use. Among the

total environmental pollution, building-related air pollution, light pollution, and electromagnetic pollution accounted for 34%, buildings waste accounts for 40% of the total waste generated by human activities [1]. In developing countries, the surge of buildings has also led to land encroachment and ecological damage [2]. Building energy saving transformation is incorporated in the general WEF Nexus structure [3], which is conducive to reducing energy consumption, saving the use of land resources and water sources, reducing the pollution of soil, water and air, improving the quality of people's lives, promoting harmony between human beings and nature, and achieving sustainable development of construction industry.

At present, the international market of building energy saving transformation mostly adopts EPC as its main operation mode [2]. There are owner financing, ESCO financing, and third-party financing available in EPC financing [4]. However, problems such as imperfect systems, imperfect governance structures and a lack of supervision are common, which cannot give full play to the role of financing in the actual operation process. In addition, ESCO is a kind of profit-making professional company that provides services such as energy utilization status diagnosis, energy-saving project design, financing, transformation, operation management, etc., and provides specialized energy-saving technical services. An important problem that cannot be ignored is that EPC is very important for transferring investment opportunities, but most of the investment in the buildings energy saving transformation market is still self-financing for owners and energy services companies (ESCO), such as owners' personal savings or ESCO's own balance sheet. Therefore, it is difficult for self-owned funds to meet their own development needs, and this type of financing cannot achieve investment growth. An open and transparent financing platform is indispensable to enhance the confidence and ability of market subjects in building energy saving transformation and encourage more extensive investment. However, there is still a lack of an objective and effective evaluation mechanism for the financing platform of building energy saving transformation in academia. Deeply understanding the operation effect of financing platform and checking whether it meets anticipated goal of the buildings energy saving transformation project will help to measure the actual benefit and improvement space of the financing platform for buildings energy saving transformation, help to overcome financing difficulties and further improve target management plan. Buildings energy saving transformation has the characteristics of various projects, different investment scales, strong professionalism, and difficult to copy project evaluation models. Solar power in buildings is augmented by its nature as a public goods [5]. In addition, the transformation object involves tall buildings [5], city morphology [6], porous building materials [7], construction project impact [8] and other special circumstances, bank loan experience is difficult to reuse, loan risk is difficult to assess, and the cost of tracking and approval is too high, which leads to financing difficulties of ESCO, restrains the enthusiasm of subjects, and slow market development. In developing countries, ESCO is faced with many difficulties, such as imperfect laws, lack of technology and talents, huge financial pressure and poor credit evaluation system [9]. In order to solve the financing dilemma of buildings energy saving transformation projects, developed countries have implemented measures to optimize the financing environment, mainly from the two aspects of deepening existing financing system and innovative financing mode. The European Union (EU) provides financial subsidies, tax incentives and scientific research support in finance, and sets up green loans, zero-interest loans and preferential loans in bank loans [10]. For example, the German Renaissance Credit Bank gives discount loans, interest-free loans or low-interest loans for energy saving investment and energy saving technology opening projects, and the interest rate of energy saving transformation loans is 0.5% lower than that of ordinary commercial banks [11–13]. The French government reduced personal income tax on investment in energy saving and implemented zero-interest loans [14]. Developed countries innovate their financing modes by setting up special funds and EPC financing modes, such as the United State Energy Program (SEP) Funds [15], and German Kreditanstalt Fuer Wiederaufbau (KFW) Fund [16].

Up to now, scholars have conducted extensive and continuous research on the policies, risks, benefits, obstacles, and modes of financing for buildings energy saving transformation. Wang [17]

believed that a stable incentive policy could effectively reduce financing risk and cost of energy saving transformation. Bjorneboe [18] pointed out that there were many problems in financing process of buildings energy saving transformation, such as information, credit, guarantee and so on, which hinder the market development. Lee [2] found that ESCO faced financing obstacles such as insufficient state support, insufficient bank awareness, and imperfect information disclosure mechanism. Kragh [19] believed that a standardized financing platform could help achieve standardization of energy saving products. Gillich [20] explored the obstacles to the development of buildings energy saving transformation market in terms of financing difficulties, high management fees and high transaction fees. Economidou [21] believed that energy saving service market lacks strong legal means to restrain owners' behavior, and specialized financing platform is an effective way to strengthen the confidence of other subjects. Marino [22] revealed that ESCO uses financing platform to convert future earnings from energy saving transformation into financing collateral, but its pursuit of maximum benefits affects the normal operation of platform. Robinson [23] emphasized that credit issue is the core of energy saving service industry to get rid of financing dilemma. This is because EPC generally has credit risk that the owner cannot meet the energy saving share.

The existing research mainly focuses on the financing influencing factors of buildings energy saving transformation, and lacks the attention to operational effectiveness of financing platform. Based on this, this paper takes market operation effectiveness of buildings energy saving transformation as the breakthrough point, uses ANP-Fuzzy method to make theoretical and practical exploration on evaluation index system and evaluation method of the operation effectiveness of buildings energy saving transformation financing platform. This paper aims to introduce an integrated method using ANP-Fuzzy to deal with the key strategic variables of financing platform operation of buildings energy saving transformation. In addition, the evaluation index system of financing platform operation is constructed, and its feasibility and operability are verified. It provides theoretical reference for relevant scholars to conduct quantitative research on financing platform operation of buildings energy saving transformation, and provides practical reference for government to formulate financing planning for buildings energy saving transformation.

The remainder of this paper is structured as follows: Section 2 introduces ANP-Fuzzy method. Section 3 constructs the effectiveness evaluation index system. Section 4 is a case study. Section 5 further discusses the result.

2. Methods

The ANP-Fuzzy method is a comprehensive evaluation method that combines the network hierarchy analysis method with the fuzzy level evaluation method. The ANP method can reflect the interaction between system elements through a network structure in a complex decision system [24]. Fuzzy comprehensive evaluation can quantitatively evaluate qualitative indicators through fuzzy mathematics membership theory in complex decision-making [25]. The method from classification refinement evaluation to overall comprehensive evaluation, and the overall evaluation results are finally obtained after multi-level evaluation.

