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Construction of a Corporate Carbon Disclosure Indicator System and Quality Evaluation: Evidence from Resource-Based Listed Companies

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Abstract: Resource-based companies are key players in reducing carbon emissions and play a central role in achieving China's dual-carbon goal. Establishing and improving an objective carbon information disclosure mechanism for companies and evaluating the quality of carbon information disclosure in a scientific and reasonable manner have significant reference value for rationally shaping the way to realize carbon peak and carbon neutrality. In view of this, this paper develops an evaluation index system based on four dimensions based on the corporate social responsibility reports of listed companies from 2018 to 2022. After excluding firms with a high degree of greenwashing, the combined weighting-TOPSIS method was used to evaluate the carbon disclosure quality of companies. The research results show that, although the quality of carbon disclosure of resource-based companies has indeed improved since the 2020 dual-carbon goal was proposed, there are differences in the quality of carbon disclosure of companies between different subsectors and regions, and relevant policy recommendations are proposed.

Keywords: carbon information disclosure; dual-carbon goal; index system

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1. Introduction

Climate change has been recognized as a major and urgent global challenge to humanity [1]. Increasing climate risks have led to a growing awareness of environmental practices and alerted companies that they need green technologies to reduce fossil fuel consumption. In this context, corporate carbon disclosure as an important part of corporate social responsibility is also a key way of mitigating climate change [2]. A scientific and objective system for evaluating the quality of corporate carbon disclosure not only helps to raise public awareness of corporate environmental performance, but also promotes the adoption of more sustainable business practices and the development of a low-carbon economy. As the world's largest emitter of CO_2, China has been actively tackling climate change in recent years. The Chinese government has planned targets to reduce carbon emissions in its economic plan, seeking to curb carbon emissions while maintaining economic growth. Carbon reduction has been part of China's economic plan for nearly two decades [3]. In 2011, for example, the first pilot carbon emissions trading market was launched in seven provinces and cities across the country. At the end of 2017, the national carbon emissions trading market was officially launched. In 2020, the Chinese government made a solemn commitment to "peak carbon dioxide emissions by 2030 and strive for

carbon neutrality by 2060". In 2022, the 20th National Congress of the CPC (Chinese Communist Party) emphasized the need to actively and steadily promote the reduction of carbon emissions [4]. Achieving the dual-carbon goal has therefore become an important part of the overall concept of building ecological civilization in China. However, compared with developed countries, the timescale of China's transition from peak carbon to carbon neutral is much shorter, and the degree of carbon emission reduction is more significant. In this context, it is particularly important to promote emission reduction among major carbon emitters and industrial companies to achieve the goals of carbon peak and carbon neutrality. An objective and ideal carbon disclosure mechanism can not only provide an important way to promote carbon emission reduction, but also lay an important foundation for full establishment of the carbon trading system and the formulation and implementation of sound carbon emission reduction policies. However, it is worth noting that, although the Administrative Measures for the Legal Disclosure of Corporate Environmental Information issued by the Ministry of Ecology and Environment of China officially came into force in February 2022, requiring compliant companies to disclose carbon emission information, there is still a lack of clear provisions on the content, format and standards of carbon information disclosure, which has long led to inaccurate disclosure of emissions data by many companies, as well as inconsistent quality of emissions data disclosure and inefficient use of emissions data. China is one of the world's largest greenhouse gas emitters and a major player in global climate change. In China, the disclosure of carbon emissions by companies in resource-based sectors such as energy and mining is particularly critical. Resource-based companies make the development and utilization of natural resources their main business activity and achieve economic benefits through the exploration, extraction, processing, and sale of natural resources such as non-ferrous metals, oil and gas mining, coal mining, and ferrous metal as part of the extractive industry. Such companies play an important role in the economy, and most of them are heavy polluters. The quality of carbon disclosure of these companies is directly related to the achievement of China's carbon emission reduction targets and response to the global climate change challenge. In recent years, the Chinese government has steadily pushed forward the construction of a national carbon emissions trading market and the implementation of the dual-carbon goal, and the disclosure of carbon emissions by companies is gradually being put on the agenda. Accurately assessing the quality of corporate carbon disclosure and evaluating the emission reduction effect of corporate carbon disclosure provide important references for rationally designing the implementation path of carbon peaking and carbon neutrality.

Against this background, based on the data of Chinese resource-based listed companies from 2018 to 2022, this paper establishes a carbon disclosure index system on the basis of past literature, innovatively considers the degree of greenwashing of companies, excludes companies with greenwashing behaviors, and evaluates the quality of carbon disclosure of companies by using the combined empowerment-TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) model, so as to make the evaluation results more objective and scientific, and finally provides some feasible suggestions to improve the carbon disclosure level of these companies, which will promote China towards a greener and lower-carbon future and promote its positive role in climate change response and sustainable development, as well as provide a useful experience for international carbon disclosure research and practice.

The contributions of this paper include the following three aspects:

First, this paper innovatively analyzes and evaluates the degree of greenwashing in carbon disclosure of resource-based companies, aiming to improve the quality evaluation system of corporate carbon disclosure and to bridge research gaps in this field;

Second, on the basis of previous studies, this study incorporates third-party evaluations, international standards, and domestic policy requirements and constructs a quality evaluation system that covers four dimensions, including intelligibility, reliability, comparability, and relevance, and twelve indicators, such as diversity of expression, negative information, consistent with external evaluation, and other indicators, in four dimensions to ensure the comprehensiveness and objectivity of the assessment;
Finally, this paper applies the constructed indicator system to evaluate the carbon emission disclosure of the sample companies, analyzes the evaluation results, and puts forward relevant policy recommendations.

The remainder of this paper is organized as follows: Section 2 reviews relevant literature; Section 3 outlines the indicator evaluation system established, as well as the data and empirical methodology used in this study; Section 4 reports and discusses our findings; and finally, Section 5 concludes this paper and proposes future research. Please refer to Appendix A, Figure A1 for the analytical framework of this study.

2. Literature Review and Development of Hypotheses

2.1. Development of the Design of Corporate Carbon Information Disclosure Systems in China and Abroad

The construction of corporate carbon disclosure systems is crucial to sustainable development and the realization of global carbon emission reduction targets. Against the backdrop of "carbon neutral and peak carbon" policies implemented by different countries, companies are increasingly focusing on the disclosure of carbon emission information. In order to facilitate measurement and report, the design of carbon information disclosure systems for companies has been explored by many authors (see [5–10], for example).

Existing research has actively investigated the principles of corporate carbon disclosure systems. In 2000, a relatively complete framework for corporate carbon disclosure was constructed internationally—the Carbon Disclosure Project (CDP). However, the CDP still has problems of weak relevance, such as incomparable information due to industry differences in the disclosure method, unclear content classification, lack of review and recognized quantification standards resulting in difficulty in quantification, failure to promote management, and lack of effective interaction between supply and demand. It also has limitations such as the lack of recognized quantification standards [5], which is a representative framework for carbon disclosure other than frameworks that guide companies to carry out carbon disclosure from different dimensions and in different ways, such as the Global Framework on Climate Risk Disclosure [6]. The U.S. Environmental Protection Agency (EPA) has developed a number of reports to standardize mandatory greenhouse gas reporting [7]. From the carbon disclosure system's regulatory perspective, Jaggi et al. set up an environmental committee supervising the improvement of the quality of carbon disclosure of listed companies [8]. Danuta et al. adapted the first theoretical framework model of climate change for hospitality firms by confirming stakeholder theory assumptions and providing a theoretical approach to explaining carbon disclosure [9]. Dong et al. constructed a sustainable development evaluation index system for electric power companies consisting of 75 indicators corresponding to the four dimensions—-economy, society, environment, and governance—-on the basis of integrating the United Nations' long-term sustainable development goals and ESG evaluation indicators of listed companies [10].

China had a corresponding policy in 2008 requiring some companies in heavy pollution industries to disclose information related to pollution emissions [11]. At present, some large listed companies in China have begun to participate in voluntary carbon information disclosure [12,13], but overall the level of corporate carbon disclosure is still low,

and there are obvious industry discrepancies [14]. The awareness and ability of corporate carbon information disclosure needs to further improve. Zhong and Yang constructed a corporate carbon information disclosure framework that integrates accounting, reporting, management, auditing, and application modules and proposed a support mechanism from the perspectives of legislative safeguard, stakeholder participation, standardization, and third-party auditing to further improve the theoretical framework of carbon information disclosure for Chinese companies [6].

2.2. Principles and Methods for Evaluating the Quality of Carbon Disclosure

China's "Enterprise Accounting Standards-Basic Guidelines" for information disclosure quality characteristics requirements are relevance, reliability, timeliness, comparability, understandability, prudence, and substance over form, but not all quality characteristics requirements in the accounting standards are applicable to the evaluation of carbon information disclosure [15]. Developing useful methods for selecting effective disclosure quality scoring principles has been the focus of attention in constructing China's carbon information quality assessment system. Wang constructed an environmental information quality evaluation system from the relevance, reliability, comparability, full disclosure, and clarity of information quality characteristics [16]; Peng and Xiong defined timeliness, truthfulness, relevance, and completeness as first-level indices when carrying out the establishment of carbon disclosure indexes and then divided 22 second-level indices into the four first-level indices [13]; Chen et al. constructed a carbon information disclosure index to analyze and evaluate the quantity and quality of carbon information disclosure of companies from the level of quality requirements such as comprehensibility, comparability, objectivity, and relevance of carbon accounting information [17]; Li et al. constructed a carbon information disclosure system by taking timeliness, reliability, comprehensibility, comparability, and completeness as first-level indices [15]; Liu and Zhang summarized the quality characteristics specified by the Global Reporting Initiative and the Research Center for Corporate Social Responsibility of the Chinese Academy of Social Sciences, conducted a questionnaire survey of stakeholders, used exploratory factor analysis to conduct empirical tests, and established a carbon information disclosure quality evaluation system by taking reliability, comprehensibility, comparability, balance, and relevance as the five characteristics of the quality of carbon information [18]; Liu and Zhang [19] used an ANP–Cloud model to establish a carbon information disclosure quality evaluation system for the electric power industry to achieve completeness, relevance, reliability, understandability, and comparability, where ANP stands for network analytic hierarchy process.

