Research on Simulation and identification method of abnormal bidding behavior of power market members based on cloud technology

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Abstract. In order to solve the problem that abnormal bidding behaviors are difficult to be identified and controlled in the electricity market, a method based on cloud technology is proposed to simulate and identify abnormal bidding behaviors of power market members, which can give real-time early warning of potential abnormal bidding behaviors in the transaction process. The application of cloud technology big data in simulation identification effectively solves the problem that potential bidding abnormal behavior is difficult to be quantitatively identified, and also overcomes the defect that general identification methods are not easy to understand. Firstly, the paper combs the members, trading methods and types of electricity market, and analyzes the influencing factors of bidding decision-making behavior of power market members; secondly, it designs the general framework and steps of identifying potential abnormal bidding behavior; at the same time, it studies the dynamic evolution trend of bidding behavior of market members, on this basis, realizes the identification of abnormal bidding behavior of market members, and manages and regulates market members.

1. Introduction
Many universities, related research institutions, power companies and IT companies at home and abroad have joined the ranks of system research and engineering application based on cloud technology. In the world, for example, IBM has made great achievements in the direction of intelligent automation, such as "smart grid evaluation and investment optimization decision-making system" to help power enterprises reasonably optimize various construction and transformation investment plans, and "power grid state intelligent perception and alarm system" which can intelligently obtain the real-time operation status of power grid and assist supervisors in decision-making. In China, with the further promotion and application of "Internet plus", domestic power companies have begun to explore the way of power big data solution based on cloud technology. State Grid Corporation of China began to implement the "SG186 project" in 2006, and has launched a number of big data research projects. Under the traditional management mode of power market members, it is difficult for all kinds of market members to get effective supervision. Under the new situation, market supervision, as an important means to ensure the fairness and efficiency of the power market, should also make adaptive adjustment and optimization with the further deepening of power market reform, so as to cope with various risks and hazards that
may exist in the new market environment. Therefore, the establishment of a set of identification methods of potential harmful behaviors in electricity market and the identification of potential harmful behaviors in the transaction process can maintain the fairness and efficiency of the market and reduce the loss of the market, which has positive research and practical significance.

At present, there are few literatures on the application of big data in power market regulation. Literature [1] pointed out that a healthy electricity market should have the effective characteristics of restraining monopoly, alliance and speculation of market members, so as to achieve the purpose of optimizing the allocation of market resources. In reference [2], based on the analysis of the characteristics of centralized regulation in the existing power market, a self-regulation index system for market participants is proposed, and an improved TOPSIS method is used for comprehensive evaluation. Literature [3] systematically studies the price formation mechanism of electricity market by using economic theory, and makes a detailed and systematic analysis of rent-seeking behavior in China's power market. In reference [4], aiming at the problem that it is difficult to identify and control the potential hazardous trading behaviors in the power market, a method based on cloud model and fuzzy Petri net is proposed to identify the potential hazardous behaviors in power market. Based on the theory of complex system, the index system of influencing factors of effective competition in power market is constructed in reference [5], and the Synergetic Evolution Model of effective competition in power market is established, and the problem of effective competition in each subsystem of power market is analyzed. In reference [6], aiming at the problem of outliers in power big data, a fast density peak outlier detection algorithm based on KNN is proposed. In reference [7], aiming at the unreasonable bidding behavior and illegal phenomenon in the power market, this paper puts forward an evaluation system of power market supervision index based on the order relation analysis method. In reference [8], according to Berge-ñs equilibrium model, the process and steps of multi-agent non cooperative game competition in power market are formulated. With the deepening of the game and the accumulation of market information, the bidding strategies among market players will gradually reach equilibrium state, so as to realize the win-win and coordinated development of all parties. On the basis of previous studies, this paper applies big data to the feature expression and reasoning process of pattern recognition, compares the real-time bidding data with the data in historical database horizontally, and proposes a method to identify abnormal bidding behavior in power market. On the basis of analyzing the influencing factors of bidding decision-making behavior of power market members, this paper constructs the identification method of abnormal bidding behavior based on cloud technology, and designs the general framework and steps of identifying potential abnormal bidding behavior. At the same time, the dynamic evolution trend of bidding behavior of market members is studied. On this basis, the identification of abnormal behavior of market members is realized, which is managed by market members to provide basis for regulation and control.

2. Classification and characteristic description of abnormal bidding behaviors of power market members

2.1. Types of abnormal bidding behaviors of power market members

According to the trading rules and the actual situation of the monthly centralized bidding trading in the power trading center, this paper selects free riding, fishing, trading collusion and profiteering pricing as the abnormal bidding behaviors of market entities to be identified in this section.

