# Assessing and Forecasting Sinopec's Sustainability through ESG Performance: A Combined Approach integrating TOPSIS, GM (1,1), and Pearson Analysis

Zening Piao[1,a*] ,Yujing Zhao[2,b], Xiangyu Wang[3,c]

[1]School of Chemical Engineering, Dalian University of Technology. Dalian, 116024 , China
[2]School of Management Science and Real Estate, Chongqing University. Chongqing, 400044, China
[3]Business School. Central South University, Changsha,410083, China

[a]yorigamishion@mail.dlut.edu.cn, [b]1293104765@qq.com, [c]1254750815@qq.com

**Abstract.** A company's performance in the Environmental, Social, and Governance (ESG) domains serves not only as a key indicator for evaluating its overall operations but also has an intricate and complex association with its sustainable development capabilities. This study constructs a comprehensive model that integrates the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model, Pearson's correlation analysis, and the grey prediction GM (1,1) model to quantitatively assess and visually present the ESG practices of Sinopec, a leading petrochemical company in China. The model reveals the company's performance across dimensions such as environmental, social, governance, and overall sustainability while delving into the intrinsic relationship between ESG performance and corporate sustainable development. The results indicate a strong correlation between the Environmental (E) indicator and sustainable development indicators, a weaker correlation between the Governance (G) indicator and sustainable development indicators, and interconnections between the Social (S) indicator and both E and G indicators. Furthermore, based on historical data, the study forecasts Sinopec's financial condition and ESG development trends for the next decade, with predictions showing that Sinopec will continue to be profitable, and that sustainable development and G indicators will continue to improve over the next ten years. The research also proposes a series of strategic recommendations aimed at enhancing corporate transparency and operational efficiency to achieve sustainable development.

**Keywords:** ESG, sustainability, TOPSIS model, GM (1,1) model, Pearson

## 1 Introduction

Over the past few decades, as concern for environmental, social, and governance issues has grown, corporate ESG performance has become one of the critical in-dicators for assessing a company's sustainable development [1]. The ESG frame-work evaluates a


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company's overall sustainability by considering its performance in environmental protection, social responsibility, and good governance, influencing the perspectives of investors, consumers, and regulatory bodies. In this context, a company's ESG performance is considered a significant factor in achieving sustainable development goals. However, the relationship between ESG performance and sustainable development is complex and multifaceted, with ongoing debates and research gaps. Additionally, the current ESG assessment system lacks consistency and standardization, complicating the comparison of corporate performance and making it difficult to achieve dynamic predictions of corporate ESG performance. Some studies suggest that companies with higher ESG scores tend to achieve better financial performance in the long term and are favored by investors [2]. Conversely, there are arguments that the link between ESG metrics and financial performance is not clear-cut, as sustainable development goals may require companies to incur certain short-term costs [3]. Therefore, understanding the correlation between corporate ESG performance and sustainable development is of great research significance, which will assist investors, corporate management, and regulatory bodies in making informed decisions and is crucial for the sustainable development of businesses. To address the existing issues, this study proposes a comprehensive model for analyzing and predicting a company's ESG performance and its relationship with sustainable development. The model integrates the TOPSIS [4] model, Pearson's correlation test [5], and the grey prediction GM (1,1) model [6]. In this research, we use the comprehensive analysis and prediction model to analyze and evaluate data from Sinopec's annual reports and social responsibility reports since 2014, revealing the Sinopec company's performance in each dimension and its overall sustainability capabilities, providing a complete assessment standard for ESG indicators.