A lack of a unified carbon disclosure standard and evaluation index system in China at present leads to differences in the quality of disclosure by companies and makes it difficult to compare and assess. Most evaluation methods on the quality of carbon disclosure are based on the content analysis method of corporate social responsibility reports and so on [18,20], which refers to analysis of various types of reports or documents that have been made public by the company, to determine the scores or values of each specific item, so as to make a general evaluation of the disclosure [17]. Patten analyzed the annual reports of U.S. corporations [21], and Clarkson et al. developed content analysis indices based on the GRI (Global Reporting Initiative) to review the relationship between environmental performance and the level of environmental information disclosure [22]. Wang and Jin used the content analysis method to construct carbon disclosure indicators [23]; Zhao et al. quantified the content disclosed in a company's listed annual report and CSR report from four dimensions [24]; Wu and Xu used the annual reports and social responsibility reports of resource-based listed companies as the object of research [12]; He et al. measured enterprise carbon information disclosure through content analysis and hierarchical analysis and

confirmed the impact of external pressure and internal governance on carbon information disclosure [25]. The broad content analysis method also includes the index method, and Chen et al. utilized the index method to construct an index of carbon disclosure to assess the quality of carbon information disclosure [17]. Although the content analysis method is more objective in the rest of the process after determining the specific items for scoring [26], the assumption implied in this method is that the more information, the greater the quantity, and thus the higher the quality of its carbon disclosure, so there are limitations in scoring by using the content analysis method [20], and there is a certain degree of subjective arbitrariness. In addition, the information disclosed by companies cannot be used to make valuable comparisons; applying machine learning methods such as text mining and deep learning in the quality evaluation of environmental information is a more efficient and sound method to evaluate the quality of carbon information disclosure [25,27], as shown by Zhang, et al. in the use of text mining method to expand the evaluation of environmental information, which is measured by the frequency of high-frequency words [28]. Li et al. combined the variable weight theory, the principle of closeness, and the improved material-element topological model to solve the problems of strong subjectivity in the determination of the weights in the traditional evaluation method and the low precision of the evaluation results and enriched the index system and the evaluation method for the evaluation of the quality of carbon disclosure [29]; Liu constructed an environmental information disclosure quality indicator system for 34 listed thermal power generation companies in China using a pursuit-seeking model and concluded that the overall sample had a low environmental information disclosure quality [30]; Liu used an entropy model and Liu and Zhang used an ANP-Cloud model in evaluating the carbon disclosure quality of listed companies in China's electric power industry, realizing the transformation from qualitative to quantitative scoring and improving the comprehensiveness and objectivity of the evaluation results [19,31]. Data Envelopment Analysis (DEA) is also widely used in constructing the evaluation index system, and most scholars use the DEA model based on the traditional CCR model (constant returns to scale) when studying the carbon performance evaluation of companies [32]. Yu Juntao and Zhang Jianyu analyzed the design principles used to evaluate the indicator system of low-carbon supply chain performance by means of hierarchical analysis, converted qualitative indicators into quantitative indicators, and then used a traditional CCR model (one of the classic DEA models) that introduced slack variables to assess the real level of the enterprise's low-carbon supply chain performance [33]. Liu and Wu use a neural network model and the comprehensive fuzzy evaluation method to construct an index system for the disclosure of carbon information in the electricity industry, tested the applicability of the system, and concluded that the quality of carbon information in the Chinese electricity industry is generally low [34]. Teng developed a carbon information disclosure indicator system for high-carbon-emission companies using a combined weight-TOPSIS method and found that the overall evaluation of information disclosure by high-carbon-emission companies in China was relatively low. However, after the introduction of the dual-carbon goal in 2020, the quality of information disclosure by high-carbon-emission companies has improved to some extent [35].

Regarding the basis for constructing the carbon information disclosure quality evaluation system, there are mainly two kinds of academic circles: the first is the four dimensions of the international carbon information disclosure project CDP, i.e., low carbon strategy, carbon accounting, emission reduction measures, and emission reduction effectiveness; the second is to take the characteristics of the information quality to construct the carbon information quality evaluation system by combining the actual situation of the industry and the sample companies.

In summary, the current academic evaluation method of the carbon information disclosure quality index system mainly adopts the hierarchical analysis method or the entropy value method alone, and the evaluation of carbon information disclosure quality from the point of view of information quality characteristics should adopt a subjective and objective combination of empowerment methods [36]. Therefore, in order to obtain a more objective and extensive evaluation of the quality of corporate carbon information disclosure, it is necessary to propose a more sound and concrete assessment method. Carbon information disclosure quality should be analyzed from a wider scope and from more complete content, set an objective weighting method for the evaluation index system, obtain a corporate carbon information disclosure score, and establish China's own carbon information disclosure quality evaluation system, which is also a research direction deserving increased attention.

2.3. Factors Influencing the Quality of Carbon Disclosure

Climate change is the most pressing challenge of our time. It is therefore of utmost importance to understand how various factors influence companies' commitment to reducing carbon emissions [1]. This provides not only evidence for establishing a comprehensive and objective framework for the carbon disclosure index system but also a theoretical basis for evaluating the results of the quality of corporate carbon disclosure. There are many scholars who have studied factors affecting corporate carbon information disclosure from the macro and micro perspectives. External macro-factors, such as media attention, market factors, and external institutional environment (public pressure), influence the willingness and quality of carbon information disclosure to some extent [37–39]. In the age of big data, the media can be a "catalyst" for companies to disclose their environmental information, but it can also have a negative impact [40]. Some empirical studies have shown that media coverage of companies' existing environmental problems can help companies improve the quality of carbon information disclosure [41]. It has been found that both long-term online media attention and investor attention are negatively related to the quality of corporate environmental information disclosure [42], that the effects of short-term media attention and investor attention on the quality of corporate environmental information disclosure are different, and that the promotion of public awareness related to environmental supervision helps to enhance the external effect of environmental information disclosure on reducing regional carbon emissions [43,44]. Additionally, under legitimacy pressure from the external environment, firms' behaviors and willingness to disclose carbon emission information are strengthened [45]. Balachandran et al. state that the level and quality of carbon disclosure are higher and better for companies with government involvement than for those without government involvement [46]; Mateo-Márquez et al. found that a country's regulatory environment positively influences the decision of companies to voluntarily disclose emissions data [47]; and Zhang et al. suggested that the adoption of a carbon market policy positively influences the environmental performance of companies [48]. The moderating effect of environmental regulatory pressure significantly mitigates the impact of carbon disclosure on the cost of debt financing for firms with socially responsible index shares.

In terms of internal micro-drivers, there is a significant correlation between enterprise size, debt level, development capability, industry type, and the extent of corporate carbon disclosure [49], and stakeholder demand and pressure factors can influence corporate decisions and behaviors in carbon disclosure. Company directors' or shareholders' attitudes and demands for corporate carbon disclosure, as well as executive characteristics such as non-financial disclosure data, directly affect corporate behaviors and practices in this area. For example, Balachandran et al. found that directors' age and gender affect corporate behaviors in terms of disclosure of environmental and social issues [46]. In addition, the political values of institutional shareholders impact the voluntary environmental disclosure

and performance of their investment firms [50]. In addition, Wegener et al. found that corporate carbon disclosure behaviors are also influenced by domestic investors [51]. Most studies show that corporate carbon disclosure is correlated with internal characteristics such as firm value [52], firm size [14], corporate internal control, profitability, shareholding structure, shareholding concentration, and industry attributes [53,54]. For example, Lv demonstrated that the quality of internal control has a subtle influence on corporate carbon disclosure using data from heavy pollution industries as a sample [55]; and Zhang argued that financial performance positively contributes to the quality of corporate carbon emission information disclosure in the next period [56].

2.4. Greenwash

"Greenwash" refers to the possibility that companies may exaggerate their emissions reduction efforts or selectively report emissions data, resulting in a misleading portrayal of their actual environmental impacts. In environmental, social, and governance (ESG) risk management, how companies respond to the threat of greenwash has become a spotlight for achieving sustainable green development. Corporate ESG disclosure typically encompasses two distinct intentions: a substantive commitment to reducing environmental impacts and a symbolic attempt to manage external stakeholder perceptions. With respect to the latter, companies often show a motivation to pander to policies in their ESG disclosures. In the existing literature, greenwashing is divided into two types: active greenwashing and passive greenwashing [57]. Active greenwashing refers to behavior in which a company deceives the public through false or misleading communication strategies, such as fabricating false statements to distort the company's environmental actions. Passive greenwashing, on the other hand, refers to a behavior in which a company strategically presents its performance to certain stakeholders by concealing negative information [58]. This includes actions such as obfuscation, omission, or selective disclosure of information. Resource-based companies, which are under significant competitive pressure and attract investor attention, often exaggerate their achievements in reducing emissions and promote green technological innovations to align with government policies or green development strategies [59]. A direct expression of this is the disclosure of such exaggerated greenwashing behaviors in corporate sustainability reports. Currently, there are relatively few academic studies on corporate greenwashing behaviors, and existing studies mainly focus on how to quantify corporate greenwashing behaviors and the economic consequences of corporate greenwashing behaviors [60,61]. However, there is little research on the development of a scientific and reasonable carbon information quality evaluation system by combining corporate greenwashing behaviors and carbon disclosure quality index systems, which therefore forms a research gap.

2.5. Summary and Research Hypotheses

Most existing literature focuses on the influencing factors and economic consequences of carbon disclosure quality, such as the impact of carbon disclosure quality on corporate financial performance or firm value, and the construction of carbon disclosure quality evaluation systems based on content analysis methods. Additionally, some studies explore how to measure corporate greenwashing behaviors. However, incorporating the degree of greenwashing into the evaluation system for carbon disclosure quality remains a significant research gap. Current carbon disclosure quality evaluation systems often fail to account for the impact of greenwashing, leading to less accurate assessments. To address this research gap, this paper establishes a carbon disclosure index system that incorporates external evaluations, international standards, and domestic policies, building upon existing literature. The study innovatively considers the degree of corporate greenwashing, excludes

companies with greenwashing behaviors, and applies the combined weighting-TOPSIS model to evaluate the quality of corporate carbon disclosure. This approach ensures that the evaluation results are more objective and scientific, enhancing the accuracy and reliability of carbon disclosure quality assessments.

Based on the summary of the above literature, this study proposes the following research hypotheses:

Hypothesis 1. *The carbon information disclosure quality score of companies with greenwashing behavior tends to be higher.*

Hypothesis 2. *The overall carbon information disclosure quality of resource-based companies is relatively low; however, after the introduction of the carbon emission targets in 2020, the quality of carbon information disclosure by resource-based companies has shown some improvement.*

3. Construction of a Corporate Carbon Disclosure Quality Indicator System

There is a lack of a unified authoritative definition of carbon information disclosure quality standards in the existing literature [22]. As such, this paper aims to identify recognized characteristics as carbon information quality characteristics standards.

3.1. Establishment of a System

Drawing on the construction principles of the indicator system and the actual situation of the quality of carbon information disclosure of companies in China at present, we believe that the selection of indicators should follow the following four principles (Figure 1):

1. Operability. First of all, operability requires that the evaluation indicators must be observable. Secondly, the evaluation indices should minimize the risk of data distortion and greenwash. Finally, the cost and difficulty of corporate carbon information disclosure should be considered, and indicators that are not easy to collect and have high observation costs should be discarded [36].
2. Refinement. When constructing the enterprise carbon disclosure quality evaluation index system, it is necessary to reflect the characteristics of the evaluation object in all aspects, eliminate duplicated information, and achieve scientific evaluation.
3. Universality. Indicator setting should take into account differences between companies.
4. Independence. Independence means that, among and within each set of indicators, situations of mutual causation, mutual dependence, and mutual intersection should be minimized as much as possible to maintain good independence.

This paper takes widely recognized international standards and relevant domestic policy documents as sources of indicator selection and fully draws on previous research results to determine the scope of relevance indicators for evaluating the quality of corporate carbon information disclosure. A total of 12 carbon information relevance indicators are collected and listed in Table 1.