2.1.1. Free riding

The concept of "free riding" was put forward by American economist Manko Olson, which refers to the non market influence of economic activities of economic entities (including manufacturers or individuals) on others and society. In the centralized bidding transaction with marginal unified clearing, some power selling companies actively participate in the market, and design reasonable bidding strategies according to market conditions and their own strength to participate in market competition, so as to obtain favorable market clearing price. In this process, these power companies need to pay costs
and bear certain risks. By adopting the "free rider" strategy, the power selling companies not only obtain the priority clearance qualification by adopting higher market quotation (or even exceeding the price agreed with users), but also often settle at a price lower than their own quotation. In this process, these companies not only did not pay the cost, nor did they bear any market risk, but also obtained the results of reasonable quotation from other market entities. In the short term, although the free riding behavior of some power sales companies will not affect the clearing price of the market, the behavior itself will weaken the competitive attribute of the market, which is not conducive to the market to optimize the allocation of resources; in the long run, the free riding mentality will gradually spread among the power sales companies, which will make more and more "free riding" power sales companies. The efficiency and efficiency of the market will be seriously damaged. In fact, free riding is very serious in direct transactions in many provinces, and the market quotation curve has shown a trend of horizontal straight line. Jiangxi Province centralized bidding transaction adopts three-stage quotation and clearing method as marginal clearing, which makes it possible for power sales enterprises to take free ride.

2.1.2."Fishing" behavior
"Fishing" behavior is a kind of quotation strategy widely used by power selling companies at present, which shows that high proportion of electricity is quoted at a high price, and a small part of electricity is quoted at a lower price, so as to ensure its high transaction rate and clear the price in the market at the same time. Fishing behavior is actually a kind of evolution of free riding behavior and a kind of utilization of market rules. Its harm is similar to "free riding" behavior, and it will hinder market competition in the long run. In fact, in the monthly centralized bidding transaction of Guangdong Province, most power sales companies adopt this bidding strategy. The overall quotation curve of power sales companies presents the shape of fishing rod, and the fluctuation range of declared price is very small. Only at the end of the declaration curve, there will be a large fluctuation, and the market lacks effective competition.

2.1.3.Conspiracy
The effectiveness of the market economy depends on the competition mechanism, and collusion is a serious harmful behavior to weaken the market competition and hinder the good development of the market. In the power market, collusion refers to the market behavior in which a single market entity does not have the ability to achieve price control, in order to avoid excessive competition and improve the profits of enterprises, enterprises build a consortium to control the market transaction price by using higher market power. Generally speaking, collusion between enterprises must meet certain conditions: the declared prices among enterprises should be similar to realize the control of market price; the collusion enterprises can achieve a more equitable distribution of interests to ensure the existence of the collusion consortium. Under such conditions, the reporting curve among collusive power selling companies will be highly consistent. However, it is worth noting that with the continuous improvement of the maturity of market entities, the forms of collusion will become more and more complex, and the identification of collusion will become more and more difficult.

2.1.4.Profit pricing
Profit pricing refers to the behavior that the market subject uses higher market power to lower the market clearing price, so as to obtain excess profits. This behavior seriously hinders the market efficiency. For example, in the monthly centralized bidding transaction in Hunan Province, power generation enterprises use market power to trade with zero price difference, which completely violates the original intention of market design to release the dividend of electricity reform through market-oriented transaction.
2.2. Description of abnormal bidding behavior of power market members

2.2.1. Centralized bidding of unified clearing

The identified abnormal behaviors of power generation enterprises include free riding, fishing, collusion and profiteering pricing. If the number of quotation segments of the market subject is 1 segment, the fishing behavior is not considered. The corresponding performance of various hazardous behaviors is as follows:

| Abnormal behavior     | Performance                                           |
|-----------------------|-------------------------------------------------------|
| Free riding           | The average quotation is low                          |
| "Fishing" behavior    | The average quotation is low                          |
|                       | The quotation of the last paragraph is high           |
|                       | The last quoted electricity accounts for a low proportion |
| Conspiracy            | High similarity of declaration information            |
| Profiteering pricing  | The average quotation is very high                    |
|                       | High market share                                     |

