Research on Electricity Market Risk Pool in China

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Abstract. At present, the construction of electricity market is accelerating in China. Relevant practical explorations on electricity market operation analysis are being carried out, but systematic analysis and evaluation tools and methods have not yet been established. This paper studies the electricity market risk pool system and establishes a market operation effectiveness and risk assessment system that adapted to the characteristics of electricity market in China. The market assessment is used to provide reference for the market operation adjustment and market construction in China.

Keywords: electricity market · market risk pool · market assessment

1 Introduction

Combined with typical market experience, the electricity market operation risks covering the national and provincial electricity market are classified. In order to analyze the electricity market risk, this paper establishes a electricity market risk database system for different scenarios such as the inter-provincial market, provincial market, the connection between the two-layer market, medium and long-term electricity market, spot market, auxiliary service market and other full-variety markets, reflecting system operation, market power, and price distortions risks.

The idea of this paper is to build an electricity market risk database for different scenarios (such as security supply risk, renewable energy consumption risk, electricity price fluctuation risk, excessive market clearing and expected deviation). This paper selects the indicators in the indicator database, and establishes a judgment logic. These scenarios are reflected in: such as spot market scenarios and non-spot scenarios, the indicators for the risk of supply and demand imbalance are different, that is, "the electricity market risk library system for different scenarios". The closed-loop linkage mechanism is reflected in: if it is not in stock, the closed-loop linkage mechanism is to organize emergency transactions.

Step 1: Historical data processing. Whether there is a historical risk label. If there is, we can use operating data and transaction data to determine risk scenarios, such as system frequency, etc. as indicators to determine whether there is a risk of supply and demand imbalance, and mark the time period.

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Step 2: Establish a risk database, select indicators in the indicator system, combine risk labels, and identify risk scenarios through big data methods. Some of the indicators are calculated on a year-on-year basis and on a month-on-month basis.

Step 3: In actual operation, iteratively optimize the corresponding relationship between the risk database and the indicators, and repeat Step 1 and Step 2.

2 Electricity Market Risk Database System

2.1 Design Ideas

This paper establishes the electricity market risk database system according to the dimensions of security, supply, market efficiency, renewable energy consumption, market service, market credit, and other dimensions. There are multiple secondary categories in each risk database (primary category), and there are multiple tertiary categories (i.e., indicators) in each secondary category.

It is worth noting that whether it is a risk library (primary classification), a secondary classification or a tertiary classification, it can be used as a risk at different levels. Taking the security supply of the risk library (first-level classification) as an example, the security supply can be considered as a (possible) risk. Among them, the secondary classification "imbalance of supply and demand" and "coal inventory" under "imbalance of supply and demand" can be regarded as risks. The risk determination methods for different levels are as follows:

For the three-level risk classification, because the calculation process is clear, it can directly determine whether the risk occurs by setting the threshold. For example, for the price of thermal coal, the spot price of thermal coal in Qinhuangdao (5500 kcal) can be used, and a price threshold (for example, 800 yuan RMB/ton) can be set. When the spot price of thermal coal in Qinhuangdao (5500 kcal) exceeds the threshold, it is determined that coal price risk has occurred.

For the first- and second-level risk classifications, specific assessments can be made based on the comprehensive evaluation method of the third-level risk classification indicators to identify whether risk scenarios occur. For example, through the analysis of hierarchy process (AHP) method, principal component analysis method, entropy weight method, expert scoring method, standard deviation method, diagonal expansion weight method, etc., the comprehensive score is obtained. The comprehensive score is then compared with the threshold memory, and if the threshold is exceeded, the risk scenario is considered to have occurred.

2.2 Principles for Constructing the Indicator System

In the research and design of the national unified electricity market benefit evaluation system, the following seven basic principles are mainly followed:

(1) The principle of combining quantitative and qualitative analysis

It not only conducts quantitative analysis on tangible and quantifiable economic and social benefit indicators, but also conducts qualitative analysis on intangible and difficult to quantify indicators. Quantitative and quantitative analysis are organically combined to comprehensively evaluate the construction and operation of the electricity market.

(2) The principle of adaptability

The evaluation index system of China's electricity market must first fully adapt to the characteristics of China's power industry and the construction needs of the current spot market system. According to the functional positioning of different levels of spot markets, as well as the characteristics and requirements of different development stages of the spot market, targeted evaluation indicators are designed.

(3) Scientific principles

The content of China's electricity market index system should be scientific and reasonable, the form is concise and easy to understand, and does not violate objective laws; it can conduct systematic and accurate assessment of the electricity market to ensure that the assessment results are comprehensive and complete; and take into account the micro and macro benefits of the market. Short-term benefits and long-term benefits, local benefits and overall benefits; technical indicators and development indicators reflect the development trend of the spot market.

(4) Systematic principles

The indicators in the indicator system are interrelated and mutually restrictive. Therefore, a systematic method should be adopted in the design of the index system, and the overall function of the evaluation index system should be optimized through the organic connection method and reasonable quantitative relationship between the indexes, reflecting the overall consideration of the various relationships among the indexes.

(5) The principle of practicality

The principle of practicality refers to practicality, feasibility and operability. In order to meet the requirements of practicability, the following points should be done: first, the indicators should be simplified and the methods should be simple; second, the data should be easy to obtain; third, the meanings, units and corresponding calculation methods of each evaluation index should be Standardization, standardization; fourth, we must strictly control the accuracy of data.