3.2. Sample Data

The coverage of the carbon market will gradually expand to include eight high-carbon-emitting industries, such as petrochemicals and chemicals, during the 14th Five-Year Plan period. Since the carbon information disclosed in annual reports is limited, and companies are likely to engage in greenwashing to embellish their environmental performance in terms of disclosure content and depth, the samples for this study were primarily drawn from resource-based companies. These companies are classified according to the industry categories of listed companies under the China Securities Regulatory Commission

(CSRC) as of the fourth quarter of 2013, including non-ferrous metals, oil and gas mining, coal mining, ferrous metal mining, extractive service industries, and non-ferrous metal, metal, and non-metal listed companies under the manufacturing sector. From these categories, a total of 209 listed companies between 2018 and 2022 were selected. Among these, 32 companies that had disclosed various types of corporate reports consistently for five consecutive years (2018–2022) and had a low degree of greenwashing were identified as sample companies for evaluating the quality of carbon disclosure of mining companies. In this study, a total of 1495 pieces of information were manually collected from various sources, including enterprise reports, WeChat tweets, government public information, and third-party certifications. Scores were assigned based on the scoring criteria outlined in Table 2, providing foundational data for evaluating the quality of carbon information disclosure. The determination of the degree of greenwashing for each company followed the methodology proposed by Yu et al., with the specific calculation method shown in Equation (1) [60]. The greenwashing degree of each enterprise was taken as the maximum value observed during the 2020–2022 period.

$$Greenwash\ Score_{i,t} = \left(\frac{ESG_{dis_{i,t}} - \overline{ESG_{dis}}}{\sigma_{dis}}\right) - \left(\frac{ESG_{per_{i,t}} - \overline{ESG_{per}}}{\sigma_{per}}\right) \quad (1)$$

The disclosure is from Bloomberg ESG, and the performance data are from Wind ESG. GWS is the greenwash score of a company, with positive values indicating severe greenwash and negative values implying that the company is covering up its green behaviors [71–73].

3.3. Methodology

This paper adopts the combination weighting-TOPSIS method to measure the quality of carbon information disclosure by resource-based companies. The entropy weight method can objectively determine the weights of indicators and overcome the influence of subjective factors, while the TOPSIS model has advantages in the comprehensive evaluation of multi-indicators [74]. The combination of these two methods enables a more scientific and reasonable evaluation of the carbon disclosure quality of resource-based companies, providing stakeholders with a more accurate basis for decision-making [75].

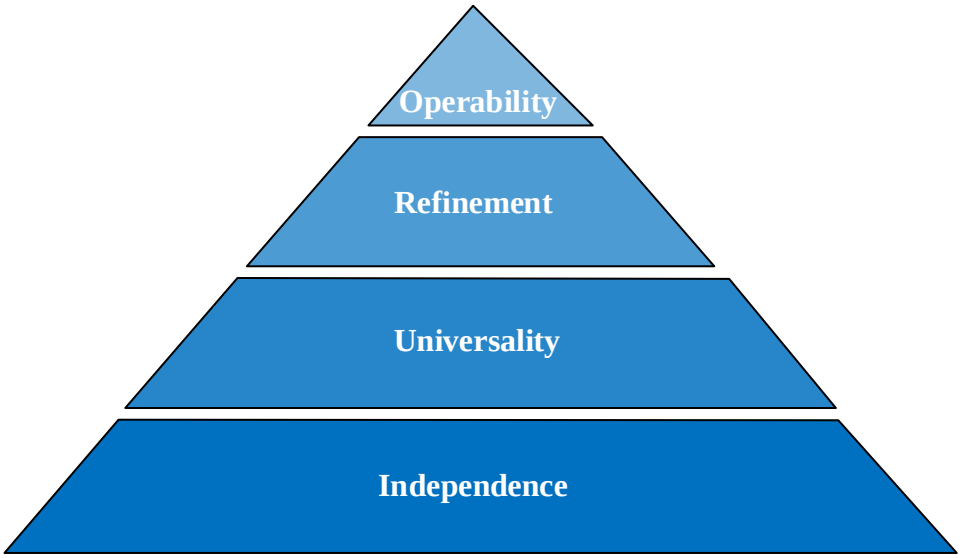

Figure 1. Principles of the carbon information disclosure indicator system.

Table 1. Evaluation system of carbon information quality.

First-Level Indicator	Second-Level Indicator	Third-Level Indicator	Sources of Indicators
Intelligibility A	Clarity A1	Diversity of expression A11	Wei Xiaoqing et al. (2019) [62]
	Conciseness A2	Catalog index A21	Huang Jun and Yingying Xu (2021) [63]
Reliability B	Neutrality B1	Negative Information B11	TCFD, GRI, etc.
	Confirmability B2	Consistent with external evaluation B12	Li Li et al. (2019) [64], Tian Yu, and Song Yajun (2019) [65]
Comparability C	Basis of accounting C1	Method and basis of accounting C11	Liu Jiexian and Zhang Chen (2020) [18]
	Consistent format C2	Stabilized establishment base C12	Huang Shizhong (2022) [66]
Relevance D	Strategy and Objective D1	Emission reduction targets and plans D11	Interim Provisions on Accounting Treatment Related to Carbon Emission Rights Trading
	Value of feedback D2	Relevant organization or system D21	Ben-Amar W et al. (2017) [67] and Zou Yuyu et al. (2022) [68]
		Operation status of carbon reduction measures and facilities D22	Song Hao et al. (2022) [69]
		Education and training D23	Ya-Li Wen et al. (2019) [70]
		Carbon emissions D24	GRI, CDP, SASB, etc.
	Timeliness D3	Time of disclosure D31	ISSB et al.

Table 2. Weight results of the corporate carbon information disclosure index system.

Third-Level Indicator	Criteria for Assigning Points	AHP Weights (%)	Weights of Entropy Method (%)	Combined Weights (%)
A11	Data or graph = 1 point, otherwise 0 points	11.51	6.89	9.24
A21	Cataloged or indexed = 1 point, otherwise 0 points	7.00	6.11	9.03
B11	Yes and disclosure = 1 point, otherwise 0 points	12.24	6.13	9.22
B12	Institutional accreditation = 1 point, otherwise 0 points	3.61	14.48	9.08
C11	Yes and disclosure = 1 point, otherwise 0 points	24.15	12.25	10.54
C12	Consistent with previous years = 2 points, slight change = 1 point, completely different = 0 points	2.87	4.4	8.85
D11	Disclosure of emission reduction target or plan = 1 point, otherwise 0 points	1.75	9.99	8.87
D21	Disclosure of carbon management = 1 point, otherwise 0 points	2.17	7.36	8.87
D22	Yes and disclosure = 1 point, otherwise 0 points	1.18	8.28	8.83
D23	Yes and disclosure = 1 point, otherwise 0 points	29.23	11.16	10.72
D24	Yes and disclosure = 1 point, otherwise 0 points	2.8	7.44	8.89
D31	Disclosure by April of the following year = 2 points, disclosure after April of the following year = 1 point, otherwise 0 points	1.48	5.51	8.82

The traditional subjective weighting method often relies on the experience and judgment of experts, which may introduce bias [60]. The entropy weight method reflects the amount of information contained in the evaluation indicators based on the degree of vari-

ability in their values and then calculates the information entropy of each indicator. This minimizes the subjectivity and arbitrariness of traditional weighting methods. The entropy weight method calculates comprehensive indicators by taking into account the amount of information provided by each factor. It has the following characteristics: (1) the value assignment method is based on the principle of "difference-driven", which highlights local differences. It uses actual data from each sample to find the optimal weight, reflecting the utility value of the indicator's information entropy and avoiding the influence of artificial factors. Thus, the indicator weights are more objective, reproducible, and credible; (2) the assignment process is transparent and reproducible; and (3) the method normalizes data through dimensionless processing, providing excellent qualities such as monotonicity, scaling independence, and total constancy [76], allowing the evaluation results to better reflect the actual situation. By adopting a combination of subjective and objective methods to evaluate the quality of carbon disclosure, this approach reduces the fluctuations caused by data variability in the entropy weighting method. Simultaneously, it addresses the subjectivity inherent in the hierarchical analysis method when constructing the judgment matrices for the indicators, making the results more objective and comparable [77].

The TOPSIS model is a distance-based comprehensive evaluation method that determines the comprehensive score of an evaluation object by calculating its distance from the ideal solution and the negative ideal solution [78], which makes full use of the information of the original data in the evaluation process and does not need to make complex transformations or assumptions about the data [79]. The combined weighting-TOPSIS method used in this paper is a multi-objective optimization decision analysis method that integrates the principles of the AHP (Analytic Hierarchy Process), the entropy weight method, and the TOPSIS method [80]. The basic assumptions of this model are: (1) non-negativity of data. The entropy weight method relies on the concept of probability distribution. Non-negative data are required to ensure the calculated entropy values and weights have reasonable significance and interpretability. In this study, the data used for evaluating the quality of corporate carbon information disclosure, such as completeness scores and quantified data accuracy, naturally meet this requirement; (2) data variability. The data are assumed to exhibit variability. If all data were identical, the entropy value would reach its maximum, making it impossible to distinguish the importance of different indicators using the entropy weight method. In actual corporate carbon information disclosure data, differences in management levels, technical capabilities, and environmental awareness across companies result in variability, providing the basis for effective application of the entropy weight method. By calculating entropy weights based on the degree of data dispersion, indicators that have a significant impact on evaluating carbon disclosure quality can be accurately identified [76,77]; (3) distance measurability. Each research object is assumed to have measurable distances to the ideal solution and the negative ideal solution. By comparing these distances, the research objects can be ranked: the closer an object is to the ideal solution, the higher its overall evaluation; the closer an object is to the negative ideal solution, the lower its overall evaluation [79].

The combined weighting-TOPSIS method comprehensively considers the impact of multiple evaluation indicators, using AHP and the entropy weight method to determine the weights of each indicator. This avoids the subjectivity of relying solely on AHP, enhancing the comprehensiveness and objectivity of the evaluation results. The TOPSIS method further evaluates alternatives by calculating their distances to the ideal and negative ideal solutions, improving the accuracy of the evaluation results [81]. Additionally, this method has relatively low data requirements, does not necessitate specific assumptions about the data or complex statistical analyses, and offers great flexibility and convenience. In summary, the combined weighting-TOPSIS method has advantages such as objectivity,

accuracy, comprehensiveness, low data requirements, intuitive understanding, and wide applicability. It has a wide range of applications in the fields of economics, environment, and management [35,82].

Based on authoritative literature, four first-level indicators—comprehensibility, reliability, comparability, and relevance—were then used to reflect the quality of carbon information disclosed by listed companies. The ESG reports, social environment reports, and sustainability reports of listed companies were analyzed using Python 3.9, and the carbon information lexicon was constructed by combining relevant indicators. Keyword frequency statistics were used to derive the word frequency of each indicator. Using the hierarchical analysis method and the entropy weight method, a comprehensive indicator reflecting carbon information disclosure was constructed, and the final scores for listed companies' carbon disclosure quality were calculated.

3.3.1. Hierarchical Analysis to Calculate Subjective Weight

The specific steps of the hierarchical analysis method are as follows. First, we establish the hierarchical structure analysis model. Second, we construct a judgment matrix, where experts score and use the nine-point scale method to compare and assign values based on importance. Finally, a consistency test is conducted after deriving the weight vector. The eigenvector corresponding to the largest eigenvalue of the judgment matrix A is normalized, resulting in the subjective weight vector for each evaluation index.

