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Establishment of Corporate Energy Management Systems and Voluntary Carbon Information Disclosure in Chinese Listed Companies: The Moderating Role of Corporate Leaders' Low-Carbon Awareness

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Abstract: The “Energy-Saving and Low-Carbon Action Implementation Plan for Ten Thousand Enterprises” urged Chinese energy users to establish an energy management system (EEM) that emphasizes energy conservation and emission reduction. This study applied the voluntary information disclosure theory, stakeholder theory, and legitimacy theory to construct a research framework for corporate voluntary carbon information disclosure (CID) under combined action of disclosure decision, EEM related to carbon information collection, and pressure to disclose. This study uses A-share listed companies from 2009 to 2017 as its research sample. Panel data regression analyses show that EEM positively affects CID in the high-carbon industry, and LLA positively affects CID in the low-carbon industry. In addition, ownership concentration has significant effects on CID. Moreover, the existence of state-owned shares positively affects CID of AH-share samples. The moderating effect test found that LLA has a negative moderating effect (a positive moderating effect) on the relationship between EEM and CID in the high-carbon industry (in AH-share samples). This study has verified the promoting effect of energy policies implementation related to carbon reduction and leaders' carbon awareness on CID. It provided a strong basis for the significance of accelerating climate-change policies and promotion effects of international capital markets.

Keywords: establishment of corporate energy management systems policy; voluntary carbon information disclosure; corporate leaders' low-carbon awareness; Chinese listed companies with AH-share; state-owned shares; ownership concentration

1. Introduction

After the “Paris Agreement”, countries and regions have made plans for carbon emission reduction. The Chinese government has taken a series of measures to optimize the energy structure and control greenhouse gas emissions, and China's carbon dioxide emissions per unit of gross domestic product (GDP) fell by 4.0% in 2018, a cumulative drop of 45.8% compared to 2005 [1–6]. However, if the 1.5-degree temperature control target is to be achieved, global carbon emissions need to be reduced by 7.6% per year between 2020 and 2030 [7]. President Xi states that hitting peak carbon emissions by 2030 and achieving carbon neutrality by 2060, as scheduled, is a broad and profound economic and social systemic change [8]. In addition, the annual carbon emission per unit of GDP needs to decline faster (by 2030, 60–65% reduction compared with 2005), which means that China will have to make greater efforts [9].

The Non-Financial Reporting Directive issued by the European Union in October 2014 is the first legal document to systematically include the three elements of ESG in regulations and regulations, raising great attention to the disclosure of non-financial information and performance of listed companies. Germany and Italy issued mandatory ESG envelope

regulations for large enterprises in 2016 and 2017, and required companies that did not comply with the regulations to make an explanation. As a country full of determination and leadership in dealing with climate change, France issued the ordinance no. 2017-1180 in 2017, requiring companies to disclose “the impact of company activities, services and products on climate change” in addition to reporting basic “environmental matters”. Promoted by the European Commission, the concept of “double materiality” has become one of the core concepts in the formulation of ESG envelope policies in many European countries, which means that a company should not only investigate the impact of a certain topic on its own development, operation, and market position, but also consider the external economic, social, and environmental impact of these issues. Hong Kong complies with similar requirements, but the mainland is still in the stage of voluntary carbon information disclosure. Therefore, it is of great significance to study the voluntary carbon information disclosure of Chinese enterprises from the perspective of stakeholder theory and legitimacy theory for the standardized development of carbon information disclosure.

Energy structure optimization through energy management and energy planning is important to achieve carbon emission reduction targets and social low-carbon transformation [10–13]. The Chinese government has formulated the “Energy Conservation and Low-Carbon Action Plan for Ten Thousand Enterprises” (ECLC), which requires industrial enterprises, transportation enterprises, commerce and trade enterprises, and other capacity and energy-consuming enterprises with comprehensive energy consumption of 10,000 tons of standard coal and above to establish sound energy management systems [14,15]. To manage energy conservation in 10,000 enterprises is an important support and guarantee for the government to achieve, with the binding targets set for a 16% reduction in energy consumption per unit of GDP and a 17% reduction in carbon dioxide emissions per unit of GDP from a broader perspective during the “Twelfth Five-Year” period [16].

