Model of Electricity Trading Risk Warning under The New Power System Reform

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Abstract. Under the new power system reform, the scale of electricity trading market in China grows rapidly, burdening power companies with more uncertainty risk relate to market trading. This paper constructs a risk warning model for electricity trading, and take market price fluctuation as the signal of market trading risk to carry out risk warning.

1 Introduction

Since the beginning of 2016, the reform of power marketization has been gradually promoted. China has issued a series of policies and measures related to promoting market-oriented electricity trading (Lei et al., 2018). The scale of transactions in the national power market has grown rapidly, and regional, inter-provincial and intra-provincial transactions have been gradually promoted. The varieties are gradually diversified, and the power trading cycle is gradually developed from medium and long-term trading to spot power trading.

However, electricity prices in the spot market are easily variable, which potentially expose market participants a great risk in turn. Therefore, while electricity trading is liberalized, the uncertainties and risk factors in the system must not to be ignored. Based on this, it's necessary to build a risk warning system, so to prevent risks and reduce losses.

Risk monitoring and risk warning are the basis for scientific decision-making. It is generally believed that the higher the accuracy of risk warning, the lower the risk of decision-making. In the liberalized electricity market, electricity prices are an important indicator of whether the market is operating normally or not. Electricity price fluctuations directly reflect market risks (Borenstein, 2006). Price risk warning is an important part of power market risk management, including electricity price level forecasting and electricity price fluctuation risk. It is necessary for power market operators and regulators to make predictions and warnings about future electricity price levels and their volatility risks based on market information.

In this paper, the GARCH theory is used to establish the electricity market price risk forecasting model (Hua et al., 2005; Conrad, 2018). In the risk early warning model, the market risk position is considered to influence the potential risk value of the price. Based on the risk

forecasting, the wind market price risk early warning model is established based on the wind value theory. In the model, the variance of on-grid price fluctuation is used as a measure of price risk, defined as the price fluctuation risk coefficient.

2 Electricity market price volatility analysis

2.1 Factors affecting prices

The reasons for the change in electricity trading prices come from many aspects, in this paper we divide that factors into two categories:

Institutional risk: The rationality of the system, the effectiveness of solving the problem, whether the forward market, the spot, the auxiliary service and other different markets are mutually complementary, is the process of quotation, clearing, execution, settlement, etc. connected or not, and the operation is not in line with reality, politically Whether there is a conflict, this is a category of institutional risk. Good institutional design is a prerequisite for effective market competition.

Market risk: The quotation game (market force behavior) and the electricity market can be said to be accompanied by each other. The electricity market is different from the general market. The power grid has obvious external characteristics. There is no way for bilateral interaction. In such a concentrated market, the individual quotation behavior will affect the price of a large number of members, and the spot market coordination amount. Large and short, this is different from the general commodity market, and it is also the particularity of the electricity market, so we must pay attention to the rationality of the members' quotation behavior.

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2.2 Selection of indicators for price fluctuations

Financial market price fluctuations, in fact, will be heteroscedastic, that is, large fluctuations or small fluctuations in prices often appear one after another, so that large fluctuations are concentrated in certain time periods, while small fluctuations are concentrated in other time periods. In the electricity trading market, changes in the market's on-grid price are generally heteroscedastic. The aggregation and heteroscedasticity of power price fluctuations make it difficult for traditional electricity price forecasting models to effectively and accurately describe the law of price changes.

Based on the $A_{ARCH}(q)$ model, a time-delay structure with conditional variance h_t is added to obtain an $G_{GARCH}(p, q)$ model, which exhibits a slowly decaying ε^2 autocorrelation trend. The conditional mean equation of the $G_{GARCH}(p, q)$ model is the same as in the $A_{ARCH}(q)$ model. The equation form is as follows:

$$y_t = E\{y_t | X_t\} + \varepsilon_t \quad (1)$$

where, y_t is the interpreted variable; X_t is the variable vector that has explanatory power to y_t . Equation (1) is a common constant term plus a model of the random error term.

The choice of model variables is the most critical part of determining the effectiveness of the prediction model. Model variables include explanatory variables and interpreted variables. The on-grid price P_t is the interpreted variable in the model. The interpretation vector in the model includes a series of lag values $P_{t-i} (i = 1, 2, \dots, n)$ of the endogenous variable P_t , and may also contain some exogenous variables and their lag values. All of the above explanatory variables together constitute the explanatory vector X_t in the model (1).

