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Research on the Development of Electricity Market Based on Performance Guarantee

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China's electricity market is currently in the development stage, and the related system is not comprehensive enough. Therefore, it is a key issue to standardize the trading behavior of the market entities and improve the operation efficiency of the electricity market. To solve this problem, this paper takes advantage of Cournot duopoly model to find Nash equilibrium on the electricity supply side and constructs a bank performance guarantee model based on the profit function on the electricity sales side. This study also sorts out the function of performance guarantee, its mechanism for risk prevention, and the feasibility of promoting the performance guarantee mechanism and other supporting systems. Finally, the conclusion is drawn that the performance guarantee mechanism can effectively prevent the risks in the electricity market, and it can be promoted with other supporting systems.

Keywords: electricity market, performance guarantee, game theory, cournot duopoly model, profit function

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1 INTRODUCTION

In recent years, with the continuous optimization of the power structure and the gradual standardization of power industry, China's power market is gradually improving. After 2013, the market reform of China's electricity industry entered the fourth stage, the system reform has entered a new normal, with market-oriented reform accelerating. Relevant supporting policies continued to be introduced, which shifted from macro control to micro guidance. With the improvement of marketization, the way of resource allocation continuously optimized, which can improve the efficiency of electricity consumption and accelerate the improvement of both the sales side and the generation side market. In addition, the electricity industry and other industries reinforce each other for mutual benefit and win-win cooperation.

However, as the marketization of the electricity market continues to advance, many problems stood out under the new normal, among which the most prominent ones are the adverse selection, and ethical risks due to information asymmetry. Electricity retailing companies would release positive signals to the market through information disclosure, thus attracting more social investment. However, some electricity retailing enterprises with relatively poor qualifications would conceal or even lie to the market and establish a positive corporate image to gain more market share during this process. When those enterprises got more market shares, they may face problems such as insufficient cash flow, a broken capital chain, to name a few, which would lead to debt problems and affect the capital flow of power plants, and increase the risk of power plants, which will lead to unstable operation of the electricity market, resulting in a certain degree of price fluctuation and increase the risk of the electricity market.

To solve this problem, the United States established the PJM information disclosure system and the United Kingdom established the ELEXON and National Grid information disclosure systems to maintain the market operation from the system design and practice. In China, electricity market has a relatively weak foundation, which makes it difficult to form a high-quality evaluation system in a short time, so many provinces have successively issued measures for the management of letters of guarantee for performance of electricity sales companies in the power market, aiming to strengthen the credit supervision of the power industry, and accelerate the construction of a new market supervision mechanism with credit as the core. So how does the bank performance guarantee system affect the behavior of various electricity market players? What is the working mechanism of the performance guarantee system? This is important for improving the transaction settlement efficiency between electricity generators and electricity retailing companies, ensuring efficient capital circulation through debt arrears so that the steady advancement of China's electricity market can be guaranteed.

Based on the above discussion, this paper takes power generators, electricity sellers and banks in the electricity market as the research objects, and takes advantage of Cournot duopoly model to investigate the behavior choice of each subject under the performance guarantee system, in order to identify the mechanism of the performance guarantee system, so as to provide conducive suggestions for the government to effectively introduce and establish a risk prevention system in the power market. The remainder of this paper is organized as follows. **Section 2** reviews previous studies' findings on credit evaluation of the electricity market, the role of bank guarantees in the electricity market and the application of game theory in electricity market; **Section 3** carries out theoretical analysis, which is analyzed from three dimensions: electricity generators, electricity retailing companies and banks; **Section 4** presents the mechanism of performance guarantee from different angles; **Section 5** provides policy suggestions based on the conclusion.

2 LITERATURE REVIEW

At present, China's electricity market is still in the stage of development and exploration with an incomplete relevant credit system for electricity retailing companies. In contrast, in countries where the electricity market developed earlier, the supporting credit system is relatively mature and has strong practicability. At the same time, a number of studies have expounded on electricity market credit evaluation.

