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A Combined Evaluation Method of Corporate Social Responsibility Based on the Difference and Similarity: A Case Study of Transportation Industry in China

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Abstract: Currently, it is becoming more essential for a company to operate in an economically, socially and environmentally sustainable manner. This study aims to evaluate corporate social responsibility (CSR) in China's transportation industry by applying indicator weighting approaches. This study evaluated 68 transportation companies with 82 associated CSR indicators. Firstly, this paper established an indicator system, including seven criteria layers that conform to the characteristics of the Chinese transportation industry. Secondly, by integrating the G1 method, standard deviation method and CRITIC (criteria importance though intercriteria correlation) approach, a combined weighting method, CWMDS (combined weighting method based on the combination of difference and similarity), was constructed, which embodies the two goals of "horizontal similarity and vertical difference". The experimental results show that CWMDS achieves better results in many aspects. The empirical results show that the air transportation subindustry was the best in CSR performance while the high-speed transportation subindustry was the worst. Finally, this paper put forward some policy suggestions to promote China's transportation enterprises to fulfill their social responsibility.

Keywords: CSR; indicator weighting; single weighting methods; combined approaches; transportation industry

Citation: Lv, L.; Fan, L.; Meng, B.; Abedin, M.Z.; Feng, H. A Combined Evaluation Method of Corporate Social Responsibility Based on the Difference and Similarity: A Case Study of Transportation Industry in China. *Sustainability* **2023**, *15*, 5561. https://doi.org/10.3390/su15065561

Academic Editor: Wen-Hsien Tsai

Received: 11 February 2023
Revised: 13 March 2023
Accepted: 16 March 2023
Published: 22 March 2023

1. Introduction

Due to organizations' significant roles in the environment, corporate social responsibility (CSR) is a topic that has become progressively more important to industries, end-users, academics and researchers. Because of global competitiveness, transportation companies are becoming increasingly attentive to CSR's consequences [1,2]. Companies thereby concentrate not only on generating revenue but also on taking institutional assessments that are morally and publicly satisfactory to all parties involved, including societies, the environment and shareholders [3,4].

As an essential industry for national economic survival, the transportation industry in China plays a decisive role in boosting economic growth, promoting social harmony and strengthening national defense security. However, a lack of social responsibility, including large pollutants, high energy consumption, frequent unfair competition and traffic safety problems, have always restricted its development. According to World Health Organization data [5], about 1.30 million people are killed in road traffic accidents worldwide every year, which has become the eighth leading cause of death. In China, for example, 327,209 traffic accidents occurred in 2021 with more than 80,000 deaths and more than 380,000 people injured, resulting in direct economic losses of more than CNY 1.2 billion [6]. Moreover, in 2021, the transportation industry consumed 436 million tons of standard coal, accounting for 20% of the total energy consumption. According to a report released by the China International Economic Exchange Center in 2020, the energy

efficiency of China's transportation industry was relatively low and the energy consumption of China's transportation industry was more than 50% higher than developed countries. According to a report from China Environment News in 2020, the national economic loss caused by traffic congestion reached CNY 1.6 trillion, including time cost, fuel cost, vehicle loss, etc [7]. At the same time, due to the low barriers to entry and fierce market competition, there exist unfair competition phenomena in the transportation industry, which will affect the service quality, consumers' interests and industrial innovation and development. All these data show the urgency of evaluating corporate social responsibility in the transportation industry.

To endorse safety production standardization, it standardizes the evaluation work and encourages companies' primary responsibility to implement safety production. In 2021, the Ministry of Transport of China issued the "14th Five-Year Development Plan for Green Transportation", which affirmed the positive results of the green development of transportation since the 13th five-year plan. Meanwhile, it further requires traffic pollution control, technology innovation, green transportation support and green transportation supervision [8]. In 2022, the Ministry of Transport of China issued an "Implementation Plan for Strengthening Transportation Safety Production" to further strengthen the requirements for the investigation, management and handling of risks and dangers in the production process of enterprises. The gradual improvement of policies and regulations shows the Chinese government's emphasis on CSR in the transportation industry [9]. At present, the concept of CSR in China is still in its infancy. Many companies in the transportation industry fail to fulfill their CSR or poorly perform their CSR, such as nonstandard, incomplete and nonobjective disclosure of CSR information. The evaluation of CSR is a review of CSR's development in China's transportation industry and a guide to further improving its practice.

This study selected 68 typically listed companies in the transportation industry of the Shanghai Stock Exchange, Shenzhen Stock Exchange and Hong Kong Stock Exchange as samples. Based on their corporate social responsibility reports, this paper empirically studied the performance of corporate social responsibility in the transportation industry. This study is of great significance in urging the transportation industry to fulfill its corporate social responsibility, adjusting the direction of corporate social responsibility investment, making up for its shortcomings and improving the performance level of social responsibility of the whole industry, which provides an essential reference for the green and sustainable development of China's transportation industry.

The academic value of this paper lies in the creation of a new combination evaluation method that takes into account both difference and similarity which was then applied to the evaluation of corporate social responsibility in the transportation industry. At present, most combined weighting studies only focus on one aspect of difference or similarity. This paper combines the two aspects of traditionally combined weighting for evaluation. It does not deviate from a single evaluation result and magnifies the differences between evaluation objects, which embodies the dual-objective idea of "seeking similarity horizontally and difference vertically". Thus, it makes the evaluation results convincing and at the same time well distinguishes the evaluation objects. The empirical results show that the combined evaluation method in this paper can produce more convincing results than the single combination weighting method in terms of consistency, difference and rank preservation.

The rest of the paper is structured as follows. Section 2 discusses the relevant literature. Section 3 introduces the methods for designing an evaluation indicator system for the Chinese transportation industry and establishes CSR's combined weighting method considering the difference and similarity. Section 4 presents the data and empirical results. Conclusions and policies are given in Section 5.

2. Literature Review

Most of the existing research directly uses the evaluation system of corporate social responsibility of third-party organizations, such as MSCI (Morgan Stanley Capital

International) [10] and the Vigeo rating agency [11]. These databases all have a relatively complete CSR evaluation system that evaluates multiple dimensions, including environment, human rights, society, product liability, community involvement, business conduct and corporate governance. For the study of Chinese companies, most scholars use the RKS (Rankings CSR Ratings) database [12]); however, other third-party data such as the CSR indicator by the Shanghai National Accounting Institute (SNAI) system [13], CSR scores by Southern Weekend [14], the CSR indicator according to the Chinese Academy of Social Sciences (CASS) standards and the CSR ranking by Fortune China also provide CSR evaluation systems and data. Additionally, some scholars have established their own CSR evaluation system based on classic standards. Carroll classifies CSR into four types: economic responsibility, legal responsibility, ethical responsibility and discretionary responsibility, ranging from the low level to the high level of CSR, which is based on most follow-up corporate social responsibility evaluation systems [15]. Saeidi et al. used a 29-item, five-point Likert scale to cover all four CSR dimensions (ethical, economic, discretionary and legal), where "1 = strongly disagree" and "5 = strongly agree" [16]. Based on corporate governance and finance, green airport and environmental management, service quality and social relationship, employee and work environment management and safety and security, Chang and Yeh used the five-point Likert type scale and analytic hierarchy process to evaluate the relative importance, feasibility and achievability of the indicators [17]. They assessed corporate social responsibility through an expert questionnaire survey. As mentioned above, the transportation industry must fulfill its corporate social responsibility. From the perspective of green supply chain management, Luo and Bi integrated various authoritative standards and established and adopted two methods, "R clustering" and "variation coefficient analysis", to establish a CSR performance evaluation system for China's transportation industry [18]. Govindan et al. explored the drivers and value-relevance of corporate social responsibility performance, measured with a composite ESG (environmental, social and governance) score and with its three subdimensions between 2011 and 2018, in the logistics sector by particularly focusing on board characteristics and ownership structure [19]. However, it is still early to evaluate CSR's performance in the transportation industry and there is a lack of an indicator system and evaluation method.

Regarding weighting methods, there are mainly single weighting methods and combination weighting methods. Based on the experts' subjective experience or mathematical analysis, a single weighting method can be divided into subjective weighting and objective weighting methods. The subjective empowerment methods mainly include the G1 method [20], the analytic hierarchy process (AHP) method [21,22]) and their improvement methods [23,24]. The subjective single weighting method reflects experts' judgment for determining significant indicators, but indicators are ignored. In addition, the experts' judgment is more or less subjective.

On the contrary, objective weighting methods overcome these problems. Tian and Zhang (2019) used entropy weighting to evaluate the logistics industry's development level in 31 provinces in China [25]. Hoy et al. developed a decomposition-based combination forecasting model using dynamic adaptive entropy-based weighting for total electricity demand forecasting at the engineering level [26]. Keshavarz-Ghorabaee et al. introduced a new method, called MEREC (Method based on the Removal Effects of Criteria), to determine criteria's objective weightings [27]. Nguyen et al. proposed a novel and efficient Spherical Fuzzy Weighted Aggregated Sum Product Assessment-Based Entropy Objective Weighting method (SF-EW and WASPAS-SF) to evaluate international payment methods with uncertain information [28]. However, the objective weighting method depends more on mathematical calculation, reflecting the relationship and difference between indicators but ignoring their importance. Therefore, it is necessary to combine subjective and objective weighting methods to establish a combination weighting method.

Nassereddine and Eskandari have proposed an integrated multicriteria decision-making (MCDM) approach for the evaluation of public transportation systems based on the Delphi method, group analytic hierarchy process (GAHP) and preference ranking

organization method for the enrichment of evaluations (PROMETHEE) [29]. Ferreira et al. used Choquet integral, a nonadditive multicriteria decision analysis (MCDA) operator, to determine the priority and weighting of ethical banking determinants [30]. Huang et al. formulated an Entropy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to evaluate the urban rail transit system's operating performance from the passengers' and governments' perspectives [31]. Lai and Ishizaka studied a new insight into the application of multicriteria decision-making methods (MCDM) to social identity issues in the context of talent management. MCDM adjusted subjective information consisting of intangible organizational political issues into a transparent, objective benchmark [32]. Du et al. proposed a comprehensive weighting method based on the association bipartite graph (ABG) [33]. Guo et al. used the Critic method and the Delphi method to assign hierarchical weightings for each dimension of the indicators [34].

