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Cost estimation of waste gas water treatment in chemical enterprises based on discrete choice model

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ABSTRACT

The traditional cost estimation method of waste gas treatment in chemical enterprises has low accuracy and long time. To solve the above problems, this experiment proposed a method of waste gas treatment cost estimation for chemical enterprises based on Discrete Choice Model (DCM). This method first analyzed the waste gas treatment cost of chemical enterprises to determine the emission amount of main pollutants in the waste gas of chemical enterprises. After that, the experiment determined the main components of waste gas treatment costs of chemical enterprises, which were mainly divided into environmental protection equipment costs, maintenance costs and pollution penalty costs. On this basis, a DCM was constructed to analyze the waste gas of chemical enterprises. Meanwhile, the model was used to estimate the waste gas treatment cost of chemical enterprises. The final experimental results showed that the accuracy of this method to estimate the waste gas treatment cost of chemical enterprises could reach 90%, and the estimation time was short, and it was feasible.

Keywords: Waste gas treatment cost; Emissions; Equipment cost; Maintenance cost; Pollution penalty cost; Discrete choice model

1. Introduction

Environmental pollution has always been a concern in our country. A good ecological environment is the well-being of HP's people and the basis for human health and survival. However, with the rapid development of China's economy, various industries in China have been greatly enhanced, but the ensuing environmental pollution problems emerge in endlessly [1]. In recent years, there have been many sudden environmental pollution incidents, causing economic losses and destroying the stability of China's ecological environment. Among them, chemical enterprises are an important cause of environmental pollution and accidents, and the waste gas produced in the production process of chemical enterprises is the primary source of environmental pollution. According to records, 80% of the sudden environmental pollution accidents from 2004 to 2008 were caused by the leakage and fire of toxic and harmful chemicals in chemical-related enterprises, which not only caused huge economic losses, but also caused irreversible environmental pollution [2]. In order to improve economic benefits, chemical companies continue to reduce the cost of waste gas pollution, resulting in incomplete purification of the treated waste gas and affecting environmental pollution. Therefore, with the goal of protecting the ecological environment, it is urgent to formulate a strategy to restrict the pollutant discharge of chemical enterprises. At present, the environmental impact assessment of domestic chemical enterprises mainly focuses on the qualitative description of the concentration distribution of pollutants and the impact of pollutants [3]. Mainly by comparing the operating cost and corresponding efficiency of pollution control facilities, the result is used as the waste gas treatment cost of chemical enterprises. However, this method of cost estimation is not scientific. How to improve the cost estimation of waste gas treatment in chemical enterprises and improve the efficiency of waste gas treatment in chemical enterprises has become a hot research issue in this field [4]. DCM is a complex and advanced multivariate statistical analysis technique for dealing with discrete, non-linear qualitative data. It has good practicability and is widely used in the fields of economics and sociology [5]. Therefore, this study introduces this model into the cost estimation of waste gas treatment in chemical enterprises, which is of great significance to the emission reduction of chemical enterprises, and it is also a relatively innovative attempt. The technical route of this paper is as follows:

- Determine the main pollutants in the waste gas of chemical enterprises by analyzing the confirmation conditions of the waste gas treatment cost of chemical enterprises, and obtain the emission volume of the main pollutants in the waste gas;
- Determine the main components of waste gas treatment costs in chemical enterprises, and extract environmental protection equipment costs, maintenance costs and pollution penalty costs, respectively;
- On this basis, the DCM is used to correct the waste gas treatment cost of chemical enterprises, and the cost estimation of chemical enterprise waste gas treatment based on the DCM is completed.
- Experimental analysis;
- Conclusion and prospect.

