Research on inventory system of highway E&M equipment affected by the environment

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Abstract. With the rapid development of China's highway construction and the gradual increase of toll road mileage, the importance of E&M equipment in highway construction has become increasingly prominent. However, in recent years, the special operation and maintenance cost of electromechanical equipment has been increasing, which has caused the cost of highway projects to increase yearly. In order to improve this phenomenon of "overgeneralization," this paper investigates the list system of highway E&M equipment affected by the environment. By adopting the Activity Based Classification based on range and difference ratio, the E&M equipment is classified, and the list of E&M equipment affected by the environment is established. The price range of highway E&M equipment was also measured. This study helps to provide a scientific basis for the quotation of E&M equipment affected by the environment and to complete the missing quotas of E&M equipment.

Keywords: E&M equipment, inventory system, Activity Based Classification, price range

1 INTRODUCTION

The construction of highways plays a critical part in modern transportation. With decades of development, the mileage of China highway construction and construction technology has improved by leaps and bounds. Until the end of 2022, the total mileage of highways in China has already reached 5,354,800 kilometers, which ranks first in the world in terms of the total mileage of highways [1]. In the meantime, according to the annual report of China's toll road statistics, the mileage of toll roads is gradually and steadily increasing, and its growth rate exceeds the rate of increase of the national highway, which proves that the government attaches great importance to toll roads. While the increasing mileage of toll highways also led to the development of E&M equipment, as the critical component of toll highway infrastructure, E&M equipment not only affects the capacity of the traffic section but also determines the overall ser-

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vice capacity of the highway network and the crucial place of intelligent digitalization. As the transportation infrastructure of "clairvoyance" and "clairaudience," the role of E&M equipment is self-evident. Nevertheless, with the increase, the number of highway mileage and investment scale has increased significantly, resulting in the cost of highway projects across the country generally showing a rising trend each year, and this rising trend in the next few years will remain unchanged and rapid growth [2]. This trend has brought hardship to the control of E&M equipment and affected the operation and maintenance level and ability.

To effectively control the phenomenon of "over-budgeting" in highway projects, scholars from various countries have conducted research in various directions on the cost analysis of highway projects. As different countries and regions adopt different costing models, the research directions of scholars from various countries are quite different. In China, the price analysis of highway projects is carried out utilizing fixed-price pricing. In the process of research, scholars from China found that the current quotas have problems such as lagging preparation methods [3-4], difficulty in ensuring the quality of determination [5], and lack of regional applicability [6-7]. For these issues, Chinese scholars have mainly studied a variety of methods to control the cost of E&M equipment, which include: the technical determination method [7-8], neural network algorithm [9-10], Monte Carlo modeling method [11], fuzzy comprehensive analysis method [12], gray theory analysis method [13], etc.

These research results provide a theoretical basis for supplementing and changing the quotas of E&M equipment. Different from China, foreign countries have different management modes in each country [14]. Take Japan and the United States as an example: ① In the cost control mechanism of highway projects in Japan, a consulting company is responsible for the design, and the government prepares the project cost [15]. The primary responsibility of consulting companies is to provide design proposals or cost estimates [16]. In contrast to China, Japan does not widely use the quota system but relies more on cost databases for cost preparation. ② The United States has adopted a commercialized model for construction cost management, typically using the cost-based or market-based pricing method [17]. The bidder provides a bill of quantities, and the contractor quotes according to the list. Bidders price the work based on their experience and market information. The highway trade associations in the United States are responsible for publishing and releasing some statements and information. At the same time, consulting firms use the information about bids, materials, equipment, labor for projects published by government agencies to create their own databases, similar to enterprise quotas in China [18]. For most consulting firms, the company's database is more reliable than the cost information published by the government or private sector [19]. In summary, the management mode of scholars for highway costs in various countries can be found to be mainly focused on the main body of the highway project. However, the research on the cost of E&M equipment is relatively limited, and the current, in-depth research on the cost management of E&M equipment is relatively lacking.