The deepening of electricity market reform provides favorable conditions for the increase of electricity retailing companies. But there are greater credit risks in the electricity market due to different qualification levels among companies and a lack of necessary monitoring mechanisms. Therefore, the credit evaluation of electricity market can avoid credit risk, debt default, and non-repayment to some extent (Chen et al., 2018). A corresponding credit rating mechanism is required to avoid credit risk. Specifically, except credit rating, market access and exit mechanism, margin mechanism, value-added service deprivation mechanism and priority contracting mechanism can be designed (Bai et al., 2017). Among all electricity markets, the American electricity market has developed for a relatively long time and is basically mature. For example, in Texas, United States, market operators and state-level regulator jointly supervise the information disclosure of electricity retailing companies (Xu et al., 2020) to avoid potential information asymmetry risks. PJM electricity market has clear requirements for capital of the electricity retailing companies entering the market and conducts credit rating and credit line estimation through mature methods (Monitoring Analytics, 2015). Meanwhile, TPS test is used to screen the participants in the electricity market, thus ensuring the sound development of the electricity market and reasonable electricity price. However, due to the short development time and weak foundation of China's electricity market, it is difficult to form a mature electricity market similar to that of the United States in a short time, which is mainly manifested in the lack of financial and assets credit evaluation mechanism, and relatively simple evaluation methods and limited coverage (Ye and Chen, 2020).

The smooth operation of China's electricity market requires a stable consumption relationship established among electricity generators, electricity retailing companies and electricity users. In the process of the influx of electricity retailing companies, it was difficult for the electricity market to quickly identify the qualification of companies, resulting in delayed transaction settlement between electricity generators and electricity retailing companies, which would slow down the development of China's electricity market. Setting market access conditions for new entrants are of great significance for market development (Cho and Honorati, 2014; Grimm and Paffhausen, 2015), which also confirmed the necessity of regulating the entry of electricity retailing companies in China's electricity market. Insurance guarantee can be used as one of the necessary criteria for electricity retailing companies to enter the market because it can effectively reduce market risks (Dankiewicz, 2017), and enterprises with guarantee can quickly gain the trust of the market and other upstream and downstream enterprises through third-party certification. In addition, enterprises with guarantee would in turn paid more attention to fulfilling their due obligations in time. For example, enterprises with bank guarantees can gain more trust by regulating their own obligations (Soltani and Ramezaniehad, 2018). Non-manufacturing businesses with bank guarantee would make more investment and improve the sales rate of enterprises (Gropp et al., 2020). Moreover, enterprises with guarantee qualifications would not increase the risk of default (Cowan et al., 2015), which could increase the credibility of enterprises with guarantee qualifications. Therefore, enterprises with guarantee qualification could improve their credibility in the market and reduce the potential risks faced by the market.

Game theory is a key analytical tool in the relevant analysis of electricity market participants, which has been applied several

times in the research of electricity market (Pilz and Al-Fagih, 2017). For example, in the electricity supply market, the non-cooperative game model represented by Stackelberg game approach was used to analyze the transaction and management of multi-micro grids (Ma et al., 2016; Liu et al., 2017; Liu et al., 2020). In addition, some scholars have studied the coordinated promotion of multi-microgrid and distribution networks from the perspective of revenue (Wang et al., 2014). Electricity generators could predict the market price and acquire more information for themselves by using game method, which can help them choose better strategies and maximize benefits (Yi, 2019). In this case, taking advantage of historical information during the evolutionary game can better fit the reality. At the same time, the non-cooperative game can not only apply to the two-participants game, but also can be used for the three-participant game, such as the electricity generators, electricity retailing companies, and end users in the electricity market (Marzband et al., 2018). In addition to non-cooperative game, cooperative game is also commonly used in electricity market research. For example, in the electricity market, end users can get extra benefits by cooperative game (Zhang et al., 2015), while non-cooperative game was based on the established benefit distribution, so users are unable to receive extra benefits (Chen and Zhu, 2017; Liang and Su, 2018). Therefore, many problems in the electricity market can be analyzed concerning game-theoretic methods, and this paradigm has been relatively mature.