2.1. Construction of ANP Model

ANP is a new practical decision-making method based on Analytic Hierarchy Process (AHP) proposed by professor Saaty in 1990s. AHP expresses the relationship of elements in the system with a network structure rather than a simple hierarchical structure. Elements in the network layer can influence and dominate each other [26]. ANP is the improvement and extension of AHP. Both of them use 1-9 scale method to measure the importance of elements, and need to construct judgment matrix, solve the eigenvector after consistency detection, and finally determine the scheme order. However, the network structure of ANP is more complex than AHP. ANP has not only hierarchical structure, but also internal dependence and feedback structure. Although both are particular cases of Markov Chains, where the "Markovization" process leads to a more robust resolution of ANP priorities when

the selections are close, i.e., increased sensitivity. Therefore, ANP can more accurately describe the relationship between objective things [27], and it is a more effective decision-making method.

2.1.1. Constructing ANP-Typical Structure

The construction of ANP model firstly analyses the mutual influence among evaluation indexes, secondly constructs the ANP typical structure, and finally describes the correlation among elements. The ANP typical structure includes control layer and network layer [28]. The control layer, also known as the control criterion layer, is the highest criterion layer, and all criteria in the control layer are independent of each other [29]. The network layer consists of multiple element sets, which are not mutually dependent, but interrelated [30]. Figure 1 indicates the typical ANP structure.
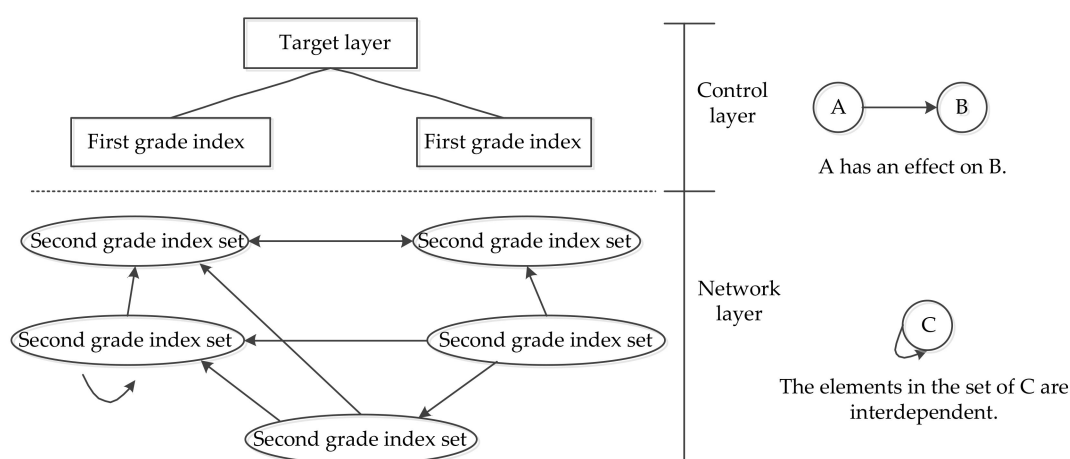

Figure 1. Typical ANP structure.

2.1.2. Determining Index Weight

The core work of ANP empowerment is to solve super matrix [31]. This is a complicated calculation process. Manual operation is very difficult. Super Decision (SD) software can solve this problem. The specific implementation steps are as follows:

1. Determine judgment matrix, construct initial super matrix and weighted super matrix. Based on the control layer elements, the structure of network layer is compared by using 1–9 scales (Table 1) Thus the judgment matrix and the eigenvector are formed [32,33].
2. According to CR = CI/RI, the consistency test of the judgment matrix is tested. If CR ≤ 0.1, the judgment matrix passes the consistency test. If CR ≥ 0.1, the judgment matrix is inconsistent and should be revised and adjusted.
3. The eigenvector generates the local weight vector matrix in matrix form, and finally forms initial super matrix.
4. Computing weighted super matrix.
5. Calculating limit super matrix.

Table 1. 1–9 Scaling method in judgment matrix.

Scale	Meaning Description
1	*i* and *j* are equally important
3	*i* is slightly more important than *j*
5	*i* is obviously more important than *j*
7	*i* is strongly important than *j*
9	*i* is extremely important than *j*
1,1/3,1/5,1/7,1/9	If the importance ratio of *i* to *j* is one of the above values, then the importance ratio of *j* to *i* is the reciprocal of *i*.

2.2. Construction of Fuzzy Comprehensive Evaluation Model

2.2.1. Establish Evaluation Object Sets and Factor Sets

Let the evaluation object set be $X = \{\chi_1, \chi_2, \cdots \chi_i\}$, the evaluation indicators set be $U = \{U_1, U_2 \cdots U_m\}$, break down each indicator U_i into several factors μ_{ij} ($U_i = \{\mu_{i1}, \mu_{i2}, \cdots \mu_{im}\}$), μ_{ij} represents the *j-th* factor of the *i-th* indicator (i $= 1, 2, \cdots$m;j $= 1, 2, \cdots$n).

2.2.2. Create Comment Sets

Assuming that there are h possible results of the total evaluation, the set of evaluation grades can be expressed as $V = \{v_1, v_2, \cdots v_h\}$, $v_k(k = 1, 2, \cdots, h)$ represents the total evaluation result of the *h-th* possibility.

2.2.3. Establish Weight Set

The weight indicates the importance of each indicator in the indicator system [34]. Multi-index comprehensive evaluation generally adopts subjective empowerment, objective empowerment or a combination of the two methods [35]. Suppose that the indicator weight U_i is A_i ($A_i = \{a_{i1}, a_{i2}, \cdots, a_{in}\}$), where a_{ij} is the weight within the group of U_i relative to μ_{ij}, and $\sum_{i}^{n} a_{ij} = 1$.