Because the current highway E&M equipment quotas are inconsistent with the actual situation, the quota of E&M equipment has some difficulties. In addition, most of the reasons for this situation are due to the influence of the environment received by

E&M equipment. Therefore, this paper will analyze the list system of highway E&M equipment affected by the environment in depth. The Activity Based Classification method evaluates and categorizes the differences between the quotas and market prices of E&M equipment affected by the environment to establish the list, and the price range estimation method measures the price ranges of the equipment on the list. Combining the above methods and assessments will establish a set of boundaries for the list system of E&M equipment on environmentally affected highways to more accurately and rationally replenish or update the E&M equipment and provide a reliable price range reference for quotations.

2 Framework for highway E&M equipment inventory system affected by environment

In highway engineering, E&M equipment, as an integral part of highway infrastructure, plays a highly critical role. Therefore, it is necessary to deeply understand the characteristics, classification, and environmental factors affecting E&M equipment to better construct a highway environmental impact-based E&M equipment inventory system structure (Figure 1), which is centered on the improvement of the existing E&M equipment inventory system, and supported by mechanisms, elements, and dimensions. Establishing the framework for E&M equipment quotas has an intense revelation, for constructing a more perfect highway E&M equipment list system has laid a theoretical foundation.

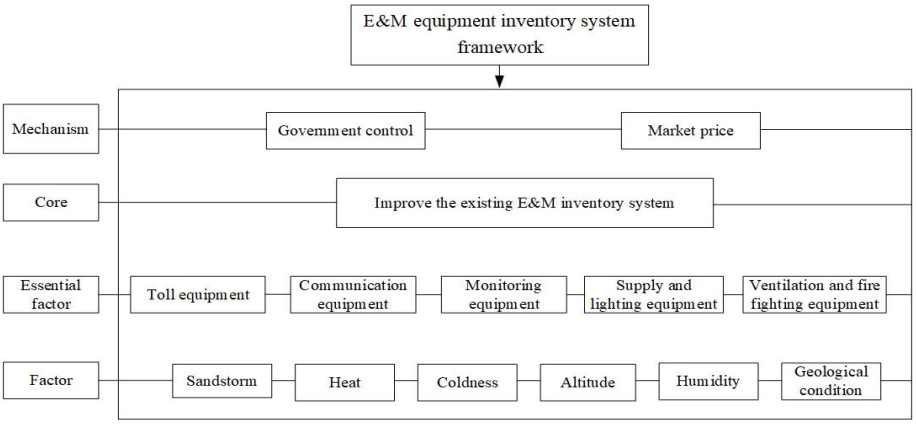

Fig. 1. E&M equipment inventory system framework

2.1 Characteristics of E&M equipment

According to the Highway Project Budget Quotas (JTG/T 3832-2018), E&M equipment can be roughly categorized into toll equipment, communication equipment, monitoring equipment, power supply and lighting equipment, and ventilation and fire-fighting equipment. This E&M equipment has the characteristics as follows:

(1) Wide variation in the time of commissioning

The wide variation in the time when E&M equipment is put into operation is a common phenomenon in highway construction. Different highway construction projects are completed differently, resulting in the E&M equipment being operated over a more extended period. Even in the same section of highway, there are also significant differences due to the "overall planning, phased implementation" of China's highways and E&M equipment in different sections of the operation time [20], which led to part of the E&M equipment in the abolition of the highway provincial boundary toll station project for upgrading, and part of the E&M equipment due to the earlier input time, specifications, and technical parameters compared to the backward.

(2) Various types

The highway E&M equipment system is complex, covering many types of E&M equipment. According to the statistics of "Inspection and Evaluation Quality Standards for Highway Engineering Section 2 Electrical and Mechanical Engineering" (JTG 2182-2020), the commonly used highway E&M equipment has more than 200 types. Moreover, different specifications, technical parameters, and manufacturers of the same type of equipment lead to performance differences and uneven quality among E&M equipment.

(3) High volume

With the continuous increase in highway kilometers, the demand for E&M equipment in transportation engineering has also improved significantly. Moreover, with the gradual increase in the scale of highway construction, the growth shows an increasingly prosperous trend.

(4) Wide distribution area

Highway E&M equipment is usually located along the highway. Due to the long mileage of the highway project, the geographical distribution is more dispersed, often through several provinces and cities; E&M equipment is distributed throughout the entire highway or road network. This results in a complex environment for using E&M equipment, and the distributed areas may have different geology, temperature, and climate differences.