Through the above analysis, it can be found that the efficient operation of the electricity market requires necessary credit evaluation schemes which call for a long time to construct. Current China's electricity market is undergoing the development stage with a relatively weak foundation, which makes it difficult to form a high-quality and full-coverage evaluation system in a short time. As an effective monitoring mechanism to reduce market risks, credit guarantee can make a difference quickly, and reduce the information asymmetry between electricity generators and electricity retailing companies, so that the efficient operation of China's electricity market is ensured. In addition, the game theory related methods are often more applicable for solving problems in the electricity market. Through reasonable assumptions, the game model can better fit the reality, making the theory and research questions more consistent. Therefore, this study aims to apply the relevant methods of game theory as the theoretical framework and introduce the performance guarantee mechanism to ensure the in-depth, efficient and sustainable development of China's electricity market.

3 THEORETICAL ANALYSIS

In general, electricity generators sell electricity to electricity retailing companies, and then electricity retailing companies sell to the consumers. This paper focuses more on the market relationship between electricity generators and electricity retailing companies. In addition, when the performance guarantee mechanism is introduced, banks need to assume the guarantee role in the transaction between electricity generators and electricity retailing companies. Therefore, this paper aims to investigate the relationship among electricity generators, electricity retailing companies, and banks by applying game-theoretic methodologies.

3.1 Analysis of Cournot Duopoly Model of Electricity Generators

Based on the actual situation, this paper uses Cournot duopoly model to simulate. Assume there are n electricity generators in the market with no difference in electricity generation capacity. The market inverse demand function be:

$$p(Q) = a - bQ \tag{1}$$

$$Q = \sum_{i=1}^{n} q_i \tag{2}$$

Where a and b are parameter, q_i is the electricity generation of electricity generator i, Q refers to the electricity generation of all electricity generators. Considering that the electricity generators have a large share of upfront investment and the nonlinear relationship between electricity generation and cost, quadratic function is used to fit the relationship between generating capacity and cost. Therefore, cost function for any electricity generators is $C_p(q_i)$:

$$C_p(q_i) = \frac{1}{2}\alpha_i q_i^2 + \beta_i q_i + c_i \tag{3}$$

Where α_i, β_i, c_i are the cost coefficients corresponding to each item of the cost function of the electricity generators. And $\alpha_i > 0$, $\beta_i > 0$, $c_i > 0$。

At this time, the profit function $\pi_p(q_i)$ of the electricity generator i is:

$$\pi_p(q_i) = pq_i - C(q_i) = \left(a - b\sum_{i=1}^{n} q_i\right)q_i - \left(\frac{1}{2}\alpha_i q_i^2 + \beta_i q_i + c_i\right) \tag{4}$$

To solve the first-order condition of profit maximization: $\partial\pi_p/\partial q_i = 0$ (5), the equilibrium electricity generation of electricity generators can be obtained;

$$q_i^c = a - \beta_i - b\sum_{i=1}^{n} q_i \Big/ b + \alpha_i \tag{6}$$

The equilibrium price p^c can be obtained by plugging the equilibrium electricity generation q_i^c into formula **1** and formula **2**:

$$p^c = \frac{a + b\sum_{i=1}^{n}(\beta_i/b + \alpha_i)}{1 + b\sum_{i=1}^{n}(1/b + \alpha_i)} \tag{7}$$

According to the above results, the total electricity generation Q of electricity generators can be obtained by applying formulas **1** and **7**, or formulas **2** and **6**.

3.2 Segment Profit Analysis of Electricity Retailing Companies

We assume that the market is cleared between the electricity generators and the electricity retailing companies, and all electricity retailing companies purchase electricity Q at a price p^c. According to the relevant management requirements of China's electricity industry, the minimum annual market sales Q_{Low} is stipulated. Generally, the minimum sales stipulated by the market is less than the total production, so $Q > Q_{Low}$. According to the market guidance and national regulation, electricity retailing companies set the price of electricity p^S sold to consumers, which can be expressed as follows:

$$p^S = p^c + \Delta p \tag{8}$$

Among them, $\Delta p > 0$, and, the values of Δp vary for different consumer groups of consumers. At the same time, different levels of electricity prices can be set according to Δp for specific consumer groups in accordance with the difference in electricity consumption and consumption period.