2.2.4. First-Level Fuzzy Comprehensive Evaluation

First, each factor U_i was evaluated separately according to the evaluation set to determine the membership degree of each indicator to the evaluation grade, and obtained the relational matrix:

$$R_i = \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1h} \\ r_{i21} & r_{i21} & \cdots & r_{i2h} \\ \vdots & \vdots & \ddots & \vdots \\ r_{in1} & r_{in2} & \cdots & r_{inh} \end{bmatrix} (1, 2, \cdots m)$$ which r_{ijk} represents the membership degree of indicator U_i to comment v_k from factor u_{ij}. The performance of indicator U_i in factoris u_{ij} described by fuzzy vector r_{ij}.

Secondly, the weight vector $A_i = \{a_{i1}, a_{i2}, \cdots, a_{in}\}$ of the index U_i is multiplied by the relationship matrix R_i to obtain the comprehensive evaluation result vector of the index U_i.

$$B_i = A_i \times R_i = (a_{i1}, a_{i2}, \cdots, a_{in}) \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1h} \\ r_{i21} & r_{i21} & \cdots & r_{i2h} \\ \vdots & \vdots & \ddots & \vdots \\ r_{in1} & r_{in2} & \cdots & r_{inh} \end{bmatrix} = (b_{i1}, b_{i2}, \cdots b_{in}).$$

2.2.5. Multi-Level Fuzzy Comprehensive Evaluation

It is assumed that the single index fuzzy evaluation is the first level fuzzy comprehensive evaluation, and the comprehensive evaluation matrix of second level fuzzy comprehensive evaluation is the vector composition matrix of the results of each level fuzzy comprehensive evaluation [36,37].

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \cdots \\ B_m \end{bmatrix} = \begin{bmatrix} A_1 \cdot R_1 \\ A_2 \cdot R_2 \\ \cdots \\ A_m \cdot R_m \end{bmatrix} = (r_{ik}) \, m \times h, \, r_{ik} = b_{ik} \, (i = 1, 2, \cdots m; k = 1, 2, \cdots, h).$$ The vector of

the result of the second-level fuzzy comprehensive evaluation is the product of the above index weight vector and the second-level fuzzy comprehensive evaluation matrix, that is $B = A \cdot R =$

$$A \begin{bmatrix} A_1 \cdot R_1 \\ A_2 \cdot R_2 \\ \cdots \\ A_m \cdot R_m \end{bmatrix} = (b_1, b_2, \cdots, b_h).$$ Similarly, the results of multi-level fuzzy comprehensive evaluation

are obtained.

2.2.6. Comprehensive Judgment of Evaluation Result

Because fuzzy comprehensive evaluation is a vector, for the multi-level fuzzy comprehensive evaluation involving multiple indexes, the evaluation result vector is generally uniformization, in order to facilitate the comparison of evaluation results and make full use of information brought by the result vector [38]. That is, assigning values to each evaluation grade in the comment set, and then

multiply them by component vectors in result vector B to get the weighted value. $C = \dfrac{\sum_{k=1}^{h} b_k^p c_k}{\sum_{k=1}^{h} b_k^p}$. P is the

undetermined coefficient and the general value is 1.

3. Construction of Effectiveness Evaluation Index System of the Financing Platform Operation for Buildings Energy Saving Transformation

3.1. Principles of Index System Construction

(1) Scientific and reasonable. This principle requires a scientific generalization hierarchy, reflecting as much as possible the key content of the evaluation system, with strong representation and large amount of information, so as to reasonably describe, analyze and evaluate key issues [39,40].

(2) Systematic. This principle requires that the index system reflect various factors that may have an impact on the evaluation object. In addition, the refinement of evaluation indicators must be logical, statistical indicators can complement each other, lower indicators and higher indicators have levels, so as to achieve a balanced and unified evaluation system

(3) Reliability. This principle requires that the evaluation index system must conform to objective facts, and each index can be easily measured and calculated [41]. Financial indicators should be supported by authoritative data and non-financial indicators should be scientifically determined, such as through scientific research or expert evaluation

(4) Combination of quantitative and qualitative indicators. This principle requires that the selection of evaluation indicators include not only quantitative analysis indicators, but also qualitative analysis indicators, while minimizing the impact of subjective factors [42].

(5) Testability. This principle requires that the index system be concise and easy to understand and data collection, evaluation results can be obtained more quickly. In order to ensure the comparability between indicators, the same type of indicators need to be unified sources, different types of indicators can be quantified, easy to calculate and compare [43].

3.2. Analysis of Evaluation Content

The operational effectiveness of a financing platform for buildings energy saving transformation depends on the extent to which it improves the financing efficiency of buildings energy saving transformation project and promotes the financing practice of buildings energy saving transformation. In order to solve the difficulty of project financing, a comprehensive investigation of the operating

benefits and efficiency of the financing platform is carried out. Compared with the general financing platform, the main difference between the financing platforms for buildings energy saving transformation is the diversity of financing subjects and the complexity of the financing implementation process [44,45]. Building particularities play a role in platform operation and a pre-entry building analysis based on BIM/BMS would be useful [46,47]. Therefore, drawing on the relevant theories of general financing platform evaluation, considering the particularity of buildings energy saving transformation financing platform [48–50], the connotation of the operational effectiveness of buildings energy saving transformation financing platform includes two meanings: the effectiveness of the operational mechanism and the effectiveness of the operational subject. Specifically, the effectiveness of the operational mechanism implementation mainly examines the degree of the system's operational objectives and the degree of advancement of buildings energy saving transformation market development. The comprehensiveness of the operational mechanism, that is, the degree of cooperation and feedback between various operational mechanisms. Coordination of operational processes, that is, linkage of various links in the operation process. The compatibility of the operating mechanism with the market environment, that is, the update and adjustment of the operating mechanism market development, and the policy differences for different market environment changes. The effectiveness of operation subject behavior mainly examines the enthusiasm of the energy-using unit, the development of the ESCO, and input and output of the investor's participation in the financing platform. The development of ESCO, that is, the extent to which ESCO's economic strength, technical level, and reputation have an impact on the platform operational efficiency. Investor enthusiasm, that is, the degree of active efforts of market supply entities. The cooperation between the subjects, that is, the cooperation between the subjects is good or not.