Regarding the combination weighting methods of corporate social responsibility, some scholars have also studied this issue. Chang and Yeh used the pairwise comparison method in AHP and the decision-making trial and evaluation laboratory method to evaluate the relative importance, feasibility and achievability of 18 CSR evaluation indicators [17]. Moktadir et al. used the Delphi method and the fuzzy analytical hierarchy process (FAHP) to identify and evaluate drivers of CSR-based sourcing in the context of Bangladesh's footwear industry [35]. Chang et al. used the fuzzy Delphi method to ask practical experts to screen indicators and then the entropy-weighted GRA method was developed to evaluate the sustainability performance [36]. Chen et al. constructed the super-efficiency DEA-Malmquist model to evaluate the food industry's performance of social responsibility behavior, which can avoid the uncertainty of the relationship between CSR and business performance in the current academic research [37].

The existing CSR combined evaluation is limited to the single weighting method or simple sum of multiple weighting results. Single weighting methods only center on the difference between the result and the mean value or the difference between two evaluation objects. For a combination of single weighting methods, most focus on one aspect of the combined results, internal discrepancies or external similarities. The results obtained by different research methods are inconsistent. The combined weighting method that focuses on internal differences magnifies the differences between evaluation objects. The differences between external objects become more extensive, making it difficult to compare with the research results that concern external similarity. The combined weighting method that concentrates on external similarity is more suitable for comparison between different approaches. Nevertheless, the differences between evaluation objects and indicators have become smaller, making it difficult to distinguish their differences. Thus, the ineffective combination of weighting methods makes the weighting result biased.

Consistent with decision-makers' subjective judgments or degree of dependence on the preferences, this study generally applies two primary weighting methodologies: the single weighting method (SWM) and the combined weighting method (CWM). Considering the advantages and disadvantages of the weighting methods, the SWM is categorized into G1 subjective weighting method, standard deviation objective weighting method and objective weighting based on criteria importance through intercriteria correlation (CRITIC); that is, one subjective weighting and two objective weighting methods. Accordingly, the CWM is also classified into three different techniques: the combined weighting method based on the difference (CWMD), the combined weighting method based on similarity (CWMS) (the first novel methodology) and the combined weighting method based on difference and similarity (CWMDS) (the second novel methodology).

Based on the "Social Responsibility Guide (ISO26000)" [38], the "Sustainability Reporting Guidelines (G4)" [39] and the "13th Five-year Plan for Energy Conservation and Environmental Protection in Transportation Industry" (2017) issued by the Ministry of Transport of China, taking into account the actual characteristics and problems in China's transportation industry, this paper put forward a new corporate social responsibility evalua-

tion system of China's transportation industry. The evaluation principle of the combination weighting system of CSR considering the difference and similarity is illustrated in Figure 1.

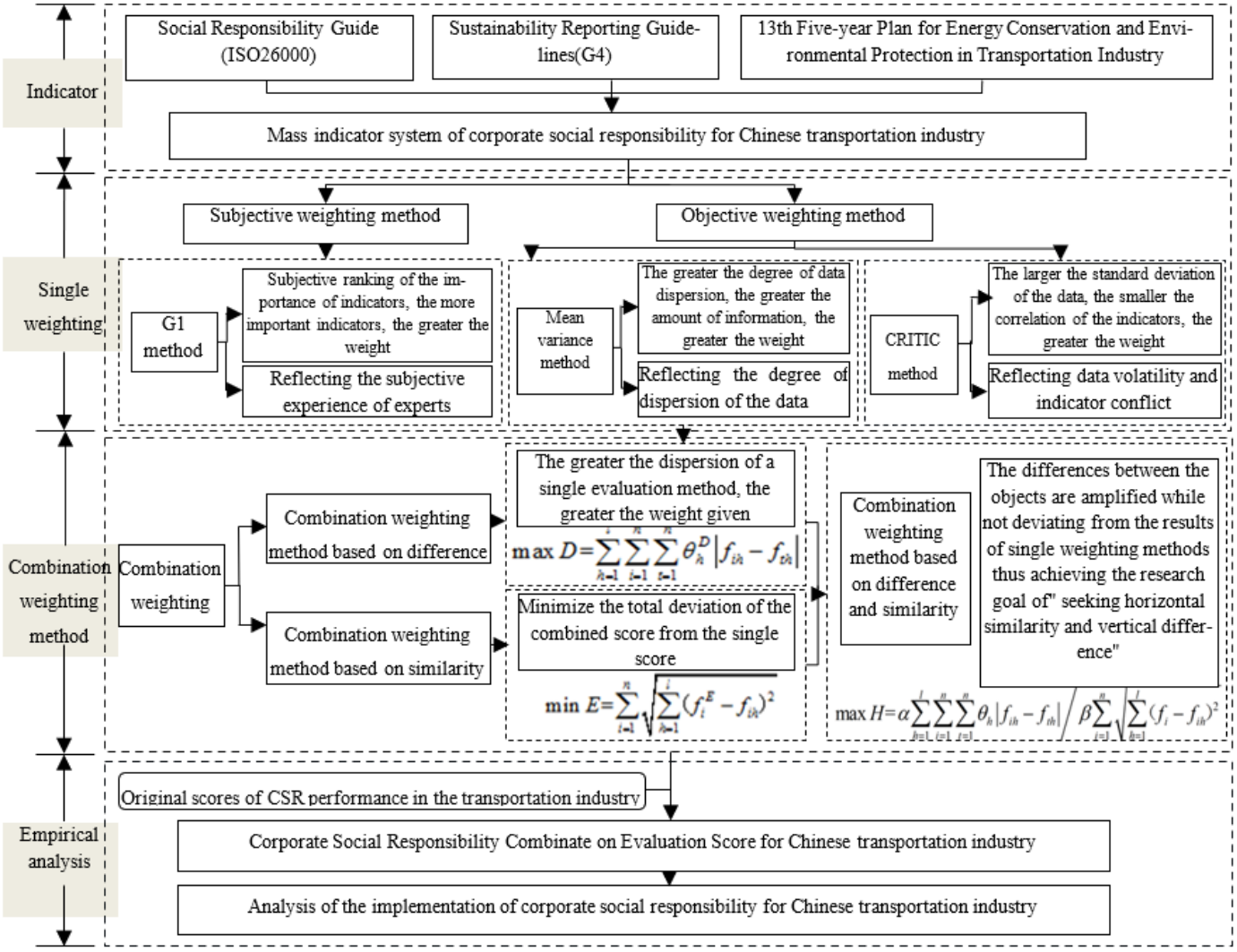

Figure 1. The evaluation principle of the combination weighting system of CSR considering the difference and similarity.

3. Methodology

3.1. Data and Sample Description

Initially, this paper collected information about the CSR of 146 transportation companies listed on the Shanghai Stock Exchange, Hong Kong Stock Exchange and Shenzhen Stock Exchange. It contains CSR report from East Money Net "http://www.eastmoney.com/ (accessed on 28 December 2020)"), CNINFO "http://www.cninfo.com.cn/new/index" (accessed on 28 December 2020), Material and Quantitative Indicators Database "http://www.mqi.org.cn/MQI_Intro.asp" (accessed on 30 December 2020) and other websites in the transportation industry. Finally, 68 typical companies were selected as research samples. Based on the above documents, this study combined the companies' annual reports and calculated the 68 companies.

Initially, there were 112 indicators in the CSR evaluation system. However, 15 indicators with excessive partial correlation coefficients and 15 indicators with large gray correlation degrees were deleted. Finally, this paper conducted research based on the evaluation system of CSR of the transportation industry with 82 indicators and seven criteria, including

responsibility governance, human rights protection, environmental protection, fair operation, product responsibility, community development and economic contribution.

3.2. Establishment of CSR Indicator

(1) CSR decision layer: Based on the CSR rating standards issued by the internationally recognized social responsibility guidelines (ISO26000), the Global Reporting Initiative (GRI)'s "Sustainable Development Reporting Guidelines" (G4) and the "13th Five-Year Plan for Energy Conservation and Environmental Protection in Transportation" issued by the Ministry of Transport of China, this paper established a corporate social responsibility evaluation system for the transportation industry with 112 indicators under seven criteria, including governance, human rights, environment, fair operation, product responsibility, community development and economic contribution. Figure 2 illustrates the seven CSR indicator selection layers. Then, a comprehensive indicator set, namely, "ratio of female members on the board of directors", "employee turnover ratio", "biodiversity planning" and so on, was constructed. In this indicator system, 23% of the indicators were quantitative indicators and these indicators were added to reduce subjective randomness. A brief illustration of the decision layer is as follows.

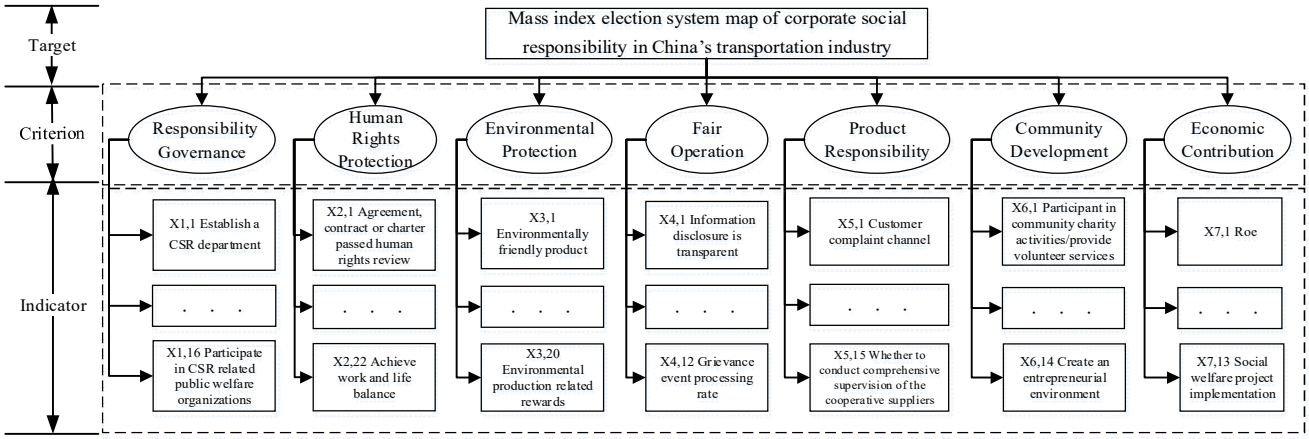

Figure 2. Mass indicators system of corporate social responsibility for the Chinese transportation industry.