Assuming there are m companies in the sales side, the market share is increasing with the expansion of the scale of the electricity retailing companies and a linear relationship is identified. Without considering the fixed cost, the cost of electricity retailing companies is only related to the purchase amount. The purchase amount of any electricity retailing company j is q_j, and λ_j stands for its market share:

$$\lambda_j = q_j / Q \tag{9}$$

$$\sum_{j=1}^{m} \lambda_j = 1 \tag{10}$$

Assume that the minimum annual sales stipulated by the sales side are distributed according to the market share of electricity retailing companies, so the minimum annual sales that the electricity retailing company j should bear is $\lambda_j Q_{Low}$. When the electricity retailing companies fail to complete the minimum sales, they will be additionally punished at K. Meanwhile, if the Q_s indicates the sales of all electricity retailing companies, the sales of electricity retailing company j is $\lambda_j Q_s$, and $Q > Q_s$.The cost function of any electricity retailing company $C_s(q_j)$ is:

$$C_s(q_j) = p^c \lambda_j Q \quad if \quad Q_s \geq Q_{Low} \tag{11}$$

$$C_s(q_j) = p^c \lambda_j Q + K \quad if \quad Q_s < Q_{Low} \tag{12}$$

The profit function $\pi_s(q_j)$ of the electricity retailing companies j is:

$$\pi_s(q_j) = (p^S - p^c)\lambda_j Q_s = \Delta p \lambda_j Q_s \quad if \quad Q = Q_s \geq Q_{Low} \tag{13}$$

$$\pi_s(q_j) = p^S \lambda_j Q_s - p^c \lambda_j Q \quad if \quad Q > Q_s > Q_{Low} \tag{14}$$

$$\pi_s(q_j) = p^S \lambda_j Q_s - p^c \lambda_j Q - K \quad if \quad Q_s < Q_{Low} \tag{15}$$

Therefore, the cost that electricity retailing companies j needs to settle with the electricity generator is $C_s(q_j)$.

3.3 Bank Performance Guarantee Model

In order to promote the development of China's electricity market, this paper introduces the performance guarantee, that is, the bank provides credit bond for electricity retailing companies to the electricity generators in the form of performance guarantee. When electricity retailing companies fail to settle the transaction in time, the bank will pay for the settlement to the electricity generators to ensure the efficient operation of the electricity market.

According to the analysis in the previous section, the profit function of the electricity retailing companies j is $\pi_s(q_j)$. In order to ensure the timely settlement of electricity retailing companies, the amount of the bank performance guarantee $M_j(q_j)$ is:

$$M_j(q_j) = \mu \pi_s(q_j) = \mu (p^S - p^c)\lambda_j Q_s = \mu \Delta p \lambda_j Q_s \quad if \quad Q = Q_s \geq Q_{Low} \tag{16}$$

$$M_j(q_j) = \mu \pi_s(q_j) = \mu p^S \lambda_j Q_s - \mu p^c \lambda_j Q \quad if \quad Q > Q_s > Q_{Low} \tag{17}$$

$$M_j(q_j) = \mu \pi_s(q_j) = \mu p^S \lambda_j Q_s - \mu p^c \lambda_j Q - \mu K \quad if \quad Q_s < Q_{Low} \tag{18}$$

where μ indicates the guarantee coefficient of the performance guarantee, and $\mu > 1$.

In actual situation, the requirements $\mu > 1$ can be relaxed for electricity retailing companies in the electricity market, and companies with different credit levels can be guaranteed by adjusting the guarantee coefficient μ. Taking Shanxi Electric Power's medium and long-term trading rules as an example, the credit rating of power sales companies is assessed annually, and the credit rating is divided into seven grades: AAA, AA, A, BB, B, C, and D. The first four grades is named of low risk, and the coefficients for submitting the performance guarantee letter are: AAA 0.1, AA 0.3, A 0.6, BB grade, and no rating 1.0; the last three grades correspond to minor, middle and major risks, respectively, and the coefficients are: general risk 1.0, middle risk 1.5 and major risk 2.0. So we assume $\mu \in [0, 2]$, and electricity retailing companies with bank performance guarantee are evaluated through the bank survey or the credit evaluation results of third parties. For those electricity retailing companies with low credit rating, let $\mu \in (1, 2]$, the guarantee amount is increased, thereby regulating their market behavior. When the credit level of those companies with low credit rating is improved, the guarantee coefficient μ can be reduced according to the standard. For electricity retailing companies with high credit rating, let $\mu \in [0, 1)$, meaning that the guarantee amount is reduced moderately, enabling those companies to attract more funds for investment and development. When $\mu = 0$, it indicates that the performance guarantee may not be issued for electricity retailing companies with high credit level and complete trust of the electricity generators.