1.1. Related work

There have been many scholars discussing the cost estimation method of waste gas treatment in chemical enterprises. Guo et al. [6] proposed a cost control method for sewage treatment plant projects based on life cycle theory. This method divided the sewage works of the sewage treatment plant according to the degree of pollution by analyzing the life cycle theory. At the same time, the method of cost control and cost management was adopted to analyze the problems existing in the project cost of the sewage treatment plant, and the budget was reviewed, and the cost control system was constructed to achieve the goal of cost control of the pollution treatment plant project. This method had high accuracy in estimating the cost of sewage treatment in sewage treatment plants. And this method was based on the whole life cycle theory, which was theoretical and practical. Researchers such as Shang and Fu [7] proposed a risk control method in the investment estimation stage of water purification plants and sewage treatment plants. The method was constructed and implemented by using the method of social capital and government cooperation (PPP). The model analyzed the reasonable return efficiency of total investment on government expenditure responsibility and social capital, and found that overestimation or underestimation of investment would bring great risks to the investment of government and social capital. In addition, the experiment also analyzed common investment risk factors in water quality evaluation, such as design treatment process selection, building and building estimation index selection, equipment and material cost value, foundation treatment cost, etc. This method clarified the processing cost by analyzing the processing risk, but the cost estimation of this method took fewer factors into account, resulting in lower accuracy of cost estimation. Zou et al. [8] proposed a method for the accounting of greenhouse gas emissions in the urban sewage treatment industry and the analysis of temporal and spatial characteristics. By analyzing the severity of greenhouse gas pollution in cities and towns, the top greenhouse gases were subdivided according to the degree of urban gas pollution, and the scale and intensity of pollution control were analyzed. Thereby slightly increasing the emission of gas pollution and reducing environmental pollution. This method subdivided gases into multiple types, which improved the accuracy of estimation, but cost estimation requires more time.

DCM is widely used in various scientific fields by researchers because of their strong practicability. Scholars such as Guzman LA proposed a hybrid DCM to understand the behavior of fare evaders to improve the fare evasion problem in the global public transportation system. The model took into account socio demographics, fare evasion records, trip characteristics, and user satisfaction with public transport systems, and used a unique method for estimating stated preferences. The final experimental results found that fare evaders on weekdays accounted for about 15%, which verified the good practical value of the model [9]. Berbeglia et al. [10] conducted an empirical study of different DCM and estimation methods, including maximum likelihood and least squares criteria. Experiments provided a large amount of synthetic data, semi-synthetic data and real data, and used the DCM to conduct a comparative study on these data. The experimental results verified the predictive ability of the DCM. Chen et al. [11] studied self-selection in DCM using full information maximum likelihood procedures. The program was able to maintain good performance for sample sets in extreme cases. At the same time, the experiment also used the "infinity identification" weight to identify the level. In the end, the researchers applied the constructed model to the selection of fishing locations, and the results showed that the model had good predictive performance and was of great economic significance.

In summary, the DCM has strong practicability, but the existing methods for estimating the waste treatment cost of chemical enterprises still have many deficiencies. Therefore, this paper tries to combine the two, and proposes a method for estimating the cost of waste gas treatment in chemical enterprises based on DCM. The method determines the main pollutants in the waste gas of the chemical company by analyzing the confirmation conditions of the waste gas treatment cost of the chemical company, and obtains the discharge amount of the main polluting gas in the waste gas of the chemical company.

2. Study on the selection of main pollutants in chemical enterprises and the treatment cost estimation model based on DCM

2.1. Construction of waste gas treatment cost pollutant selection model based on DCM

Waste gas treatment cost, as the cost of chemical enterprises to protect the natural environment, should meet the traditional cost recognition conditions. However, due to its particularity, the confirmation conditions should be summarized in combination with environmental protection regulations [12,13]. Considering the characteristics of waste gas treatment cost, the conditions for confirming the cost of waste gas treatment are summarized as follows:

- Transactions or events leading to waste gas treatment costs have indeed occurred. This is not only the first condition of traditional cost recognition, but also the first condition of environmental cost recognition. Environmental cost is the outflow of economic benefits of an enterprise, and its accounting performance is the consumption of assets or the increase of liabilities.
- The transaction or event must be related to the environment. According to the connotation of environmental cost, we can know that to recognize the expenditure of a transaction or event as environmental cost, we must first conform to its definition.
- The amount of cost incurred should be able to be reliably measured or reasonably estimated. From an accounting point of view, all economic events must be able to be reflected in currency or reasonably estimated before being recognized. For the confirmation of waste gas treatment cost, part of the expenditure can be measured reliably, but a part of the expenditure related to the environment cannot be accurately measured in the current period. For this part of expenditure, it should be estimated with the information model of environmental economics and other related disciplines, and its value should be estimated through the relevant model, and internalized, and recognized as the environmental cost of thermal power enterprises.