## 2 Related Work

In recent years, a multitude of methodologies have been proposed for assessing corporate ESG performance. For instance, the Analytic Hierarchy Process (AHP) [7], as a quantitative technique, has been widely applied to approximate clear decision-making scenarios. Furthermore, a hybrid approach combining the AHP method with the Weighted Aggregate and Assessment Product method has been introduced to evaluate ESG performance in a spherical fuzzy environment [8]. Despite its ap-plications, the AHP method has certain limitations, such as relatively low precision in ranking and a significant reliance on the subjective judgments, choices, and preferences of decision-makers, which can markedly affect the outcomes of the AHP method. In contrast, the TOPSIS model, as another evaluation and model-ling method, provides a more precise relative ranking by directly utilizing raw data to calculate the distances between each alternative and the ideal and negative solutions. In practice, studies have employed the entropy weight method in conjunction with the TOPSIS model to establish a coal mine safety evaluation index system, with case studies demonstrating the simplicity, clarity, and reliability of the evaluation results, suggesting widespread adoption in coal mine safety assessments [9]. Although widely used, the TOPSIS model's reliance on historical data and static risk assessment limits its effectiveness in predicting intrinsic uncertainties and evolving future risks. To capture these dynamic changes, the Grey Prediction GM(1,1) model offers a more flexible and adaptive risk forecasting method. As a grey prediction model, GM (1,1) is particularly suited for small-sample and incomplete information prediction problems. For example, in applications such as landslide deformation prediction [10] and sea-level rise prediction [11], the improved GM(1,1) model has proven its effectiveness in environmental change forecasting. However, the integration of the TOPSIS model and the Grey Prediction GM(1,1) model in the application of ESG performance indicators and sustainable development indicators and other related research fields still warrants further exploration. Pearson correlation analysis is a statistical method used to measure the strength and direction of the linear relationship between two continuous variables. For instance, [12] J. Wang and others analyzes the use of auxiliary information provided by the correlation coefficient from multiple perspectives. Combining multiple analytical methods appears to be an efficient way to assess [13]. The comprehensive model proposed in this study integrates the TOPSIS model, Pearson correlation analysis, and the grey prediction GM (1,1) model, exploring the application of these methods in assessing and forecasting ESG performance and sustainability indicators. Building upon the standard ESG indicator assessment criteria established by the TOPSIS, the GM (1,1) model is introduced to address the issue of the traditional TOPSIS model's excessive reliance on historical data and its limitation to static risk assessment, successfully predicting the financial and ESG performance of Sinopec for the next decade. In terms of the correlation analysis between ESG performance and sustainability indicators, the integrated model proposed in this paper also effectively utilizes Pearson's correlation test to analyze how ESG performance in Sinopec's reports contributes to and re-lates to the company's sustainable development. Compared to traditional static assessment and modeling methods, the application of this method will help companies gain a deeper understanding of the relationship between ESG performance and their own sustainability. This will assist investors, corporate management, and regulatory bodies in making wiser decisions and promoting the achievement of sustainable development goals.

## 3 Methodology

In the data preprocessing stage of this research, we first gather relevant data from the annual and social responsibility reports of Sinopec, as well as authoritative sources like East Money, covering the years from 2015 to 2022. We then thoroughly clean the raw dataset, which includes removing duplicate entries and irrelevant data, and identify and address outliers through regression analysis.

The basic idea of the TOPSIS method is to process the raw data towards a uniform trend, construct a normalized matrix, and then calculate the differences between the evaluated objects and the best and worst vectors to measure the degree of divergence of the evaluated objects. The TOPSIS model is used to establish an assessment model. Assuming there is n evaluated objects and m criteria, the basic steps of the TOPSIS method are as follows: The raw data is normalized and aligned with the same trend due to the presence of "positive indicators" and "negative indicators" on the platform.

Preprocessing is carried out separately for these two types of data. Subtracting 0.0001 from the minimum value and adding 0.0001 to the maximum value is done to accommodate cases where an entire column has the same value, which has a negligible impact on the overall results and can be disregarded.

The Pearson correlation test is a statistical method used to measure the strength and direction of linear correlation between two continuous variables. It measures the degree of correlation between two variables by calculating Pear-son's correlation coefficient, which ranges from -1 to 1. when the correlation coefficient is close to 0, the two variables are not linearly correlated. At first, we need to calculate the covariance, letting E(X) and E(Y) denote the expected value of X and Y, respectively, which is the mean. We also note a prob-lem in that these variables all carry measures. If the values of x are all around 0.01 and the values of y are all around 1000, the covariance is easily skewed by the influence of y. To solve this magnitude problem, we need to eliminate the magnitude and get a dimensionless metric, the Pearson correlation coefficient. Lastly, we employ the Grey Prediction GM (1,1) model for individual forecasting, sequentially substituting and continuously incorporating new information to gradually reduce the greyness of the data sequence until the prediction target is reached. After constructing the model, it is necessary to perform an accuracy check on the relational term. Commonly, residual tests and posteriori difference tests are used. The grey prediction model is more accurate for the discrimination of data with strong linear correlation, so we use the grey prediction model to predict the four indicators of shareholders' equity, the amount paid to employees, the total amount of assets and rural revitalization. The specific evaluation framework is shown in Figure 1.