The ECLC accelerates carbon data collection, statistics and monitoring, and other related work, which can promote enterprises’ voluntary carbon information disclosure [17]. Furthermore, the voluntary carbon information disclosure of enterprises is an effective supplement to carbon emission data monitoring, annual reports, and verification work at the national, provincial, and key emission industry levels; it also provides a data basis for carbon emission quota allocation and corporate performance (agreement), which will help continue to improve the basic statistical system of greenhouse gas emissions in the present situation of Chinese companies’ carbon disclosure far below the international advanced level in terms of average response rate and disclosure level [18–24]. Namely, only four companies (Huawei Technologies Co., Ltd., Shenzhen, China; Ping An Insurance Group Company of China, Ltd., Shenzhen, China; China Mobile, Beijing, China; and Fuyao Glass Industry Group Co., Ltd., Fuzhou, China) have reached the leadership level, compared to 145 US companies that have reached the leadership level [13]. Even mainland companies that are classified as carbon emission reporting companies or key emission control units only need to declare their greenhouse gas information on a specific platform on which only the government, the companies themselves, and verification agencies can obtain carbon emissions data [25–31]. At this stage, the “Social Responsibility Report” and “Environmental, Social and Governance Report” published by listed companies or stock exchanges in China have become the authoritative means for investors and the public to obtain corporate carbon information and judge corporate carbon performance [32]. In addition, corporate carbon information disclosure not only will promote corporate carbon emission reduction, facilitate firms’ innovation, productivity, and profitability but also can increase low-carbon awareness of leaders, enhance the green image of companies, and accelerate the transition to low-carbon finance with the far-reaching influence of research and application of global low-carbon target index, global low-carbon leadership index (market listed companies), low-carbon index, and Low Carbon 100 Europe Index [33–37]. Moreover, leaders’ low carbon awareness is essential for the effective management of carbon and climate change risk and also promotes soft low-carbon behaviors such as organizational structures or management systems improvements, which also prompt energy companies

to provide more thorough and meaningful climate risk information disclosure [38–43]. Therefore, the investigation of low-carbon awareness and energy management systems improvements is important for the in-depth understanding of voluntary carbon information disclosure and is conducive to the effective management of carbon and climate change risk as well as the realization of carbon emission reduction targets.

This study constructed the research framework for the factors influencing voluntary carbon information disclosure in two markets (A-share stock market and H-share primary market) to reveal the reasons for the low level of voluntary carbon information disclosure of listed companies in China from the perspective of management decision-making and the implementation perspective of voluntary carbon information disclosure based on stakeholders theory and legitimacy theory. The following questions are proposed: 1. Does enterprise leaders' low-carbon awareness affect voluntary carbon information disclosure? 2. Will the establishment of corporate energy management systems (corporate low-carbon actions) under the policy "Energy Conservation and Low-Carbon Action Plan for Ten Thousand Enterprises" promote the voluntary disclosure of corporate carbon information? 3. Does the major shareholder play a role in voluntary carbon information disclosure? 4. Does the proportion of state-owned shares play different roles (pioneer/promoting role or responsibility/restraining role) in voluntary carbon information disclosure in the A-share stock market and H-share primary market?