3.3. Construction of Evaluation Index System

In order to ensure that the evaluation results can effectively reflect the objective reality, this study adheres to the system's comprehensive and scientific principles, according to the content analysis of the effectiveness evaluation of the financing platform to sort out the existing research results. Through sorting out, classifying, deleting, and refining the evaluation indexes, we preliminarily obtain the effectiveness evaluation index system structure of financing platform. On this basis, the expert consultation method is used to consult 10 experts from enterprises, building energy saving consultation institutions and universities, determining the content of evaluation index system and ultimately to construct an effectiveness evaluation index system structure of buildings energy saving transformation financing platform is shown in Table 2.

Table 2. Evaluation index system structure.

Target Layer	First Grade Index	Second Grade Index	Third Grade Index
Effectiveness of financing platform for buildings energy saving transformation	Effectiveness of operating mechanism implementation	Systematization of operating objectives [49]	Target consistency [46]
			Efficiency of platform organization and management
			Degree of information sharing among departments [10]
		Comprehensiveness of operation mechanism	Coordination of operation mechanism
			Diversity of mechanism functions [12]
			Effectiveness of feedback mechanism [48]
		Coordination of operation process	Rationality of operation process
			Linkage of operation links
		Compatibility between operating mechanism and market environment	Dynamic change of operating process
			Differences in operating mechanism
	Effectiveness of operation subject's behavior	Development of ESCO	ESCO's economic strength [39]
			ESCO's technical level
			ESCO's market credit
		Energy saving enthusiasm of owners	Demand for energy saving transformation of owners
			Proportion of owner's investment [20]
		Investor enthusiasm	Investor's willingness to invest [17]
			Investor's income distribution ratio [29]
		Cooperation among subjects	Trust level among operating subjects
			Benefit sharing ratio of energy saving transformation
			Input of operating mechanism and supporting funds
			Risk sharing ratio of energy saving transformation [46]

4. Case Study

Energy Performance Contracting Financing Trading Platform in Beijing was officially launched on June 6, 2010. It is the first platform to publicly list EPC as a trading category in the world. With the help of third-party investment, this platform breaks the bottleneck of insufficient self-owned funds and long turnover period of ESCO, connects energy saving service industry with financial industry, integrates relevant resources, and fully exchanges project information and investor information on the platform through value-added services. This platform is an important measure to accelerate EPC

by using market mechanism, and a powerful tool to promote energy saving and emission reduction by means of financial innovation. It is of great significance to develop the buildings energy saving transformation market, and build an environment-friendly and resource-conserving society. In the development process of nearly ten years, the platform has made some achievements. However, from the perspective of operational effectiveness of the platform, due to the late establishment, few listing and trading projects, and the lack of experience in operation of the platform, the comprehensive benefits of the financing platform are restricted. One problem that cannot be ignored is that due to the lack of a sound regulatory mechanism and tax mechanism in the market, the integrity environment within the platform is poor, which directly affects normal operation of the financing platform. Therefore, based on the contract amount concluded within the platform from June 2010 to June 2019, this paper evaluates operational effectiveness of financing platform for buildings energy saving transformation.

4.1. ANP Structure for Effectiveness Evaluation of Financing Platform Operation

In the process of constructing the indicator system, only the evaluation indicators are identified. To establish the ANP model, it is necessary to study the feedback and dependence between the evaluation indicators [51]. The correlation of the research indicators was obtained in the form of a two-dimensional table through expert questionnaires. By analyzing the mutual influence relationship among each evaluation index for financing platform operational effectiveness of buildings energy saving transformation, the ANP typical structure is constructed and the elemental relevance is described [52], as shown as in Figure 2.
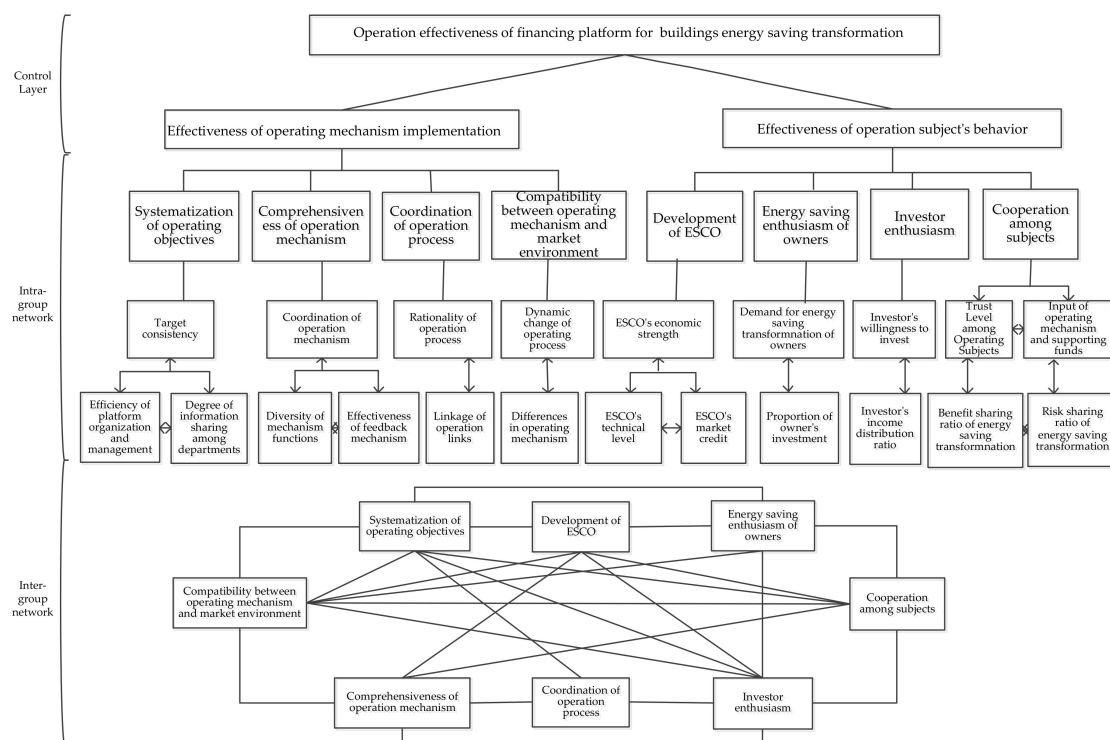