(i) Responsibility Governance: A total of 16 indicators belong to the first decision layer. This helps construct a sound CSR department with a ratio of independent directors, female members, CSR risk management mechanisms, etc.
(ii) Human Rights: The second decision layer carries 22 indicators. It deals with the employees' rights and protections, such as paid vacation, extra compensation, a healthy and safe working environment, etc.
(iii) Environmental Protection: The third decision layer includes a total of 20 indicators. It contains indicators like pollutant emissions, biodiversity, resource sustainability and environmental investment and impact assessment.
(iv) Fair Operations: This includes 12 indicators. This decision layer generates indicators like an anticorruption-related system, governance mechanism, appeal method, etc.
(v) Product Liability: this includes 15 indicators that correspond to customer rights protection, product services and supplier-evaluation-related issues.
(vi) Community Development: This corresponds to physical- and mental-health-related issues, employment skills development, community participation, education, wealth creation problems, etc. A total of 14 indicators includes in this layer.
(vii) Economic Contribution: 13 indicators belong to this layer: return on net asset, quick ratio, average annual salary, etc.

(2) Pre-processing: We have revised and improved the indicator system based on the existing construction method of the research index system. We pruned the 112 indicators

from two perspectives. First, within the same criterion layer, if the partial correlation coefficient of two indicators is greater than 0.4, then these two indicators reflect information duplication [40,41]. Among duplicated indicators, this paper deleted those with a smaller gray correlation degree and less information content and deleted 15 indicators in total. Second, if the gray correlation degree of the indicator is too small, it means that the indicator has less information content and contributes less to the evaluation [42,43], so it should be deleted. In the same criterion layer, this paper deleted the indicators with a gray correlation degree of less than the average value and deleted 15 indicators in total. Table 1 shows the indicators in each criterion layer. It also illustrates the deletion and inclusion of the respective indicator. Since this process is relatively complex and it can produce a separate paper, this paper does not discuss it in detail.

Table 1. CSR indicator systems and screening situation.

Criteria Layer	Order	Indicator Layer	Status	Criteria Layer	Order	Indicator Layer	Status
X_1 Responsibility Governance	1	$X_{1,1}$ Establishment of corporate social responsibility department	×	X_3 Environmental Protection	57	$X_{3,19}$ Environmental spending and investment	×
	2	$X_{1,2}$ Appointment of a head of corporate social responsibility department	×		58	$X_{3,20}$ Number of awards related to environmental protection	×
	3	$X_{1,3}$ Ratio of independent directors on the board of directors	×	X_4 Fair Operation	59	$X_{4,1}$ Information disclosure is transparent	√
	4	$X_{1,4}$ Ratio of female members on the board of directors	×		60	$X_{4,2}$ Establish an anticorruption-related system	⊠
	5	$X_{1,5}$ Leadership commitment, responsibility and attention	√		61	$X_{4,3}$ Corruption response situation	√
	6	$X_{1,6}$ Clear stakeholder	√		62	$X_{4,4}$ Operation level internal control assessment implementation level	√
	7	$X_{1,7}$ Identify stakeholder appeals	√		63	$X_{4,5}$ Legal proceedings	⊠
	8	$X_{1,8}$ Establishment of a dedicated communication channel for stakeholders	√		64	$X_{4,6}$ Fines and noneconomic penalty events	√
	9	$X_{1,9}$ Respond to stakeholder appeals	√		65	$X_{4,7}$ Property lawsuit	√
	10	$X_{1,10}$ Whether the report contains substantive issues	√		66	$X_{4,8}$ Compliance training	√
	11	$X_{1,11}$ Establishment of corporate social responsibility risk management mechanism	√		67	$X_{4,9}$ Is there a grievance agency for fair operations?	√
	12	$X_{1,12}$ The degree of perfection of the risk management control system	√		68	$X_{4,10}$ Appeal method	⊠
	13	$X_{1,13}$ Explain the concept or goal of corporate social responsibility	×		69	$X_{4,11}$ Follow-up actions for appeals	√
	14	$X_{1,14}$ Identification of Corporate Social Responsibility Report	√		70	$X_{4,12}$ Grievance event processing rate	√

Table 1. *Cont.*

Criteria Layer	Order	Indicator Layer	Status	Criteria Layer	Order	Indicator Layer	Status
	15	$X_{1,15}$ Comply with or refer to the corresponding domestic and international standards to prepare reports	√		71	$X_{5,1}$ Customer complaint channel	√
	16	$X_{1,16}$ Participate in corporate-social-responsibility-related public welfare organizations	√		72	$X_{5,2}$ Whether to protect consumers' right to know	☒
X_2 Human Rights	17	$X_{2,1}$ Agreement, contract or charter passed human rights review	☒	X_5 Product Liability	73	$X_{5,3}$ Customer satisfaction	√
	18	$X_{2,2}$ Equal employment and elimination of discrimination	√		74	$X_{5,4}$ Customer complaint processing time	√
	19	$X_{2,3}$ Public Affairs Participation and Freedom of Association	☒		75	$X_{5,5}$ Customer information security mechanism	√
	20	$X_{2,4}$ Employees' democratic management rights and basic rights protection	☒		76	$X_{5,6}$ Customer complaint processing rate	√
	21	$X_{2,5}$ Employee turnover ratio	√		77	$X_{5,7}$ Safety production inspections	☒
	22	$X_{2,6}$ Whether to do maternity leave to stay	√		78	$X_{5,8}$ Safety hazard rectification rate	√
	23	$X_{2,7}$ Protection of female workers' rights and interests	√		79	$X_{5,9}$ Emergency drills	√
	24	$X_{2,8}$ Whether to benefit from bad labor practices	√		80	$X_{5,10}$ Violation of products and services	√
	25	$X_{2,9}$ Whether to achieve paid vacation	√		81	$X_{5,11}$ Do not provide controversial services	√
	26	$X_{2,10}$ Equal pay for equal work	√		82	$X_{5,12}$ Whether to provide personalized service	√
	27	$X_{2,11}$ Whether overtime work is paid extra compensation	√		83	$X_{5,13}$ No vicious advertising competition	√
	28	$X_{2,12}$ Is there an employee security organization?	√		84	$X_{5,14}$ Is there a supplier access screening mechanism?	☒
	29	$X_{2,13}$ Provide a healthy and safe working environment	√		85	$X_{5,15}$ Whether to conduct comprehensive supervision of the cooperative suppliers	√
	30	$X_{2,14}$ High-risk employee welfare	√	X_6 Community Develop-ment	86	$X_{6,1}$ Participate in community charity activities/provide volunteer services	√
	31	$X_{2,15}$ Whether to provide health and safety training for employees	√		87	$X_{6,2}$ Appropriate financial support	☒
	32	$X_{2,16}$ Whether to provide regular health checkups for employees	√		88	$X_{6,3}$ Share corporate values and build long-term relationships with local communities	√
	33	$X_{2,17}$ Does the company's trade union provide assistance to employees?	√		89	$X_{6,4}$ Establishment of community welfare facilities	√
	34	$X_{2,18}$ Strengthening employability, skills management and lifelong learning programs	√		90	$X_{6,5}$ Participate in local associations	√

Table 1. *Cont.*

Criteria Layer	Order	Indicator Layer	Status	Criteria Layer	Order	Indicator Layer	Status
	35	$X_{2,19}$ Education and training	√		91	$X_{6,6}$ Promote the development of community education	√
	36	$X_{2,20}$ Performance and career development assessment	√		92	$X_{6,7}$ Note the physical and mental health of community residents	√
	37	$X_{2,21}$ Establish and improve the communication mechanism	√		93	$X_{6,8}$ Community and Charity Awards	√
	38	$X_{2,22}$ Achieve work–life balance	√		94	$X_{6,9}$ Promote community culture development	√
X_3 Environmental Protection	39	$X_{3,1}$ Environmentally friendly product	√		95	$X_{6,10}$ Creation of local employment	√
	40	$X_{3,2}$ Improve the technical level of environmental protection and improvement	√		96	$X_{6,11}$ Skills training for community residents	√
	41	$X_{3,3}$ Use of recycled materials	√		97	$X_{6,12}$ Strive to eradicate poverty	√
	42	$X_{3,4}$ CNY 10,000 output value comprehensive energy consumption	×		98	$X_{6,13}$ Integrate all aspects of strength to create community wealth	√
	43	$X_{3,5}$ Degree of use of renewable materials in packaging and transportation	×		99	$X_{6,14}$ Creation of an entrepreneurial environment	√
	44	$X_{3,6}$ Water-saving measures	√	X_7 Economic Contribution	100	$X_{7,1}$ Return on net asset	√
	45	$X_{3,7}$ Unit income water consumption	×		101	$X_{7,2}$ Quick ratio	√
	46	$X_{3,8}$ Total energy saved by adopting energy-saving measures and improving utilization efficiency	☒		102	$X_{7,3}$ ROA	☒
	47	$X_{3,9}$ Ecosystem protection and restoration	√		103	$X_{7,4}$ Return on equity	√
	48	$X_{3,10}$ Plant greening	×		104	$X_{7,5}$ Average annual salary of employees	×
	49	$X_{3,11}$ Biodiversity planning	×		105	$X_{7,6}$ Remuneration payment rate	☒
	50	$X_{3,12}$ Transportation or disposal of hazardous waste	√		106	$X_{7,7}$ Accounts payable turnover	√
	51	$X_{3,13}$ Reduce sewage discharge	√		107	$X_{7,8}$ Tax growth rate	√
	52	$X_{3,14}$ Major pollution incident	×		108	$X_{7,9}$ Government subsidy receivable (CNY 100 million)	√
	53	$X_{3,15}$ Solid waste discharge	√		109	$X_{7,10}$ Donation income ratio	☒
	54	$X_{3,16}$ Plan to reduce carbon emissions	√		110	$X_{7,11}$ Social contribution per share	√
	55	$X_{3,17}$ Smoke dust emission and emission reduction	√		111	$X_{7,12}$ R&D investment	☒
	56	$X_{3,18}$ Greenhouse gas emissions with reduced output value per CNY 10,000	×		112	$X_{7,13}$ Social welfare project implementation	√

Note: × represents the indicators that were deleted because of the excessive partial correlation coefficient. ☒ represents the indicators that were deleted because of the large degree of gray correlation. √ represents reserved indicator.