2.2 Environmental impact factors on E&M equipment

(1) Effect of cold

Highways in alpine regions usually face severe winters and relatively low temperatures and sometimes suffer from heavy snowfall. Under extreme cold conditions, E&M equipment may suffer from phenomena such as freezing and difficulty starting; certain plastic materials tend to become brittle at low temperatures, which may affect the impact resistance and durability of E&M equipment.

(2) Effect of high altitude

High altitude generally refers to 1500 meters above the geographical area [21]; China's high-altitude areas are roughly distributed in the Tibetan Plateau and its surroundings. High-altitude areas are usually accompanied by low oxygen content, significant temperature differences, unstable soil conditions, and other diseases, which can lead to the operation of E&M equipment may be affected. For example, reduced oxygen levels may affect the combustion efficiency and performance of internal com-

bustion engines. The effects of low temperatures on E&M equipment are also considered, as temperatures are lower at higher altitudes.

(3) Effects of High Temperature

Under high-temperature conditions, E&M equipment tends to accumulate heat, which affects performance and life, so E&M equipment requires an effective cooling system. At the same time, high-temperature environments can affect the regular operation of electronic equipment and even cause it to fail. Therefore, in high-temperature environments, the heat dissipation capability of E&M equipment and the heat resistance of the equipment is of particular concern.

(4) Effects of Humidity and Precipitation

Highway E&M equipment may experience corrosion and water leakage problems in humid environments. High humidity can cause corrosion and oxidation of metal parts of E&M equipment. In areas of high precipitation, E&M equipment may require additional waterproofing or higher levels of waterproofing to prevent moisture from entering the E&M equipment and causing failure. Therefore, E&M equipment requires enhanced moisture and waterproofing measures in humid conditions.

(5) Effects of sandstorm

In the sandstorm environment, wind and sand particles may enter the interior of E&M equipment and affect the regular operation of E&M equipment. At the same time, wind and sand can also cause wear and damage to the surface of the equipment, reducing the overall life of the E&M equipment. E&M equipment must be equipped with effective dust and sand prevention measures, such as installing sealing covers and dust filters to prevent wind and sand from entering the interior of the equipment and regular cleaning of the equipment.

(6) Effects of soil geological conditions

Soil geological conditions are influential factors that cannot be ignored in highway E&M equipment. The bearing capacity and stability of the soil directly affect the operational safety of E&M equipment. The soil in some areas may be loose, lacking sufficient bearing capacity, resulting in equipment in operation quickly falling or settling, affecting stability. Therefore, highway E&M equipment must be constructed with appropriate reinforcement measures according to the soil and geological conditions to ensure the firmness and stability of the foundation.

2.3 Challenges in analyzing E&M equipment pricing

Through the comprehensive study of the characteristics and classification methods of E&M equipment and the in-depth analysis of the various environmental influences on E&M equipment, it is possible to have a deeper understanding and appreciation of the attributes that E&M equipment possesses. Moreover, these attributes, to a certain extent, make the price analysis of E&M equipment difficult. The problems of price analysis of E&M equipment are mainly reflected in the following aspects:

(1) Complex specifications and technical parameters of E&M equipment that make quoting difficult

The critical parameters of essential E&M equipment are closely related to the price of the equipment, and since the abolition of provincial boundary highway toll stations,

the types and models of E&M equipment have been constantly introduced to improve the efficiency of highway traffic and toll collection [22]. The time of E&M equipment put into operation varies widely, and the equipment's function, technical parameters, and quality are uneven. Currently, the price is mainly obtained from the highway engineering standard quotas and the mainstream equipment manufacturers in the industry to request quotations. There must be more equipment types and a mismatch between equipment parameters, price ranges, and the actual situation. In the construction process, highway E&M equipment needs more refined equipment parameters, which causes the lack of reference prices in the bidding and controlling bids. In contrast, the quota base price could be higher, resulting in difficulties in the bidding work of highway projects.

(2) Outdated E&M equipment quotas caused inaccurate quotes.

At present, quota pricing is one of the essential methods of managing the quotations of highway E&M equipment in China, and the quotations are mainly based on the highway engineering industry standards and recommended standards issued by the Ministry of Transport and Communications of China. However, the preparation of new quotations takes about 5-10 years. Such an extended period cannot keep up with the rapidly developing technical processes [23], so some new equipment and new processes cannot find the appropriate guide price, resulting in a delay that causes a significant deviation in the preparation of quotations. Although the quotation library is updated regularly, it still can not come close to the rapid changes in the market.