In the process of confirming the cost of waste gas treatment in chemical enterprises, it is a research difficulty to divide the capitalization and expense. Because different accounting treatment will have a great impact on the current and future financial performance of the enterprise, which will have a negative impact on the enthusiasm of enterprise environmental management activities. This paper holds that the view of FASB is more in line with the actual needs of chemical enterprises. That is, environmental expenditure should meet one of the following conditions to be capitalized:

- The cost of prolonging the service life of enterprise assets, improving its safety or improving its efficiency;
- Reducing or preventing the occurrence of environmental pollution is conducive to protecting the environment;
- The necessary costs incurred before the sale of the assets originally prepared for sale are of high value and long service life.

Based on the above analysis, the confirmation process of waste gas treatment cost in chemical enterprises is summarized, as shown in Fig. 1.

The multivariate logit model is the most widely based model among the DCM. The model is based on random utility theory, and considers that various decision-making schemes of decision makers are mutually exclusive, complete and limited. The specific expression of the Logit model is:

$$P_{\mathrm{ni}} = \frac{e^{V_{\mathrm{ni}}}}{\sum_{j=1}^{C_n} e^{V_{\mathrm{nj}}}} \quad (1)$$

where n represents a certain decision maker and j represents a certain decision-making scheme. C_n for the set of all decision alternatives, V_{ni} select i the utility fixed term of the decision tree alternative for the decision maker. n the pollutants in the exhaust gas of chemical enterprises include SO_2, No, CO_2, fly ash, suspended particulate matter, etc. In chemical enterprises, the discharge of these exhaust gas pollutants is the main factor affecting the cost of exhaust gas treatment. In this paper, the types of pollutants in the governance cost of chemical enterprises are determined by obtaining the emissions of pollutants in the exhaust gas of chemical enterprises.

- Calculation of sulfur dioxide emissions:

$$P_{\mathrm{so}_2} = 2a_p \times \xi_b \times K_{\mathrm{so}_2}\left(1 - \nu_{\mathrm{so}_2}\right) \quad (2)$$

where a_p represents the coal consumption rate, kg/(kWh), ξ_b represents the sulfur content of coal-fired applications, K represents the conversion rate of sulfur from coal to flue gas, and ν represents the desulfurization efficiency.

- Carbon dioxide emissions:

$$P_{\mathrm{CO}_2} = 3.66a_p \times D_{\mathrm{ar}} \times K_{\mathrm{CO}_2} \quad (3)$$

where P_{co_2} represents the carbon dioxide emission and K_{co_2} represents the oxidation rate of carbon in the dye.

- Calculation of carbon monoxide emissions:

$$P_{\mathrm{co}} = 0.20\mathrm{kg} \times 10^{-3} a_p \quad (4)$$

where P_{co} represents carbon monoxide emissions.

2.2. Construction of waste gas treatment cost estimation model for chemical enterprises based on DCM

Based on the pollution emission which is the most likely to exist in the chemical enterprise waste obtained above, the waste disposal cost is obtained. Waste gas treatment costs are the expenses paid by chemical enterprises to reduce environmental pollution and engage in environmental protection activities, mainly including equipment investment and annual operating expenses [14]. The costs of waste gas treatment in chemical enterprises include: Project construction fee, unforeseeable fee, project Guoheng design fee and other miscellaneous expenses. The annual operation and maintenance cost mainly includes the cost of raw materials, such as absorbent, industrial water, power, steam, fuel, etc. This includes the cost of labor and the annual cost of overhauling and overhauling equipment.

The cost of environmental protection equipment in the equipment installation cost of chemical enterprises is:

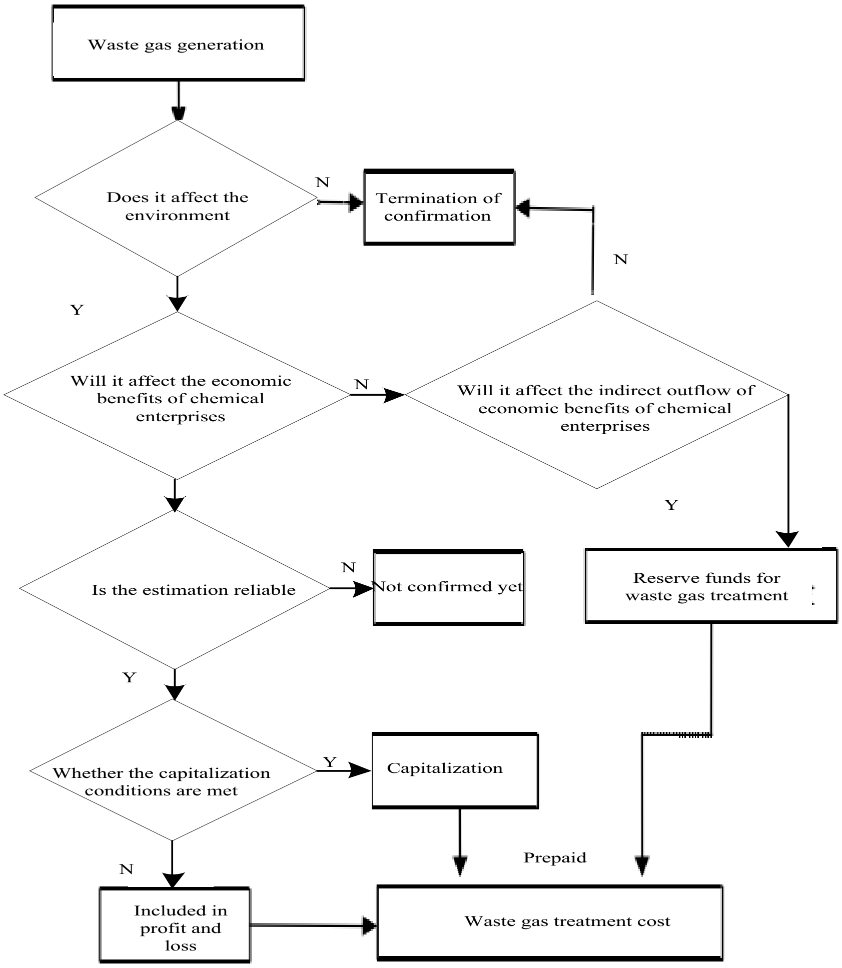

Fig. 1. Waste gas treatment cost confirmation process for chemical enterprises.

$$H_i = m_o \times A_{\text{CRF}} \tag{5}$$

where m_0 denotes the sum of installation costs and construction and construction cycle interest on behalf of waste gas treatment of chemical enterprises; A_{CRF} represents the financial recovery coefficient of waste gas treatment equipment after installation in chemical enterprises.

After the installation of environmental protection equipment, after a certain stage of waste gas treatment, the equipment needs to be maintained regularly. At this time, maintenance costs also account for a certain proportion, environmental protection equipment maintenance costs are:

$$H_j = \sum_{i=1}^{n} \sigma_j \tag{6}$$

where σ_1 represents the maintenance cost of type j environmental protection equipment in a chemical enterprise.

In the waste gas treatment of chemical enterprises, it is inevitable that the emission of polluting gases exceeds the standard, and the relevant departments will fine them at this time. This project is also a part of the waste gas treatment cost of chemical enterprises. The cost of the waste gas pollutant in chemical enterprises is:

$$H_c = \sum_{i=1}^{n} \left(\vartheta_i \times G_i \right) \tag{7}$$

where H_c represents the emission cost of waste gas pollutants from chemical enterprises, ϑ_i represents the discharge charge standard for the type i gas pollutant, G_i represents the total emission of waste gas pollutants.

The above are the main costs involved in the accounting of waste gas treatment in chemical enterprises. Accounting for it is conducive to improving the accuracy of the cost estimation of waste gas treatment in enterprises, and it can also better allow enterprises to choose a reasonable waste gas treatment plan for treatment. The purpose of chemical enterprises to calculate the cost of waste gas treatment is to choose a treatment plan. This paper analyzes the utility of cost accounting by choosing a discrete model to improve the accuracy of waste gas treatment costs in chemical enterprises.

Based on the above analysis, this paper further improves the waste gas treatment of chemical enterprises by selecting discrete models. DCM is consistent with Lancaster demand theory, that is, consumer choice is determined by utility or value, and utility or value comes from a particular commodity or service attribute. Assuming that the total utility of an alternative can be represented by a utility equation, the scheme with large total utility is selected [15]. The utility of waste gas treatment in chemical enterprises is an important basis for cost estimation. It is assumed that the utility of waste gas treatment in chemical enterprises consists of two parts, namely:

$$G_j = F_i + \varepsilon_i \tag{8}$$

where F_i represents the observable composition of the utility of waste gas treatment cost options in chemical enterprises and the unexplained part of waste gas treatment costs in chemical enterprises.