Studying the influencing mechanism of the voluntary carbon information disclosure of Chinese listed companies has important practical significance for the formulation of the information disclosure institution of public companies. Compared with the previous literature, the possible contributions of this study are as follows. Theoretically, an influencing factors model for the voluntary carbon information disclosure of public companies is constructed, which considers management decisions, specific corporate actions, and securities market information disclosure norms. Specifically, this study divides the factors that affect managers' carbon information disclosure decisions into leaders' low-carbon awareness, pressure from major shareholders and public expectations about state-owned shares. In addition, this study verifies that the government's energy-saving and low-carbon actions to force companies to build energy management systems contribute to the voluntary carbon information disclosure of companies in high-carbon industries, and that enterprise leaders' low-carbon awareness positively affects the voluntary carbon information disclosure of companies in low-carbon industries, which conform to legitimacy theory. Making better use of the synergistic effect of enterprise leaders' low-carbon awareness and low-carbon actions on voluntary carbon information disclosure will help the capital market to deepen the understanding of low-carbon development. Furthermore, the foresight and influence of large shareholders are well demonstrated in voluntary carbon information disclosure. The impact of large shareholders is more helpful for corporate carbon information disclosure when the power of large shareholders is more concentrated rather than decentralized, which is consistent with the stakeholder theory. Moreover, the voluntary information disclosure of state-owned shares is affected differently by the Hong Kong stock market and A-shares. Thus, the social responsibility of state-owned shares is accomplished, and their pioneer image is shaped in a low-carbon economy. In contrast, the proportion of state-owned shares in A-share public companies has a negative effect on voluntary carbon information disclosure, indicating that state-owned shares are more reluctant to show detailed corporate carbon information to the public. State-owned shares may be trying to take on a responsible role that social endows rather than pioneers in disclosure in A-share stock market. Improving the effective binding force of the market in state-owned enterprises' voluntary carbon information disclosure has promoted the standardization of the carbon information disclosure system, which will help state-owned shares to actively assume social responsibilities in voluntary carbon information disclosure.

2. Materials and Methods

2.1. Theories Related to Carbon Information Disclosure

In fact, voluntary carbon information disclosure is used more by investors since mandatory carbon information disclosure fails to provide investors with useful incremental information [44–48]. The voluntary information disclosure theory supports the fact that companies can show market participants more of their own low-carbon awareness, hard work, and other social responsibilities and corporate advantages over poor environmental performance through disclosing voluntary carbon information [49]. In addition, many Chinese listed companies have disclosed key carbon information such as sector carbon emissions or carbon emission reductions, which can help investors to evaluate the impact of carbon emissions on corporate business and financials. Moreover, the signal theory also opposes the widespread implementation of a mandatory disclosure system because the indiscriminate disclosure behavior of companies brought about by mandatory information disclosure reduces the usefulness of information and hinders the management's channel to transmit positive signals to the market [50]. This is also an important reason most countries still allow companies to choose to disclose their own carbon information.

The stakeholder theory explains the purpose and content of voluntary carbon information disclosure from the perspective of information demanders and contends that companies need to act responsibly toward investors, governments, and other stakeholders and provide them with true and unique environmental information to meet multiple conflicting demands [47,51,52]. Employees and consumers also demand corporate carbon information, but their influence on corporate carbon information disclosure decisions is far less than that of the government, managers/leaders, big shareholders, and important shareholder investors (creditors). Actually, corporate low-carbon awareness, corporate governance, state-owned shares (government ownership), and regulations for supporting corporate legal compliance development with industry carbon characteristics do affect voluntary carbon information disclosure [53–57]. Low-carbon awareness refers to a firm's attitude toward climate change, green development, and a low-carbon economy [58–61]. Sharma (2000) indicates that firms' strong awareness of environmental issues (carbon mitigation) promotes pro-environmental activities, such as the search for and adoption of innovative technologies, creative problem solving, and collaborative interactions with stakeholders [40,59,62,63]. In addition, low-carbon awareness could promote soft low-carbon behaviors, such as organizational structures or management systems improvements, which in turn may affect corporate voluntary carbon information disclosure [41,49,64,65].