3.3. Indicator Scaling

The purpose of the indicator scaling is to transform the indicator data into [0, 1] to eliminate the inconsistency of the unit and the dimension, which lays a foundation for the evaluation of CSR in China's transportation industry [43]. If positive indicators have greater values, they will be better, such as "return on net assets". If negative indicators have smaller values, they will be better, such as "customer complaint processing time". The indicator scaling equations of positive indicators and negative indicators are described in Equation (1) and Equation (2), respectively.

$$x_{ij} = \frac{v_{ij} - \min\limits_{1 \le i \le n} (v_{ij})}{\max\limits_{1 \le i \le n} (v_{ij}) - \min\limits_{1 \le i \le n} (v_{ij})} \quad (1)$$

$$x_{ij} = \frac{\max\limits_{1 \le i \le n} (v_{ij}) - v_{ij}}{\max\limits_{1 \le i \le n} (v_{ij}) - \min\limits_{1 \le i \le n} (v_{ij})} \quad (2)$$

In the above equations, x_{ij} ($i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$) is the scaling score of the ith CSR sample of the jth indicator, v_{ij} is the original CSR data of the ith sample of the jth indicator; n is the total number of CSR evaluation samples.

3.4. CSR Indicator Weighting Method

Numerous techniques have been applied in the literature to establish indicators' weightings in multiple indicator decision-making problems. The selection criteria are complicated, as CSR indicator weighting is more demanding today. Consistent with decision-makers' subjective judgments or degree of dependence on the preferences, this study generally applied two primary weighting methodologies: the single weighting method (SWM) and the combined weighting method (CWM). Considering the advantages and disadvantages of the weighting methods, the SWM is categorized into the G1 subjective weighting method [20], standard deviation objective weighting method [44]) and objective weighting based on criteria importance through intercriteria correlation (CRITIC) [45]); that is, one subjective weighting and two objective weighting methods. Accordingly, the CWM is also classified into three different techniques, such as the combined weighting method based on the difference (CWMD), combined weighting method based on similarity (CWMS) (the first novel methodology) and combined weighting method based on difference and similarity (CWMDS) (the second novel methodology).

The subjective single weighting method reflects experts' judgment for determining significant indicators, but the indicators are ignored. Moreover, judgment is greatly influenced by the subjective consciousness of experts. However, the objective weighting method depends more on mathematical calculation, reflecting the relationship and difference between indicators but ignoring their importance. To overcome the deficiencies of these two single weighting methods, this paper combined the above three standalone weighting methods to comprehensively reflect experts' subjective experience and the objective characteristics of data. Considering the internal difference and the external similarity helps avoid the single weighting methods' limitations and improves the indicator weighting reliability. This study included three different integrated approaches, for example, the combined weighting method based on the difference (CWMD) [46], the combined weighting method based on similarity (CWMS) [47]) and the combined weighting method based on the combination of difference and similarity (CWMDS). The second and third approaches are the new hybrid methodology applied in this study. However, the following section elaborately discusses their methodological issues.

The combined weighting method based on the difference (CWMD) reflects the internal differences of the combined weighting method and the combined weighting method based on similarity (CWMS) reflects the external similarities with other methods, both of which jointly reflect the combined weighting method's characteristics. Therefore, the combined weighting method based on difference and similarity (CWMDS) considers

internal and external similarities and constructs a hybrid weighting method to reflect these two characteristics further.

In Equation (3), based on the principle of taking differences and similarities into account, the objective function with the largest deviation is divided by the objective function with the smallest deviation. The maximum value of this model is ensured. In this way, the nonlinear objective programming function is constructed and the combined weighting considering the difference and similarity is optimized. This kind of weighting method can keep the differences among evaluation objects to the greatest extent and its result is similar to that obtained by other single weighting methods.

$$\begin{aligned} &\max H = \frac{\alpha \sum_{h=1}^{l} \sum_{i=1}^{n} \sum_{t=1}^{n} \theta_h \left| f_{ih} - f_{th} \right|}{\beta \sum_{i=1}^{n} \sqrt{\sum_{h=1}^{l} \left(f_i - f_{ih} \right)^2}} \\ &s.t. \begin{cases} \alpha + \beta = 1, \alpha > 0, \beta > 0 \\ \sum_{h=1}^{l} \theta_h = 1 \\ \theta_h > 0, h = 1,\ 2,\ \cdots, l \end{cases} \end{aligned} \tag{3}$$

where, $\theta = \left[\theta_1, \theta_2, \cdots, \theta_l\right]^T$ is the weighting vector of each single weighting method, $f_{ih} (i = 1, 2, \cdots, n; h = 1, 2, \cdots, l)$ is the score of the ith object under the single method h and $f_i = \sum_{h=1}^{l} \theta_h f_{ih}$.

After that, Equation (4) is applied to calculate the final score based on CWMDS.

$$f_i = \theta_1 f_{i1} + \theta_2 f_{i2} + \cdots + \theta_l f_{il} \tag{4}$$

where α and β indicate the decision-makers' focus or preference for feature differences and similarities in the combined weighting method, solving the Equation (3), this study found θ_{h} (h = 1, 2, . . . , l) that is the combined weighting of G1 weighting method, standard deviation weighting method and CRITIC weighting method. Finally, by taking the combined value into Equation (4), the final combined weighting score can be obtained. Accordingly, two aspects of characteristics concerned with the traditional weighting research methods are combined in this method. The differences between the objects are amplified while not deviating from the results of single weighting methods. Thus, it achieves the research goal of "seeking horizontal similarity and vertical difference".

4. Empirical Results and Discussion

4.1. Scaling of Indicators

Equation (1) and Equation (2) apply to conduct standardized data processing that eliminates the dimensional effect. The obtained primary data of CSR evaluation and standardized results are shown in Table 2.

Table 2. Standardization data of CSR in the transportation industry.

(1) Criterion	(2) Indicator	Standardization Data for Indicators of 68 Companies				
		(3) Daqin Railway	(4) Guangshen Railway	⋯	(69) Hong Kong Aircraft Engineering	(70) China International Marine Containers (Group)
X_1 Responsibility governance	$X_{1,1}$ Establishment of corporate social responsibility department	0.00	1.00	⋯	0.00	0.50
	⋯	⋯	⋯	⋯	⋯	⋯

Table 2. *Cont.*

(1) Criterion	(2) Indicator	Standardization Data for Indicators of 68 Companies				
		(3) Daqin Railway	(4) Guangshen Railway	…	(69) Hong Kong Aircraft Engineering	(70) China International Marine Containers (Group)
	$X_{1,16}$ Participate in corporate-social-responsibility-related public welfare organizations	0.25	0.25	…	0.50	0.50
X_2 Human rights protection	$X_{2,1}$ Agreement, contract or charter passed human rights review	0.00	0.35	…	0.00	0.85
	…	…	…	…	…	…
	$X_{2,22}$ Achieve work–life balance	0.35	0.75	…	0.70	0.70
X_3 Environmental protection	$X_{3,1}$ Environmentally friendly product	0.20	0.35	…	0.40	0.40
	…	…	…	…	…	…
	$X_{3,20}$ Number of awards related to environmental protection	0.00	0.00	…	0.60	0.00
X_4 Fair operation	$X_{4,1}$ Information disclosure is transparent	0.75	0.75	…	0.00	1.00
	…	…	…	…	…	…
	$X_{4,12}$ Grievance event processing rate	0.50	0.50	…	0.50	0.50
X_5 Product responsibility	$X_{5,1}$ Customer complaint channel	0.00	1.00	…	0.75	1.00
	…	…	…	…	…	…
	$X_{5,15}$ Whether to conduct comprehensive supervision of the cooperative suppliers	0.00	0.00	…	1.00	0.00
X_6 Community development	$X_{6,1}$ Participate in community charity activities/provide volunteer services	1.00	1.00	…	1.00	1.00
	…	…	…	…	…	…
	$X_{6,14}$ Creation of an entrepreneurial environment	0.00	0.00	…	0.00	0.00
X_7 Economic contribution	$X_{7,1}$ Return on net asset	0.14	0.04	…	0.00	0.08
	…	…	…	…	…	…
	$X_{7,13}$ Social welfare project implementation	0.70	1.00	…	0.40	0.40

4.2. Indicator Weighting

Tables 3 and 4 illustrate the weighting outcomes and scoring results of six weighting methods, respectively. This section highlights their descriptions.

Table 3. Indicator weightings of six weighting methods.