Figure 2. ANP structure.

4.2. Empowerment of Evaluation Indicators Based on ANP

The relationship between each group and each node in the ANP structure is input into the SD software, and ten industry experts are invited to score the importance of each index according to the 1–9 scale method, and the score results are sorted and input into the software (Figure 3). The ten experts in this paper are composed of six professors who are engaged in the research of building energy saving in universities and four staff members who have more than five years' experience in energy

saving service companies. Using the software to obtain super matrix, the matrix consistency test result is 0.0960 < 0.1, indicating that the super matrix has good consistency, as shown in Figure 4.

Figure 3. An example of SD software scoring interface.
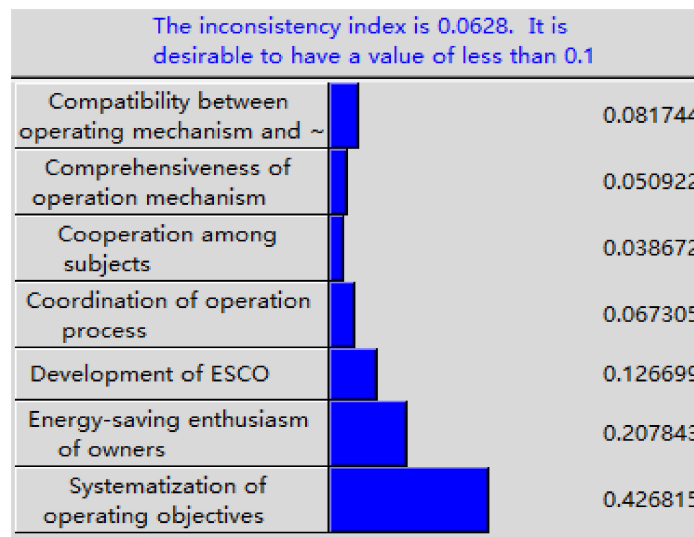

Figure 4. Consistency test results of SD software.

The SD software is used to obtain the objective weight (Figure 5), and the weights in group are obtained by using the formula: Intra-group weight = (the objective weight of the third grade index under the second grade index)/(the sum of all the three grade index of the second grade index) [53]. The weight results are sorted and the final calculation results of the index weights at all levels are obtained in Table 3.

Here are the priorities.			
Icon	Name	Normalized by Cluster	Limiting
No Icon	Target consistency	0.30656	0.040751
No Icon	Efficiency of platform organization and managem~	0.34479	0.045832
No Icon	Degree of information sharing among departments	0.34865	0.046345
No Icon	Coordination of operation mechanism	0.33381	0.044373
No Icon	Diversity of mechanism functions	0.32361	0.043017
No Icon	Effectiveness of feedback mechanism	0.34258	0.045539
No Icon	Rationality of operation process	0.56502	0.075107
No Icon	Linkage of operation links	0.43498	0.057821
No Icon	Dynamic change of operating process	0.51772	0.068820
No Icon	Differences in operating mechanism	0.48228	0.064108
No Icon	ESCO's economic strength	0.34042	0.026861
No Icon	ESCO's technical level	0.34042	0.026861
No Icon	ESCO's market credit	0.31916	0.025184
No Icon	Demand for energy saving reconstruction of owners	0.48198	0.064069
No Icon	Proportion of owner's investment	0.51802	0.068860
No Icon	Investor's willingness to invest	0.50000	0.061762

Figure 5. Calculating results of third grade index weight of SD software.

Table 3. The effectiveness evaluation index weights.

Target Layer	First Grade Index	Second Grade Index	Third Grade Index	Intra-Group Weight	Objective Weight
Effectiveness of financing platform for buildings energy saving transformation	Effectiveness of operating mechanism implementation 0.4722	Systematization of operating objectives 0.2084	Target consistency	0.3070	0.0408
			Efficiency of platform organization and management	0.3446	0.0458
			Degree of information sharing among departments	0.3484	0.0463
		Comprehensiveness of operation mechanism 0.2916	Coordination of operation mechanism	0.3336	0.0443
			Diversity of mechanism functions	0.3237	0.0430
			Effectiveness of feedback mechanism	0.3426	0.0455
		Coordination of operation process 0.2500	Rationality of operation process	0.5651	0.0751
			Linkage of operation links	0.4349	0.0578
		Compatibility between operating mechanism and market environment 0.2500	Dynamic change of operating process	0.5177	0.0688
			Differences in operating mechanism	0.4823	0.0641
	Effectiveness of operation subject's behavior 0.5278	Development of ESCO 0.2376	ESCO's economic strength	0.3440	0.0268
			ESCO's technical level	0.3440	0.0268
			ESCO's market credit	0.3220	0.0251
		Energy-saving enthusiasm of owners 0.2469	Demand for energy saving transformation of owners	0.4816	0.0640
			Proportion of owner's investment	0.5184	0.0689
		Investor enthusiasm 0.2907	Investor's willingness to invest	0.4996	0.0617
			Investor's income distribution ratio	0.5004	0.0618
		Cooperation among subjects 0.2248	Trust level among operating subjects	0.2380	0.0398
			Benefit sharing ratio of energy saving transformation	0.2500	0.0418
			Input of operating mechanism and supporting funds	0.2614	0.0437
			Risk sharing ratio of energy saving transformation	0.2506	0.0419