3.3.2. Entropy Weighting Method to Calculate Objective Weights

The specific steps of the entropy weight method are the following.

Firstly, the indicator data is standardized. Data standardization is carried out for n indicator values of the given m evaluation objects.
Secondly, the weights are calculated. The entropy value of j indicators is:

$$e_j = -\sum_{i=1}^{n} p_{ij} \frac{ln(p_{ij})}{ln(n)}, j = 1, 2, 3....., m \quad (2)$$

The weight of the ith evaluation object under the jth indicator in relation to that indicator is:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \quad (3)$$

If $p_{ij} = 0$, then $\lim_{p_{ij} \to 0} p_{ij} \ln p_{ij} = 0$, and we determine the weight of each indicator based on their entropy value e_j:

$$w_i = \frac{(1 - e_j)}{m - \sum_{j=1}^{m} e_j}. \quad (4)$$

3.3.3. Determination of the Combined Weights of the Data Based on the AHP and Entropy Weighting Methods

The composite weight is a weighted average of the primary and objective weights, and the composite weight is calculated by the formula:

$$W_i = \frac{W_{AHP} w_i}{\sum_{i=1}^{n} W_{AHP} w_i} \quad (5)$$

The calculation results of the weights of each evaluation index obtained based on AHP and entropy weighting method are shown in Table 2.

3.3.4. Combined Empowerment-TOPSIS Approach

The TOPSIS method, also known as the superiority and inferiority distance method, is a commonly used comprehensive evaluation method which can make full use of the original data information, and its results can accurately reflect the gap between the evaluation programs. The specific steps are as follows: in the first step, we construct an initial discriminant matrix R. For instance, this paper needs to evaluate 173 sets of data from 37 companies, and a total of 10 evaluation indicators are established. The second step is to construct the standardized weighted decision matrix Z. The discriminant matrix R is normalized and then normalized to the standardized matrix $Q = \left(q_{vf}\right)_{s\times t}$, which is multiplied by the weights of the indicator combinations, and the weights of the indicator combinations are multiplied by the weights of the indicator combinations. The matrix is normalized to a standardized matrix and then multiplied with the weights of the indicator combinations, $Z = \left(z_{vf}\right)_{s\times t} = w_v q_{vf}$. The third step is to calculate the distance to the ideal solution:

$$S_V^+ = \sqrt{\sum_{f=1}^{t}\left(z_{vf} - z_f^+\right)^2} \tag{6}$$

$$S_V^- = \sqrt{\sum_{f=1}^{t}\left(z_{vf} - z_f^-\right)^2} \tag{7}$$

In the above equations, S_V^+ and S_V^- are the Euclidean distances between the scheme and the positive and negative ideal solutions, respectively; z_f^+ and z_f^- are the elements, with values corresponding to the positive and negative ideal solutions, respectively; and z_{vf} and q_{vf} are the values obtained after correction by weighting coefficients. In the fourth step, the closeness between each evaluation object and the optimal solution is calculated as follows:

$$C_V = \frac{S_V^+}{S_V^+ + S_V^-} \tag{8}$$

where $0 \leq C_V \leq 1$. The closer C_V is to 1, the more advantageous the CID (Carbon Information Disclosure) quality is.

4. Discussion and Evaluation Results

4.1. Evaluation Index System

Based on the existing research and the practical context of resource-based companies, this study addresses two key research hypotheses concerning the relationship between corporate greenwashing behaviors and the quality of carbon information disclosure. Building upon existing literature, this paper integrates external evaluations, international standards, and domestic policies into the developed carbon information disclosure indicator system, thereby advancing the theoretical framework of the previous carbon information quality evaluation system. Importantly, we quantified the extent of greenwashing behaviors exhibited by companies and excluded those identified as engaging in greenwashing. To assess the impact of greenwashing on the overall quality of carbon information disclosure, we compared the average carbon information disclosure quality scores of companies that were not excluded for greenwashing with those of companies that were excluded for greenwashing behaviors. The comparison reveals that greenwashing behaviors result in an inflated carbon information disclosure quality [58,59], as illustrated in Figure 2. Hypothesis 1 was, therefore, verified.

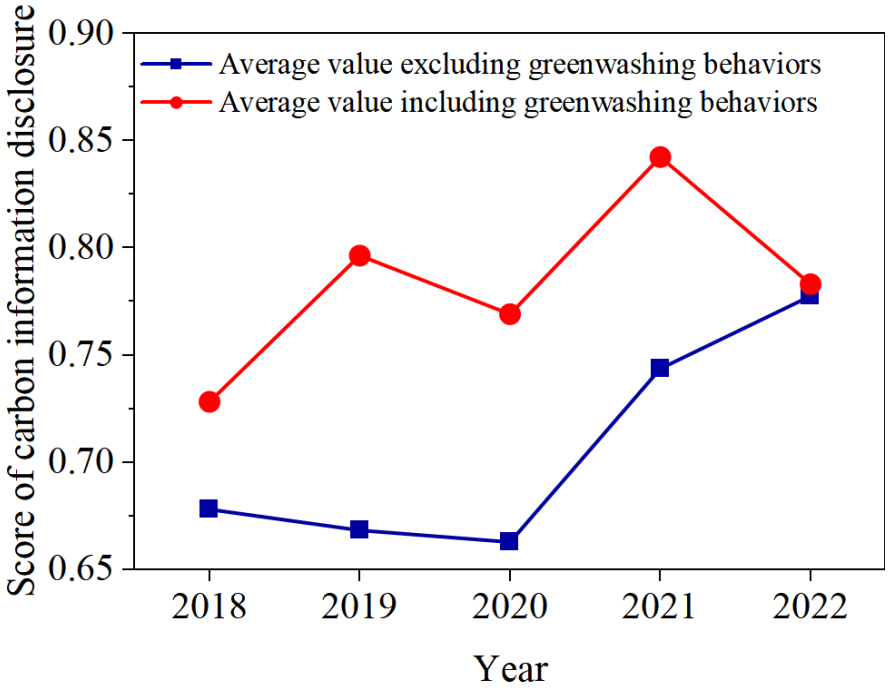

Figure 2. Scores for corporate carbon information disclosure considering greenwashing behaviors.

4.2. Analyzation of the Evaluation Results

4.2.1. Overall Carbon Disclosure by Resource-Based Companies

First, the quality of carbon information disclosure by resource-based companies has steadily improved, but the overall level remains low [30,34,35]. As shown in Figure 3, the average comprehensive score of carbon information disclosure quality for resource-based companies has steadily improved over the past five years. The average comprehensive score rose from 0.6629 in 2020 to 0.7776 in 2022, and the maximum value increased from 0.9826 to 0.9883, indicating a year-on-year upward trend. This is because, after 2020, achieving the dual-carbon goals has become a critical component of the overall national ecological civilization construction framework. In this context, both corporate production decisions and investors' investment decisions have had to take climate risks into account. Under the frameworks of legitimacy theory and voluntary disclosure theory, high-quality carbon information disclosure not only demonstrates that companies can effectively address climate risks and maintain their legitimacy, but also helps investors identify high-emission companies, thereby reducing investment risks. Consequently, after 2020, companies have become more proactive in disclosing carbon information. The minimum quality score of corporate carbon information disclosure remains at 0 for two main reasons. First, mandatory carbon information disclosure has not yet been implemented in the country, and some companies failed to release social responsibility reports in certain years, resulting in discontinuous data collection. Second, the carbon performance scores in the corporate social responsibility reports disclosed by some companies in specific years were poor, leading to a carbon information disclosure quality score of 0 for these companies based on the scoring criteria outlined in Table 2. Since 2019, the quality of carbon information disclosure has risen from 0 to 0.3994, significantly improving CID quality. In conclusion, Hypothesis 2 has been verified.

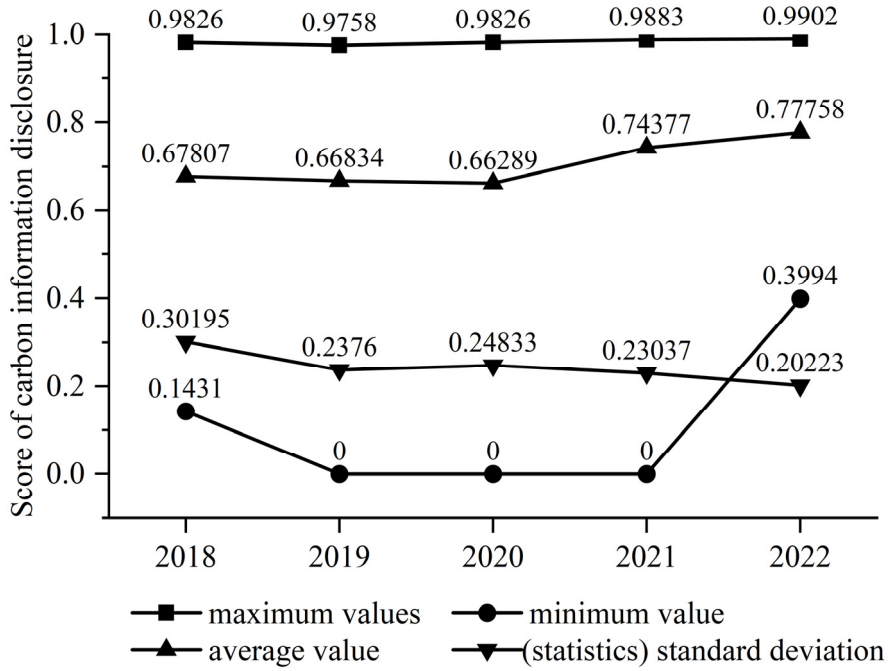

Figure 3. Comprehensive carbon information quality score for resource-based companies.

Second, the quality of carbon information disclosure (CID) among companies is uneven. The standard deviation of the composite scores over five years shows an upward trend before 2020, increasing from 0.1950 to 0.2483, and a downward trend after 2021, decreasing from 0.2483 to 0.2022. Although companies have paid more attention to the quality of carbon information disclosure since the dual-carbon targets were introduced, a unified quality evaluation system for carbon information disclosure has yet to be established in China. As a result, the quality gap in carbon information disclosure among companies remains significant and has not reached a minimum acceptable level. As shown in the Figure 3, the minimum value of CID scores rose by 4.5% before 2020, while the maximum value increased by 22%. This indicates that the carbon information disclosure quality of lower-ranked companies has improved to some extent but remains at a relatively low level. Meanwhile, the carbon disclosure quality of top-ranked companies has widened the gap compared to other companies. However, after the dual-carbon targets were proposed in 2020, the gap between the disclosure quality of top-ranked and bottom-ranked companies has narrowed somewhat, though the reduction remains insignificant. The three best-performing companies over the five-year period achieved composite scores ranging from 0.9826 to 0.9902, which are close to the maximum possible score of 1. In contrast, the worst-performing companies—Guangsheng Nonferrous, Northern Rare Earths, and Golden Molybdenum—scored 0, 0.1431, and 0.2995, respectively. The difference between the highest and lowest performers primarily lies in comprehensibility and relevance. These include factors such as whether the disclosures are supplemented with charts and graphs, whether a table of contents or index is provided, and whether companies report on their carbon emission strategies and plans, emission reduction investments, education and training initiatives, and carbon emissions. Additionally, better-performing companies tend to use various charts and graphs to compare data across multiple years, while poorer performers often limit their disclosures to the current year's data. This discrepancy may be attributed to the absence of mandatory disclosure requirements and standardized reference frameworks. Furthermore, local guidelines for carbon information disclosure vary, leading companies to adopt a more casual approach to reporting their carbon-related information.