The desire to legitimize an organization's operations is one of the many possible motivations for social and environmental disclosure [66]. The legitimacy theory is concerned with whether firms conform to society's expectations of them, expecting firms to legitimize their existence and the greenhouse gas emissions of their members by disclosing information about climate change issues [67,68]. Enterprises' carbon information disclosure not only conforms to the global carbon emission reduction situation, but also meets the expectations for the disclosure of corporate environmental information of China's securities and future market regulators. In addition, the information disclosure of the Ministry of Environmental Protection has also some positive impacts, such as improving the financial and environmental performance of companies, reducing financing costs, and establishing reputation for companies, by shaping a good corporate image [49,69]. Furthermore, the institutional theory focuses on the relationship between the environment and the organization, encouraging firms to incorporate institutional norms to achieve legitimacy from society's perspective [47,70]. The institutional theory promotes the development of corporate norms and reveals the possible impact of a regulated carbon information system and other related carbon activities on voluntary carbon information disclosure. Namely, industry regulation as well as media coverage and competitions led to an appreciation and financial slack level, as well as a social reputation that positively affects voluntary carbon information disclosure in public companies [71,72].

From the perspective of legitimacy and the relationship between the environment and the organization, the “Energy Conservation and Low-Carbon Actions for Ten Thousand Enterprises” requires enterprises that achieve a certain amount of emissions to establish a sound energy management system, strengthen energy measurement and statistics, and formulate energy-saving plans [16]. This is an extension of the overall energy management planning work at the national, regional, and industry levels and also a specific code of conduct for the main participants in low-carbon initiatives. Actions related to environmental, social, and governance (ESG) that conform to the corporate code of conduct for low-carbon activities are more critical in financial performance in the long term, which is beneficial to carbon information disclosure [73–75]. According to the scope and field of implementation, the establishment of energy management systems can improve the energy efficiency of regions (countries, suburbs, cities, etc.), energy systems, municipalities, buildings, transportation, and so on [76–80]. District energy planning assists in realizing a lower carbon target [10]. A lot of research is carried out on designing energy management systems to promote a grid-connected microgrid or isolated micro-grid and developing hybrid energy systems from the perspective of online approach, application of demand response, reduction of greenhouse gas emissions (such as hourly energy balance calculations of a year), energy utilization scheduling, and intelligent energy management controller [81–88].

In addition, existing studies have conducted a lot of in-depth research on the relationship between carbon performance and carbon information disclosure. However, firms might use the SEC disclosures to obscure their climate change performance and do greenwashing in mandatory disclosure [47]. The relationship between air pollution and corporate EID is significantly negative in heavily polluting industries with different environmental information transparency [89]. However, the significant association between disclosure scoring by the CDP and carbon performance is not found in 3192 company-year observations on the CDP list [90]. The unclear and complex relationship between carbon information disclosure and carbon performance is affected by multiple factors, such as corporate greenwashing intentions and the response of the capital market to disclosure.

The above literature review shows that previous studies only considered the decision-making role of managers (board characteristics, etc.) in carbon information, but they ignored leaders’ low-carbon awareness (speech), corporate low-carbon behaviors, and different market regulations that may promote the collection of carbon information and may have positive impact on voluntary carbon information disclosure.

2.2. Research Hypotheses

2.2.1. Leaders’ Low-Carbon Awareness and the Establishment of an Energy Management System

Mandatory disclosure of carbon emission information is costly and may lead to a price decrease and a decrease in profitability with reputation damaged in the current period, and the adverse impact of greenhouse gas emissions is compounded by the hit to the firm’s reputation for corporate social performance [91–93]. However, high-quality disclosure has a stronger effect on creating environmental reputation amongst executive and investor stakeholder groups, prompting corporate goodwill impairment reports to be more timely and evoking less negative market responses as well as positive externalities when corporate emission levels decrease [92–95]. From a management perspective, managers choose to disclose information for disclosure can improve managers’ continuation value by increasing their option value of withholding disclosure in the future [91]. Furthermore, CEO integrity enhances the positive impact of corporation social responsibility (CSR) disclosure on firm reputation significantly [96]. We tend to believe that leaders’ low-carbon speech in the CSR disclosure can represent leaders’ genuine intention rather than the personal actions of the report editor. This is good for the company’s reputation and helps in information disclosure. Moreover, the content of voluntary carbon information disclosure does not only include greenhouse gas emissions data, which leads to the conclusion that the disclosure of leaders’ low-carbon awareness is helpful to the voluntary carbon information disclosure