From the above analysis, it can be found that the choice of chemical enterprises in the cost accounting of waste gas treatment is not determined according to the actual scale of public utilities, but is formed by comprehensive consideration of factors. Due to the existence of random items in waste gas cost accounting, chemical enterprise managers cannot be very sure to predict the preferences of residents. For all options, the cost treatment options are:

$$\psi_i = \delta\left[\left(F_i + \varepsilon_i\right)\right] > \left(F_j + \varepsilon_j\right)\forall_{i \neq j} \tag{9}$$

Assuming that the random errors in the waste gas cost control of chemical enterprises exist independently of each other or are not related in the cost accounting scheme, there will be certain limitations in the determination of the cost accounting scheme [16–19]. At this time, on the basis of the DCM, according to the Logit model, the cost estimation scheme is estimated, that is:

$$\phi_r = \frac{\exp^{\lambda L_i}}{\sum_{j=1}^{n} \exp^{\lambda L_j}} \tag{10}$$

where $L_i = L(x_i,R)$ is the utility function representing cost accounting, x_i represents the vector of waste gas cost composition of chemical enterprises, R is vectors representing environmental properties, λ represents scale parameters, usually its value is 1.

In the utility function L_i, there are many different forms of representation function. In this paper, it is applied to the waste gas cost treatment of chemical enterprises. Only the simplest form of function is considered, that is, according to the nature of the function. To improve the accuracy of waste gas treatment in chemical enterprises, the waste gas treatment cost plan [20–22] was determined, namely:

$$L_i = R + \sum \alpha_u X_u \left(i = 1,2,\ldots N, u = 1\ldots U\right) \tag{11}$$

On the basis of the above utility function analysis, the ultimate purpose of selecting the discrete model is to obtain the unbiased estimation of the cost processing parameter α. α is used to explain the selection behavior and also includes the marginal utility of the cost estimation attribute. Therefore, to achieve the cost accounting estimation of chemical enterprises [23–25], vector α needs to be rectified, namely:

$$L_i = \tau + \sum D \times s_h + \sum \alpha_u X_u + \sum \alpha_u \times s_h \tag{12}$$

where τ represents the constant term of the specified scheme for waste gas treatment costs of chemical enterprises, X is the attribute variable representing the selected set in cost accounting, s_h is Attitude variables representing social environmental and economic variables.

3. Performance verification of waste gas treatment cost estimation model of chemical enterprises based on DCM

In order to verify the scientific effectiveness of the proposed method, simulation experiments are carried out. The experiment was carried out by comparing the proposed method, literature method, literature method and literature method [4–6].

3.1. Experimental environment and parameters

The object of the experiment is a small and medium-sized chemical enterprise, which covers an area of 300 m^2. The waste gas produced by its chemical products is more consistent than that produced by the same industry. The experiment was carried out on the MATLAB platform, and the experimental data were collected and analyzed by SPSS 13.0 software. The specific experimental environment is shown in Fig. 2. Fig. 2 shows the waste gas treatment instrument, which includes the instrument battery, the instrument power control device, and the instrument display platform. Waste gas treatment instrument QL series UV photolysis waste gas treatment equipment, its model is QLHB, the ignition temperature is 10°C, and the treatment concentration is 1,000 mg/L.

The experimental parameters are shown in Table 1.

In the above experimental parameters and experimental environment setting, a comparative method was adopted to compare the proposed method, literature method, literature method and literature method [4–6]. The accuracy of waste gas treatment cost estimation and the time of waste gas treatment cost estimation were taken as experimental indexes.

3.2. Analysis of experimental results of the model

3.2.1. Accuracy analysis of cost estimation of waste gas treatment

To verify the scientific effectiveness of the proposed method, the accuracy of waste gas treatment cost estimation of the proposed method, literature method, literature method and literature method is analyzed experimentally [4–6]. The experimental results are shown in Fig. 3.

It can be seen from Fig. 3 that the accuracy of the four methods of waste gas treatment cost estimation varies with the number of iterations. Among them, the method proposed in this paper and the method in literature has higher cost estimation accuracy [4]. The method in this paper is higher than that in literature [4], which can reach 90%. The recognition rate of the method in literature is about 88% [4], about 75% in literature [5], and about 72% in literature [6]. In contrast, the proposed method has the highest estimation

Fig. 2. Experimental environment.