(3) Lack of regional applicability of E&M equipment quotas results in inaccurate quotes.

The existing quotas are universal, as the price standards are based on standardization, normalization, and universal application. The state must still prepare special quotas and cost standards for some regions with unique characteristics. Generally, it adopts multiplying a specific coefficient to calculate the price for some special construction conditions or special climatic and geological conditions. However, with E&M equipment, unique climatic conditions and geological conditions of E&M equipment must meet the particular equipment specifications, the corresponding construction technology, and other reasons, so this form of adjustment coefficients can not be further applied to the special evaluation conditions. Continue to use this way to prepare the bid, and the cost can not entirely reflect the actual construction cost, resulting in bidding difficulties; over-profiling is not uncommon.

2.4 Inventory boundaries of E&M equipment affected by environment

E&M equipment is a crucial element in highway projects, but environmental factors can significantly impact the performance and life of E&M equipment. These effects lead to particular environmental conditions where ordinary E&M equipment may not be able to be used in unique environments, thus requiring E&M equipment with particular technical parameters. Such special requirements lead to price differences between different E&M equipment. Therefore, this paper focuses on the inventory boundaries of E&M equipment for highways affected by the environment. The list boundary covers detailed E&M equipment list items and price ranges (Figure 2).

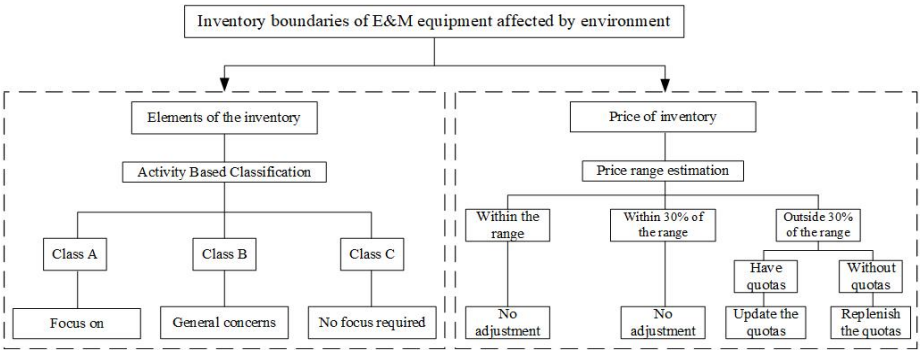

Fig. 2. Inventory boundaries of E&M equipment affected by environment

The E&M equipment inventory item contains a hierarchical list of E&M equipment affected by the environment and a table of equipment requiring additional quotas. In order to obtain a hierarchical list of this E&M equipment affected by the environment, the Activity Based Classification can be used, which has its origins in the "Pareto Analysis," also known as the Pareto Principle or Pareto Law, which originated from the studies of the Italian economist Vilfredo Pareto at the end of the 19th century.

Based on this research, the "80/20 rule" has been proposed, which states that 80% of the effects often come from 20% of the causes. Activity Based Classification is based on this principle, which categorizes the objects under control into three groups according to their value or importance. Activity Based Classification is typically used in areas such as supply chain management, inventory control, and purchasing decisions. The most common calculation method is based on sales or inventory value. According to the amount of money as a criterion, the varieties that account for about 60% of the amount per year are classified as Class A, about 30% as Class B, and about 10% as Class C [24]. The criteria for the division of Activity Based Classification are shown in Table 1:

Table 1. ABC Classification Standard for E&M equipment

Classification	Feature	Percentage of cumulative	Management approach
Class A	High amount of variance	60%	Focus and add corrections
Class B	Moderate amount of variance	30%	General concern about
Class C	Low amount of variance	10%	No focus required

While developing the list of E&M equipment items, an accurate estimate of the price range of these environmentally affected E&M equipment items is also required to evaluate the cost of environment-related E&M equipment so that a reasonable budget plan can be developed. The price interval estimation method is commonly used in statistics to estimate a variable's uncertainty range. That is the range of possi-

ble actual values of a variable at a given interval level. Standard price interval estimation techniques include:

(1) Confidence interval:

They are used to estimate the range of uncertainty in the total parameter. It is usually expressed as a confidence level (usually chosen as the 95% confidence level), which means that in the case of repeated sampling, there is a 95% confidence interval containing the actual value of the total parameter.