of enterprises. However, high-carbon industries face great pressure to disclose, and the impacts of air pollution on corporate EID also differ in enterprises located in regions with different environmental information transparency [89]. Environmental information disclosure in high-carbon industries may involve greenwashing issues, which make the link between leaders' low-carbon awareness and voluntary carbon information disclosure more complicated. In contrast, companies in low-carbon industries face less media pressure and social pressure when disclosing carbon information, and they need to weigh less or consider less option for carbon information disclosure and have more freedom of disclosure. Therefore, hypothesis 1 is proposed:

For companies in low-carbon industries, leaders' low-carbon awareness positively affects voluntary carbon information disclosure.

China's strategy for pollution reduction involves a mixture of top-down (central government to local governments) and bottom-up (environmental information disclosure) approaches, which all require the government as the main body of responsibility to set emission reduction targets and disclose heavy polluters' emission data and other environmental information [33]. Affected by regulation and legislation, higher emitters have higher levels of voluntary disclosures [97]. Public environmental appeal and firm-level governance factors, such as green production practices and substantive actions, are more important in deterring greenwashing than country factors. Moreover, green production practices and substantive actions (actual ESG activities, good implementation, and goal alignment) have also proved to be significantly positive and more critical in influencing firm reputation and environmental and financial performance in the long term in heavily polluting enterprises, which will in turn affect carbon information disclosure [73–75,98–101].

In China, there are many policies that encourage companies to implement environmental information disclosure. In contrast, there are very few targeted policies related to carbon information disclosure. "Energy-Saving and Low-Carbon Action Implementation Plan for Ten Thousand Enterprises" made an estimate of carbon emission reduction and put forward the requirements for establishing an energy management system for low-carbon development in enterprises. Moreover, it emphasizes the important link between energy management and carbon emissions, helps companies collect more carbon information, such as low-carbon efforts, and facilitates the compilation of carbon information reports, which is beneficial to system optimization and legitimacy. As a very important corporate specific low-carbon action, the establishment of a corporate energy management system can enhance the reputation of companies in high-carbon industries and improve corporate performance. Reputation, corporate performance, and the ease of collecting carbon information all contribute to carbon information disclosure [74,75]. Therefore, hypothesis 2 is proposed:

For companies in high-carbon industries, the establishment of an energy management system has a positive impact on voluntary carbon information disclosure.

2.2.2. Ownership Concentration

In addition, the agency relationship between the controlling and minority shareholders may also affect carbon information disclosure decisions due to the influence that large shareholders can have on managers [102,103]. Ownership concentration (shares over 5%) negatively affects corporate social responsibility, and this effect exists in the stage of rapid economic development but is not significant in a period with moderate economic growth, which is China's situation [104,105]. Ownership concentration as an endogenous response to the poor legal protection of investors and its negative impact on innovation are not obvious at low levels of the equity stake of the main shareholder [103,106,107]. Moreover, environmental regulations and corporate social responsibility are positively related to firm innovation because of the interactive role of ownership concentration [108]. In particular, ownership restriction, namely, the shareholding ratio of the top 10 major shareholders, has a positive effect on R&D since it helps to solve the agency problem between the controlling and minority shareholders [109]. Based on stakeholder theory, combining the positive

effects of corporate environmental performance, innovation, and carbon information disclosure, we propose that the negative effect of ownership concentration on carbon information disclosure may not be significant. Therefore, hypothesis 3 is proposed:

The higher the ownership concentration, the more voluntary carbon information companies will disclose.