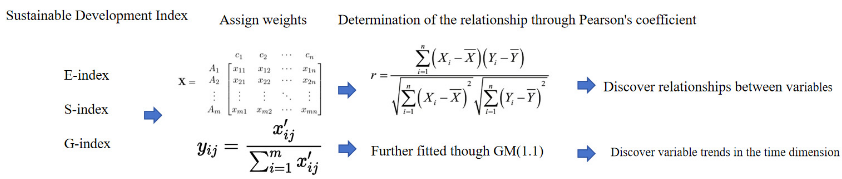


**Fig. 1.** ESG Measurement Framework

## 4 Experiment Result

First, we determine the weights of the G indicator and S indicator parameters using the entropy weight method. The weight calculation results of the entropy weight method show that the weight of EPS (deducted/basic) (yuan) is 8.516%, the weight of net profit (10,000 yuan) is 13.965%, the weight of ROE (TTM) (%) is 13.118%, the weight of total operating income (10,000 yuan) is 17.867%, the weight of the number of employees (person) is 15.044%, the weight of taxes paid (10,000 yuan) is 7.574%, the weight of cash paid to and for employees (10,000 yuan) is 12.494%, and the weight of total operating cost (10,000 yuan) is 11.42%. Among them, the maximum indicator weight is total operating income (10,000 yuan) (17.867%), and the minimum value is taxes paid (10,000 yuan) (7.574%). For the S indicator, the calculation results show that the weight of aid to Tibet and Qinghai (headquarters) (10,000 yuan) is 19.253%, the weight of R&D expenditure (10,000 yuan) is 21.954%, the weight of rural revitalization targeted poverty alleviation input (headquarters) (10,000 yuan) is 21.55%, the weight of social donations (100 million yuan) is 18.677%, and the weight of shareholders' equity (10,000 yuan) is 18.566%. Among them, the maximum indicator weight is R&D expenditure (10,000 yuan) (21.954%), and the minimum value is shareholders' equity (10,000 yuan) (18.566%). Next, we conduct TOPSIS modelling for the G indicator and S indicator. The results obtained are shown in Figure 2.

As shown in Table 1, according to the results of the Pearson correlation test, we can find that sustainability has a relatively strong positive correlation with the environment, a certain correlation with corporate governance, but a negative correlation with social contribution. Therefore, based on the above information, we can conclude that the impact of the environment on sustainable development is enormous, and the negative impact of social contribution on sustainable development is also significant. However, this does not mean that the social contribution indicator is negative. For a company, we can find from the table that the social contribution indicator can have a counteracting effect on the environmental indicator and corporate governance indicator, so the social contribution indicator is also indispensable. To ensure the rigor of the conclusion, we also conduct a Pearson correlation test on the ranking indicators, further strengthening the reliability of the argument. The results are shown in Table2. This shows that there is some endogenous restriction relationship or time lag effect between the measurement index of social contribution and the measurement index of sustainable development. This interaction suggests that when companies engage in social contribution activities, they may not immediately see their direct impact on sustainable development. For example, a company's investment in social contribution projects may limit its funds and resources for other sustainable development projects. For example, for environmental protection and green technology innovation. Sinopec may adopt more expensive mining technologies or processing methods, leading to a decline in the company's assessment of its sustainable development. In addition, the results of social contribution activities often take a long time to be reflected. Sinopec companies may have invested heavily in clean energy and community development projects. Although these activities have a positive impact on society, their positive impact on corporate sustainability indicators may be delayed.