Table 1
Experimental parameters

Parameter	Values
SO_2 emission concentration (Mg/M³)	200
NO emission concentration (Mg/M³)	300
Smoke (Mg/M³)	30
Sampling interval (S)	2
Number of iterations (times)	50

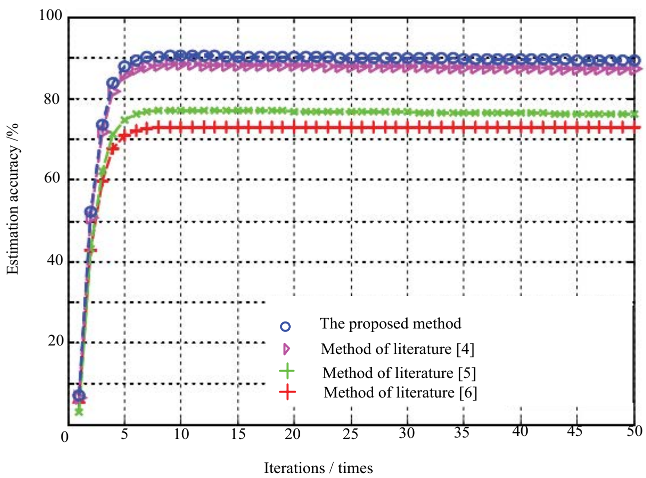

Fig. 3. Comparison of accuracy of waste gas treatment cost estimation.

accuracy. This is because the proposed method determines the main pollutants in the waste gas of chemical enterprises by analyzing the confirmation conditions of the waste gas treatment cost of chemical enterprises, and obtains the emission of the main polluting gases in the waste gas. After the experiment determined the main components of the waste gas treatment cost of chemical enterprises, the cost of environmental protection equipment, maintenance cost and pollution penalty cost were respectively extracted. On this basis, the DCM is introduced to correct the waste gas treatment cost of chemical enterprises, so it has higher accuracy.

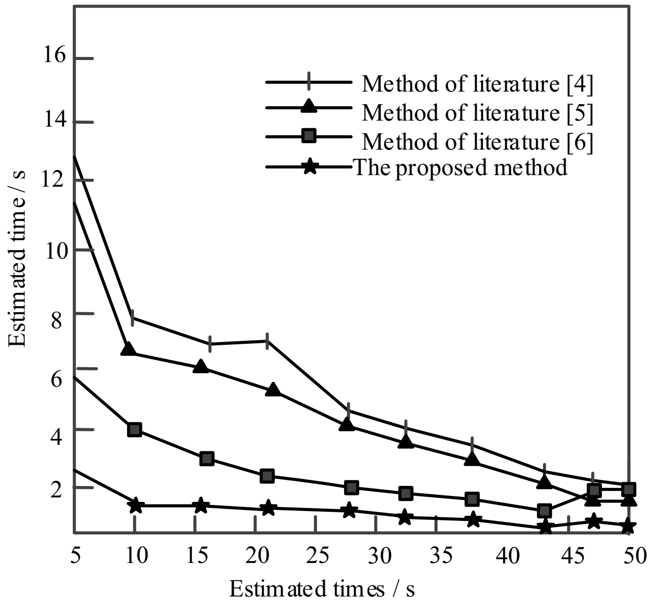

Fig. 4. Time-consuming comparison of waste gas treatment cost estimates.

3.2.2. *Time-consuming analysis of waste gas treatment cost estimation*

In order to further verify the feasibility of the proposed method, the experiment analyzed the waste gas treatment cost estimation time of the proposed method, the method in literature and the method in literature [4,5]. The experimental results are shown in Fig. 4.

Experimental results in Fig. 4, it is not difficult to find that the four methods all have a certain time-consuming cost estimation, and there is a certain gap in the time-consuming process. Wherein the evaluation time of the DCM constructed in this paper is about 0.2 s; The evaluation time of the method in is about 3 s [4]; The evaluation time of the method in is about 2 s [5]; and the method in the evaluation time of is about 1.8 s [6]. In contrast, the method constructed in this paper is much less time-consuming than the experimentally selected references. Therefore, it is verified that the method for estimating the cost of waste gas treatment in chemical enterprises based on the DCM has superior estimation performance and strong practicability.