4.2.2. Specific Analysis of Carbon Disclosure Quality Evaluation of Resource-Based Companies

First, corporate carbon information disclosure exhibits a high degree of greenwashing and low decision-making value. Among 209 resource-based companies, only 32 were identified as having a relatively low level of greenwashing compared to the industry average, indicating that symbolic disclosure practices have led to severe greenwashing issues in resource-based companies. To begin with, the decision-making value of corporate carbon information disclosure is low, making it difficult for stakeholders to understand and utilize. Among the relevant indicators disclosed by companies, the most prominent are carbon emission reduction effectiveness, the operation of carbon reduction measures and facilities, compliance, and carbon emissions. In terms of disclosure timing and frequency, except for the year 2021, over 45% of companies disclosed carbon information only once, after March of the following year. While such disclosures offer high feedback value, their decision-making value remains insufficient. Each year, only about 33% to 50% of companies provide both a table of contents and an index to locate carbon information, and only 25% to 67% of companies use data supplemented by charts and graphs for additional explanation. This lack of targeted information often results in repetition from previous years, and half of the companies failed to compare current data with previous years in percentage terms. Additionally, the lack of reliability may undermine the credibility of carbon information disclosure. Among the sampled companies, only three reported being audited for two consecutive years, further indicating that the reliability of corporate carbon information disclosure remains poor.

Second, to further compare the carbon disclosure practices of resource-based firms across sub-industries, this paper examined the quality of carbon disclosure by sub-industry for each year, based on the corresponding mean values. The annual mean values of carbon disclosure for the resource-based sub-industries covered in this study are presented in Figure 4. Figure 4 shows that, in general, the carbon disclosure quality of most firms in the sub-industries during 2018 and 2019 was lower than the average value for those years, and there was little variation in carbon disclosure quality among the sub-industries. By 2020, however, the carbon disclosure quality of most manufacturing sub-industries had significantly improved. Among them, the ferrous metal smelting and rolling processing industry demonstrated the highest quality of carbon disclosure, with substantial improvement compared to 2018 and 2019. The differences in carbon disclosure quality among sub-industries can be attributed to the varying carbon emission intensities of the industries, which lead to differentiated disclosure strategies by companies. According to Fu et al., among resource-based sub-industries, the non-metallic mineral products industry, the ferrous metal smelting and rolling industry, and the non-ferrous metal smelting and rolling industry are classified as high-emission-intensity industries [83]. Under the frameworks of legitimacy theory and stakeholder theory, when excessive carbon emissions undermine a firm's ability to address climate risks, thereby threatening its legitimacy, the firm may enhance the quality of its carbon disclosure to influence stakeholders' perceptions of its legitimacy [84]. As a result, firms in medium- and high-emission-intensity industries have stronger incentives to disclose carbon information. This trend has been particularly evident since the dual-carbon goals of peaking carbon dioxide emissions by 2030 and achieving carbon neutrality by 2060 were introduced. Consequently, the differences in carbon disclosure quality among firms in different sub-industries have become more pronounced.

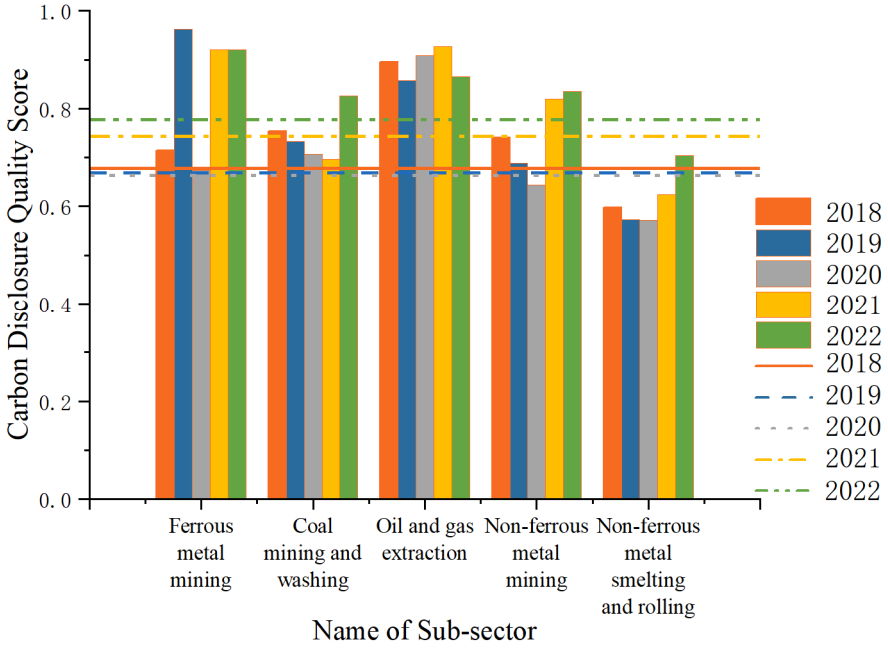

Figure 4. Changes in carbon disclosure by sub-sector for resource-based companies between 2018 and 2022.

Third, to further analyze the carbon information disclosure of resource-based companies across provinces, this study calculates the annual average carbon information disclosure quality for all provinces, autonomous regions, and municipalities. The corresponding results are presented in Figure 5. As can be seen from Figure 5, it can be observed that, in 2018, the carbon information disclosure quality of resource-based companies in regions such as Beijing, Qinghai, Guangdong, Hunan, Shanxi, Sichuan, Xinjiang, and Zhejiang was higher than the national average for that year, with Sichuan achieving the highest average among resource-based companies. In 2019, the carbon information disclosure quality of resource-based companies in regions such as Guangdong, Jiangxi, Qinghai, Shandong, Shanxi, Tianjin, Tibet, Yunnan, and Zhejiang was higher than the national average for that year, with Tianjin achieving the highest value. In addition, compared to 2018, the carbon information disclosure quality of resource-based companies in Tianjin improved significantly in 2019. In 2020, the carbon information disclosure quality of regions such as Liaoning, Tibet, Guangdong, Fujian, Inner Mongolia, Beijing, and Shanghai exceeded the national average for that year. Compared to 2018 and 2019, most regions experienced a significant improvement in the carbon information disclosure quality of resource-based companies in 2020.

There are significant differences between regions in terms of economic development levels, resource endowments, industrial structures, environmental policies, and stakeholder attention [85]. Therefore, it is necessary to analyze the quality of carbon information disclosure of resource-based companies in China separately for the central, eastern and western regions. As shown in Figures 6–8, there are regional differences in the quality of carbon information disclosure among resource-based companies in China. The overall level of the eastern provinces is relatively high, with many provinces consistently showing scores above the average over the years. This reflects the advantages of developed regions in areas such as environmental information disclosure systems. These favorable factors enable resource-based companies in the eastern provinces to more easily meet or exceed the annual average level. In the central provinces, the scores in previous years may have been slightly lower than in the eastern provinces. However, the quality of disclosure in some provinces has gradually improved and is approaching or even exceeding the annual

average reference line, showing a catch-up trend. This can be attributed to recent industrial structure optimization and increased awareness of information disclosure in the central region. The overall disclosure quality in the western region appears to be somewhat inconsistent. While some provinces perform well, approaching or even exceeding the annual average, others remain at a relatively low level. However, the overall trend is also improving, which is likely due to the introduction of the National Western Development Strategy and the promotion of green development concepts [86].

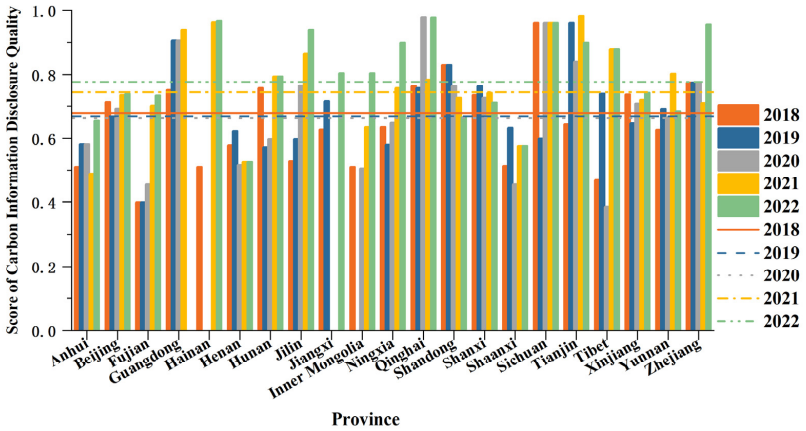

Figure 5. Changes in carbon information disclosure of resource-based companies across provinces from 2018 to 2022.

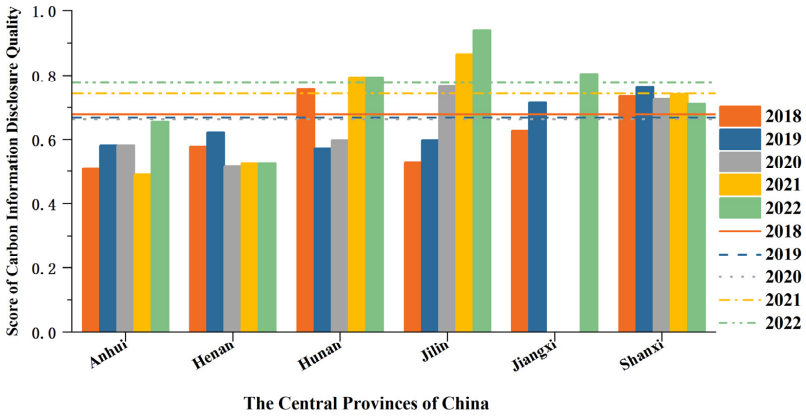

Figure 6. Changes in carbon information disclosure of resource-based companies in the central provinces of China from 2018 to 2022.

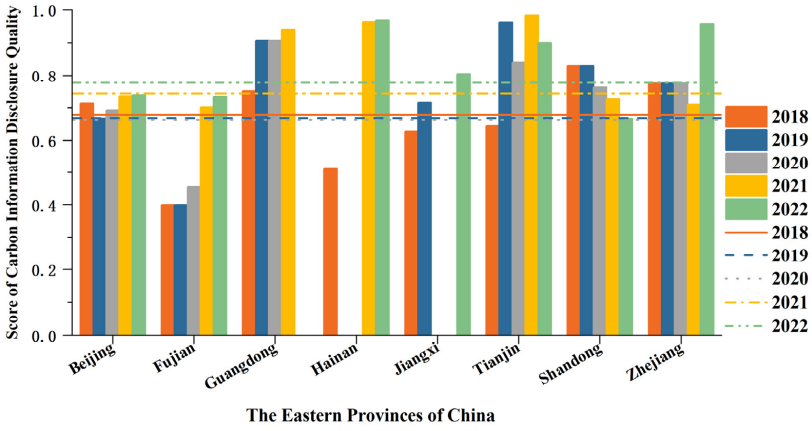

Figure 7. Changes in carbon information disclosure of resource-based companies in the eastern provinces of China from 2018 to 2022.

