Research on Energy Data Price Evaluation Index Based on Analytic Hierarchy Process

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Abstract. Currently, the pricing of energy data products has not yet formed a relatively mature research result, which greatly restricts the development of the energy digital economy. This article starts with the factors that affect energy data prices, constructs an energy data price evaluation index system that covers the dimensions of data quality and data application value, and calculates the weight of the index based on Analytic Hierarchy Process, providing reference for energy data pricing.

Keywords: Energy data; Analytic Hierarchy Process; Evaluation index

1 Introduction

Currently, data has become a fundamental resource, important productivity, and key production factor in the digital economy era [1]. With the construction and operation of energy big data centers in various provinces, the demand for energy data trading is becoming increasingly urgent [2]. However, there is currently no mature research results on the pricing of energy data products, which greatly restricts the development of the energy digital economy. This article starts with the factors that affect energy data prices and constructs a price evaluation index suitable for energy data, providing reference for energy data pricing.

2 Data price evaluation indicators

At present, some research institutions have conducted research on the influencing factors of data prices, such as the China Institute of Information [3] and Communications, well-known foreign research institutions Gartner [4], and Alibaba Research Institute, from different perspectives, and have classified the influencing factors of data prices.

Comprehensive reference to the above research and digital economics, data pricing related research [5-11], we classify the influencing factors of data prices into two categories: data quality and data application value.

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2.1 Data quality evaluation indicators

Data quality is an analysis of the factors that affect data prices from the perspective of the data itself, mainly including data integrity, uniqueness, accuracy, and consistency.

(1) Integrity

Describe the completeness dimension of data, including the completeness of data fields and data volumes that contain information. The situation of missing data may be due to the missing record of the entire data, or it may be due to the missing record of a certain field in the data.

(2) Uniqueness

Used to measure which data is duplicate or which attributes of data are duplicate. For example, a person can only have a unique ID number.

(3) Accuracy

Describe whether the data is consistent with the characteristics of its corresponding objective entity, and whether the data format, length, and value should comply with specific data formats and value ranges. For example, the ID number number should be 18 digits without punctuation.

(4) Consistency

Describe whether the values of the same attribute of the same entity are consistent across different datasets. Is there any difference or contradiction in the same data within each independent business system.

2.2 Data Application Value Evaluation Indicators

The application value of data is a reflection of its value. The application value of data varies depending on the industry and application scenarios. This article evaluates it from four dimensions: scarcity, timeliness, multi-dimensionality, and scenario economy.

(1) Scarcity

Scarcity refers to the richness of a certain type of data in the data trading market. Generally speaking, the rarer the data, the higher the value of this type of data.

(2) Timeliness

Timeliness refers to the degree to which the time provided by data satisfies the application. Different applications have different requirements for the time limit for providing data.

(3) Multidimensional nature

Multidimensionality refers to the richness of the dimensions of a dataset. Generally speaking, the more dimensions of data, the higher the value.

(4) Scenario Economy

Scenario economy refers to the economic value obtained by data in scenario applications. The value of data may vary depending on the scenario, and it is necessary to evaluate the value of data based on specific scenarios.

The evaluation of dimensions such as data scarcity, timeliness, multi-dimensionality, and scenario economy is different from the evaluation of data quality. There is no specific measurement standard, and the application value evaluation is

mainly based on the experience of experts. Therefore, this article uses expert scoring method to evaluate the application value of data.

The expert scoring method is to first anonymously solicit the opinions of all experts on the question, and then collect and organize the comprehensive opinions. Then feedback the comprehensive opinions to each expert and seek their opinions again. Each expert will modify their own opinions based on the comprehensive opinions and then summarize them. After multiple rounds of anonymous consultation and feedback, the final result was formed. The final results of each expert were based on the opinions of other experts, and the results were relatively reasonable.

3 Weights of energy data price evaluation indicators

3.1 Determination of weights for energy data price evaluation indicators based on Analytic Hierarchy Process

This article selects the Analytic Hierarchy Process to determine the weight of energy data price evaluation indicators [11-12]. This method mainly works from the following five aspects:

(1) Build a hierarchical structure. Based on the evaluation object, construct a hierarchical structure that includes target layer, criterion layer, and indicator layer.

(2) Build a judgment matrix. Use the 1-9 scale method and expert scoring method to determine the importance of evaluation indicators at the same level, and construct a judgment matrix.

(3) Conduct hierarchical single sorting. Calculate the weights of each indicator in the same layer against the indicators in the previous layer based on the judgment matrix.

1) Calculate the maximum eigenvalue λ_{max} of the judgment matrix and the normalized eigenvector W.