4. Discussion

The article discusses from the perspective of the cost of waste gas treatment by chemical companies. In order to enable chemical companies to ensure their own economic benefits while dealing with waste gas emissions in a timely manner, this article proposes a cost estimation method for chemical companies to treat waste gas. The proposed method is implemented based on a DCM. Compared with other current cost processing and control methods, the method in this paper has certain advantages. The pollution treatment cost control method based on the life cycle theory in literature also has good practicability [6], but it does not consider the discharge and types of pollutants, and its overall method is not comprehensive enough. The cost control method for sewage treatment in literature considers many risks [7], but the factors considered for cost estimation are not enough, resulting in low accuracy of final cost estimation. In literature [8], a greenhouse gas emission accounting method based on spatio-temporal feature analysis is proposed. This method comprehensively considers the types of emitted gases, so you can improve the accuracy of the overall estimation, but it does not account for the time-consuming estimation. Advantage. In contrast, this experiment method has the highest estimation accuracy and is less time-consuming. The main reason is that the method in this paper firstly determines the main pollutants and their emissions in the waste gas of chemical enterprises. After that, the cost of environmental protection equipment, maintenance cost and pollution penalty cost in chemical enterprises are explored. The DCM finally introduced in the experiment corrected the cost of waste gas treatment in chemical enterprises to improve the estimation accuracy of waste gas treatment costs in chemical enterprises. Compared with the current waste gas treatment cost control method, the DCM introduced by the method in this paper is a relatively innovative measure.

5. Conclusion

Problem of low estimation accuracy in the cost accounting of waste gas treatment in chemical enterprises, which leads to the increase of enterprise costs, this paper proposes a method for estimating the cost of waste gas treatment in chemical enterprises based on DCM. By analyzing the conditions for determining the cost of waste gas treatment, the main pollutants in the waste gas of chemical enterprises are determined, and the emission of main polluting gases in the waste gas is obtained. The main components of waste gas treatment cost in chemical enterprises are determined, and the cost of environmental protection equipment, maintenance cost and pollution penalty cost are extracted, respectively. On this basis, the DCM is used to correct the waste gas treatment cost of chemical enterprises, and the cost estimation of chemical enterprise waste gas treatment based on the DCM is completed. Compared with the traditional method, the cost estimation accuracy of the waste gas treatment method proposed in this paper can reach 90%, which has a certain degree of credibility. Using this method to estimate the cost of waste gas treatment in chemical enterprises takes a short time, about 0.2 s, which can improve work efficiency to a certain extent. The results of this experiment have basically achieved the purpose of the experiment, and the proposed model can be applied to the actual accounting of chemical waste treatment costs. In addition, this model can also be applied to the field of waste pollution treatment cost control in the civil aviation transportation industry to a certain extent, and its application prospect is quite wide. However, although the method proposed in this paper is feasible at this stage, there are still some limitations. For example, more consideration should be given to the factors of exhaust pollution control, so as to further improve the accuracy of cost estimation. How to continuously improve the processing cost estimation scheme of chemical enterprises can become the next research direction.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest

It is declared by the authors that this article is free of conflict of interest.

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References

[1] L.P. Wang, F.L. Chen, R. Yang, Research on ecological compensation standard of haze pollution in the Beijing-Tianjin-Hebei region, Acta Sci. Circum., 38 (2018) 2518–2524.
[2] Y.M. Wu, Y.J. Zhou, H.Z. Tian, J.W. Ma, B.W. Sun, Research advances of atmospheric emission from the whole process of municipal solid waste treatment and disposal in China, Res. Environ. Sci., 31 (2018) 991–999.
[3] J.X. Fan, Q. Li, J.X. Hou, X. Feng, H. Karimian, S.F. Lin, A spatio-temporal prediction framework for air pollution based on deep RNN, Sci. Surveying Mapping, 42 (2017) 76–83,120.
[4] Z.W. Wang, J.Y. Yang, D.H. Wang, M. Li, LCC analysis process research on railway vehicles design, Comput. Simul., 37 (2020) 118–122,259.
[5] H. Yang, H.C. Zhou, Technology of space lab risk identification and control, J. Astronaut., 40 (2019) 295–301.
[6] S.J. Guo, H.W. Huang, X. Dong, S. Zeng, Calculation of greenhouse gas emissions of municipal wastewater treatment