3.4 Summary

This section mainly focuses on the transaction process between electricity generators and electricity retailing companies in the electricity market. With regard to electricity generators, Cournot

duopoly model is applied based on corresponding assumptions, and equilibrium electricity price p^c between electricity generators and electricity retailing companies and the optimal generation capacity of electricity generators q_i^c are obtained. Under the market conditions of equilibrium electricity price p^c and optimal generation capacity q_i^c, the electricity generator i can obtain maximum profits. The results show that the equilibrium electricity price p^c is related to the set value of both the counter-demand function and cost function of each electricity generator in the electricity market. The equilibrium electricity price p^c contains the relevant information of each electricity generator, indicating that electricity generators need to comprehensively consider the actual situation of each participating generator in the current pricing process. We can understand q_i^c from two perspectives, according to $Q = \sum_{i=1}^{n} q_i$, the optimal electricity generation q_i^c of electricity generators i is related to the total electricity generation Q, and a negative correlation between them has been identified, meaning that the greater the total electricity generation, the smaller the optimal electricity generation of electricity generators. Considering $p(Q) = a - bQ$, there is a positive relationship between the optimal electricity generation q_i^c and price p, which shows the optimal electricity generation of the generator will grow with the price rises. Therefore, this set of results $q_i^c = a - \beta_i - b\sum_{i=1}^{n} q_i/b + \alpha_i$, $p^c = \frac{a+b\sum_{i=1}^{n}(\beta_i/b+\alpha_i)}{1+b\sum_{i=1}^{n}(1/b+\alpha_i)}$ also shows that there is a simple linear relationship between the optimal power generation q_i^c and the total electricity generation Q or price P, which confirms that under certain parameters, the optimal electricity generation q_i^c and equilibrium electricity price p^c of the electricity generation i are unique.

For electricity retailing company j, under the basic assumption of market clearing, all electricity retailing companies will purchase total production electricity Q. However, under the constraints of relevant policies and management measures, companies need to achieve a minimum sales amount Q_{Low}. Penalty will be implemented if they fail to sell this share. Therefore, the cost function and profit function of electricity retailing companies vary according to the value range of the electricity sales Q_s. There will be two kinds of impact on electricity retailing companies when the minimum sales Q_{Low} and penalty K are introduced. First, it will improve the enthusiasm of electricity selling enterprises and have a certain impact on the price of electricity selling market; Second, it will play a guiding role in the development of electricity retailing companies. This study assumes that the greater the market share of electricity retailing companies, the more the minimum sales they need to bear. Because of the existence of penalty K, electricity retailing companies need to predict the future sales based on their own development status. Pessimistic prediction can help companies avoid penalty by reducing the scale or exiting the sales side market. This also shows that the existence of minimum sales and penalty will raise the entry threshold of the sales side of the electricity industry, and the entry threshold will increase accordingly with the increase of the minimum sales Q_{Low} and penalty K, which can not only prevent some low-quality enterprises with speculative mentality from entering the market, but also eliminate the enterprises with behavior of dishonesty, thus ensuring the high quality of the electricity retailing companies from the sales side.