In order to accurately describe the possible impact of external factors on market prices, consider the holding capacity of power generation, and introduce the capacity adequacy I_{CSR} and the required operating rate I_{mrr} as indicators of market position as exogenous variables.

(1) Capacity adequacy, is an indicator reflecting the change in the relationship between the system load D and the available capacity Q_c of the system, thus more accurately reflecting the market supply and demand situation.

$$I_{CSR} = Q_c / D \quad (2)$$

(2) Required operating rate is the sum of the operating rate indicators of each power producer, the dependence on each power producer in the market, when its value is greater than zero, indicates that the market has generated absolute market demand for some power producers. The market must run rate indicator I_{mrr} is calculated as follows:

$$I_{mrr} = \sum_{i=1}^n I_{mrr_i} = \sum_{i=1}^n \max[0, (D - \sum_{j \neq i} Q_{c_j}) / Q_c] \quad (3)$$

where, $\sum_{j \neq i} Q_{c_j}$ denotes to the total available capacity of other power producers other than the generator i in the market; Q_c is the total available capacity of all generators in the market.

2.3 Model

In addition to introducing the forecasted market position indicator (I_t^{CSR}, I_t^{mrr}) as an exogenous variable, the hysteresis values of some of these exogenous variables ($I_{t-i}^{CSR}, I_{t-i}^{mrr}$) can also be introduced. The final determination of the interpretation vector and its lag order in the model also requires a correlation test between the interpreted variable and each explanatory variable.

Using the autocorrelation test and the partial correlation test to determine the explanatory variables that have strong correlation with the interpreted variables, the least squares method is used to obtain the mean value equation of the on-grid electricity price as follows:

$$P_t = c + \sum_{i=1}^m \alpha_i P_{t-i} + \sum_{i=0}^n \beta_i I_{t-i}^{CSR} + \sum_{i=0}^l \gamma_i I_{t-i}^{mrr} + \varepsilon_t \quad (4)$$

where, ε_t is the random error of the on-grid price P_t at time t ; α is the coefficient of the hysteresis link of the endogenous variable P ; β is the capacity adequacy index and the coefficient of the lagging link; γ is the coefficient of the required operating rate index and its lagging link; m, n , and l are the number of explanatory vectors that are significantly non-zero after the t -test coefficient.

Then, the conditional heteroscedastic equation for establishing the fluctuation of on-grid electricity price based on GARCH modeling theory is:

$$R_t = \phi_0 + \sum_{i=1}^q \phi_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \phi_j R_{t-j} \quad (5)$$

where, R_t is the conditional heteroscedasticity of on-grid electricity price fluctuation, $\phi_0 > 0$, ϕ_i is the coefficient of the square of the residual value of the feed-in tariff, and $\phi_i \geq 0, i = 1, \dots, q$; ε_{t-i} is the residual value of the on-grid price; ϕ_j is the coefficient of the variance of the lag condition, and $\phi_j \geq 0, j = 1, \dots, p$. Drawing on the theory of financial risk analysis, we define R_t as the risk coefficient of electricity price fluctuation, which is used to characterize the price fluctuation risk of electricity market.

3 Risk warning model

3.1 Market price risk warning based on VaR

After calculating the potential price risk level of the market R_t , according to its size, carry out different levels of risk warning, and use the VaR theory to determine the risk warning warning line. The exact definition of V_{aR} is: the maximum possible loss of a particular portfolio of assets over a specified period of time under normal market conditions and a certain level of confidence (Jorion, 1997). The expression for defining the price risk of electricity market is:

$$P_r(R_t > V_{aR} | \Omega_{t-1}) = 1 - \alpha \quad (6)$$

Where, P_r represents the probability statistical value, R_t is the price fluctuation risk coefficient obtained by the GARCH model; V_{aR} is the risk value under the confidence level α ; V_{aR} is the set of all previous information. This formula indicates that the probability

that the market price risk is greater than VaR within Δt is $1 - \alpha$, or the probability that the market price risk is not greater than VaR within Δt is α . Based on VaR, the risk value at different confidence levels can be established as a warning line for price risk warning:

$$\begin{cases} P_r(R_t > VaR_{red}) = 1 - 95\% \\ P_r(R_t > VaR_{orange}) = 1 - 90\% \\ P_r(R_t > VaR_{yellow}) = 1 - 85\% \\ P_r(R_t > VaR_{blue}) = 1 - 80\% \end{cases} \quad (7)$$

In the formula, VaR is the warning value of the electricity price risk coefficient, and the warning color is green when the predicted $R_t < VaR$.