Indicator (1)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD	CWMS	CWMDS
	r_j (2)	Weighting (3)	Standard Deviation (4)	Weighting (5)	Amount of Information (6)	Weighting (7)	Weighting (8)	Weighting (9)	Weighting (10)
$X_{1,5}$ Leadership commitment, responsibility and attention	—	0.005	0.401	0.016	25.739	0.015	0.012	0.012	0.012
$X_{1,6}$ Clear stakeholder	0.7	0.007	0.405	0.016	25.578	0.014	0.013	0.012	0.013

Table 3. *Cont.*

Indicator (1)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD	CWMS	CWMDS
	r_j (2)	Weighting (3)	Standard Deviation (4)	Weighting (5)	Amount of Information (6)	Weighting (7)	Weighting (8)	Weighting (9)	Weighting (10)
$X_{1,7}$ Identify stakeholder appeals	0.9	0.007	0.401	0.016	25.193	0.014	0.013	0.013	0.013
$X_{1,8}$ Establishment of dedicated communication channel for stakeholders	1.2	0.006	0.415	0.017	26.751	0.015	0.013	0.013	0.013
$X_{1,9}$ Respond to stakeholder appeals	1.3	0.005	0.403	0.016	25.485	0.014	0.012	0.012	0.012
$X_{1,10}$ Whether the report contains substantive issues	1.2	0.004	0.434	0.018	26.474	0.015	0.013	0.012	0.013
$X_{1,11}$ Establishment of corporate social responsibility risk management mechanism	0.7	0.006	0.231	0.009	15.857	0.009	0.008	0.008	0.008
$X_{1,12}$ The degree of perfection of the risk management control system	0.9	0.006	0.246	0.010	17.243	0.010	0.009	0.009	0.009
$X_{1,14}$ Identification of Corporate Social Responsibility Report	1.4	0.004	0.266	0.011	21.508	0.012	0.009	0.009	0.010
$X_{1,15}$ Comply refers to the related local and international standards to prepare reports	0.8	0.006	0.308	0.012	20.928	0.012	0.010	0.010	0.010
$X_{1,16}$ Participate in corporate-social-responsibility-related public welfare organizations	1.2	0.005	0.222	0.009	16.517	0.009	0.008	0.008	0.008
$X_{2,2}$ Equal employment and elimination of discrimination	0.6	0.008	0.221	0.009	15.189	0.009	0.008	0.008	0.008
$X_{2,5}$ Employee turnover ratio	0.8	0.010	0.395	0.016	26.002	0.015	0.014	0.013	0.014
$X_{2,6}$ Whether to do maternity leave to stay	1.3	0.007	0.436	0.018	27.784	0.016	0.014	0.014	0.014
$X_{2,7}$ Protection of female workers' rights and interests	0.8	0.009	0.416	0.017	25.583	0.014	0.014	0.013	0.014
$X_{2,8}$ Whether to benefit from bad labor practices	1.2	0.008	0.418	0.017	27.300	0.015	0.014	0.013	0.014
$X_{2,9}$ Whether to achieve paid vacation	0.8	0.010	0.407	0.016	26.053	0.015	0.014	0.014	0.014
$X_{2,10}$ Equal pay for equal work	0.8	0.012	0.433	0.017	26.447	0.015	0.015	0.015	0.015
$X_{2,11}$ Whether overtime work pays extra compensation	1.2	0.010	0.294	0.012	21.248	0.012	0.011	0.011	0.011
$X_{2,12}$ Is there an employee security organization?	0.9	0.011	0.276	0.011	19.601	0.011	0.011	0.011	0.011
$X_{2,13}$ Provide a healthy and safe working environment	0.7	0.016	0.284	0.011	20.334	0.011	0.013	0.013	0.013
$X_{2,14}$ High-risk employee welfare	1.4	0.011	0.284	0.011	22.316	0.013	0.012	0.012	0.012
$X_{2,15}$ Whether to provide health and safety training for employees	0.8	0.014	0.331	0.013	22.396	0.013	0.013	0.013	0.013
$X_{2,16}$ Whether to provide regular health checkups for employees	1.5	0.009	0.271	0.011	20.477	0.012	0.011	0.011	0.011
$X_{2,17}$ Does the company's trade union provide assistance to employees?	0.8	0.012	0.321	0.013	25.019	0.014	0.013	0.013	0.013

Table 3. *Cont.*

Indicator (1)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD	CWMS	CWMDS
	r_j (2)	Weighting (3)	Standard Deviation (4)	Weighting (5)	Amount of Information (6)	Weighting (7)	Weighting (8)	Weighting (9)	Weighting (10)
$X_{2,18}$ Strengthening employability, skills management and lifelong learning programs	0.7	0.017	0.375	0.015	25.069	0.014	0.015	0.015	0.015
$X_{2,19}$ Education and training	0.9	0.019	0.150	0.006	11.944	0.007	0.010	0.010	0.010
$X_{2,20}$ Performance and career development assessment	1.5	0.013	0.295	0.012	21.587	0.012	0.012	0.012	0.012
$X_{2,21}$ Establish and improve communication mechanism	1.3	0.010	0.167	0.007	13.979	0.008	0.008	0.008	0.008
$X_{2,22}$ Achieve work–life balance	0.7	0.014	0.337	0.014	24.440	0.014	0.014	0.014	0.014
$X_{3,1}$ Environmentally friendly product	1.2	0.011	0.238	0.010	15.969	0.009	0.010	0.010	0.010
$X_{3,2}$ Improve the technical level of environmental protection and improvement	0.7	0.016	0.253	0.010	16.620	0.009	0.012	0.012	0.012
$X_{3,3}$ Use of recycled materials	1.4	0.012	0.345	0.014	23.837	0.013	0.013	0.013	0.013
$X_{3,6}$ Water-saving measures	1.3	0.009	0.316	0.013	20.617	0.012	0.011	0.011	0.011
$X_{3,9}$ Ecosystem protection and restoration	0.6	0.015	0.255	0.010	19.827	0.011	0.012	0.012	0.012
$X_{3,12}$ Transportation or disposal of hazardous waste	1.5	0.010	0.353	0.014	24.797	0.014	0.013	0.013	0.013
$X_{3,13}$ Reduce sewage discharge	1.3	0.008	0.331	0.013	23.670	0.013	0.012	0.011	0.012
$X_{3,15}$ Solid waste discharge	1	0.008	0.293	0.012	19.930	0.011	0.010	0.010	0.011
$X_{3,16}$ Plan to reduce carbon emissions	1	0.008	0.236	0.010	16.216	0.009	0.009	0.009	0.009
$X_{3,17}$ Smoke dust emission reduction	1.3	0.006	0.297	0.012	23.246	0.013	0.011	0.010	0.011
$X_{4,1}$ Information disclosure is transparent	0.8	0.007	0.369	0.015	31.079	0.018	0.014	0.013	0.014
$X_{4,3}$ Corruption response situation	1.3	0.006	0.455	0.018	34.570	0.019	0.015	0.015	0.015
$X_{4,4}$ Operation level internal control assessment implementation level	0.7	0.008	0.353	0.014	27.355	0.015	0.013	0.013	0.013
$X_{4,6}$ Fines and noneconomic penalty events	0.7	0.012	0.181	0.007	13.269	0.007	0.009	0.009	0.009
$X_{4,7}$ Property lawsuit	1	0.012	0.243	0.010	18.123	0.010	0.010	0.011	0.010
$X_{4,8}$ Compliance training	0.7	0.017	0.346	0.014	24.078	0.014	0.015	0.015	0.015
$X_{4,9}$ Is there a grievance agency for fair operations?	1.5	0.011	0.451	0.018	32.476	0.018	0.016	0.016	0.016
$X_{4,11}$ Follow-up actions for appeals	0.8	0.014	0.151	0.006	11.566	0.007	0.008	0.009	0.008
$X_{4,12}$ Grievance event processing rate	1	0.014	0.085	0.003	6.220	0.004	0.006	0.007	0.006
$X_{5,1}$ Customer complaint channel	0.7	0.020	0.396	0.016	27.222	0.015	0.017	0.017	0.017
$X_{5,3}$ Customer satisfaction	**0.5**	**0.040**	0.050	0.002	3.486	0.002	0.013	0.014	0.012
$X_{5,4}$ Customer complaint processing time	1.4	0.028	0.239	0.010	19.100	0.011	0.015	0.016	0.015

Table 3. *Cont.*

Indicator (1)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD	CWMS	CWMDS
	r_j (2)	Weighting (3)	Standard Deviation (4)	Weighting (5)	Amount of Information (6)	Weighting (7)	Weighting (8)	Weighting (9)	Weighting (10)
$X_{5,5}$ Customer information security mechanism	**0.7**	**0.040**	0.465	0.019	33.488	0.019	**0.025**	**0.026**	**0.025**
$X_{5,6}$ Customer complaint processing rate	1.2	0.034	0.157	0.006	11.131	0.006	0.014	0.015	0.014
$X_{5,8}$ Safety hazard rectification rate	1	0.034	0.031	0.001	2.440	0.001	0.011	0.012	0.010
$X_{5,9}$ Emergency drills	1.7	0.020	0.200	0.008	14.899	0.008	0.012	0.012	0.011
$X_{5,10}$ Violation of products and services	0.9	0.022	0.478	0.019	**35.075**	**0.020**	0.020	0.020	0.020
$X_{5,11}$ Do not provide controversial services	1	0.022	0.214	0.009	15.579	0.009	0.013	0.013	0.012
$X_{5,12}$ Whether to provide personalized service	0.9	0.024	0.381	0.015	28.885	0.016	0.018	0.019	0.018
$X_{5,13}$ No vicious advertising competition	1.5	0.016	0.336	0.014	24.223	0.014	0.014	0.014	0.014
$X_{5,15}$ Whether to conduct comprehensive supervision of the cooperative suppliers	0.8	0.020	**0.484**	**0.020**	31.503	0.018	0.019	0.019	0.019
$X_{6,1}$ Participate in community charity activities/provide volunteer services	1.7	0.012	0.315	0.013	21.550	0.012	0.012	0.012	0.012
$X_{6,3}$ Share corporate values and build long-term relationships with local communities	0.9	0.013	0.262	0.011	19.750	0.011	0.012	0.012	0.011
$X_{6,4}$ Establishment of community welfare facilities	1.7	0.008	0.380	0.015	28.442	0.016	0.013	0.013	0.014
$X_{6,5}$ Participate in local associations	1	0.008	0.295	0.012	21.807	0.012	0.011	0.011	0.011
$X_{6,6}$ Promote the development of community education	0.7	0.011	0.437	0.018	30.371	0.017	0.016	0.015	0.016
$X_{6,7}$ Note the physical and mental health of community residents	1	0.011	0.321	0.013	24.038	0.014	0.013	0.013	0.013
$X_{6,8}$ Community and Charity Awards	1.5	0.007	0.320	0.013	23.575	0.013	0.011	0.011	0.012
$X_{6,9}$ Promote community culture development	0.7	0.011	0.333	0.013	25.269	0.014	0.013	0.013	0.013
$X_{6,10}$ Creation of local employment	0.8	0.013	0.389	0.016	27.312	0.015	0.015	0.015	0.015
$X_{6,11}$ Skills training for community residents	1.4	0.010	0.222	0.009	17.155	0.010	0.009	0.009	0.009
$X_{6,12}$ Strive to eradicate poverty	0.8	0.012	0.412	0.017	29.775	0.017	0.015	0.015	0.015
$X_{6,13}$ Integrate all aspects of strength to create community wealth	1.2	0.010	0.338	0.014	27.082	0.015	0.013	0.013	0.013
$X_{6,14}$ Creation of an entrepreneurial environment	1.4	0.007	0.182	0.007	14.684	0.008	0.008	0.008	0.008
$X_{7,1}$ Return on net asset	0.6	0.012	0.148	0.006	12.474	0.007	0.008	0.008	0.008
$X_{7,2}$ Quick ratio	1.3	0.009	0.143	0.006	11.931	0.007	0.007	0.007	0.007
$X_{7,4}$ Return on equity	0.8	0.011	0.159	0.006	12.377	0.007	0.008	0.008	0.008
$X_{7,7}$ Accounts payable turnover	1.2	0.009	0.210	0.008	18.318	0.010	0.009	0.009	0.009