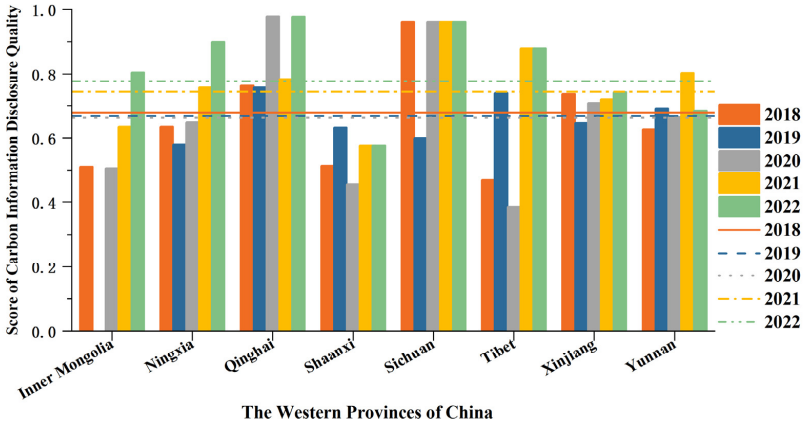

Figure 8. Changes in carbon information disclosure of resource-based companies in the western provinces of China from 2018 to 2022.

5. Conclusions and Policy Recommendations

5.1. Conclusions

Based on previous research, this study incorporated the four dimensions of carbon information disclosure—intelligibility, reliability, comparability, and relevance—and integrated third-party evaluations, international standards, and domestic policies. A total of 12 indicators were designed, including diversified presentation formats, directory indices, and external evaluations, to construct a carbon information disclosure quality evaluation system. Using data from resource-based companies listed on the A-share market between 2018 and 2022 as the research sample (excluding companies with greenwashing behaviors), the combined weighting-TOPSIS method was employed to objectively evaluate the carbon information disclosure quality of Chinese resource-based companies. On this basis, an in-depth analysis was conducted on the carbon information disclosure quality of the five sub-industries within the resource-based sector and their respective provinces. The following research findings were obtained:

(1) Corporate greenwashing behaviors are primarily reflected in the falsification of sustainable development reports and social responsibility reports. Analyzing the carbon information disclosure quality within corporate sustainable development reports can result in inflated evaluation outcomes. As demonstrated in Equation (1), excluding companies with greenwashing behaviors is essential to ensure that the evaluation results are more objective and scientifically reliable [35];

(2) Based on the constructed corporate carbon information disclosure quality evaluation system, it can be concluded that, overall, the carbon information disclosure quality of resource-based companies has improved since the dual carbon goals were proposed in 2020 [84]. However, the average carbon information disclosure quality score for resource-based companies remained around 0.6–0.7 from 2018 to 2022, indicating that the overall carbon information disclosure quality of resource-based companies is relatively low, which is consistent with the research findings of Liu [30], Liu and Wu [34], Teng [35];

(3) The overall level of carbon information disclosure among China's resource-based companies remains relatively low, with significant variations in the quality of carbon information disclosure observed across companies, sub-industries, and regions. These differences are evident both within sub-industries in the resource sector and across the various regions where these companies operate [85]. Notably, the quality of carbon information disclosure has shown substantial improvement after 2020 compared to 2018 and 2019.

5.2. Policy Recommendations and Prospects

Based on the main conclusions drawn from the research, this paper puts forward the following policy recommendations:

(1) Environmental regulation plays a key role in curbing corporate greenwashing, but it also has the potential to increase corporate greenwashing [87]. Many aspects covered by ESG reports, such as greenhouse gas emissions, have clear public good attributes. The externalities of these public goods are difficult to eliminate solely through market mechanisms. Voluntary disclosures lack rigid constraints, making it challenging to curb greenwashing behaviors by companies. Therefore, moderating government regulation is necessary. Transitional regulations encourage companies to minimize compliance rather than pursue meaningful environmental initiatives [88,89]. Based on our research findings, we propose several following policy recommendations to reduce corporate greenwashing behaviors. First, government authorities should play a supervisory and coordinating role, continuously improving environmental compliance through legislation. Legislative work not only helps standardize corporate ESG reporting but can also significantly reduce the gray area of "greenwashing". By legislating the preparation and disclosure of ESG reports, we can fundamentally rectify and curb greenwashing behaviors, thereby safeguarding carbon peaking and carbon neutrality [90]. Second, based on the aforementioned quality evaluation index system, companies can introduce an independent verification mechanism for sustainable development reports, which can exert a certain degree of constraint on greenwashing, helping to enhance the credibility and public trust of corporate sustainable development reports [91]. Last, in addition to external constraints, under legal pressure, the board of directors and the CEO, as internal supervisory entities, play a role in improving climate-related governance mechanisms and internal training systems, regularly evaluating environmental issues and incorporating important environmental topics into governance decision-making processes [1]. Media attention can effectively align corporate environmental actions with stakeholder expectations, thereby reducing greenwashing behaviors.

(2) Scientifically and effectively evaluating the quality of corporate carbon information disclosure helps to further enhance the quality level of corporate carbon information disclosure and plays a positive role in enabling companies to achieve carbon peaking and carbon neutrality in China on schedule [19]. Currently, carbon information disclosure by Chinese companies still relies mainly on voluntary disclosure, lacks corresponding incentive mechanisms, and has not yet established clear regulations on the content, format, and standards of carbon information disclosure. This directly results in arbitrary carbon information disclosure by many companies, varying quality of carbon information disclosure, and low efficiency in the use of carbon information [92]. It is worth noting that the Ministry of Ecology and Environment issued the "Administrative Measures for the Disclosure of Environmental Information by Companies" on 31 December 2021, which required "key pollutant discharge units and other types of companies to disclose their carbon emission information" for the first time. Undoubtedly, the carbon information of companies in our country is gradually shifting from voluntary disclosure to mandatory disclosure. The mandatory disclosure system for carbon information established through policies and regulations needs to be continuously improved in subsequent practice. On one hand, the current regulations require a limited number of types of companies to disclose information, and the number of companies involved is also small. The scope of mandatory disclosure for companies still needs to be further expanded. On the other hand, the government and relevant institutions should quickly explore the establishment of a unified, scientific, and objective carbon information disclosure quality evaluation system. This system should further refine the content and format requirements for carbon information

disclosure. Under a unified carbon emission accounting system, companies should disclose carbon emission-related data according to standardized formats and requirements. This will achieve comparability in the quality of carbon information disclosure across different industries and better evaluate the quality of carbon information disclosure. Finally, in terms of supervising corporate carbon information disclosure, it is necessary to strengthen regulatory constraints and ensure the implementation of the carbon information disclosure system. The carbon information disclosed by companies should be made public to the entire society and jointly reviewed and evaluated by stakeholders such as the government, shareholders, and citizens. Companies with high-quality carbon information disclosure should be given material rewards or corresponding honors, while those with poor-quality disclosures should be appropriately penalized.

(3) Due to differences in the quality of carbon information disclosure among companies in different sub-industries, and considering the varying regions and carbon information disclosure quality scores of these companies, a one-size-fits-all approach should not be adopted under environmental policy regulations. Instead, tailored and categorized guiding policies should be formulated to improve the quality of carbon information disclosure [85,93], thereby enhancing the quality of carbon information disclosure for resource-based companies. First, regionally differentiated policy guidelines should be strengthened to promote balanced development of the quality of carbon information disclosure. For the eastern region, efforts should be made to further consolidate its advantages in carbon information disclosure and increase both transparency and depth. In the central region, optimization of industrial structure should be supported while improving the standardization and scope of carbon information disclosure for resource-based companies. For the western region, efforts should focus on addressing the issue of uneven disclosure quality by prioritizing support for regions and companies with lower levels of disclosure; second, incremental disclosure targets and detailed guidelines tailored to the actual development level of each region should be implemented to gradually improving the standardization and comparability of corporate disclosures; and third, close attention should be paid to differences within the region and targeted support policies should be implemented based on local conditions. Specific measures should be adopted to assist low-performing companies within regions, such as providing training and technical support, setting up dedicated policy guidance funds, and improving the disclosure capabilities of these companies. Fourth, regional cooperation mechanisms should be strengthened to facilitate sharing of experiences in carbon information disclosure. Companies in different regions should enhance communication and learning, particularly with companies in the central and western regions drawing lessons from those in the eastern region. Additionally, intergovernmental collaboration between regions should be encouraged to establish regulatory frameworks that promote corporate carbon information disclosure and contribute to reducing carbon emissions.

As China gradually introduces and refines its enterprise carbon disclosure system, corporate carbon emission data will become increasingly accessible in the future, enabling more accurate measurement of companies' carbon emission levels. Simultaneously, the content of corporate carbon disclosures will become progressively standardized, leading to steady improvements in disclosure quality. This will significantly enhance the accuracy of evaluating the emission reduction effects of corporate carbon information disclosure. Moreover, while research on corporate carbon information disclosure has become increasingly extensive, studies focusing on urban carbon information disclosure remain scarce. With the advancement of China's dual-carbon goals, it is not only corporations that are required to disclose carbon information, but also cities, as key contributors to carbon emissions and products of industrialization. Urban carbon information disclosure is crucial for improving decision-making capacity in reducing carbon emissions and optimizing industrial

layouts. Extending the research methodologies used to evaluate the quality of corporate carbon information disclosure to the urban level presents a valuable opportunity for future research.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Section 1 introduces the background, research significance, and research contents of this paper. Section 2 presents our relevant literature. Section 3 outlines the indicator evaluation system established, as well as the data and empirical methodology used in this study. Section 4 reports and discusses our findings. Finally, we provide a conclusion in Section 5. The framework of this study is illustrated in Figure A1.

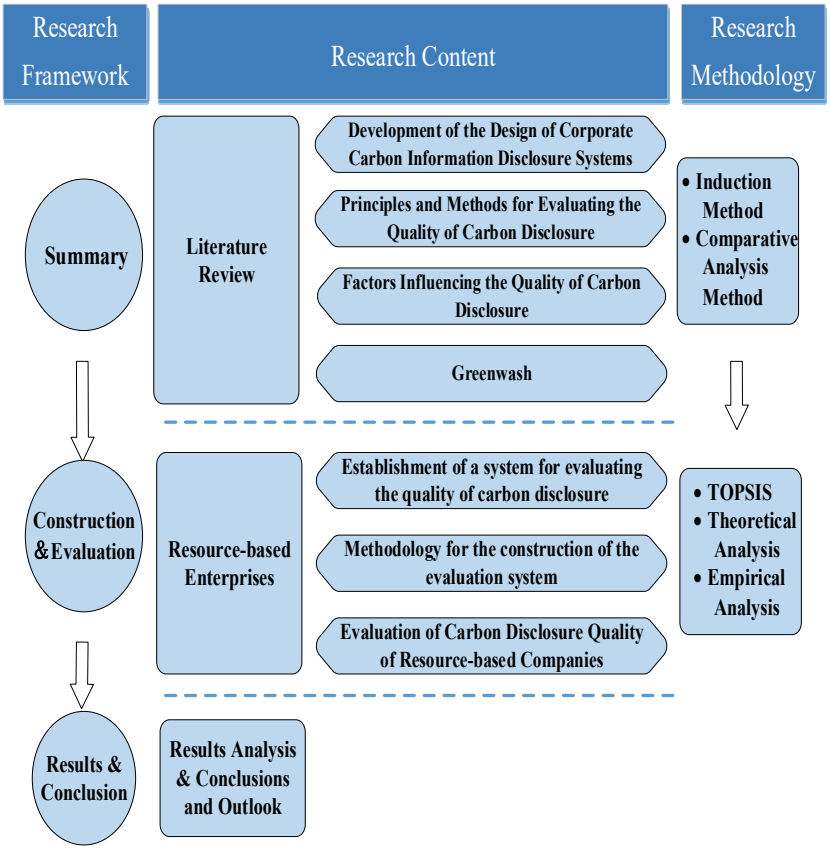

Figure A1. Framework of this study.