Using the VaR historical simulation method, the price risk coefficient R observed in a certain period of history is investigated, and the probability distribution curve is drawn. VaR at different confidence levels can be obtained (for example, there are 100 observation samples, confidence) The VaR under 95% corresponds to the sixth price risk coefficient R in descending order, which can be used as a warning line for different warning levels for price risk warning (Dahlgren et al.,2003) .

As shown in Figure 1, corresponding to the setting method of the market status alert level, when the price risk level R_t exceeds the threshold, a level 5 warning {red, orange, yellow, blue, green} is made, and the price risk plan is promptly reacted according to the price risk plan.

Fig.1 Classification of warning line

3.2 Electricity market price risk warning process

The proposed early warning model for electricity market price risk includes two parts: price risk prediction modeling based on GARCH and price risk early warning modeling based on VaR. The specific flow chart is shown in Figure 2.

Fig. 2 Modeling flowchart of price risk warning

4 Conclusion and countermeasures

According to the risk warning system in the electric power trading market, the operation and risk occurrence of the electric power trading market can be evaluated in real time, and the changes of each indicator can be monitored at any time, so that the electric power regulatory department can clearly and intuitively understand the operation of the electric power market, and take corresponding regulatory measures in time. By establishing various evaluation indexes, the risk early-warning system can not only predict the risk of

various price fluctuations in the trading market, but also carry out early-warning analysis of possible external risks in the electric power trading market. According to the international experience and lessons, in the early stage of the construction and operation of the power generation market, some power producers often exercise their market power to manipulate the market. Therefore, in the early stage of China's power marketization reform, it is of great guiding significance to establish a scientific and reasonable risk warning system to analyze, evaluate, make decisions and supervise power grid operators, market dispatcher and market supervisors.

Through the above research, this paper puts forward

three policy suggestions:

(1) Implementing hierarchical management of the power trading market and strengthening the awareness of risk warning. In view of all kinds of risk problems faced by electric power enterprises, the government can make enterprises improve their awareness of risk warning by implementing hierarchical management. Some enterprises have weak risk management awareness and lack of comprehensive understanding and analysis of various risk management problems. Based on this, it is necessary to implement hierarchical management. Through the method of group division of labor, the managers of electric power enterprises can divide the risk management problems existing in each link of electric power transaction, and let the team members work together to complete the division of labor based on the division of labor model.

(2) Establishing the risk warning mechanism of power trading market. It is far from enough to have a complete index system and early warning model for the operation of risk early warning system. The comprehensive collection of information, scientific analysis and accurate decision making are the key to the establishment of risk warning system, so it is essential to establish a set of relatively complete warning information management system. First, establish an information monitoring system. Electric power regulatory departments should establish and improve risk control methods and procedures and formulate corresponding information monitoring system according to various possible risk problems in the electric power trading market. Second, the establishment of early warning information reporting system (CARDELL et al., 1997). Electric power operating institutions should strengthen the collection and submission of information so as to accurately grasp and timely understand various factors that may cause market trading risks and provide basis for the decision-making of regulatory authorities. Only through the close combination of technology and system can the normal operation of the early-warning system of power market risk be guaranteed effectively.

(3) Adjusting and improving risk warning system timely. With the gradual progress of China's electric power marketization reform, the statistics and measurement standards of risk indicators are further standardized and improved. More and more early-warning indicators that reflect the marketization level can be added, so as to establish a more effective early-warning indicator system of risk. At the same time, we should also pay attention to that the risk warning of the electricity trading market is a dynamic process. With the change of economic and social environment, the relative importance of indicators will change. Therefore, in the process of risk early warning, we should not look at problems from a fixed perspective, but look at problems from the perspective of development and dynamics, and constantly adjust and improve the early warning system. Only in this way can we better play the role of early warning and improve the trading efficiency of the market.

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