As the third party between electricity generators and electricity retailing companies, banks act as guarantee in the transaction process of both parties, so as to reduce the transaction risk of both parties. This paper introduces the performance guarantee mechanism to regulate the transaction settlement of electricity retailing companies, which mainly depends on the guarantee coefficient μ in the performance guarantee mechanism. According to the current situation of China's electricity market, China's electricity market is in a stage of development, and lacking a mature management scheme. Therefore, the performance guarantee mechanism can play a crucial role in China's electricity market monitoring mechanism in the near future. At the same time, the establishment of credit evaluation system in China's electricity market can be advanced with the performance guarantee mechanism simultaneously, and the monitoring results of electricity-selling enterprises in the electricity market can be used as an important basis for credit evaluation. For electricity retailing companies with different credit ratings, banks can make differentiated guarantees by adjusting the guarantee coefficient, that is, a lower guarantee coefficient can be applied for enterprises with higher credit ratings, while performance guarantee can be exempted for those companies with excellent credit ratings. Therefore, the introduction of the performance guarantee mechanism in the electricity market can not only significantly reduce the transaction risk between the electricity generators and electricity retailing companies, but also are aligned with the current monitoring system and credit rating system. Additionally, the performance guarantee mechanism can also improve the entry threshold of the electricity sales side of the market to some extent, prevent some companies with a poor qualification from entering the market, and eliminate companies with a low qualification in the market, thus ensuring the stable and sound development of the whole electricity industry.

4 PERFORMANCE GUARANTEE MECHANISM

Performance guarantee mechanism is mainly used for electricity retailing companies, whose main function is to prevent risks in electricity market. In addition to risk prevention, this mechanism can also work with other mechanisms to make joint efforts to promote the sound development of the electricity market. To be specific, if collaborating with market monitoring organizations, performance guarantee system can improve the monitoring quality of the electricity market through information exchanges; If cooperating with the "blacklist" system, electricity retailing companies with low credit ratings can be better identified so that the trustworthiness of the electricity market can be improved; If collaborating with power market rules, performance guarantee system can make the power market

system dynamically perfect; If collaborating with end users, performance guarantee system can provide reference to set important parameters of the electricity market, thus guiding the sound development of the electricity market. Details are as follows:

4.1 Reduce the Risk of Electricity Market Transactions

The introduction of the bank performance guarantee mechanism into the electricity market can significantly reduce the transaction risk in the electricity market, which is mainly manifested in the following two aspects. First, the introduction of performance guarantee mechanism requires electricity retailing companies to carry out certain qualification mortgage, which can prevent some speculative enterprises from entering the power market. The qualification mortgage can also reflect their own strength to a certain extent. Second, the introduction of the performance guarantee mechanism has raised the entry threshold for electricity retailing companies in the electricity market, and made those companies with poor qualifications withdraw from the market. Therefore, this mechanism will standardize the trading behavior of electricity retailing companies and improve their endogenous driving force. At the same time, the adjustment of guarantee coefficient can encourage the electricity retailing companies to continue to regulate their own trading behavior so as to realize the effective regulation of the electricity market. Additionally, the performance guarantee mechanism avoids the risk of delayed transaction settlement in the transaction process, ensures smooth capital circulation of electricity generators, and avoids the hidden risk caused by enterprise capital chain fracture. Therefore, the system can reduce the potential risks of transactions between the two parties, and strengthen the transaction links between generators and electricity retailing companies, thus promoting the stable development of the electricity market. Considering that China's electricity market is still in the development stage, a stable and close trading relationship within the electricity market can promote the sound development of the electricity market.

4.2 Collaborate With the Supervision to Improve the Quality of Market Monitoring

The current market monitoring and supervision of China's electricity market is still in the process of exploration, and has not yet transitioned to a mature stage. Therefore, the current power market monitoring has not fully played its role. At this stage, the introduction of the performance guarantee mechanism can cooperate with the supervision departments to improve the monitoring of the electricity market. On the one hand, the implementation of bank performance guarantee requires the necessary qualification examination of electricity retailing companies, so the independent examination of banks will force companies to disclose real corporation information. At the same time, the supervision departments monitor the electricity retailing companies according to regulations, which will form dual monitoring. High-intensity and high-density monitoring will increase the cost of concealing information and reduce the possibility of speculation, thus promoting the sound development of electricity retailing companies, and improving the monitoring of China's electricity market. On the other hand, the collaboration between bank monitoring and electricity market supervision departments can enable banks to update companies' evaluations in a timely manner, thus greatly reducing the possibility of false reporting and concealing of companies, and avoiding information asymmetry in the electricity market to a certain extent. Meanwhile, the financial information that the bank focuses on monitoring can make the supervision departments quickly understand the financial status of each electricity retailing company and the electricity sales side, and then timely promote the implementation of relevant policies.