To further observe the relationship between contribution and sustainable development, we used the gray prediction GM (1,1) model to predict the future development trends of the four indicators of shareholder equity, employee compensation, total assets, and rural revitalization. The tabular results are shown in Table 3. The growth of total assets and shareholders' equity suggests that the company's economic strength is improving steadily. This is a positive signal for the 'environment' and 'governance' dimensions of ESG indicators, indicating that the company could invest resources in environmental protection activities and improve the corporate governance structure. The rise in employee compensation reflects the company's efforts to improve employee benefits and the working environment. This has significantly contributed to enhancing the company's social dimension. Indicators such as rural revitalization have significantly increased, reflecting the company's contribution to social responsibility. Specifically, the company has made efforts to support communities and promote rural development, resulting in a positive impact on the social dimension. This also supports to a certain extent that in the long term, the company's sustainable development and social contribution are growing steadily. However, the specific endogenous pattern of the relationship between the two is currently unclear, so more information is needed. More data and some machine learning algorithms based on XGBoost [14] or LightGBM [15] will be discussed in depth.

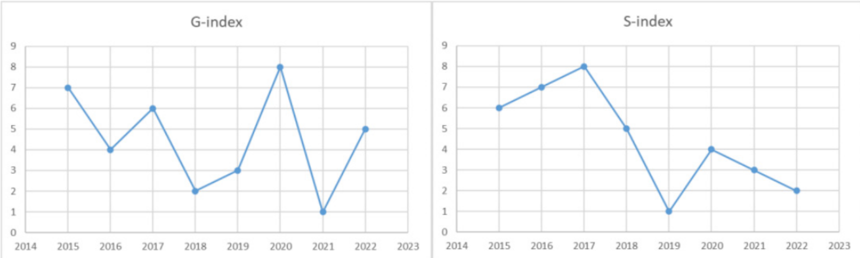


**Fig. 2.** Ranking result graph of G index and S index per years

**Table 1.** Results of Pearson correlation test model (score)

| | Sustainable Development Index | E-index | S-index | G-index |
|---|---|---|---|---|
| G-index | 0.047 | 0.859 | 0.309 | 1 |
| S-index | -0.783 | 0.046 | 1 | 0.309 |
| E-index | 0.307 | 1 | 0.046 | 0.859 |
| Sustainable Development Index | 1 | -0.783 | 0.047 | 0.047 |

**Table 2.** Results of Pearson correlation test model (rank)

| | Sustainable Development Index | E-index | S-index | G-index |
|---|---|---|---|---|
| G-index | 0 | 0.738 | 0.333 | 1 |
| S-index | -0.811 | -0.238 | 1 | 0.333 |
| E-index | 0.429 | 1 | -0.238 | -0.738 |
| Sustainable Development Index | 1 | 0.429 | -0.811 | 0 |

**Table 3.** Prediction model Results (Five-year interval)

| Year | Total assets | Stockholders' equity | Cash paid | Rural Revitalization Designated poverty alleviation investment (ten thousand yuan) |
|---|---|---|---|---|
| 2015 | 144,312,900.00 | 78,562,300.00 | 5,513,700.00 | 7518 |
| 2020 | 173,380,500.00 | 88,387,600.00 | 8,377,200.00 | 13375.2 |

| | | | | |
|---|---|---|---|---|
| 2025 | 221810600.40 | 98477866.28 | 12955302.75 | 22452.69 |
| 2030 | 275594358.70 | 108250271.10 | 19206535.64 | 38261.17 |

## 5 Conclusion

The study proposes a comprehensive model that integrates the TOPSIS model, Pearson's correlation analysis, and the GM (1,1) grey prediction model to quantitatively evaluate and analyze the ESG performance of Sinopec, China's leading petrochemical company. The model effectively reveals Sinopec's performance across the environmental, social, governance, and overall sustainability dimensions while investigating the intricate relationship between ESG indicators and corporate sustainable development capabilities. The research findings confirm that Sinopec's environmental performance has a significant positive impact on its sustainable development, while its social contribution indicators have a detrimental effect on its sustainable development. By utilizing historical data, the GM (1,1) model successfully predicts Sinopec's financial status and trends in environmental, social, and corporate governance development over the next decade. The forecast indicates that Sinopec will continue to be profitable, and its sustainable development and G indicators will continue to improve. However, if the current status is maintained, it may lead to a decline in the E and S indicators. Based on the analysis results, the study recommends establishing a dedicated ESG database to stream-line information management and enhance transparency. Additionally, adopting cutting-edge technologies such as machine learning and deep learning can strengthen data analysis capabilities and support more accurate ESG assessments. It also advises reinforcing the monitoring and regulatory disclosure of ESG indicators to enhance credibility and stakeholder confidence. Overall, this comprehensive modelling approach offers an effective framework for companies to predict and analyze the complex relationship between ESG performance and sustainable development. It enables organizations to make informed decisions, optimize resource allocation, and implement targeted strategies to achieve long-term sustainable growth while meeting the expectations of investors, stakeholders, and society at large. In future work, polynomial fitting or Machine learning could be considered to obtain more precise results, and more comprehensive data could be utilized to enhance the model's reliability.