Table 3. *Cont.*

Indicator (1)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD	CWMS	CWMDS
	r_j (2)	Weighting (3)	Standard Deviation (4)	Weighting (5)	Amount of Information (6)	Weighting (7)	Weighting (8)	Weighting (9)	Weighting (10)
$X_{7,8}$ Tax growth rate	1.2	0.008	0.136	0.005	11.296	0.006	0.006	0.007	0.006
$X_{7,9}$ Government subsidy receivable (CNY 100 million)	1.2	0.007	0.421	0.017	33.592	0.019	0.015	0.014	0.015
$X_{7,11}$ Social contribution per share	0.7	0.009	0.205	0.008	16.793	0.009	0.009	0.009	0.009
$X_{7,13}$ Social welfare project implementation	1.1	0.009	0.343	0.014	26.256	0.015	0.013	0.012	0.013

Note: The bold figures indicate the maximum weightings and scores across six weighting methodologies.

Table 4. CSR enterprises scores of six weighting methods.

Subindustry (1)	Company (2)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD		CWMS		CWMDS	
		Score (3)	Rank (4)	Score (5)	Rank (6)	Score (7)	Rank (8)	Score (9)	Rank (10)	Score (11)	Rank (12)	Score (13)	Rank (14)
Railway transportation	Daqin Railway	33.17	47	30.36	46	30.94	46	31.48	47	31.37	47	31.32	47
	Guangshen Railway	41.76	34	38.56	37	38.71	36	39.67	36	39.53	36	39.48	36
	MTR	45.02	21	47.67	22	47.01	19	46.57	21	46.68	21	46.73	21
	China Railway Tielong Container Logistics	54.34	7	58.75	5	57.98	5	57.03	5	57.22	5	57.30	5
Road transportation	Dazhong Transportation	31.44	50	27.59	50	28.10	50	29.03	50	28.87	50	28.80	50
	Delixi Xinjiang Transportation	24.57	62	18.41	65	18.74	66	20.56	64	20.29	64	20.19	64
	Heilongjiang Transport Development	25.96	57	21.91	56	22.06	58	23.30	57	23.12	57	23.05	57
	Jiangxi Changyun	39.05	40	37.38	38	37.82	38	38.08	39	38.01	39	37.98	39
	Shanghai Qiangsheng Holding	33.55	45	30.86	45	31.01	45	31.80	46	31.68	46	31.64	46
	Shanghai Shentong Metro	27.77	56	25.58	53	26.22	53	26.52	54	26.43	55	26.39	54
	Transport International Holdings	51.38	12	54.12	13	52.49	13	52.66	12	52.77	12	52.83	12
	Ningbo Marine	32.51	49	29.01	48	30.11	47	30.54	48	30.39	48	30.33	48
	Pacific Basin Shipping	37.26	43	36.27	41	36.07	42	36.53	43	36.48	43	36.47	43
	Sinotrans	42.63	31	39.30	34	38.89	35	40.26	32	40.11	32	40.06	32
	COSCO SHIPPING Development	42.43	32	48.11	20	46.81	21	45.79	22	46.03	22	46.13	22
	COSCO SHIPPING Ports	56.87	4	63.36	4	61.50	3	60.58	4	60.85	4	60.97	4
	COSCO SHIPPING Holdings	55.51	5	58.05	8	57.04	6	56.87	6	56.98	6	57.02	6

Table 4. *Cont.*

Subindustry (1)	Company (2)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD		CWMS		CWMDS	
		Score (3)	Rank (4)	Score (5)	Rank (6)	Score (7)	Rank (8)	Score (9)	Rank (10)	Score (11)	Rank (12)	Score (13)	Rank (14)
Water-way transportation	COSCO SHIPPING Energy Transportation	53.31	9	57.58	9	55.87	9	55.59	9	55.77	9	55.85	9
	COSCO SHIPPING Specialized Carriers	44.56	23	45.46	23	45.29	23	45.11	23	45.14	23	45.16	23
	Chu Kong Shipping Companies	41.21	35	39.79	33	39.40	34	40.13	33	40.07	33	40.04	33
Port transportation	Dalian Port	44.88	22	40.14	32	40.42	31	41.80	31	41.59	31	41.51	31
	Guangzhou Port	32.54	48	27.99	49	28.85	49	29.78	49	29.59	49	29.51	49
	Jiangsu Lianyungang Port	29.93	52	33.47	44	33.01	44	32.14	44	32.29	45	32.36	44
	Jinzhou Port	28.88	55	26.28	52	26.88	52	27.34	53	27.23	53	27.18	53
	Ningbo Zhoushan Port	22.95	66	19.68	63	20.47	63	21.03	63	20.89	63	20.83	63
	QinHuangDao Port	43.73	27	49.21	17	47.80	18	46.93	20	47.15	20	47.25	20
	Qingdao Port International	**62.78**	**1**	63.51	3	62.24	2	**62.84**	**1**	**62.86**	**1**	**62.88**	**1**
	Rizhao Port	37.57	42	37.18	39	37.53	39	37.43	41	37.41	42	37.40	41
	Shanghai International Port	54.74	6	55.33	10	53.61	11	54.55	10	54.57	10	54.59	10
	Shenzhen Yan Tian Port Holdings	28.90	54	25.01	55	25.83	54	26.57	55	26.41	54	26.34	55
	Tangshan Port Group	25.94	58	21.00	60	21.84	59	22.92	60	22.71	60	22.62	60
	Tianjin Port	38.95	41	40.57	31	40.27	32	39.93	34	40.00	35	40.03	34
	Xiamen Port Development	48.47	17	48.22	19	46.98	20	47.88	18	47.86	18	47.87	18
	Yingkou Port	24.87	61	20.12	62	21.01	61	21.99	62	21.79	61	21.71	62
Air transportation	Cathay Pacific Airways	49.18	14	49.08	18	48.03	17	48.75	17	48.74	17	48.75	17
	HNA Infrastructure	47.66	18	53.91	14	52.44	14	51.35	14	51.61	14	51.72	14
	Hainan Airlines Holding	48.73	16	50.70	16	48.86	16	49.42	16	49.50	16	49.54	16
	China Eastern Airlines	60.87	3	**64.19**	**1**	**62.36**	**1**	62.47	2	62.61	2	62.67	2
	Air China	61.32	2	63.52	2	61.46	4	62.09	3	62.17	3	62.22	3
	China Southern Airlines	53.87	8	58.71	6	56.86	8	56.48	7	56.68	7	56.77	7
	Sinotrans Air Transportation Development	25.81	60	21.55	57	22.41	56	23.25	58	23.07	58	22.99	58
Airport transportation	Beijing Capital International Airport	48.87	15	48.10	21	46.57	22	47.83	19	47.79	19	47.79	19
	Guangzhou Baiyun International Airport	22.99	65	18.67	64	19.68	64	20.44	65	20.26	65	20.18	65