4.3. Fuzzy Comprehensive Evaluation

4.3.1. Establish Factor Sets and Weight Sets for Evaluation

Build a set of factors $U = \{u_1, u_2, \cdots u_{21}\}$ divide U into two subsets of U_1, $U_2 \cdot U_1$ indicates the effectiveness of operating mechanism implementation, and U_2 indicates the effectiveness of operation subject's behavior. Among them, $U_1 = \{U_{11}, U_{12}, U_{13}, U_{14}\}$ $U_2 = \{U_{21}, U_{22}, U_{23}, U_{24}\}$ U_{11}, U_{12}, U_{13}, U_{14}, U_{21}, U_{22}, U_{23}, U_{24}, are second grade index. $U_{11} = \{u_1, u_2, u_3\}$ $U_{12} = \{u_4, u_5, u_6\}$ $U_{13} = \{u_7, u_8\}$ $U_{14} = \{u_9, u_{10}\}$ $U_{21} = \{u_{11}, u_{12}\}$ $U_{22} = \{u_{13}, u_{14}, u_{15}\}$ $U_{23} = \{u_{16}, u_{17}\}$ $U_{24} = \{u_{18}, u_{19}, u_{20}, u_{21}\}$. Among them, u_i ($i = 1, 2, \cdots 21$) is first grade index.

According to the results of the index weights obtained above, the evaluation index weights are obtained: $W = (0.472\,2, 0.527\,8)$ $W_1 = (0.208\,4, 0.291\,6, 0.250\,0, 0.250\,0)$ $W_2 = (0.237\,6, 0.246\,9, 0.290\,7, 0.224\,8)$ $W_{11} = (0.307\,0, 0.344\,6, 0.348\,4)$ $W_{12} = (0.333\,6, 0.323\,7, 0.342\,6)$ $W_{13} = (0.565\,1, 0.434\,9)$ $W_{14} = (0.517\,7, 0.482\,3)$ $W_{21} = (0.344\,0, 0.344\,0, 0.322\,0)$ $W_{22} = (0.481\,6, 0.518\,4)$ $W_{23} = (0.499\,6, 0.500\,4)$ $W_{24} (0.238\,0, 0.250\,0, 0.261\,4, 0.250\,6)$.

4.3.2. Establish a Platform Operation Effectiveness Review Set

The evaluation object of the review set is the operation effect of the financing platform for the energy saving transformation. Hypothesis commentary set is V {very good, good, average, poor, very poor}. The review set can reflect the platform effectiveness [54].

4.3.3. First-Level Fuzzy Comprehensive Evaluation

Inviting 10 industry experts to be divided into operational efficiency indicators of the energy saving transformation financing platforms, score the results, and obtain the following single-factor fuzzy evaluation matrix:

$$R_{11} = \begin{bmatrix} 0.15 & 0.2 & 0.3 & 0.25 & 0.1 \\ 0.1 & 0.3 & 0.35 & 0.25 & 0 \\ 0.15 & 0.35 & 0.25 & 0.2 & 0.05 \end{bmatrix} \quad R_{12} \begin{bmatrix} 0.2 & 0.35 & 0.2 & 0.1 & 0.05 \\ 0.25 & 0.25 & 0.3 & 0.15 & 0.05 \\ 0.3 & 0.25 & 0.35 & 0.05 & 0.05 \end{bmatrix}$$

$$R_{13} = \begin{bmatrix} 0.15 & 0.2 & 0.35 & 0.2 & 0.1 \\ 0.1 & 0.2 & 0.3 & 0.25 & 0.15 \end{bmatrix} \quad R_{14} = \begin{bmatrix} 0.2 & 0.2 & 0.35 & 0.2 & 0.05 \\ 0.3 & 0.25 & 0.3 & 0.15 & 0 \end{bmatrix}$$

$$R_{21} = \begin{bmatrix} 0.3 & 0.35 & 0.2 & 0.1 & 0.05 \\ 0.2 & 0.25 & 0.3 & 0.1 & 0.15 \end{bmatrix} \quad R_{22} = \begin{bmatrix} 0.1 & 0.25 & 0.3 & 0.3 & 0.05 \\ 0.25 & 0.15 & 0.4 & 0.1 & 0.1 \\ 0.05 & 0.25 & 0.3 & 0.25 & 0.15 \end{bmatrix}$$

$$R_{23} = \begin{bmatrix} 0.35 & 0.25 & 0.2 & 0.15 & 0.05 \\ 0.15 & 0.2 & 0.3 & 0.25 & 0.1 \end{bmatrix} \quad R_{24} = \begin{bmatrix} 0.3 & 0.35 & 0.2 & 0.1 & 0.05 \\ 0.25 & 0.25 & 0.3 & 0.1 & 0.1 \\ 0.2 & 0.3 & 0.15 & 0.15 & 0.2 \\ 0.3 & 0.25 & 0.25 & 0.15 & 0.05 \end{bmatrix}$$

Using the $M\ (\cdot, +)$ fuzzy algorithm to perform the synthesis operation, we get:

$$\begin{aligned} R_{11} = W_{11} \cdot R_{11} &= (0.307\,0, 0.344\,6, 0.348\,4) \begin{bmatrix} 0.15 & 0.2 & 0.3 & 0.25 & 0.1 \\ 0.1 & 0.3 & 0.35 & 0.25 & 0 \\ 0.15 & 0.35 & 0.25 & 0.2 & 0.05 \end{bmatrix} \\ &= (0.132\,8, 0.286\,8, 0.299\,9, 0.232\,6, 0.063\,5) \end{aligned}$$

