State Evaluation Method, Monitoring Method and Monitoring Analysis of Small and Medium-Sized Enterprises Based on Power Data

Zhanjun Li[1], Yong Wang[1], Shasha Liu[*2], Yongrui Li[1], Jia Yu[1], Shuo Yang[3]

{Shasha Liu[*]:yinhongling_123@163.com, Zhanjun Li : zhouxiaoming_112@163.com
Yong Wang: yangxiaobo_bj@163.com, Yongrui Li: herong_19771@163.com
Jia Yu: zhangchuanyuan_123@163.com, Shuo Yang : chenhuag_111 hongying_11989@163.com}

[1]State Grid Liaoning Electric Power Supply Co., Ltd.Shenyang, Liaoning,110015, China
[2]Beijing Guodian Tong Network Technology Co. , Ltd.Beijing,100085, China
[3]State Grid Liaoning Electric Power company limited Economic Research Institute， Shenyang, Liaoning,110015, China

Abstract. The purpose of this paper is to discuss the state evaluation method and monitoring method of SMEs (small and medium-sized enterprises) based on power data, analyze its advantages and limitations, and show how to use power data to effectively monitor and analyze the state of enterprises. It is hoped that this new evaluation method will provide more accurate and timely decision-making basis for relevant institutions and enterprises. In this paper, the power data is used to construct the power evaluation index for the development of small and micro enterprises, and the weight of each power index is calculated by EWM(Entropy weight method). The rank sum ratio method is used to analyze and get the evaluation results of the development of small and micro enterprises in various regions. Based on K means clustering method, the energy efficiency utilization of enterprises is evaluated, and the evaluation model and implementation path are given. Finally, a comprehensive energy monitoring and analysis system is established to provide a platform for data integration, model operation and result display for comprehensive energy consumption analysis of enterprises. Through comprehensive energy monitoring and mining analysis, the weak links of comprehensive energy management in enterprises are accurately located, and the optimization scheme is provided for energy-using enterprises. The power data also shows correlation with some economic indicators, which provides a new way to predict the economic trend of enterprises. This method provides a simple and intuitive enterprise health assessment tool for the government and financial institutions, and has a wide application prospect.

Keywords: small and medium-sized enterprises; power data;monitoring; evaluation.

1 Introduction

With the rapid development of social economy, SMEs (Small and Medium-Sized Enterprises) are playing an increasingly important role in national economic construction, and they have become an important support and source of innovation for economic development. However, due to the limitation of funds, technology and management, there are certain uncertainties in the operation and development of SMEs. How to accurately and timely evaluate and warn the operation status of SMEs is an important issue of concern to the government, financial

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institutions and various partners[1]. Traditionally, the evaluation of SMEs is based on financial data, business activities and market research. However, these methods often have problems such as time lag, difficulty in obtaining data and strong subjectivity. In recent years, with the rapid development of technologies such as big data, Internet of Things and smart energy, power data as a direct, real-time and objective data source has been paid more and more attention. Power data can directly reflect the production activities, work intensity and operation status of enterprises. For example, continuous low power consumption may mean that the production line of an enterprise is shut down or productivity is reduced, while a sudden surge in power consumption may be manifested as rapid expansion or high-intensity operation of the enterprise. Therefore, power data has great potential value, which can provide a new perspective and method for the evaluation and monitoring of SMEs.

The purpose of this paper is to discuss the state evaluation method and monitoring method of SMEs based on power data, analyze its advantages and limitations, and show how to use power data to effectively monitor and analyze the state of enterprises with practical cases. It is hoped that this new evaluation method will provide more accurate and timely decision-making basis for relevant institutions and enterprises[2].

2 Research method

2.1 SMEs state evaluation method

Electric power economic correlation coefficient is a coefficient used to describe the relationship between various economic and technical indicators in power system. These coefficients play a key role in power economic analysis and decision-making. Electric power is the vane of economic growth, and the correlation coefficient of electric power economy is R. The closer R is to 0, the weaker the correlation between regional electricity consumption and regional GDP [3]. When $R > 0$ means positive correlation, the regional GDP increases with the increase of regional electricity consumption; When $R < 0$ indicates negative correlation, the regional GDP decreases with the increase of regional electricity consumption.

$$R_{X,Y} = \frac{\mathrm{cov}(X,Y)}{(\sigma_X, \sigma_Y)} \tag{1}$$

Where: X is the regional GDP; Y is the regional electricity consumption; $R_{X,Y}$ represents the correlation coefficient of electric power economy; $\mathrm{cov}(X,Y)$ is X,Y covariance; σ_X is the variance of X; σ_Y is the variance of Y.