(2) Percentile intervals:

They were used to estimate the range of uncertainty in the data distribution. For example, the data's 15%, 50%, and 85% quartiles are calculated to form the percentile intervals, which can cover most of the data values, conform to the normal distribution, and reflect some characteristics of the data distribution.

(3) Prediction intervals:

They are used to predict the possible range of new sample values. The prediction interval is wider than the confidence interval because it also considers the uncertainty of the error term.

3 List of E&M equipment inventory for highways affected by environment

E&M equipment is a massive volume of business, and different types of equipment present the essential characteristics of multiple types, large quantities, and wide distribution. Therefore, specific methods should be used to classify and grade the degree of difference between equipment quotas and market prices and implement targeted quota correction or additional quota preparation processes according to the different levels of equipment differences, which can solve the problem of new technology quota differences. In this paper, we will introduce an activity-based classification method to evaluate and classify the difference between the standard quota price and the market price of E&M equipment unit price of highway projects and to classify the importance of additional quotas for E&M equipment.

In assessing the difference in the unit price of E&M equipment between the standard highway project quotas and the market price, the equipment can be categorized into three classes: Class A (priority needs to be supplemented or corrected), Class B (general needs to be supplemented or corrected), and Class C (does not need to be supplemented or corrected). However, in the actual price of E&M equipment, the price of E&M equipment varies in size. The fluctuations in the unit price of E&M equipment cannot be fully reflected by using only one indicator, the extreme deviation or the spread rate, for evaluation. The extreme variation focuses only on the difference between the maximum and minimum values. In contrast, the variation rate reflects only the magnitude of the change in the unit price, ignoring the complete picture of price fluctuations. Some equipment unit prices may have small price changes, but the overall price fluctuations are large. In contrast, some equipment unit prices may have hefty price changes, but the overall price fluctuations are negligible. Therefore, Activity Based Classification, which combines extreme variance and variance

rate measures, provides a more comprehensive and accurate assessment and categorization.

3.1 Activity Based Classification for extreme range

When using the extreme range between the quota price and the market price of E&M equipment for Activity Based Classification, the materials are sorted from highest to lowest in terms of the size of the extreme range, and the ABC category is based on the cumulative percentage of the extreme range.

First, calculate the extreme range Q_i between the quota price Q_i and the market price M_i for each E&M equipment, the larger the extreme range Q_i, the larger the deviation between the quota price and the market price. The specific method of calculating the range D_i is as Formula (1):

$$D_i = Q_i - M_i \tag{1}$$

Next, calculates the percentage of each material's range in the total range, denoted as P_i. Specific calculations are given in Formula (2):

$$P_i = \frac{D_i}{\sum_{i=1}^{n} D_i} \times 100\% \tag{2}$$

Then calculate the cumulative positive variance percentage, denoted as C_i. The cumulative positive variance percentage represents the cumulative percentage of the extreme variance of the first i materials in the total extreme variance. The specific calculation method is as Formula (3):

$$C_i = \sum_{j=1}^{i} P_j \tag{3}$$

Lastly, the ABC category is classified based on the cumulative positive range percentage C_i. Typically, the first 60% of the cumulative positive deviation is classified as Class A equipment, the next 30% is classified as Class B equipment, and the remaining equipment is classified as Class C equipment.

3.2 Activity Based Classification for difference ratio

When using the difference ratio between the quoted price and the market price of electromechanical equipment for ABC classification, the difference ratios should be sorted in descending order, and the categorization should be based on the cumulative percentage of the difference ratios.