By the same logic, we can get

$$B_{12} = W_{12} \cdot R_{12} = (0.250\ 4,\ 0.283\ 3,\ 0.283\ 7,\ 0.099\ 0,\ 0.050\ 5)$$
$$B_{13} = W_{13} \cdot R_{13} = (0.256\ 5,\ 0.306\ 5,\ 0.156\ 5,\ 0.100\ 0,\ 0.093\ 6)$$
$$B_{14} = W_{14} \cdot R_{14} = (0.248\ 2,\ 0.224\ 1,\ 0.325\ 9,\ 0.175\ 9,\ 0.025\ 9)$$
$$B_{21} = W_{21} \cdot R_{21} = (0.136\ 5,\ 0.218\ 1,\ 0.337\ 4,\ 0.218\ 1,\ 0.099\ 9)$$
$$B_{22} = W_{22} \cdot R_{22} = (0.2482,\ 0.298\ 2,\ 0.251\ 8,\ 0.100\ 0,\ 0.1018\ )$$
$$B_{23} = W_{23} \cdot R_{23} = (0.250\ 0,\ 0.225\ 0,\ 0.250\ 0,\ 0.200\ 0,\ 0.075\ 0)$$
$$B_{24} = W_{24} \cdot R_{24} = (0.261\ 4,\ 0.286\ 9,\ 0.224\ 5,\ 0.125\ 6,\ 0.101\ 7)$$

4.3.4. Second-Level Fuzzy Comprehensive Evaluation

According to the above first-level fuzzy comprehensive evaluation results, the second-level fuzzy comprehensive synthesis operation is also carried out by using the $M\ (\cdot, +)$ synthesis algorithm.

$$B_1 = W_1 \cdot R_1 = W_1 \begin{bmatrix} B_{11} \\ B_{12} \\ B_{13} \\ B_{14} \end{bmatrix} =$$

$$(0.208\ 4,\ 0.291\ 6,\ 0.250\ 0,\ 0.250\ 0) \begin{bmatrix} 0.132\ 8 & 0.286\ 8 & 0.299\ 9 & 0.232\ 6 & 0.063\ 5 \\ 0.250\ 4 & 0.283\ 3 & 0.283\ 7 & 0.099\ 0 & 0.050\ 5 \\ 0.256\ 5 & 0.306\ 5 & 0.306\ 5 & 0.100\ 0 & 0.093\ 5 \\ 0.248\ 2 & 0.224\ 1 & 0.325\ 9 & 0.175\ 9 & 0.0259 \end{bmatrix}$$
$$= (0.226\ 9,\ 0.275\ 0,\ 0.251\ 8,\ 0.146\ 3,\ 0.057\ 8)$$

By the same logic, we can get

$$B_2 = W_2 \cdot R_2 = W_2 \begin{bmatrix} B_{21} \\ B_{22} \\ B_{23} \\ B_{24} \end{bmatrix}$$

$$= (0.237\ 6,\ 0.246\ 9,\ 0.290\ 7,\ 0.224\ 8) \begin{bmatrix} 0.136\ 5 & 0.218\ 1 & 0.337\ 4 & 0.218\ 1 & 0.099\ 9 \\ 0.248\ 2 & 0.298\ 2 & 0.251\ 8 & 0.100\ 0 & 0.101\ 8 \\ 0.250\ 0 & 0.225\ 0 & 0.250\ 0 & 0.200\ 0 & 0.075\ 0 \\ 0.261\ 4 & 0.286\ 9 & 0.224\ 5 & 0.125\ 6 & 0.101\ 7 \end{bmatrix}$$
$$= (0.225\ 2,\ 0.255\ 3,\ 0.265\ 5,\ 0.162\ 8,\ 0.093\ 5)$$

4.3.5. Third-Level Fuzzy Comprehensive Evaluation

Based on the above results, the effectiveness evaluation set of the financing platform operation of the buildings energy saving transformation can be obtained as follows:

$$B = W \cdot R = (0.472\ 2,\ 0.527\ 8) \begin{bmatrix} 0.226\ 9 & 0.275\ 0 & 0.251\ 8 & 0.146\ 3 & 0.057\ 8 \\ 0.225\ 2 & 0.255\ 3 & 0.265\ 5 & 0.162\ 8 & 0.093\ 5 \end{bmatrix}$$
$$= (0.226\ 1,\ 0.191\ 4,\ 0.258\ 3,\ 0.154\ 1,\ 0.074\ 7)$$

4.4. Comprehensive Judgment of Evaluation Results

According to the evaluation result B, the factors in the evaluation set V are quantified and assigned to 100, 80, 60, 40, and 20 respectively. The weighted average formula is $V = 0.226\ 0 \times 100 + 0.264\ 6 \times 80 + 0.259\ 0 \times 60 + 0.155\ 0 \times 40 + 0.076\ 6 \times 20 = 67.04$.

Furthermore, the fuzzy comprehensive evaluation values of all levels of indicators are calculated, and the fuzzy evaluation values of third grade index under second grade index are obtained. $V_{11} =$

64.792, $V_{12} = 69.096$, $V_{13} = 63.653\,5$, $V_{14} = 69.856$, $V_{21} = 62.064$, $V_{22} = 69.82$, $V_{23} = 67.5$, $V_{24} = 69.62$. Among them, the scores of V_{11}, V_{13} and V_{21} are all lower than the comprehensive evaluation value.

5. Discussion

The effectiveness evaluation result of the financing platform operation for buildings energy saving transformation in Beijing was 67.04, which was between "average" and "good" and inclined to "average". Judging from the evaluation results, although the financing platform has achieved certain results, from the perspective of the overall development of the buildings energy saving transformation market, the platform operation effect is not significant, and there is still much room for optimization. According to the actual situation of the buildings energy saving transformation market development, the operation of the financing platform is in the stage of continuous exploration, the demand for the financing platform is also in the stage of continuous development, and the evaluation results are basically consistent with the actual situation of the platform operation.