Table 4. *Cont.*

Subindustry (1)	Company (2)	G1 Method		Standard Deviation Method		CRITIC Method		CWMD		CWMS		CWMDS	
		Score (3)	Rank (4)	Score (5)	Rank (6)	Score (7)	Rank (8)	Score (9)	Rank (10)	Score (11)	Rank (12)	Score (13)	Rank (14)
High-speed transportation	Anhui Expressway	37.10	44	38.90	36	39.46	33	38.50	37	38.58	37	38.60	37
	Fujian Expressway Development	23.40	64	18.28	66	18.85	65	20.16	66	19.94	66	19.85	66
	Henan Zhongyuan Expressway	30.81	51	26.43	51	27.19	51	28.13	51	27.95	52	27.87	51
	Huayu Expressway Group	29.43	53	20.66	61	21.03	60	23.68	56	23.31	56	23.16	56
	Jilin Expressway	23.76	63	21.18	59	20.88	62	21.93	61	21.81	62	21.77	61
	Jiangsu Expressway	47.17	19	51.77	15	50.09	15	49.68	15	49.87	15	49.96	15
	Jiangxi Ganyue Expressway	20.62	67	14.03	68	14.76	68	16.46	68	16.18	68	16.06	68
	Shandong Hi-speed	25.89	59	21.48	58	22.13	57	23.16	59	22.97	59	22.89	59
	Shenzhen Expressway	44.25	24	41.16	30	41.43	30	42.27	28	42.14	28	42.09	28
	Sichuan Expressway	41.15	36	42.64	29	42.16	29	41.98	29	42.05	29	42.07	29
	Yuexiu Transport Infrastructure	42.09	33	39.28	35	38.66	37	40.00	35	39.87	34	39.83	35
	Zhejiang Expressway	42.96	30	34.86	43	35.16	43	37.64	42	37.29	41	37.15	42
Logistics and transportation	Changan Minsheng APLL Logistics	45.59	20	44.31	25	42.89	25	44.25	24	44.19	24	44.17	25
	Orient Overseas	52.55	11	55.15	11	54.23	10	53.98	11	54.08	11	54.13	11
	Kerry Logistics Network	39.18	39	29.24	47	29.42	48	32.58	45	32.15	44	31.98	45
	Dragon Crown Group Holdings	33.32	46	25.42	54	25.80	55	28.16	52	27.82	51	27.68	52
	STO Express	43.09	28	35.91	42	36.37	41	38.44	38	38.13	38	38.01	38
	Shenzhen International Holdings	44.07	25	43.78	27	42.85	26	43.56	26	43.54	26	43.54	26
	S.F. Holding	39.89	38	36.43	40	36.64	40	37.64	40	37.49	40	37.43	40
	YTO Express Group	43.08	29	45.12	24	44.02	24	44.07	25	44.15	25	44.19	24
	CMST Development	40.26	37	42.99	28	42.26	28	41.84	30	41.96	30	42.01	30
Transportation equipment	Daido Group	49.57	13	54.17	12	52.89	12	52.22	13	52.41	13	52.49	13
	Jinhui Holdings	19.92	68	15.01	67	15.12	67	16.67	67	16.46	67	16.37	67
	Hong Kong Aircraft Engineering	43.78	26	43.82	26	42.37	27	43.31	27	43.30	27	43.31	27
	China International Marine Containers	52.68	10	58.14	7	56.88	7	55.91	8	56.14	8	56.24	8

Note: The bold figures indicate the best-performing CSR enterprises across the subindustries.

(1) Subjective weighting scores based on the G1 method

The importance ratio of 82 indicators was determined by considering expert opinions. A total of 18 experts, including 14 professors and associate professors from the Corporate Social Responsibility and Sustainable Development Institute, Dalian Maritime University and four departmental heads of Risk Management Division from China Railway Tielong Container Logistics Co. Ltd. and Yingkou Port Group Co. Ltd. Column 2 of Table 3 shows the maximum weightings that appear in the product responsibility criterion level. The weightings of customer satisfaction, $X_{5,3}$ and customer information security mechanism, $X_{5,5}$ are 0.04 and 0.04. The minimum value is for $X_{1,14}$, identification of CSR report, which is 0.004. Moreover, Table 4 shows the Qingdao Port score of 62.78, which ranks first. After that, the subsequent rank is for Air China, China Eastern Airlines, COSCO Shipping Ports and COSCO Shipping Holdings and their scores are 61.32, 60.87, 56.87 and 55.51, respectively. On the contrary, Jinhui Holdings scored 19.92, which secured the lowest rank on the scoreboard.

(2) Objective weighting scores based on the standard deviation method

Columns 4 and 5 of Table 3 describe the value of standard deviation and weighting under the standard-deviation-based objective weighting method. The product responsibility criterion level carries the largest as well as the smallest weightings. That is to say, $X_{5,15}$ (*whether to conduct comprehensive supervision of the cooperative suppliers*) belongs to the largest weighting, which is 0.020 and $X_{5,8}$ (*safety hazard rectification rate*) carries the smallest weighting, which is 0.001. Across the enterprises' score and ranking, China Eastern Airlines ranks first with 64.19 points. After that, the subsequent order is Air China, Qingdao Port International, COSCO SHIPPING Ports, China Railway Tielong Container Logistics and their scores are 63.52, 63.51, 63.36 and 58.75, respectively. In contrast, the Jiangxi Ganyue Expressway ranks last with 14.03 points.

(3) Objective weighting scores based on CRITIC method

The weightings of the CRITIC method are consistent with the standard deviation method. The *safety hazard rectification rate* ($X_{5,8}$) also carries the smallest weighting, which is 0.001. In contrast, $X_{5,10}$ (*violation of products and services*) has the largest weighting, which is 0.020. The first and final positions are also similar to the earlier approach. That is, China Eastern Airlines ranks in the first position with 62.36 points and the subsequent rankings are for the Qingdao Port International, the COSCO SHIPPING Ports, Air China, the China Railway Tielong Container Logistics and their scores are 62.24, 61.50, 61.46 and 57.98, respectively, while the Jiangxi Ganyue Expressway ranks in last place with 14.76 points.

(4) Combined weighting scores based on the difference (CWMD)

Substituting the single weighting method scores f_i^G, f_i^S, f_i^C of the G1 method, the standard deviation method and the CRITIC method into the CWMD model, the CWMD identifies the final combined weightings $\theta_1^D = 0.34, \theta_2^D = 0.36, \theta_3^D = 0.30$. Column 8 of Table 3 illustrates the CWMD technique's indicator weightings by multiplying the weightings of three single weighting approaches. The combined weighting score f_i^D is based on the difference principle. Column 9 of Table 4 shows the weighting scores. The largest weighting is 0.020 of $X_{5,5}$ (*customer information security mechanism*) and the smallest weighting is 0.006 of $X_{4,12}$ (grievance event processing rate) and $X_{7,8}$ (*tax growth rate*). Moreover, Table 4 shows that the Qingdao Port scores 62.84, ranking in the first position. The subsequent order is China Eastern Airlines, Air China, COSCO SHIPPING Ports and China Railway Tielong Container Logistics and their scores are 62.47, 62.09, 60.58 and 57.03, respectively. However, the Jiangxi Ganyue Expressway scores 16.46, ranking in the last position.

(5) Combined weighting scores based on similarity (CWMS)

This determines the final combined weighting $\theta_1^E = 0.34, \theta_2^E = 0.33, \theta_3^E = 0.33$ based on similarity principles. Column 9 of Table 3 shows the CWMS approach's weightings

obtained by multiplying the indicators' values from three single weighting methods. After that, column 11 of Table 4 shows the weighting score f_i^E based on the similarity principle established by substituting the weightings $\theta_1^E, \theta_2^E, \theta_3^E$ into the CWMS model. Table 4 shows the maximum weighting is 0.026 of $X_{5,5}$ (*customer information security mechanism*) and the minimums are 0.007 of $X_{4,12}$ (*grievance event processing rate*), $X_{7,2}$ (*quick ratio*) and $X_{7,8}$ (*tax growth rate*), respectively. As for the scores and rankings, the Qingdao Port still ranks in the first position, then the subsequent order is China Eastern Airlines, Air China, COSCO SHIPPING Ports and China Railway Tielong Container Logistics and their scores are 62.61, 62.17, 60.85 and 57.22, respectively. On the contrary, Jiangxi Ganyue Expressway is in the last position scoring 16.18 points.

(6) Combined weighting scores based on difference and similarity (CWMDS)

Optimizing Equation (3), the combined weightings of $\theta_1 = 0.34$, $\theta_2 = 0.28$ and $\theta_3 = 0.38$, have been determined by following the CWMD procedures. It determines the parameter values are $\alpha = \beta = 0.5$. Multiplying the weightings of the three single methods and the weighting of the CWMDS method is obtained in Column 10 of Table 3. By substituting the weightings θ_1, θ_2, θ_3 of the three single methods into Equation (4), the combined weighting score f_{i} based on the CWMDS principle is obtained. The weighting results are shown in column 13 of Table 4. The maximum and minimum weightings are the same as the results of the CWMD. The largest weighting is 0.020 of $X_{5,5}$ (*customer information security mechanism*) and the smallest weighting is 0.006 of $X_{4,12}$ (*grievance event processing rate*) and $X_{7,8}$ (*tax growth rate*). The results of the scores and rankings are also consistent with the results of the first two combined methods. The Qingdao Port ranks first with 62.88 points. The subsequent rankings are China Eastern Airlines, Air China, COSCO SHIPPING Ports and China Railway Tielong Container Logistics and their scores are 62.67, 62.22, 60.97 and 57.30, respectively. On the other hand, Jiangxi Ganyue Expressway ranks last with 16.06 points.

4.3. Analysis of Results

The 68 companies in the transportation industry were classified into nine subindustries: railway transportation subindustry, road transportation subindustry, waterway transportation subindustry, port transportation subindustry, air transportation subindustry, airport transportation subindustry, high-speed transportation subindustry, logistics and transportation subindustry and transportation equipment subindustry.

The average scores of CSR fulfillment in the nine subindustries was calculated under the integrated weighting method based on difference and similarity and a bar chart was drawn, as shown in Figure 3. It can be seen that the air transportation subindustry has the best CSR fulfillment, with the highest average score of 50.67 points, followed by the waterway transportation subindustry and the railway transportation subindustry, with an average score of 45.78 points and 43.70 points, respectively. The road transportation subindustry and high-speed transportation subindustry are the worst. Their average scores are only 31.55 points and 31.78 points.

In general, the CSR fulfillment in the nine subindustries is not satisfactory. The average scores of the nine subindustries are less than 60 points, indicating the poor performance of CSR in all transportation industries. Even if the highest average score in the air transportation subindustry exists, there is still a company ranked 58th in the countdown. The gap between the nine subindustries is relatively large. The poorly performing industries such as the road transportation subindustry and the high-speed transportation subindustry must be aware of their problems and improve their corporate social responsibility performance.