2.2.3. State-Owned Shares in H-Share Company

The stock prices of Chinese capital markets and other emerging capital markets are more affected by market-level factors and have high stock price synchronization. Moreover, when ownership increases, synchronicity increases at an increasing rate, so it is difficult to reflect the company's fundamental information [110,111]. China has continuously promulgated and improved policies and regulations on corporate environmental information disclosure (systems) to mandate key pollutants to disclose environmental information and guide listed companies to disclose environmental information according to their own wish [112–116]. However, guidelines for the environmental information disclosure of listed companies do not provide detailed regulations on how to disclose environmental information content, which makes the environmental accounting information disclosure of Chinese enterprises lack reliability and relevance [117,118].

In contrast, Hong Kong Exchanges and Clearing Limited (HKEX) has a clear awareness of carbon emission reduction. After the Hong Kong Environmental Protection Department launched the Carbon Reduction Charter, HKEX pledged to support the reduction of greenhouse gas emissions [119]. Hong Kong Exchanges and Clearing officially issued the “Environmental, Social and Governance Reporting Guidelines (Revised Edition)”, which have a number of environmental indicators including greenhouse gas emissions and intensity included in the scope of “explain if you don't comply” on 21 December 2015 [120]. In total, 82 Hong Kong listed companies provided a total of 224 carbon footprint reports from 2011 to 2017. In order to alleviate the concerns and meet the information needs of regulators, investors, and other stakeholders for certain climate-related issues, the Hong Kong Stock Exchange offered guidance to issuers on how to provide a more decision-useful report (climate change-related impacts, climate-related financial disclosures) to investors by ESG reporting [121].

Since the carbon information disclosure systems (requirements) of the mainland stock market and the Hong Kong market are quite different, the image of state-owned shares in the two markets may have different emphasis. In terms of organizational legitimacy, or public stakeholders, State-owned enterprises should disclose more information in Hong Kong market. In order to attract high-quality investors, state-owned shares in the Hong Kong market need to abide by the emission disclosure system and create a compliant image. Furthermore, the improvement of environmental disclosure is related more to the greater political intervention enabled by the leadership shift and power consolidation during the anti-corruption campaign [122]. Meanwhile, disclosures made by industry peers induce firm disclosure, and peer effects are stronger when a firm's dependence on external financing is greater in capital markets [123]. Furthermore, disclosure saves central government controlled state-owned enterprises, which mandatorily disclose CSR information, from negative news reports and litigation risks [124]. At the same time, new media put pressure on companies to improve the quality of environmental information disclosure of state-owned shares [125,126]. Moreover, state ownership is associated with worse information asymmetry [127].

State-owned shares care more about their responsibility image maintained in the mainland market. The state's equity interest is positively correlated with Chinese state-owned enterprises' responsiveness to the Party's mandate [128]. However, the transparency policy exerts significant influences only on non-politically connected polluters other than state-owned enterprises, and the Chinese EID program has a greater impact on the corporate mitigation investment in non-state-owned shares [129]. Moreover, Zhang et al. showed that green behaviors in CSR impact corporate value negatively using a sample of 795 firms

in China over an eight-year period (2010–2017) [129]. Under the performance evaluation system for the economic value-added of state-owned assets, companies with state-owned shares may pay more attention to corporate value rather than performance, so they are less willing to disclose environmental information. Therefore, hypothesis 4 is proposed:

State-owned shares in an AH-share company have different effects on the voluntary carbon information disclosure compared to an A-share company.

2.2.4. Moderating Effect of Leaders' Low-Carbon Awareness on the Relationship between the Establishment of an Energy Management System and Voluntary Information Disclosure