According to the above research results can be obtained, to improve the level of buildings energy saving transformation market development and financing platform operation effect, can run to improving the systematization of operating objectives and the coordination of operation process two aspects promote effectiveness, from improving the enthusiasm of owners' energy saving enthusiasm to save energy to enhance the effectiveness of operation subject behavior. Specific optimization suggestions are as follows:

1. Improve the information management system and standardize the platform-operating environment. First, develop an information sharing system to make the financing platform an interactive channel and resource-sharing platform for energy saving information. The energy saving information is more timely and accurate feedback to all participants. Under the integration of resources, the financing platform becomes the cooperation medium between the owners and ESCOs. Secondly, establish an information rating system to break the market information asymmetry and reduce the information status difference between the owners and ESCOs. Owners can better understand ESCO credit information and save on the cost of evaluating corporate credit. ESCO can reach deals with owners based on lower costs, increase trust between subjects, and lay the foundation for cooperation. Finally, establish a standardized management and monitoring system for transaction information to ensure the fairness and order of the project financing transaction market, help to create a cooperative environment of mutual trust, and attract more participants to actively participate in the platform construction. Through the information management system, improve market transparency and create a good market competition environment.

2. Enhance the owner's enthusiasm for energy saving and expand the scale of platform transactions. The owner is the subject of buildings energy saving transformation and provides endogenous power for market development. That is to say, the demand of the owner determines the market size. First, the government should continuously strengthen the implementation of incentive policies, provide more powerful external support for the owners to implement energy saving transformation, avoids failure of the owners to worry about the investment due to excessive transformation costs, and guide more owners to participate in the construction of the platform. Thereby expanding the source of funds and playing a greater role in the financing platform. Second, innovative financing products, such as future earnings securitization, carbon trading, energy-saving income bonds, etc. will expand the scale of platform trading. Deeply understand market demand, promote the diversification of platform functions, achieve scale effect, promote platform development, and improve the success rate of financing. Thirdly, change the owner's consumption concept and enhance the owner's social responsibility consciousness. Owners should actively respond to the call of the national low-carbon policy, change consumption concepts, establish a green low-carbon consumption concept, and enhance social responsibility awareness.

3. Optimizing the systematization of operational objectives is in line with the development trend of the platform. First of all, we should pay attention to the impact of changes in national policy

environment, the changes of demand of the main body of operation, the level of development of related industries, and energy saving technological innovations on the overall development of the platform. According to those, the optimization system is adjusted to adapt to the dynamic development characteristics of the market. Secondly, from the perspective of improving the system of optimization objectives, we can improve the degree of inter-organizational information interaction, enhance the efficiency of organizational management and the consistency of optimization objectives among the subjects by building an energy saving management information exchange platform. Finally, pay attention to the optimization of links, in-depth market research, feedback of optimization effect, to avoid occurrence of optimization process segmentation.

6. Conclusions

In this paper, from the perspective of the effectiveness of operation mechanism implementation and the effectiveness of operation subject's behavior for building energy saving transformation market, considering factors such as platform organization and management efficiency, target consistency, information sharing degree, establishing an evaluation index system for operation effectiveness of existing building energy saving transformation financing platform, analyzing the interaction between indicators, using ANP to determine the weight of indicators, and combine qualitative and quantitative analysis, building a multi-level fuzzy comprehensive evaluation model. According to the results of an empirical study, on the basis of Section 5. Discussion, the following suggestions are put forward to provide theoretical reference for optimizing the buildings energy saving transformation financing platform and promote the development of buildings energy saving transformation market in China.

1   Improve the cooperation between subjects and improve operation efficiency of the platform. The operation of financing platform needs to be based on a certain relationship framework. In order to optimize the subject' cooperation relationship, it is necessary to strengthen the level of information sharing among the platform operators, such as establish the information exchange platform, the information sharing mechanism and feedback mechanism, so as to improve the trust between the subjects and lay the foundation for their cooperation. At the same time, corresponding management policies should also be formulated for the stability of the cooperation between the subjects to ensure the stability and long-term of the cooperation, such as guarantee mechanism, reputation rating mechanism, etc. It can also help to optimize the institutionalization and legalization of cooperative relations through other ways.

2   Pay attention to the formulation and implementation of financing guarantee policies for building energy saving transformation. Because of the differences in the characteristics and laws of different financing subjects in economic activities, it is necessary for the state to establish buildings energy saving transformation project financing guarantee policy system from system level. On the one hand, the government should improve existing laws and regulations and basic policy planning, establish specific safeguard measures and policy evaluation methods, and create a good environment for project financing. On the other hand, we should strengthen the application of insurance strategy. Through the establishment of perfect insurance policies, the implementation of various insurance strategies, according to the different nature and types of enterprises to develop targeted insurance strategies, reduce the risk coefficient of project financing failure. According to the different nature and types of enterprises, government should make targeted insurance strategies to reduce the risk coefficient of project financing failure. This can not only improve the cost-effectiveness of project financing, but also ensure that investors can safely invest the funds into the financing platform, and provide more sufficient financial support for the existing building energy saving transformation projects.

3   Strengthen the capital management of buildings energy saving transformation financing platform, and improve the cost-effectiveness of project financing. After the EPC project is completed, the financing platform shall repay the principal and interest to the investors in time according to relevant contract, so as to improve social reputation of the financing platform. At the same time,

the financing platform should also strengthen management of the asset pool, determine the cash flow during project operation, strengthen the management of idle funds, and take effective measures to ensure the maintenance and appreciation of the invested capital through the energy measurement and audit of buildings energy saving transformation project.

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