4.3 Collaborate With the "Blacklist" to Improve Trustworthiness of the Electricity Market

The introduction of supporting policies of performance guarantee and "blacklist" of market entities in the electricity market can effectively improve the trustworthiness of the electricity market. The "blacklist" can provide a reference for the promotion of the performance guarantee mechanism. In order to maintain the stable development of the electricity market, relevant departments in China have put forward the "blacklist" against the problem of dishonesty. For enterprises that violate regulations, disciplines and laws in the electricity market, there will be constraints of credit; for those who are extremely serious, they should withdraw from the market; for those enterprises whose credit is corrected, they can be removed from the "blacklist". Therefore, during the implementation of the "blacklist" scheme, all enterprises in the market will be examined in an all-round way, and then the information of companies can be obtained comprehensively. This information can provide the bank with other important information except financial information to handle performance guarantee business for a particular enterprise, so that the bank can have a comprehensive understanding of the enterprise and avoid potential business risks. On the other hand, the implementation of performance guarantee mechanism can provide a useful reference for "blacklist" management. The "blacklist" not only monitors the financial information of enterprises in the electricity market, but also takes into account other factors, such as whether market manipulation is abused or whether there is market discrimination. Therefore, from the perspective of financial information, the monitoring degree of "blacklist" is slightly lower than that of bank monitoring. Banks can provide monitoring results to "blacklist" supervision departments, which can improve their monitoring quality. The collaboration between performance guarantee and the "blacklist" system can more accurately identify low-credit enterprises and impose penalties, thus improving the overall trustworthiness of the electricity market credit.

4.4 Revision of Market Rules and Dynamically Improve the Electricity Market System

Electricity market rules are regulations to maintain the sound and stable development of electricity market, which are used to regulate market behaviors of market entities, so as to promote the effective allocation of resources in the electricity market. Generally speaking, the formulation and revision of electricity market rules mainly depend on the monitoring results of the electricity market, and the rules are revised based on the monitoring results. The introduction of the performance guarantee mechanism can also provide necessary information for the revision of electricity market rules. In the process of handling the performance guarantee business, although the bank will examine the qualification of the electricity retailing companies, and there will still be mistakes. For the bank's failed business, we can collect relevant information and report it to the market rules management departments to provide more reference information, thus promoting the continuous improvement of the power market rules, which can indirectly improve the monitoring quality of the electricity market. When the performance guarantee mechanism gradually becomes part of the electricity market monitoring mechanism, the electricity market rules can also provide necessary legal protection for the promotion of performance guarantee and reduce potential risks faced by banks. At the same time, the guarantee coefficient in the performance guarantee can be used as a quantitative reference for the advancement and retreat rules of the electricity market. By adjusting the guarantee coefficient, the entry threshold of the sales side market can be quantitatively and dynamically adjusted. Therefore, the two-way linkage between the performance guarantee system and the revision of the power market can dynamically improve the power market system, and realize the efficiency of the electricity industry and maximize the benefits of the whole society by establishing and maintaining a competitive electricity market.

4.5 Cooperate With the End Users to Guide the Development of the Electricity Market

The previous analysis shows that, in the expression of performance guarantee, the penalty of electricity retailing companies K mainly depends on the sales volume Q_s of companies and the annual minimum sales Q_{Low} of companies. Reasonable setting of annual minimum sales is of great significance to ensure efficient operation of power market. After the bank performance guarantee mechanism is steadily promoted, the banking sector can work with relevant electricity departments to focus more on the changing trend of electricity bills business, and analyze the electricity consumption of the consumer. In addition, heterogeneity analysis is necessary. For example, it is necessary to analyze residential electricity consumption and industrial electricity consumption separately, and to analyze the changes of tiered electricity consumption, and then predict the future trend of consumers in a rational way and share the information of the annual minimum sales volume in real time with the department so as to set the parameters suitable for the stable and sound development of the electricity market. At the same time, reasonable setting of annual minimum sales volume Q_{Low} and penalty K can provide a useful reference for electricity retailing companies. For the sales side of the electricity market, reasonable parameters also provide an invisible threshold for entering the industry, avoiding the entry of enterprises with low qualifications. Meanwhile, companies can rationally adjust their own development scale and speed according to the parameters. For enterprises with better development, they can consider expanding investment and their scale. For enterprises with poor development situations, they can try to adjust their development strategies, or reduce their scale, or even withdraw from the market, and stop losses in time.