Although the green credit policy and green credit development increase the debt financing cost of high-polluting and high-emission enterprises, the establishment of an energy management system helps leaders better understand corporate low-carbon behavior [130]. However, the establishment of an energy management system may indicate that companies perform a heavier task of reducing carbon emissions, which may give the public and investors a bad impression. Furthermore, investors react to the carbon disclosure announcements of firms working in carbon-intensive industries or the Dow Jones Sustainability Index (DJSI) announcements in a more significantly negative or indifferent way, and enterprises may also gain only limited benefits from sustainability activities [131,132]. Learning from disclosures is an active economic choice, and the complex impact of the integration cost (implications for firm value) of information disclosure on market outcomes will affect the management's disclosure strategy [133]. Under various external pressures, most heavily polluting enterprises choose conservative environmental behavior [134]. However, the pressure to establish a positive representation in the environment may decouple the appearance of conservative environmental behavior from actual activities [135]. Since investors may not pay attention to green actions, leaders' low-carbon awareness disclosure is only a formality and cannot promote the link between low-carbon actions and voluntary carbon information disclosure. Moreover, from the perspective of government environmental control, companies that have reached a certain carbon emission intensity are required to report corporate carbon emissions. However, this mandatory report is opaque to investors and the public. With the premise of compliance, leaders' low-carbon awareness in high-carbon industries promotes their tendency to disclose less carbon information to balance the increase in financing costs and reputation that may be brought about by the disclosure of carbon information. Therefore, hypothesis 5 is proposed:

For companies in high-carbon industries, leaders' low-carbon awareness disclosure has a negative moderating effect on the relationship between the establishment of an energy management system and voluntary information disclosure.

The market response to goodwill impairments is more negative for firms with low disclosure quality as evidenced in a sample of UK listed firms [95]. In addition, information asymmetry reduction resulting from high-quality CSR disclosure reduces AH-share premium [136]. The cross-listing status can also dissuade firms from engaging in greenwashing [137]. Chinese enterprises are developing from a long power distance to a short power distance, forming a modern corporate system. A U-shape relationship exists between power distance and green proactivity [138]. The joint effect of leaders' low-carbon awareness and the establishment of an energy management system (green proactivity) will facilitate voluntary carbon information disclosure. Therefore, hypothesis 6 is proposed:

For listed companies with AH shares, leaders' low-carbon awareness has a positive moderating effect on the relationship between the establishment of an energy management system and voluntary carbon information disclosure.

2.3. Research Methodology

Sample Selection

This study selected China's A-share main board listed companies as the research objects and collected carbon information disclosure data from the 2009–2017 social responsibility reports, sustainability reports, and environmental, social, and governance reports

published by companies or stock exchanges. The sample in this research covers the reports that disclose information about carbon emissions and carbon emission reductions, including electricity, heat production and supply, manufacturing, mining, and financial industries. If the report contains only non-numerical carbon information or some carbon information that cannot represent the company's carbon performance, it will not be considered as the sample for this study. For example, only disclosing the amount of coal savings without disclosing the corresponding carbon emission reductions indicates that the company has not tried to use carbon data as the key to disclosure; thus, it is not used as our final research sample. The sample size is 244, involving 26 industries (Industrial classification for 97 national economic activities) and most high-carbon industries in this study.

With reference to Liu's classification of carbon-intensive industries, the production and supply of electric power and heat power, smelting and pressing of ferrous metals, non-metallic mineral products industry, coal mining and washing industry, chemical raw materials and chemical products manufacturing, smelting and pressing of non-ferrous metals, and gas production and supply industry are defined as high-carbon-intensive industries. In the sample, companies in high-carbon-intensive industries account for 47.54%, as shown in Table 1. Production and supply of electric power and heat power enterprises have the highest proportion (21.48%). The proportion of computers, communications, and other electronic equipment manufacturing companies in low-carbon-intensive industries is 10.94%. About two-thirds of the listed companies in the oil and natural gas extraction industry have disclosed carbon information, while less than one-third of the listed companies in the gas production and supply as well as the electric power and heat power production and supply industries, plus less than one-third of ferrous metal ores processing companies, have disclosed carbon information. Judging from the type of carbon performance disclosed (carbon emission reduction data or carbon emission data), the number that disclosed corporate carbon emission reduction performance is 148, which exceeds the carbon emission performance sample (96). Companies may prefer to disclose data on carbon emission reduction performance rather than carbon emissions.

Table 1. Sample distribution.