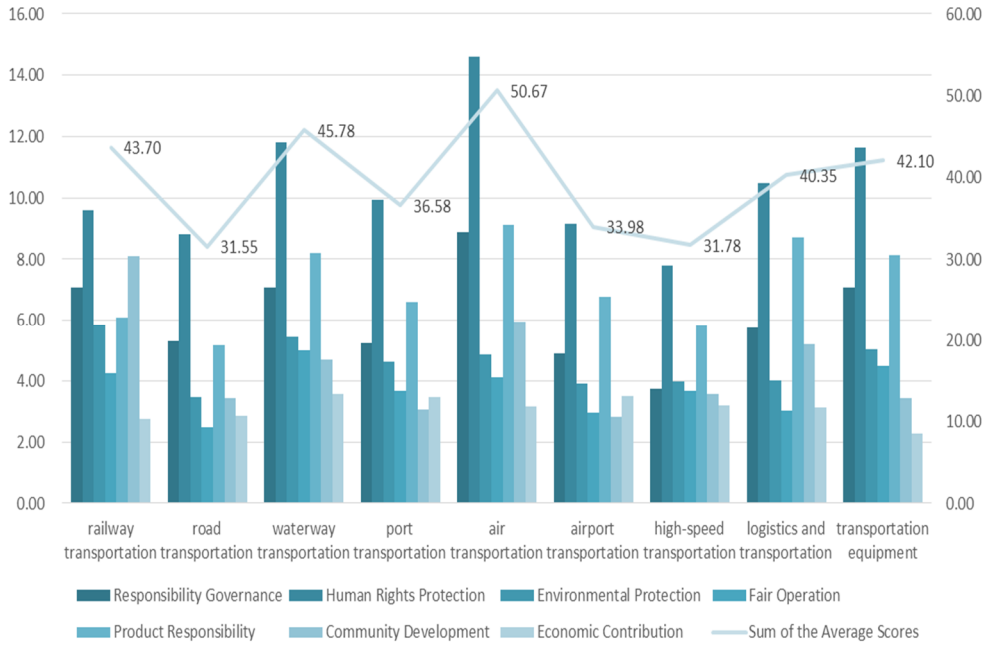

Figure 3. Average scores of all criteria in nine subindustries.

In the criterion layer, each indicator's average score was multiplied by the integrated weighting based on difference and similarity and the scores of the same criterion were added together. Finally, the score of the criterion was obtained (Figure 4). It can be seen that the criteria of human rights production and product responsibility have good performance for most companies, with scores of 10.30 and 7.13, respectively, while the two criteria of proper operation and economic contribution are the worst, with scores of 3.74 and 3.18 points, respectively. When implementing corporate social responsibility, each company needs to improve the performance of these two criteria.

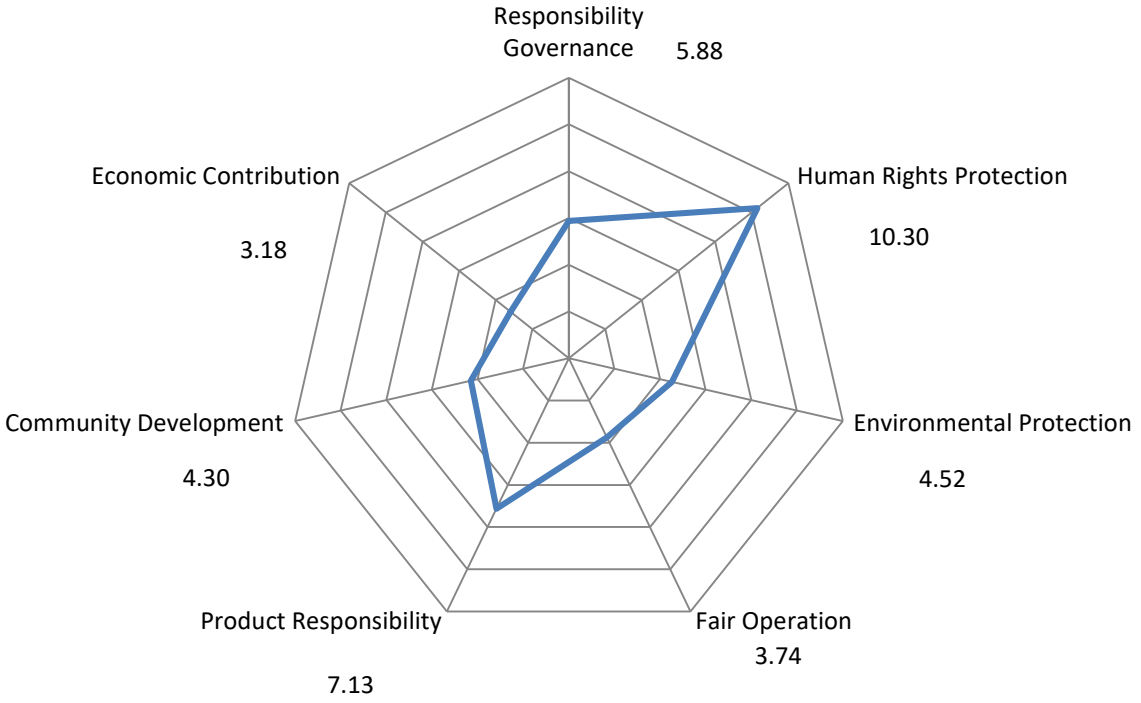

Figure 4. Scores in seven criteria.

The overall performance of the highway transportation subindustry and high-speed transportation subindustry's is low, primarily due to the imbalance between China's growing number of cars and the drivers' quality that can hardly be improved, leading to the high accident rate. In 2019, the number of civil vehicles in China was 209.0667 million, with an average of one vehicle per 6.6 people. However, the test and standard of motor vehicle driver's license are different from those of trains and airplanes, which require a long time of training practice and strict assessment. After only a few months of simple training, a car driver's license to go on the road can be obtained. Moreover, the personal fluke psychology and the neglect of the rules also contribute to drunk driving, fatigue driving, overloading, etc. In 2019, China's motor vehicle accident rate accounted for 89.8% of all traffic accidents, the death toll accounted for 92.8% and the direct economic loss was as high as 90.0% [43].

The lack of performance at the economic standards level is more likely associated with the transportation industry's characteristics. The transportation industry is an important facilitator of national economic development. Without it, people and goods from all walks of life are difficult to circulate. The transportation industry's growth and profitability are not the most critical goal of its operation. Furthermore, the institutional problems of the non-separation of functions between the government and enterprises also restrict the transportation industry's economic development. Especially in the railway transportation industry, the Ministry of Railways still controls the functions of primary production, operation, investment and distribution. Railway transportation enterprises cannot transform into standardized market entities and legal entities or independently allocate transportation resources to the market. Since the state imposes price control on railway transportation, which is neither from the market supply and demand situation nor from the enterprise's cost, the railway transportation enterprises cannot obtain their normal economic benefits from the product price.

5. Conclusions

The importance of corporate social responsibility in the transportation industry is gradually emerging. It is imperative to evaluate corporate social responsibility in the transportation industry. With the corporate social responsibility reports of 68 listed companies in the Shanghai Stock Exchange, Shenzhen Stock Exchange and Hong Kong stock exchange, this paper performed an empirical study on the transportation industry's corporate social responsibility performance by using the CWMDS method. Given the lack of evaluation tools that can reflect the characteristics of the transportation industry, this paper constructed an indicator system of CSR through gray correlation degree and partial correlation analysis.

Given the current situation that most combined weighting methods only focus on a certain feature of the research results, this study adopted the integrated weighting method that considers the internal differences and external consistency. In this study, two aspects concerned with the traditional weighting methods were combined for weighting. The differences between the research objects were amplified while not deviating from the results obtained by single weighting methods to reflect the research goal of "seeking horizontal similarity and vertical difference". The empirical results show that the combined weighting method that considers the difference and similarity is better than the single weighting method in terms of consistency, contrast and orderliness.

Based on the results of the practical application of CWMDS in the transportation industry, the following conclusions were drawn in this paper. The air transportation subindustry's CSR performance is the best, while that of the high-speed transportation subindustry is the worst. The criterion of human rights production performs well, but the criterion of economic contribution needs to be improved in the transportation industry. In addition, there are significant gaps within each subindustry.

In theory, this paper has established a combined evaluation method reflecting both the importance of the indicators and the relationship between the data. This method solves the

problem that different evaluation methods lead to different evaluation results and provides a new idea and method for combined weighting evaluation.

In practice, the implementation of CSR in the transportation industry is promoted and the CSR awareness of the entire industry's is enhanced. The empirical evaluation of CSR in the transportation industry reveals the current status of CSR in various subindustries. It establishes the concept of maximizing social benefits, which is used in enterprises' development planning and business activities and promotes the transportation industry's green development. At the corporate level, companies need to be aware of their shortcomings in fulfilling their corporate social responsibilities, which will help them to improve their reputation and better comply with government and industry regulations. At the government level, the government needs to understand the issue of corporate social responsibility and guide enterprises to better fulfill social responsibilities in a targeted manner to bring more economic, social and humanistic value.

This paper provided a reference direction for the government to formulate and improve relevant CSR policies. Research shows that most companies perform worst in the two criterion layers of fair operation and economic contribution. It is necessary for transportation companies to further promote the awareness and training of fair operation to minimize their own economic penalties and property rights lawsuits and establish appeal and supervision mechanisms to ensure timely and accurate internal and external information transmission and problem solving. At the same time, all enterprises should also strive to improve their operation capabilities and actively serve society by increasing direct economic and social contributions such as return on net assets and average annual wages of employees. Furthermore, they should actively disclose relevant economic and CSR information to the public.

The limitations of this paper include two aspects. First, due to the limited information disclosure of corporate social responsibility, data such as legal disputes and corporate fines could not be obtained. In the future, it is necessary to further enrich the CSR evaluation system in the transportation industry. Second, due to the complexity of the CSR evaluation system in the transportation industry, the evaluation methods in this paper still need to be further explored.

Author Contributions: Conceptualization, L.L., L.F. and B.M.; methodology, L.L. and B.M.; software, B.M. and H.F.; validation, M.Z.A. and H.F.; formal analysis, L.F.; investigation, L.F. and M.Z.A.; resources, L.L.; data curation, B.M. and H.F.; writing—original draft preparation, L.L. and L.F.; writing—review and editing, L.F. and M.Z.A.; visualization, B.M.; supervision, L.L., L.F. and M.Z.A.; project administration, L.L. and B.M.; funding acquisition, L.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by [Liaodong University Doctoral Research Startup Fund Project] grant number [2021BS003]; [Liaodong University Joint Fund Program] grant number [2021YB001]; [Liaodong University Funded Opening and Bidding Project in 2022] grant number [XCZX20220205].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available in reference [43].

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

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