Firstly, calculate the difference ratio R_i for each E&M equipment, which is the absolute difference between the quoted price Q_i and the market price M_i divided by the market price. The larger the difference ratio, the greater the deviation between the quoted price and the market price. The specific calculation method for the difference ratio is as Formula (4):

$$R_i = \frac{|Q_i - M_i|}{Q_i} \times 100\% \tag{4}$$

Next, sort all E&M equipment by difference ratio from highest to lowest to get a sorted list. Calculate the percentage of each material's difference ratio in the total difference ratio, denoted as P_i, as Formula (5):

$$P_i = \frac{R_i}{\sum_{i=1}^{n} R_i} \times 100\% \tag{5}$$

Then, the cumulative difference ratio percentage is calculated and denoted as C_i. The cumulative difference ratio percentage represents the cumulative percentage of the difference ratio of the previous i materials in the total difference ratio. The specific calculation method is as Formula (6):

$$C_i = \sum_{j=1}^{i} P_j \tag{6}$$

Lastly, the ABC category is classified based on the cumulative difference ratio percentage C_i. Typically, the first 60% of the cumulative positive deviation is classified as Class A equipment, the next 30% is classified as Class B equipment, and the remaining equipment is classified as Class C equipment.

3.3 Classified list of E&M equipment

After comprehensively considering the two indicators of extreme range and difference ratio for Activity Based Classification, the classification results of extreme range between fixed price and the market price of E&M equipment can be taken as the main focus, supplemented by the results of the division of difference ratio between fixed price and the market price of E&M equipment. The list of E&M equipment classification can be derived according to the classification results. The results are shown in the following table (Table 2):

Table 2. Activity Based Classification of highway E&M equipment affected by environment

ABC category	Type of E&M equipment	Classification of E&M equipment	Need for additional quotas
Class A	Toll equipment	Weighing equipment, ETC road side equipment	Yes
	Supply and lighting equipment	Long-distance power supply boosting equipment	No
Class B	Toll equipment	Scanning terminal, Vehicle detector	Yes
		Automatic railing machine	No
	Communication equipment	Accumulator	Yes
	Monitoring equipment	Variable Message Sign, Weather detector	Yes
	Supply and lighting equipment	UPS	Yes
		Outdoor integrated cabinet	No
	Other equipment	Industrial ethernet rail switch	Yes
Class C	Toll equipment	Outdoor camera	Yes
		Self-service payment machine, license plate recognition, lane control machine, ETC handheld machine	No
	Firefighting equipment	Electrical tracing heat	Yes
		Fan, submersible pump	No
	Supply and lighting equipment	Luminaire	Yes
		Outfield distribution box	No

E&M equipment is categorized into Class A, B, and C based on the classification of the grading list. Equipment in Class A has large extremes and high difference ratios, with fluctuating price differences, and requires focused attention. In contrast, equipment in Class B has medium extremes and difference ratios, with more even price differences. It requires moderate general attention, and equipment in Class C has small extremes and low difference ratios, with minor price differences, and can be used without any change in quotas.

3.4 E&M equipment which requiring supplemental quotas

The collection and consolidation of E&M equipment data have made it possible to produce a detailed and comprehensive breakdown of environmentally impacted E&M equipment. The breakdown includes E&M equipment with standardized quotas. This breakdown provides a comprehensive picture of the current status of E&M equipment and highlights the lack of standardized quotas and the urgent need for additional quotas. The results are shown in the following table (Table 3):

Table 3. List of highway E&M equipment affected by environment

Type of E&M equipment	Need for quotas replenishment	Quotas replenishment not required
Toll equipment	ETC road side equipment, ETC handheld machine, fill light, HD infrared camera, HD dome camera, HD remote PTZ camera, radar vehicle detector, code scanning terminal, axle group weight counting equipment	Fog lights, electric railing arms, vehicle detectors, toll booth distribution boxes, lane controllers, license plate recognizers, electric railing machines, toll booth cameras, toll lane cameras, high-definition cameras, canopy signal lights
Communication equipment	Maintenance-free battery packs, valve regulated sealed battery packs	/
Monitoring equipment	Gantry variable message sign, cantilevered variable message sign, variable message sign in tunnel, weather detector	Traffic warning light
Supply and lighting equipment	Upper unit, lower unit, UPS	Outdoor integrated cabinet
Ventilation and firefighting equipment	Electrical tracing heat	Fan, submersible pump
Other equipment	Industrial ethernet rail switch	/

4 Measuring the price range of highway E&M equipment affected by environment

Accurate and stable quotations are crucial for business decisions in highway E&M equipment quotation and cost control. However, due to market complexity and information asymmetry, the quotation of E&M equipment faces a situation of significant differences between market prices and quotas. Therefore, to solve the quota deviation of highway E&M equipment, we need to promptly compare the current prices of mainstream E&M equipment in the market with the quota prices and come up with the price range of the equipment to make timely corrections and additions to the quotas.