Electricity consumption elasticity index (electricity demand elasticity or electricity price elasticity) describes the changing relationship between electricity demand and electricity price, income or other related variables. It is a measure to indicate the sensitivity of electricity demand to price or other variables. In economics, elasticity is usually used to describe the response of demand or supply to price changes.

The elasticity index of electricity consumption quoted in this paper is a macro index reflecting the relationship between the annual average growth rate of electricity consumption and the annual average growth rate of the national economy [4-5].

$$I_{EC} = \frac{R_{AVG}}{R_{AVGGDP}} \tag{2}$$

Where: I_{EC} is the elasticity index of power consumption; R_{AVG} is the average annual growth rate of electricity consumption; R_{AVGGDP} is the average annual growth rate of GDP.

Indicators can objectively reflect the adaptability of electric energy consumption and economic development, which is of great significance for judging the stage of regional economic development and industrial structure analysis.

At present, the real-time collection of power data is mainly realized through intelligent collection terminals, which ensures the timeliness and accuracy of enterprise power consumption data. Therefore, relying on power data to evaluate enterprise development can ensure the scientificity and reliability of analysis results [6]. In order to objectively evaluate the development level of small and micro enterprises, the power evaluation index of small and micro enterprises is constructed by using power data, and the weight of each power index is calculated by EWM(Entropy weight method). The rank sum ratio method is used to analyze and get the evaluation results of small and micro enterprises in each region.

EWM is a method to determine the weight based on information theory. This method is mainly used in multi-attribute decision analysis, and the weight of each index is determined by calculating the entropy value of each evaluation index, thus providing a more objective decision-making basis [7].

The basic principle of EWM is: if the variability of an index is large, then the more information it contains, the greater the corresponding weight should be; Conversely, if the variability of an indicator is small, its weight should also be reduced.

Data standardization: First, the original data should be standardized and converted to the same order of magnitude. Commonly used standardization methods include 0-1 standardization, Z-Score standardization and so on.

Calculate entropy value: for the standardized value of the i evaluation object of an indicator j is x_{ij}, then its probability p_{ij} can be expressed as:

$$p_{ij} = \frac{x_{ij}}{\sum_{i-1}^{n} x_{ij}} \tag{3}$$

Where n is the number of evaluation objects. Then calculate the entropy value e_j of the j index:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln\left(p_{ij}\right) \tag{4}$$

Where $k = 1/\ln(n)$ is a constant to make the range of e_j between [0, 1].

Calculate redundancy: Redundancy d_j can be expressed as:

$$d_j = 1 - e_j \tag{5}$$

Determine the weight: Finally, the weight w_j of each index can be determined according to the redundancy:

$$w_j = \frac{d_j}{\sum_{j-1}^{m} d_j} \tag{6}$$

Where m is the number of indicators.

This method is particularly useful when dealing with a large number of indicators and seeking weights, because it can not only give the weights of each indicator, but also provide an objective evaluation of the importance of each indicator for decision makers.

Rank sum ratio method is a nonparametric statistical test method for two independent samples, which is mainly used to compare whether the median of two groups of data is significantly different. This method is especially suitable for cases where the sample size is small or the data does not meet the assumption of normal distribution [8].

The steps of rank sum ratio method are as follows:

Merge two sets of data: merge two sets of data into one data set.

Rank sorting: sort the merged data sets from small to large, and give each data a rank.

Calculate rank sum: add up the ranks of each original group of data respectively to get two rank sums.

Calculation of inspection statistics: commonly used statistics are W , and the calculation formula is:

$$W = n_1 \times n_2 + \frac{n_1(n_1+1)}{2} - R_1 \tag{7}$$

Where n_1, n_2 is the sample size of the two groups of data, and R_1 is the rank sum of the first group of data.

Judging significance: compare with the critical value corresponding to a given significance level (usually 0.05), and judge whether the value of W is significant. If the value of W is greater than or less than the critical value, the median of the two groups of data is significantly different.