References

1. Shahrour, M.H.; Arouri, M.; Tran, D.V.; Rao, S. Carbon consciousness: The influence of CEO ownership. *J. Environ. Manag.* **2024**, *364*, 121455. [CrossRef] [PubMed]
2. Li, H.; Lu, J. Temperature change and industrial green innovation: Cost increasing or responsibility forcing? *J. Environ. Manag.* **2023**, *325*, 116492. [CrossRef] [PubMed]
3. Yu, H.C.; Kuo, L.; Ma, B.L. The drivers of carbon disclosure: Evidence from China's sustainability plans. *Carbon. Manag.* **2020**, *11*, 399–414. [CrossRef]
4. Chen, J.; Shi, Q.; Zhang, W. Structural path and sensitivity analysis of the CO_2 emissions in the construction industry. Environ. Impact. *Assess. Rev.* **2022**, *92*, 106679.
5. Tan, D.; Zou, S. Current Situation of International Development of Carbon Information Disclosure and the Construction of Carbon Information Disclosure Framework in China. *Stat. Decis. Mak.* **2010**, *36*, 126–128. (In Chinese)
6. Zhong, F.; Yang, B. Research on the framework construction and support mechanism of carbon information disclosure of companies in China. *J. Northeast. Norm. Univ. (Philos. Soc. Sci. Ed.)* **2015**, *65*, 67–71. (In Chinese)
7. Li, X.-T.; Song, C.; Guo, X.-M. Study on the correlation between carbon disclosure and corporate value. *Manag. Rev.* **2017**, *29*, 175–184. (In Chinese)
8. Jaggi, B.; Allini, A.; Macchioni, R.; Zagaria, C. The factors motivating voluntary disclosure of carbon information: Evidence based on Italian listed companies. *Organ. Environ.* **2017**, *31*, 178–202. [CrossRef]
9. de Grosbois, D.; Fennell, D.A. Determinants of climate change disclosure practices of global hotel companies: Application of institutional and stakeholder theories. *Tour. Manag.* **2022**, *88*, 104404. [CrossRef]
10. Dong, R.Y.; Shao, C.F.; Xin, S.Q.; Lu, Z.R. A Sustainable Development Evaluation Framework for Chinese Electricity companies Based on SDG and ESG Coupling. *Sustainability* **2023**, *15*, 8960. [CrossRef]
11. Yang, Z.; Peng, J.; Tang, Q. Comparative study of mandatory and voluntary carbon disclosure system-experience from Chinese capital market. *J. Syst. Manag.* **2018**, *27*, 452–461. (In Chinese)
12. Wu, X.; Xu, X. Research on the evaluation of corporate carbon disclosure quality—Empirical evidence from resource-based listed companies. *Sci. Technol. Manag. Res.* **2015**, *35*, 229–233. (In Chinese)
13. Peng, J.; Xiong, D. An empirical study on the impact of carbon disclosure on investor protection: Based on the empirical data of listed companies in Shanghai and Shenzhen from 2008 to 2010. *Shanghai Manag. Sci.* **2012**, *34*, 63–68. (In Chinese)
14. Zhu, H.; Chen, Y. Research on Influencing Factors of Voluntary Carbon Disclosure—A Case Study Based on 2012–2016 CDP Reports. *Financ. Account. Newsl.* **2018**, *39*, 12–16. (In Chinese)
15. Li, H.; Fu, S.; Wang, R. The construction of carbon disclosure evaluation system. *Stat. Decis. Mak.* **2015**, *31*, 40–42. (In Chinese)
16. Wang, J. A study on the relevance of environmental information disclosure, industry differences and external institutional pressure—Empirical evidence from environmental information disclosure of listed companies in Shanghai, China. *Account. Res.* **2008**, *29*, 54–62. (In Chinese)
17. Chen, H.; Wang, H.; Jing, X. Carbon Disclosure in China: Definition of Content, Measurement Methods and Current Status. *Account. Res.* **2013**, *12*, 18–24+96. (In Chinese)
18. Liu, J.; Zhang, C. The construction of carbon disclosure quality evaluation system for Chinese companies. *J. Syst. Eng.* **2020**, *35*, 849–864. (In Chinese)
19. Liu, Z.; Zhang, C. Quality evaluation of carbon information disclosure of public companies in China's electric power sector based on ANP-Cloud model. *Environ. Impact. Asses.* **2022**, *96*, 106818. [CrossRef]
20. Zhang, C.; Hu, S.; Ji, Y.; Zhu, J. Research progress and future prospect of environmental information disclosure based on scientific knowledge mapping. *Arid. Zone. Resour. Environ.* **2022**, *36*, 48–58. (In Chinese)
21. Patten, D.M. Exposure, legitimacy and social disclosure. *J. Account. Public Policy* **1991**, *10*, 297–308. [CrossRef]
22. Clarkson, P.M.; Li, Y.; Richardson, G.D.; Vasvari, F.P. Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Account. Organ. Soc.* **2008**, *33*, 303–327. [CrossRef]
23. Wang, Z.; Jin, X. Study on the correlation between carbon disclosure and corporate value. *Macroecon. Res.* **2013**, *35*, 86–90. (In Chinese)
24. Zhao, X.; Huo, S.; Wu, X. Political Affiliation, Government Intervention and Carbon Disclosure Levels—A Panel Data Analysis Based on Resource-based companies. *Sci. Technol. Manag. Res.* **2015**, *35*, 222–226. (In Chinese)
25. He, P.; Shen, H.; Zhang, Y.; Ren, J. External Pressure, Corporate Governance, and Voluntary Carbon Disclosure: Evidence from China. *Sustainability* **2019**, *11*, 2901. [CrossRef]
26. Li, Z.; Xiang, R. A study on the content definition, measurement method and current status of CSR disclosure in China. *Acc. Res.* **2007**, *28*, 3–11+95. (In Chinese)
27. Li, H.; Chen, Z.; Fu, S. Technical realisation of carbon disclosure quality evaluation. *Stat. Decis. Mak.* **2016**, *32*, 70–72. (In Chinese)

28. Zhang, X.; Yang, L.; Wu, Y.; Cao, L.; Xu, Y. Improvement of Environmental Information Disclosure Indicator System Based on Text Mining Methods—An Example of Listed companies in Sichuan and Chongqing Economic Zones. *Soft Sci.* **2014**, *28*, 65–71. (In Chinese)
29. Li, S.; Ge, Y.; Wang, R. Evaluation of carbon disclosure quality based on improved variable-weighted object elemental topological model. *Stat. Decis. Mak.* **2019**, *35*, 57–61. (In Chinese)
30. Liu, Z.; Liu, M. Quality Evaluation of Enterprise Environmental Accounting Information Disclosure Based on Projection Pursuit Model. *J. Clean. Prod.* **2020**, *279*, 123679. [CrossRef]
31. Liu, Z.-B.; Zhang, Y.-Z.; Wang, Y.; Sun, Y.; Yang, S. Carbon disclosure quality evaluation using entropy weight-objective topological model. *Electr. Pow. Sci. Eng.* **2023**, *39*, 53–61. (In Chinese)
32. Zhang, Y.; Liu, Q. Construction and Measurement of Corporate Carbon Performance Indicator System. *Stat. Decis. Mak.* **2020**, *36*, 166–169. (In Chinese)
33. Yu, J.; Zhang, J. Research on low carbon supply chain performance evaluation based on AHP-DEA. *Econ. Syst. Reform* **2015**, *33*, 44–51. (In Chinese)
34. Liu, Z.; Wu, J. Evaluation index system for carbon information disclosure quality in China's electric power sector based on a Mutual Information and Back Propagation neural network model. *Util. Policy* **2024**, *89*, 101781. [CrossRef]
35. Teng, X.; Xie, Y. Construction and Application of Carbon Disclosure Quality Evaluation System for High Carbon Emission companies. *Financ. Econ. Mon.* **2023**, *44*, 73–79. (In Chinese)
36. Peng, Z.; Zhang, A.; Wang, S.; Bai, Y. Design principles and construction process of comprehensive evaluation index system. *Res. Manag.* **2017**, *38* (Suppl. 1), 209–215. (In Chinese)
37. Wu, D.; Memon, H. Public Pressure, Environmental Policy Uncertainty, and companies' Environmental Information Disclosure. *Sustainability* **2022**, *14*, 6948. [CrossRef]
38. Jin, L.; Choi, J.H.; Kim, S.; Yang, D.H. Government Environmental Pressure and Market Response to Carbon Disclosure: A Study of the Early Chinese ETS Implementation. *Sustainability* **2021**, *13*, 13532. [CrossRef]
39. Mia, P.; Rana, T.; Ferdous, L.T. Government Reform, Regulatory Change and Carbon Disclosure: Evidence from Australia. *Sustainability* **2022**, *13*, 13282. [CrossRef]
40. Luo, Y.; Xiong, G.; Mardani, A. Environmental information disclosure and corporate innovation: The "Inverted U-shaped" regulating effect of media attention. *J. Bus. Res.* **2022**, *146*, 453–463. [CrossRef]
41. Zhou, W.; Chen, F.; Zhu, Y.; Xiang, L.; Lei, L. Media attention, negative reports and textual information of banks' ESG disclosure. *Int. Rev. Econ. Financ.* **2024**, *96*, 103583. [CrossRef]
42. Chen, H.; Fang, X.; Xiang, E.; Ji, X.; An, M. Do online media and investor attention affect corporate environmental information disclosure? Evidence from Chinese listed companies. *Int. Rev. Econ. Financ.* **2023**, *86*, 1022–1040. [CrossRef]
43. Li, N.; Shi, B.; Kang, R. Information Disclosure, Coal Withdrawal and Carbon Emissions Reductions: A Policy Test Based on China's Environmental Information Disclosure. *Sustainability* **2021**, *13*, 9758. [CrossRef]
44. Dan, E.; Shen, J. Establishment of Corporate Energy Management Systems and Voluntary Carbon Information Disclosure in Chinese Listed Companies: The Moderating Role of Corporate Leaders' Low-Carbon Awareness. *Sustainability* **2022**, *14*, 2714. [CrossRef]
45. Luo, W.; Guo, X.; Zhong, S.; Wang, J. Environmental information disclosure quality, media attention and debt financing costs: Evidence from Chinese heavy polluting listed companies. *J. Clean. Prod.* **2019**, *231*, 268–277. [CrossRef]
46. Muniandy, B.; Ali, M.J.; Huang, H.; Obeng, V.A. Board generational cohorts, gender diversity and corporate environmental and social disclosures: Evidence from China. *J. Account. Public Policy* **2023**, *42*, 107066. [CrossRef]
47. Mateo-Márquez, A.J.; González-González, J.M.; Zamora-Ramírez, C. Components of Countries' Regulative Dimensions and Voluntary Carbon Disclosures. *Sustainability* **2021**, *13*, 1914. [CrossRef]
48. Zhang, T.; Xie, L. The protected polluters: Empirical evidence from the national environmental information disclosure program in China. *J. Clean. Prod.* **2020**, *258*, 120343. [CrossRef]
49. Wang, Z.; Yang, Y. Research on internal motivation of corporate carbon disclosure. *Enterp. Econ.* **2017**, *36*, 14–21. (In Chinese)
50. Kim, I.; Ryou, J.W.; Yang, R. The color of shareholders' money: Institutional shareholders' political values and corporate environmental disclosure. *J. Corp. Financ.* **2020**, *64*, 101704. [CrossRef]
51. Wegener, M.; Elayan, F.A.; Felton, S.; Li, J. Factors Influencing Corporate Environmental Disclosures. *Account. Perspect.* **2013**, *12*, 53–73. [CrossRef]
52. Yuan, L.; Chen, Y.; He, W.; Kong, Y.; Wu, X.; Degefu, D.M.; Ramsey, T.S. The influence of carbon emission disclosure on enterprise value under ownership heterogeneity: Evidence from the heavily polluting corporations. *Environ. Sci. Pollut. Res.* **2022**, *29*, 69753–69770. [CrossRef] [PubMed]
53. Zhao, X.; Wu, X. Firm Characteristics and Voluntary Carbon Disclosure—Empirical Evidence Based on CDP China Report. *Stat. Inform. Forum* **2014**, *29*, 61–66. (In Chinese)