and its temporal and spatial trend in China, Water Wastewater Eng., 45 (2019) 56–62.
[7] M. Shang, Y.J. Fu, Marginal emission reduction cost estimation of main pollutant in coal enterprises: taking SHJT enterprise as an example, Sci. Technol. Manage. Res., 39 (2019) 232–237.
[8] L.L. Zou, Y.S. Liu, Y.S. Wang, Shadow prices and pollution costs of agricultural pollutants in China from 1978 to 2017, Trans. Chin. Soc. Agric. Eng., 36 (2020) 223–230.
[9] L.A. Guzman, J. Arellana, J.P. Camargo, A hybrid discrete choice model to understand the effect of public policy on fare evasion discouragement in Bogotá's Bus Rapid Transit, Transp. Res. Part A Policy Pract., 151 (2021) 140–153.
[10] G. Berbeglia, A. Garassino, G. Vulcano, A comparative empirical study of discrete choice models in retail operations, Manage. Sci., 68 (2022) 4005–4023.
[11] Y.A. Chen, A.C. Haynie, C.M. Anderson, Full-information selection bias correction for discrete choice models with observation-conditional regressors, J. Assoc. Environ. Resour. Econ., 10 (2023) 231–261.
[12] Q.L. Zhang, Fully discrete convergence analysis of nonlinear hyperbolic equations based on finite element analysis, Appl. Math. Nonlinear Sci., 4 (2019) 433–444.
[13] H. Li, Research on the impact of tax preference and adjustment cost on corporate RandD investment behavior, Contemp. Finance Econ., 15 (2018) 25–34.
[14] D. Wang, X. Xiang, R. Nie, International experience in air pollution prevention and control and its enlightenment to China, J. China Univ. Min. Technol. (Social Sci.), 20 (2018) 57–69.
[15] H. Zhang, Environmental expenditure, interregional competition and environmental pollution—an explanation on the environmental issue of "race to the bottom", J. Shanxi Finance Econ. Univ., 40 (2018) 1–14.
[16] L.P. Wang, F.L. Chen, R. Yang, Research on ecological compensation standard of haze pollution in the Beijing-Tianjin-Hebei region, Acta Sci. Circum., 38 (2018) 2518–2524.
[17] X.Q. Han, D. Zhang, J.J. Yan, S.R. Zhao, J.P. Liu, Process development of flue gas desulphurization wastewater treatment in coal-fired power plants towards zero liquid discharge: energetic, economic and environmental analyses, J. Cleaner Prod., 261 (2020) 121144, doi: 10.1016/j.jclepro.2020.121144.
[18] L. He, F. Shao, L.X. Ren, Sustainability appraisal of desired contaminated groundwater remediation strategies: an information-entropy-based stochastic multi-criteria preference model, Environ. Dev. Sustainability, 23 (2021) 1759–1779.
[19] L. He, J. Shen, Y. Zhang, Ecological vulnerability assessment for ecological conservation and environmental management, J. Environ. Manage., 206 (2018) 1115–1125.
[20] W.C. Ling, Y.M. Fan, C.H. Sun, G.Z. Liu, Best management practices for non-point sources pollution control: a review of current research focuses, Environ. Pollut. Control, 41 (2019) 362–366.
[21] X. Hu, H. Chong, X.Y. Wang, Sustainability perceptions of off-site manufacturing stakeholders in Australia, J. Cleaner Prod., 227 (2019) 346–354.
[22] J.K. Liu, Y.D. Liu, X.T. Wang, An environmental assessment model of construction and demolition waste based on system dynamics: a case study in Guangzhou, Environ. Sci. Pollut. Res., 27 (2020) 37237–37259.
[23] F.Z. Song, K.X. Li, Y.N. Li, D.J. Zhang, P.L. Lu, F. Wang, A fuzzy mathematics based on pricing model for emissions trading benchmark price and its application, Res. Environ. Sci., 31 (2018) 194–200.
[24] J.K. Liu, Y.Q. Yi, X.T. Wang, Exploring factors influencing construction waste reduction: a structural equation modeling approach, J. Cleaner Prod., 276 (2020) 123185, doi: 10.1016/j.jclepro.2020.123185.
[25] Q. Lv, H.B. Liu, J.T. Wang, H. Liu, Y. Shang, Multiscale analysis on spatiotemporal dynamics of energy consumption CO_2 emissions in China: utilizing the integrated of DMSP-OLS and NPP-VIIRS nighttime light datasets, Sci. Total Environ., 703 (2020) 134394, doi: 10.1016/j.scitotenv.2019.134394.