## Reference

1. G. L. Clark, A. Feiner, and M. Viehs, "From the Stockholder to the Stakeholder: How Sustainability Can Drive Financial Outperformance," J. Appl. Corp. Finance, vol. 27, no. 3, pp. 44-53, 2015.
2. C. Flammer, "Corporate social responsibility and shareholder reaction: The environmental awareness of investors," Acad. Manag. J., vol. 56, no. 3, pp. 758-781, 2013.
3. J. D. Margolis, H. A. Elfenbein, and J. P. Walsh, "Does it pay to be good? A meta-analysis and redirection of research on the relationship between corporate social and financial performance," Work. Pap., Harvard Bus. Sch., 2018.

4. C. L. Hwang and K. Yoon, "Multiple attribute decision making methods and applications a state-of-the-art survey," in Lecture Notes in Economics and Mathematical Systems. Berlin: Springer, 1981, pp. 58-191.
5. K. Pearson, "Note on regression and inheritance in the case of two parents," Proc. R. Soc. Lond., vol. 58, pp. 240-242, 1895.
6. J. L. Deng, "Introduction to grey system theory," J. Grey Syst., vol. 1, no. 1, pp. 1-24, 1989.
7. T. L. Saaty, "The Analytic Hierarchy Process," Math. Model., vol. 1, no. 1, pp. 69-73, 1977.
8. M. R. Sadeghzadeh, A. Fakhrabadyl, and S. M. Aghdas, "Assessing environmental, social and governance (ESG) performance using a hybrid AHP and WASPAS method in a spherical fuzzy context," J. Clean. Prod., vol. 285, p. 125472, 2023, doi: 10.1016/j.jclepro.2021.125472.
9. L. X. Li, K. S. Wang, L. W. Liu, J. Xin, H. R. Yang, and C. Y. Gao, "Application of the Entropy Weight and TOPSIS Method in Safety Evaluation of Coal Mines," Procedia Eng., vol. 26, pp. 2085-2091, 2011.
10. Z. Wang, Q. Xu, X. Fan, and J. Zeng, "Application of renewal gray GM(1,1) model to prediction of landslide deformation with two case studies," Eng. Geol. Environ., vol. 39, no. 2, pp. 105-110, 2009, doi: 10.1007/s10040-008-0189-5.
11. L. Liu, M. Zheng, J. Wen, and G. Lei, "Prediction of Sea Level Rise of an Island Based on Improved Metabolic GM(1,1) Model," Softw. Eng. Appl., vol. 9, no. 5, pp. 427-433, 2020, doi: 10.12677/sea.2020.95049.
12. J. Wang and H. Yang, "The Comprehensive Utilization of Correlation Coefficient Information in the Empirical Study," Stat. Appl., vol. 3, no. 04, pp. 193-202, 2014, doi: 10.12677/SA.2014.34026.
13. Shen, X., Luo, S., & Zhang, M. (2023). House quality index construction and rent prediction in New York City with interactive visualization and product design. *Computational Statistics*, *38*(4), 1629-1641.
14. Dai, W., Jiang, Y., Mou, C., & Zhang, C. (2023, September). An Integrative Paradigm for Enhanced Stroke Prediction: Synergizing XGBoost and xDeepFM Algorithms. In Proceedings of the 2023 6th International Conference on Big Data Technologies (pp. 28-32).
15. Li, S., Dong, X., Ma, D., Dang, B., Zang, H., & Gong, Y. (2024). Utilizing the LightGBM Algorithm for Operator User Credit Assessment Research. arXiv preprint arXiv:2403.14483.