54. Cui, Y.; Li, B.; Sun, Y. Can corporate governance and financial status influence the quality of carbon disclosure? —Based on data from listed companies in China's power industry. *Econ. Manag. Res.* **2016**, *37*, 125–133. (In Chinese)
55. Lv, M. Research on the impact of internal control quality on corporate carbon information disclosure—Based on empirical data of A-share listed companies in heavy pollution industry in Shanghai from 2019 to 2021. *Mod. Bus.* **2022**, *17*, 93–96. (In Chinese)
56. Zhang, J. Research on the Relationship between Carbon Disclosure Quality and Financial Performance of Listed Companies under the Perspective of Low-Carbon Economy. *J. Lanzhou Univ. (Soc. Sci. Ed.)* **2018**, *46*, 154–165. (In Chinese)
57. Gatti, L.; Pizzetti, M.; Seele, P. Green lies and their effect on intention to invest. *J. Bus. Res.* **2021**, *127*, 228–240. [CrossRef]
58. Olekalns, M.; Kulik, C.T.; Chew, L. Sweet Little Lies: Social Context and the Use of Deception in Negotiation. *J. Bus. Ethics* **2014**, *120*, 13–26. [CrossRef]
59. Zheng, R.; Lei, J. Research on carbon emission auditing of resource-based enterprises. *Coop. Econ. Sci. Tech.* **2023**, *39*, 138–140. (In Chinese)
60. Yu, L.-P.; Du, W. Research on systematic error generation mechanism of TOPSIS method in academic evaluation. *Intell. Theor. Pract.* **2024**, *47*, 11–20. (In Chinese)
61. Cao, Q.; Zhou, Y.; Du, H.; Ren, M.; Zhen, W. Carbon information disclosure quality, greenwashing behavior, and enterprise value. *Front. Psychol.* **2022**, *13*, 892415. [CrossRef] [PubMed]
62. Wei, X.; Sun, G.; Feng, M. Research on Comprehensive Government Financial Reporting Presentation Model and Quality Evaluation. *Financ. Account. Mon.* **2019**, *40*, 76–82. (In Chinese)
63. Huang, J.; Xu, Y. A study on the impact of female executives on the readability of corporate social responsibility reports. *Econ. Manag. Rev.* **2021**, *37*, 114–124. (In Chinese)
64. Li, L.; Liu, Q.; Tang, D. Carbon performance, carbon disclosure quality and cost of equity financing. *Manag. Rev.* **2019**, *31*, 221–235. (In Chinese)
65. Tian, Y.; Song, Y.J. Carbon disclosure, surplus quality and financial performance of heavy polluters. *Financ. Account. Newsl.* **2019**, *40*, 87–91. (In Chinese)
66. Huang, S. 'Greenwashin' and Anti-Greenwashing in ESG Reporting. *Financ. Account. Mon.* **2022**, *42*, 3–11. (In Chinese)
67. Ben-Amar, W.; Chang, M.; McIlkenny, P. Board gender diversity and corporate response to sustainability initiatives: Evidence from the carbon disclosure project. *J. Bus. Ethics* **2017**, *142*, 369–383. [CrossRef]
68. Zou, Y.; Ma, T.; Tian, G. Institutional isomorphism pressure, firm life cycle and carbon disclosure quality. *Stat. Inform. Forum.* **2022**, *37*, 78–88. (In Chinese)
69. Song, H.; Zhu, L.; Zhang, C. Research on the construction of carbon accounting system of refining and chemical companies under the dual-carbon goal. *Financ. Account.* **2022**, *44*, 49–52. (In Chinese)
70. Wen, Y.; Liao, Y.; Wang, J. Research on company characteristics and carbon disclosure quality based on low-carbon agriculture. *Agric. Econ.* **2019**, *39*, 114–116. (In Chinese)
71. Liu, X.; Wang, B.; Chen, K.; Jiao, Y.; Li, G. Research on low carbon economy evaluation based on close value improved TOPSIS. *Technol. Econ.* **2021**, *40*, 74–84. (In Chinese)
72. Yu, E.P.Y.; Van Luu, B.; Chen, C.H. Greenwashing i n environmental, social and governance disclosures. *Res. Int. Bus. Financ.* **2020**, *52*, 101192. [CrossRef]
73. Zhang, D. Green financial system regulation shock and greenwashing behaviors: Evidence from Chinese firms. *Energy Econ.* **2022**, *111*, 106064. [CrossRef]
74. Zhao, J.-P.; Zhang, X.-Y.; Cui, M.-X. Evaluation of carbon disclosure quality based on CRITIC-TOPSIS model. *Energy Technol. Manag.* **2023**, *48*, 33–35. (In Chinese)
75. Wei, Y.; Wang, B.; Zhu, L. Measurement of the level of high-quality economic development based on spatio-temporal entropy weighted TOPSIS evaluation method—Taking Guangdong Province as an example. *Stat. Decis. Mak.* **2023**, *39*, 91–95. (In Chinese)
76. Feng, Z.; Zhao, Q. Research on the Construction and Measurement of the Indicator System of Digital Governance Capability of the Chinese Government: An Empirical Analysis Based on Entropy Weight TOPSIS Method. *J. Yunnan Univ. Financ. Econ.* **2023**, *39*, 98–110. (In Chinese)
77. Chen, M.; Wang, Y.; Zhang, P. Comprehensive Evaluation of Postdoctoral Mobile Stations in the Context of 'Double First-class' Construction: Multi-level Indicator System and Evaluation Method Based on TOPSIS Model. *Sci. Technol. Manag. Res.* **2023**, *43*, 86–95. (In Chinese)
78. Chen, H.-Y.; Cao, W.-D.; Fan, Y.-C.; Xiang, X.; Fan, D. Study on the evolution and coupling coordination of urban innovation capacity in Anhui Province based on improved TOPSIS model. *World Geogr. Res.* **2023**, *32*, 92–103.
79. Liu, Y.; Zhong, Y.; Yang, L. Constructing and empirical research on the indicator system of smart tourism development level based on AHP-TOPSIS method. *Acad. Explor.* **2024**, *32*, 132–140.
80. Chen, P.Y. Effects of the entropy weight on TOPSIS. *Expert Syst. Appl.* **2021**, *168*, 114186. [CrossRef]
81. Zhu, J.; Sun, H.P.; Liu, N.Y.; Zhou, D.Q.; Taghizadeh-Hesary, F. Measuring carbon market transaction efficiency in the power industry: An entropy-weighted TOPSIS approach. *Entropy* **2020**, *9*, 973. [CrossRef] [PubMed]

82. Wang, Y.; Zhao, H.; Duan, F.; Wang, Y. Initial provincial allocation and equity evaluation of China's carbon emission rights—Based on the improved TOPSIS method. *Sustainability* **2018**, *10*, 982. [CrossRef]
83. Fu, H.; Li, G.; Zhu, T. Carbon emissions in China's manufacturing sector: Sectoral differences and driver decomposition. *Reform* **2021**, *34*, 3852. (In Chinese)
84. Guo, S.; Yuan, Z.; Lei, G. Research on the Evaluation of the Quality of Corporate Carbon Information Disclosure and Its Influencing Factors. *J. Earth Environ.* **2023**, *14*, 848–860.
85. Wojewodzki, M.; Cheong, T.S.; Shen, J.; Cheng, L.T.W. Does corporate carbon performance converge in the global market? Evidence from a distribution dynamic approach. *J. Environ. Manag.* **2023**, *342*, 118355. [CrossRef]
86. Lei, G. Research on the Evaluation of Corporate Carbon Information Disclosure Quality and Its Emission Reduction Effects. Master's Thesis, Southwest University of Science and Technology, Mianyang, China, 2023. (In Chinese).
87. Tan, R.; Cai, Q.; Pan, L. Faking for fortune: Emissions trading schemes and corporate greenwashing in China. *Energy Econ.* **2024**, *130*, 107319. [CrossRef]
88. Miao, X.; Feng, E.; Siu, Y.L.; Li, S.; Wong, C.W.Y. Can China 's carb-on intensity constraint policies improve carbon emission performance? Evidence from regional carbon emissions. *J. Environ. Manag.* **2023**, *348*, 119268. [CrossRef]
89. Keum, D.D. Innovation, short-termism, and the cost of strong corporate governance. *Strat. Manag.* **2021**, *42*, 3–29. [CrossRef]
90. Tao, M.; Lin, B.; Poletti, S. From policy to practice: How China's emissions trading scheme shapes ESG greenwashing at the firm level? *J. Environ. Manag.* **2024**, *370*, 86. [CrossRef]
91. Zhu, Q.; Zhao, X.; Wu, M. Third-party certification: How to effectively prevent greenwash in green bond market? —Analysis based on signalling game. *Environ. Dev. Sustain.* **2024**, *26*, 16173–16199. [CrossRef]
92. Liu, Z.B.; Zhu, Y.J. The impact of carbon information disclosure quality on the financial performance based on UNC combination weight and FA: Evidence from public companies in China's electric power industry. *Environ. Sci. Pollut. Res.* **2023**, *30*, 75564–75580. [CrossRef] [PubMed]
93. Bai, D.; Du, L.; Xu, Y.; Abbas, S. Climate policy uncertainty and corporate green innovation: Evidence from Chinese A-share listed industrial corporations. *Energy Econ.* **2023**, *127*, 107020. [CrossRef]