2) Conduct consistency checks. The formula is as follows:

$$CR = CI / RI \tag{1}$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

In the formula, CR is the consistency ratio, CI is the consistency indicator, and RI is the random consistency indicator (see Table 1). When CR<0.1, it indicates passing the one-time inspection; Otherwise, it is necessary to reconstruct the judgment matrix until it passes the consistency check.

Table 1. Random consistency indicators

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.52	1.54

(4) Repeat step (3) to sort all lower level indicators in a hierarchical manner.

(5) Total hierarchical sorting. Sort from the highest level to the lowest level to determine the relative importance of each indicator to the target layer.

3.2 Calculation of weights for energy data price evaluation indicators

Based on the analysis of the second chapter, the Evaluation Index System of energy data price influence factors can be carded as shown in Figure 1

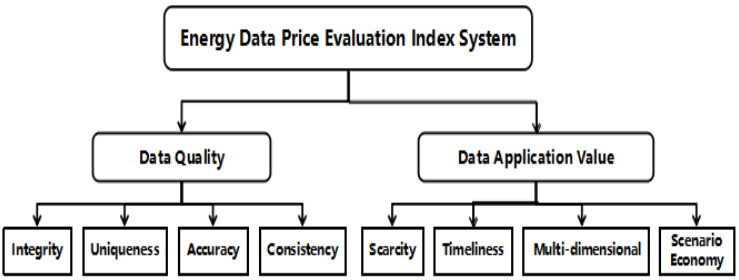

Fig. 1. Energy Data Price Evaluation Index Sytem

Determine the weights of each secondary indicator under the two primary indicators of data quality and data application value based on expert scoring and Analytic Hierarchy Process.

(1) Judgment matrix and weight of data quality evaluation indicators

Based on expert opinions, compare the four data quality evaluation indicators in pairs and rank them according to their importance. Data integrity and accuracy are the most important, followed by consistency and uniqueness.

Calculate the values of each element in the judgment matrix based on the transitivity of indicator importance, and obtain the following judgment matrix:

$$R = \begin{pmatrix} 1 & 1 & 3 & 5 \\ 1 & 1 & 3 & 5 \\ 1/3 & 1/3 & 1 & 3 \\ 1/5 & 1/5 & 1/3 & 1 \end{pmatrix} \tag{3}$$

Firstly, perform a matrix consistency check, and then calculate the weight values of each indicator based on matrix R:

$$\omega_{\mathrm{i}} = \sqrt[n]{\prod_{\mathrm{j}=1}^{n} r_{ij}} \Big/ \sum_{i=1}^{n} \sqrt[n]{\prod_{\mathrm{j}=1}^{n} r_{ij}} \tag{4}$$

The weights of each evaluation dimension calculated from the above equation are shown in the table 2:

Table 2. Analytic Hierarchy Process for Calculating Weights of Each Dimension

Dimensional	Integrity	Accuracy	Consistency	Uniqueness
Weight	0.32	0.32	0.21	0.15

(2) Judgment Matrix and Weights of Data Application Value Evaluation Indicators

Based on expert opinions, compare the four data application value evaluation indicators in pairs and rank them according to their importance. The multidimensional nature of the data is the most important, followed by scarcity, timeliness, and scenario economy.

Calculate the values of each element in the judgment matrix based on the transitivity of indicator importance, and obtain the following judgment matrix:

$$R = \begin{pmatrix} 1 & 1/3 & 1/5 & 1/9 \\ 3 & 1 & 1/3 & 1/3 \\ 5 & 3 & 1 & 1/3 \\ 9 & 3 & 3 & 1 \end{pmatrix} \tag{5}$$

Firstly, perform a matrix consistency check, and then calculate the weight values of each indicator based on matrix R:

$$\omega_{\mathrm{i}} = \sqrt[n]{\prod_{\mathrm{j}=1}^{n} r_{ij}} \Big/ \sum_{i=1}^{n} \sqrt[n]{\prod_{\mathrm{j}=1}^{n} r_{ij}} \tag{6}$$

The weights of each evaluation dimension calculated from the above equation are shown in the table 3:

Table 3. Analytic Hierarchy Process for Calculating Weights of Each Dimension

Dimensional	multi-dimensional	scarcity	timeliness	scenario economy
Weight	0.44	0.31	0.14	0.11

4 Conclusions

This article starts with the factors that affect energy data prices, analyzes the evaluation indicators that affect data prices, and constructs a price evaluation index suitable for energy data, providing reference for energy data pricing. The price evaluation index constructed in this article mainly includes data quality evaluation indicators and data application value evaluation indicators. Among them, data quality evaluation indicators mainly include data integrity, correctness, consistency, repeatability, and timeliness, while data application value evaluation indicators mainly include data scarcity, timeliness, multi-dimensionality, and scenario economy.

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