2.2 Monitoring and analysis of comprehensive energy efficiency of enterprises

Monitoring and analysis of enterprise comprehensive energy efficiency Monitoring and analysis of enterprise comprehensive energy efficiency is a systematic analysis method that pays

attention to the overall energy consumption and energy efficiency level of enterprises. Through this method, enterprises can understand their energy consumption, find potential energy waste points, and take corresponding measures to improve energy efficiency and reduce energy costs. Based on EWM, K means clustering and other methods, this paper evaluates the energy efficiency utilization of enterprises, and gives the evaluation model and implementation path. Finally, a comprehensive energy monitoring and analysis system is established to provide a platform for data integration, model operation and result display for comprehensive energy consumption analysis of enterprises. Through comprehensive energy monitoring and mining analysis, the weak links of comprehensive energy management in enterprises are accurately located, and the optimization scheme is provided for energy-using enterprises[9].

The comprehensive energy efficiency monitoring and analysis of enterprises based on big data aims to provide enterprises with comprehensive and in-depth insight into their energy efficiency through the collection, processing and analysis of a large number of data. This analysis can help enterprises find opportunities to improve energy efficiency, reduce costs and reduce environmental impact. Implementing comprehensive energy efficiency monitoring and analysis of enterprises based on big data can help enterprises better understand their energy consumption, find opportunities to improve energy efficiency and achieve sustainable management. Based on the terminal information of supply side, demand side and other links, the comprehensive monitoring and analysis of energy is realized, which provides data support for energy consumption, intelligent operation and maintenance, and energy improvement of various users. Figure 1 shows the comprehensive energy efficiency monitoring and analysis structure based on big data.

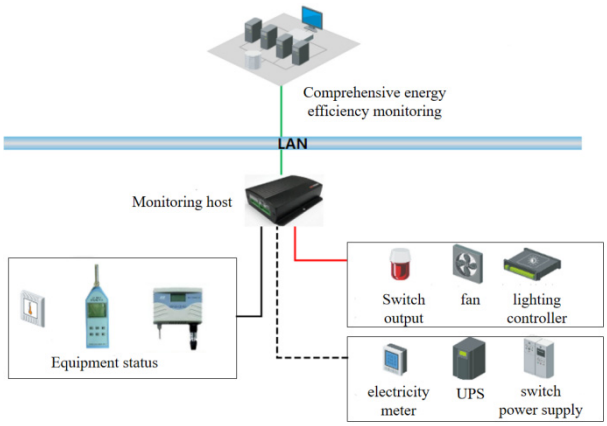

Figure 1. Comprehensive energy efficiency monitoring and analysis structure based on big data

K-means is an iterative clustering algorithm used to divide data into k different clusters/groups. Algorithm flow:

(1) Initialization: randomly select k points from the data set as the initial cluster center (or use other initialization methods, such as K-means++).

(2)Assignment: Assign each point in the data set to the nearest cluster center. This is usually done by calculating the Euclidean distance from each point to the center of all clusters.

(3)Update: Recalculate the center of each cluster, usually by taking the average of all points in the cluster.

(4)Iteration: Repeat steps 2 and 3 until the cluster center no longer changes significantly or reaches the predetermined number of iterations.

K-means is a simple and widely used clustering algorithm. It is widely used in various application fields, such as market segmentation, image compression and data compression. Using clustering algorithm to group energy-using enterprises and screen valuable users. The data of training sample set includes power consumption increase, industry characteristics, power consumption growth rate, etc. After iterative cluster analysis, energy user value can be subdivided.

3 Result analysis

The electricity consumption of industries in H city from 2016 to 2021 (electricity consumption data of small and micro enterprises) was obtained through the electricity collection system, and the GDP data of H city in recent 6 years was obtained in the statistical yearbook. In this paper, the evaluation indexes are preprocessed and normalized to get the normalized results of each index.

The power consumption elasticity index of H city is calculated, and the result is shown in Figure 2.

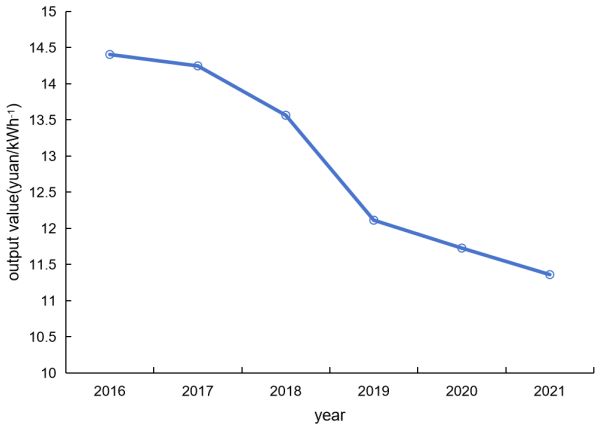

Figure 2. Analysis of elasticity index of power consumption

It can be seen that the output value of kilowatt-hour electricity shows a downward trend, with an average output value of 13.57 yuan per kilowatt-hour. The industrial structure of H city needs further optimization and support to enhance the economic development momentum.