The abnormal bidding behavior and corresponding characteristics of the identified power selling companies (power consumers) are shown in the table below:

| Abnormal behavior     | Features                                           |
|-----------------------|----------------------------------------------------|
| Free riding           | High proportion of electricity quoted high price    |
|                       | The average quotation is high                       |
| "Fishing" behavior    | High proportion of electricity quoted high price    |
|                       | The third paragraph offers a low price              |
|                       | Low proportion of electricity quoted low price      |
|                       | The last quoted electricity accounts for a low proportion |
| Conspiracy            | Similar declared price series                      |
|                       | The sequence of the proportion of declared volume was similar |
|                       | High similarity of declaration information          |
| Profiteering pricing  | Low price for high proportion of electricity        |
|                       | The average quotation is very low                   |
|                       | Great market power                                  |
|                       | Low market share                                    |

2.2.2. A centralized bid that matches the high and low

The identified abnormal bidding behavior includes: conspiracy, windfall pricing 2 categories. The corresponding feature set is shown in the table below:

| Abnormal behavior | Performance                                      |
|-------------------|--------------------------------------------------|
| Profiteering pricing | The average quotation is very high               |
|                    | High market share                                |
| Conspiracy         | High similarity of declaration information       |
3. Identification of bidding anomalies by power market members based on cloud technology
The market member bid anomaly behavior recognition process for cloud technology-based platforms is shown in the following diagram:

Figure 1. An identification flowchart of bidding anomalies for market members based on the cloud technology

(1) Collect the quotation data of the market participants (the giver) of the power trading center, the market price and other historical data, and write it into the database.
(2) Collect the quotation data of the market participants (the parties) of the power trading center, as the object of analysis and identification.

(3) Calculate the average and standard deviation of all quotation data. The calculation is as follows:

\[
\bar{P} = \frac{\sum_{i=1}^{N} P_i Q_i}{\sum_{i=1}^{N} Q_i}
\]

\[
\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (P_i - \bar{P})^2}
\]

In the formula, \( \bar{P} \) is the declared average price of each transferor, \( Q_i, P_i \) are the declared electricity quantity and electricity price of the transferor respectively, and \( N \) is the number of transferors in the electricity market.

(4) According to the confidence probability theory of normal distribution, the reasonable range of the seller’s offer is determined as follows: \( (\bar{P} - k\sigma, \bar{P} + k\sigma) \).

Among them: \( K \) is the confidence factor, when \( k = 1 \), the probability of the price declared by the transferor falls within the quotation range by 68.27%; when \( k = 2 \), the probability of the price declared by the transferor falls within the quotation range; when \( k = 3 \), the probability of the price declared by the transferor is 99.73%. The value of \( K \) depends on the degree of market tolerance.

(5) According to the confidence probability interval, the rationality of each transferor’s declaration of electricity price is judged, and all the possible malicious bidders are screened out. The judgment basis is as follows:

When \( P_i < \bar{P} - k\sigma \), it is considered that the transferor may maliciously offer a low price; when \( P_i > \bar{P} + k\sigma \), it is considered that the transferor may maliciously offer a high price.

(6) According to the possible malicious quotation transferors screened in step (5), the deviation range between the current quotation and the historical quotation mean value is calculated, and compared with the judgment threshold set by the trading center, the malicious quotation subject is determined. The calculation method of deviation amplitude is as follows:

\[
\theta_i = \left| \frac{P_i - \bar{P}}{\bar{P}} \right|
\]

When \( \theta_i \leq \alpha \), it is considered that the quoting strategy of transferor I is stable and belongs to normal bidding behavior;

When \( \theta_i > \alpha \), it is considered that the quotation of transferor I is obviously deviated from the historical quotation law, which is suspected of malicious quotation.

Among them, \( \bar{P} = \frac{1}{n} \sum_{j=1}^{n} P_{ij} \), \( n \) is the historical quotation times of transferor I, and \( P_{ij} \) is the j-th declared price of transferor I. \( \alpha \) is the judgment threshold set by the power trading center.

For power generation enterprises, the deviation between the quoted price and its marginal cost is further compared. If the deviation exceeds a certain range, the quotation is considered abnormal.

4. Conclusion

This paper analyzes the influencing factors of bidding decision-making behavior of power market members through analyzing the influencing factors of bidding decision-making behavior of power market members, and designs the general framework and steps of identifying potential abnormal bidding behavior. Meanwhile, by studying the dynamic evolution trend of bidding behavior of market members, it realizes the identification of abnormal bidding behavior of market members, and provides the basis for management and regulation of market members. It effectively solves the problem that the potential bidding abnormal behavior is difficult to be identified quantitatively, and also overcomes the defect that the general identification method is not easy to understand. In the process of trading, real-time early warning of potential abnormal bidding behavior is carried out.
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