5 CONCLUSION AND POLICY RECOMMENDATIONS

China's electricity market is currently in the development stage, and the introduction of performance guarantee system in the transactions of the electricity market can effectively promote the further advancement of China's electricity market. Through model building and mechanism explanation, this study discusses the performance guarantee system in the electricity market, and draws the following research conclusions and policy suggestions:

First, the performance guarantee system can effectively avoid the risks in the electricity market, which should be gradually introduced into the transaction process between the supply side and the sales side of the electricity market. In the model of bank performance guarantee, by adjusting the guarantee coefficient, the electricity retailing companies can be evaluated to a certain extent, which indirectly improves the entry threshold of the sales side of the electricity industry, prevents some companies with a speculative mentality from entering the market, and greatly improves the quality of electricity retailing companies in the market.

Second, the performance guarantee system and other systems can work together in multiple directions to promote the sound development of the electricity market. Therefore, the way for the performance guarantee system to collaborate with other systems should be improved. The performance guarantee system collaborating with the electricity market supervision department can realize information exchange and improve the information disclosure level of electricity retailing companies; The performance guarantee system collaborating with the "blacklist" system can better identify the electricity retailing companies with low credit ratings; The performance guarantee system collaborating with the electricity market rules and can make the power market system dynamically improved; The performance guarantee system collaborating with end users can reasonably set important parameters of the electricity market, thus reasonably guiding the sound development of the electricity market.

Third, the introduction of the performance guarantee system can avoid the information asymmetry between the supply side

and the sales side of the electricity market to a large extent, and strengthen the transaction links between the two sides. The transaction behavior of banks, electricity generators and electricity retailing companies should be process-oriented, standardized and concise. Through the model analysis, it can be found that when the bank introduces a suitable guarantee coefficient, the electricity retailing companies will actively regulate their own transaction settlement behavior, so as to improve their own credit evaluation, and obtain the qualification to use a smaller guarantee coefficient. Under the guarantee of the bank, the transaction speed between the power generator and the electricity retailing companies will be greatly raised, and then the operation efficiency of the electricity retailing companies will be improved. With the increase in the number of transactions, the transaction relationship between electricity generators and electricity retailing companies gradually tends to be stable.

Based on the results of this study, we mainly summarize the following policy recommendations.

1) The market monitoring organizations should exchange monitoring information with banks in a timely manner, so that both sides can grasp the quality of enterprises in the market, and gradually standardize the trading behavior of electricity retailing companies. Banks should make full use of existing enterprise credit evaluation information, reasonably adjust the guarantee coefficient, and combine it with the credit evaluation of electricity retailing companies, so as to form a quantifiable guarantee coefficient system, which will be released to the companies and provide information reference for new companies, provide incentives for enterprises in the sales side.
2) The relevant departments should work together with banks to find cooperation areas for supporting the promotion of the system, so as to improve the efficiency of the joint system. At the same time, the relevant departments of the power market should build a communication platform with banks to exchange information in time, accurately grasp the development trends of electricity retailing companies in the electricity market, timely correct deviations, and gradually revise market management rules according to the interactive information, so as to accelerate the maturity of China's electricity market.
3) In the early stage of the performance guarantee system, banks should consider how to simplify the process and reduce the participation cost of electricity retailing companies and electricity generators while standardizing the performance guarantee business. In the later stage of the performance guarantee system, based on the guarantee coefficient stipulated by banks, they can attempt to allow electricity generators and electricity retailing companies to adjust the guarantee coefficient together in the form of contracts, thus promoting the long-term development of the power market.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

LJ: Propose innovative points and be responsible for model building. QL: Responsible for variable selection and literature review writing. JY: Responsible for data collection. MW: Responsible for data processing and text content writing. WW: Responsible for proofreading and literature arrangement.

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Conflict of Interest: LJ and QL are employed by Zhejiang Power Exchange Center Co., Ltd. JY, MW, and WW are employed by Zhejiang Huayun Information Technology Co., Ltd.

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