4.1 Data preprocessing

Data preprocessing is required before collecting data to calculate the price range of E&M equipment to eliminate possible outliers, outliers, and data noise. Furthermore, data preprocessing can reduce the effect of unbalanced quotations in the original data.

Unbalanced bidding refers to the inappropriate pricing of different quantities in the bidder's bid, which makes the unit price of different quantities significantly different. This phenomenon can be caused by unreasonable pricing strategies, such as low bid and high return, high bid and low return [25]. Moreover, the equipment price appeared to have uneven distribution, so the analysis results need to be more accurate to make the price of E&M equipment deviate from the actual value. Therefore, it is necessary to preprocess the data to ensure the accuracy of the analysis results. Some common ways of preprocessing are as follows:

(1) Missing value handling

Sometimes some values need to be added to E&M equipment price data. In the preprocessing of E&M equipment price data, missing value handling is an essential step because, in reality, the data collected often need to be completed or included. Missing values can be caused by measurement errors, data entry problems, sample selection, Etc., and the presence of missing values can affect the analysis and modeling results of the data, so it is necessary to take appropriate missing value processing methods. Common ways to deal with missing values include deletion, interpolation filling, particular value substitution, and multiple interpolations.

(2) Outlier Handling

Outlier processing is a critical step in preprocessing E&M equipment price data because outliers can adversely affect data analysis and modeling. Outliers are data points significantly different from other observations and may be caused by measurement errors, data entry errors, data collection problems, or other unknown factors. These outliers can distort the distribution and statistical properties of the data, leading to errors or inaccurate predictions in the model. Therefore, proper handling of outliers is critical to obtaining reliable analysis results. Common ways to handle outliers include outlier removal, outlier replacement, outlier analysis, and statistical model building.

(3) Data transformation processing

In E&M equipment price data preprocessing, data transformation is a standard processing method used to change the original scale or distribution of data to meet the requirements of data analysis or improve the data's nature. Data transformation can reduce the skewness of the data to some extent, improve the relationship between features, and reduce the discrepancy between data, thus making the data more suitable for statistical analysis, modeling, and prediction. Mostly used for tasks like price forecasting [26] and market trend analysis [27]. Common types of data transformation include logarithmic transformation, square root transformation, normalization, Box-Cox transformation [28], Etc.

4.2 Price range measurement

The measurement of the price range of E&M equipment is based on the price quotations collected for the same type of E&M equipment for different projects. In this paper, the percentile range method is used to estimate the price range of the data. Better cost control and budget planning can be achieved through reasonable price range measurement.

Assume there are n data points $X = \{x_1, x_2, \ldots, x_n\}$, where X_i denotes the ith data point and the number of quantile points calculated is denoted as Q_m. In this paper, the 15th percentile point Q_{15}, the 50th percentile point Q_{50} and the 85th percentile point Q_{85} need to be calculated.

First, the data points must be sorted in ascending order:

$$X_{(1)} \leq X_{(2)} \leq \ldots \leq X_{(n)} \tag{7}$$

Next, the index position is calculated, and if the index position k is not an integer, a linear interpolation calculation is required:

$$k = 1 + (n - 1) \times m \times 0.01 \tag{8}$$

Finally, the value of the percentile can just be obtained:

$$Q_m = x_{(k)} \tag{9}$$

Once an E&M equipment price range has been established, the price range is compared to the equipment's quota price. No quota adjustment is required for E&M equipment where the difference is within the range or within 30%. However, an allocation update is required if the difference is more significant than 30%. This way, environmentally sensitive E&M equipment costs can be managed more effectively, ensuring consistency between quotas and actual prices.

5 Conclusion

In this study, through the study of highway E&M equipment list system affected by the environment, we have carefully categorized and sorted E&M equipment and compiled a list of E&M equipment affected by the environment. Meanwhile, we measured the price range of highway E&M equipment to provide a scientific basis for the quotation of E&M equipment. Moreover, we provided methodological justification for establishing the supplementary breakdown of the full quotas of E&M equipment.

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