The rank sum ratio method can be used to get the evaluation results of the development of small and micro enterprises in various regions, and to sort and classify them. The evaluation results,

comprehensive ranking and grading interval of each region are obtained by ranking the rank sum and grading, as shown in Table 1.

Table 1. Grading sorting result

Area number	Probability unit value	Rank sum ratio regression value	Rank sum ratio sorting	Grading
E	6.865	0.641	1	3
D	6.849	0.597	2	3
C	6.558	0.524	3	3
B	6.007	0.514	4	3
A	5.989	0.397	5	2
F	5.375	0.37	6	2
G	5.32	0.154	7	1

Through the analysis of G region, we can find that the new industry expansion index of enterprises in this region is low, and the recession rate of enterprises is high, which indicates that the development of enterprises is not good. It is suggested to pay attention to enterprises with a large decline in electricity consumption, strengthen assistance and attention, and promote the healthy and high-quality development of enterprises.

Rank sum ratio method is applied to rank and file the development of enterprises, and the overall operation situation of enterprises in each region is analyzed. By comparing the indicators of different grades of regions, the weak links in backward areas are found, management is strengthened, and the development level of enterprises is promoted in an all-round way[10].

Using the energy Internet sharing service platform, we will build a visual analysis scenario for energy efficiency monitoring of important energy-using enterprises, display energy efficiency and energy efficiency information more intuitively, locate the weak links in optimizing energy utilization, and provide energy consumption prediction and analysis. Through centralized monitoring of the energy use of end users, it provides data support for the development of energy efficiency diagnosis and treatment, enterprise energy saving evaluation and transformation.

4 Conclusions

By tracking and analyzing the power data of many SMEs, we find that the power consumption of enterprises is closely related to their production and operation activities. Through the real-time monitoring of enterprise power data, we can find out the abnormal situation in enterprise operation in time, such as the sudden increase or decrease of power consumption. Through the analysis of power data, we can not only evaluate the health status of enterprises, but also predict the economic development trend of enterprises. Considering the important position of SMEs in China's economy, the enterprise state evaluation method based on power data is expected to be widely used in government decision-making, risk management of financial institutions and enterprise's own operation management. Power data provides us with a new perspective to evaluate the health status and economic development trend of SMEs. This method is simple, intuitive and relatively accurate, and is worth further promotion and application.

References

[1]Zhang Yuming, & Duan Shengsen. (2012). Research on Evaluation System of Growth Ability of Small and Medium-sized Enterprises. Scientific Research Management, 33(7), 8.

[2] Yu Xinyu, Zhang Tienan,&Shi Zhuqing. (2010). Research on the Evaluation Model of the Growth Ability of Innovative SMEs. Modern Management Science (5), 3.

[3] Xing Wenjie, & Zhang Dechao. (2013). Research on evaluation index system of small and micro enterprises' development ability in underdeveloped areas. People's Forum (3), 82-83.

[4] Wang Zijing, & Zhang Yuming. (2017). Research on the evaluation system of small and micro enterprises' development ability that meets the new demand. dongyue tribune (9), 7.

[5] Wang Shuang, Liu Yanbing,&Liu Yifang. (2013). Research on the Evaluation of the Development Ability of Science and Technology Innovative Enterprises in Haidian District. Practice and Understanding of Mathematics, 43(19), 8.

[6] Tao Jinguo, Gao Juemin, Wang Xue,&Du Zhenzhen. (2013). Research on Evaluation of Sustainable Development Capability of Enterprises in Chemical Industry Park —— Based on the questionnaire data of enterprises in Nanjing Chemical Industry Park. China Industrial Economy (8), 12.

[7] Sajjad Ghanbari Ali Ghiasian.(2024).Smart traffic routing and service allocation strategy to reduce water consumption in data centers through power reduction.Sustainable Computing: Informatics and Systems100974-.

[8] Li Yichao,&Dai Guilin. (2018). Research on evaluation of enterprise performance improvement based on network capability. statistics and decision (10), 3.

[9] Yin Feng,&Gao Zhiyuan. (2019). Research on Evaluation of Innovation Capability of Equipment Manufacturing Enterprises Based on Grey g1 Method. Machine Tools and Hydraulics (22).

[10] Tom Eisenberg.(2024).Missing data and the effects of market deregulation: Evidence from Chinese coal power.International Journal of Industrial Organization103054-.