2.3 Examples of Indicators

(1) Market competition indicator

The market competition indicator is a measure of the degree of competition in the market.

$$I_{MCR} = (P'_{cap} - P')/P'_{cap}$$

where:

I_{MCR}—the degree of market competition;
P'—market clearing price, yuan/MWh;
P'_{cap}—The upper limit of the market price, Yuan/MWh.

The lower the indicator is, the greater the extent to which the market price is too high, the lower the market competitiveness, and the greater the exercise of market power.

(2) Year-on-year growth rate of CO_2 emission reduction

The ratio of CO_2 emissions reduced through renewable energy grid access and power generation right trading during the statistical period to the CO_2 emissions reduced through renewable energy grid access and power generation right trading in the previous statistical period. The reduced CO_2 emissions should be calculated as follows.

$$\begin{aligned} O_{CPF} &= k_{CO} \times E_{CSQ} \times 10000 \\ &= k_{CO} \times \sum_{i=1}^{N} (E_{BTD,i} \times R_{BTD,i} - E_{TD,i} \times R_{TD,i}) \times 10000 \end{aligned}$$

where:

O_{CPF}—CO_2 emissions reduced through renewable energy grid connection and power generation rights trading, the unit is ton;

k_{CO}—CO_2 emission conversion factor.

The greater the year-on-year growth rate of CO_2 emission reduction, the more obvious the CO_2 emission reduction effect.

3 Comprehensive Evaluation Method Based on Risk Indicators

In order to make the evaluation process simple, transparent and intuitive, this paper introduces a graphical comprehensive evaluation method based on radar map, that is, the diagonal scaling weight method, which improves the shortcomings of the radar map method and makes the comprehensive evaluation results more accurate. The drawing steps are as follows:

(1) Make a unit circle.
(2) M rays are drawn from the center of the circle, and the circle is equally divided into m fan-shaped areas, each area representing an evaluation index. Note the intersection of the circle and each ray as A, B.
(3) Taking the center of the circle as the starting point, draw an angle bisector for each sector area, and the angle bisector represents the coordinate axis of each index. On each angle bisector, the scale is scaled with a scale of k_j, where $k_j = m\omega_j$, the point corresponding to the k index value 1 is represented by $P_1, P_2, \ldots$.
(4) On each angle bisector, with $k_j\tilde{x}_{ij}$ as the length, mark the corresponding point of the value of the indicator, represented by $p_1, p_2, \ldots$.
(5) Make a quadrilateral with the center O, the point p_j and the two intersection points adjacent to p_j as vertices. The quadrilateral area represents the contribution of the corresponding index to the comprehensive evaluation value.

An example of the results of a completed comprehensive risk assessment is shown in Fig. 1.

Points P_1–P_5 in the figure represent 1 after scaling and scaling, which is also the maximum value that each indicator can obtain; points p_1–p_5 represent the actual value of each indicator; the area of the quadrilateral formed by points O, A, p_1, and E represents The contribution of index 1 to the comprehensive evaluation value, the situation of other indicators is similar to that of index 1.

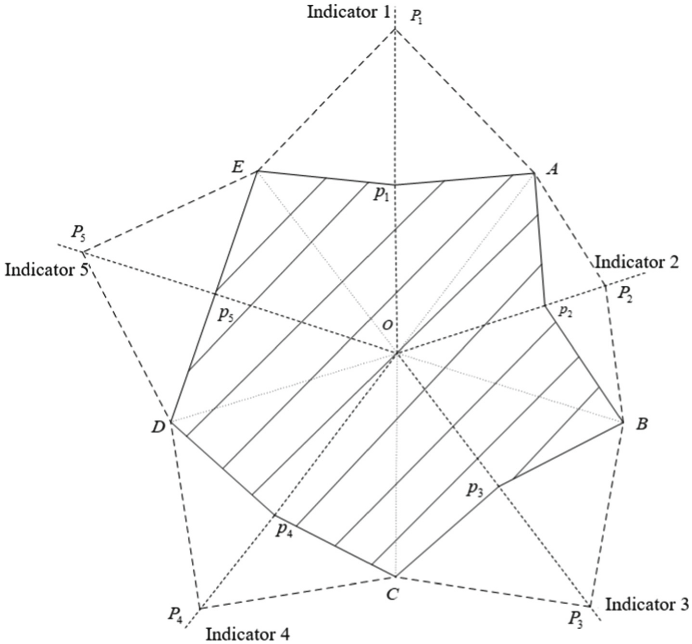

Fig. 1. Examples of comprehensive evaluation indicators for market risk

The area of the quadrilateral representing each index is obtained by the following formula:

$$S_i = \sum_{j=1}^{m} k_j \tilde{x}_{ij} h = \sum_{j=1}^{m} m\omega_j \tilde{x}_{ij} h$$

In the formula: h is 1/2 of the diagonal length of each quadrilateral perpendicular to the index coordinate axis, and the length is equal for each quadrilateral.

The area of the optimal state is given by:

$$S_{opt} = mh$$

The comprehensive evaluation index of risk identification is represented by the percentage value of the actual area of the evaluation object and the optimal state area, namely:

$$y_i = \frac{S_i}{S_{opt}} \cdot 100\% = \sum_{j=1}^{m} \omega_j \tilde{x}_{ij} \cdot 100\%$$

4 Conclusion

This paper establishes a market operation effectiveness and risk assessment system adapted to the characteristics of China's electricity market, including security and supply, market efficiency, renewable energy consumption, market service, market credit and other aspects. This paper aims to use market evaluation to guide the adjustment of market operation and market construction. In this paper, the market competition degree and the year-on-year growth rate of CO_2 emission reduction are analyzed with examples, and a comprehensive evaluation method based on risk indicators is established.

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