CI Code	Sector	Frequency	Percentage (%)	Cum. (%)
Panel A: Distribution by industry				
1	Production and supply of electric power and heat power	55	22.54	22.54
1	Non-metallic mineral products industry	23	9.43	31.97
1	Gas production and supply industry	12	4.92	36.89
1	Coal mining and washing industry	11	4.51	41.40
1	Manufacturing raw chemical materials and chemical products	10	4.10	45.50
1	Other high-carbon industries	5	2.05	47.54
0	Computer, communications, and other electronic equipment manufacturing	28	11.48	59.02
0	Financial industry	21	8.61	67.62
0	Manufacturing general machinery	13	5.33	72.95
0	Car industry	12	4.92	77.87
0	Manufacturing electrical machinery and equipment	11	4.51	82.38
0	Manufacturing medicines	8	3.28	85.66
0	Special purpose equipment	5	2.05	87.70
0	Petroleum and natural gas extraction	6	2.46	90.16
0	Mining and processing of non-ferrous metal ores	5	2.05	92.21
0	Other low-carbon industries	19	7.79	100.00
	Total	244	100	

1, 0 represent high-carbon industries and low-carbon industries, respectively.

2.4. Research Model

In order to solve the problem of missing variables, this study fully considers the cross-section, time series, and individual characteristics and uses the panel data model to perform

regression. We use Equations (1) and (2) to measure carbon disclosure in year t and examine the impact of leaders' low-carbon awareness, establishment of an energy management system, ownership concentration, and state-owned shares on carbon information disclosure. Furthermore, using Equations (3) and (4), we examine the moderating effect of leaders' low-carbon awareness on the relationship between energy management systems and voluntary carbon information disclosure.

$$CID = \alpha_0 + \alpha_1 LAD + \alpha_2 EEM + \alpha_3 LOWN + \alpha_4 STATESR + \alpha_5 SIZE + \alpha_6 SALE + \alpha_7 ROA + \alpha_8 LPSR + \alpha_9 Industry\ dummy + v_i + \varepsilon_{it} \quad (1)$$

$$CID = \alpha_0 + \alpha_1 LAD + \alpha_2 EEM + \alpha_3 LOWN + \alpha_4 STATESR + \alpha_5 SIZE + \alpha_6 SALE + \alpha_7 ROA + \alpha_8 LPSR + \alpha_9 Hshares\ dummy + v_i + \varepsilon_{it} \quad (2)$$

$$CID = \alpha_0 + \alpha_1 LAD + \alpha_2 EEM + \alpha_3 LAD * EEM + \alpha_4 LOWN + \alpha_5 STATESR + \alpha_6 SIZE + \alpha_7 SALE + \alpha_8 ROA + \alpha_9 LPSR + \alpha_{10} Industry\ dummy + v_i + \varepsilon_{it} \quad (3)$$

$$CID = \alpha_0 + \alpha_1 LAD + \alpha_2 EEM + \alpha_3 LAD * EEM + \alpha_4 LOWN + \alpha_5 STATESR + \alpha_6 SIZE + \alpha_7 SALE + \alpha_8 ROA + \alpha_9 LPSR + \alpha_{11} Hshares\ dummy + v_i + \varepsilon_{it} \quad (4)$$

2.5. Variables

2.5.1. Dependent Variable: Voluntary Carbon Information Disclosure

Voluntary carbon information disclosure (CID) means that companies use social responsibility reports; environmental, social, and governance reports; and other media to show the public the amount of corporate carbon emissions, carbon emission reductions, climate change risks, and other carbon reduction efforts they want to disclose. When designing the carbon information disclosure items, this study used the content of the CDP questionnaire for reference and retrospectively revised the designed carbon information disclosure items based on the description of the carbon information in the social responsibility report issued by China's listed companies. We identified 62 carbon information disclosure items, as shown in Table 2. The carbon information items include corporate carbon emission data, carbon emission calculation methods, the substantial impact of climate-related risks or opportunities on the company, internal corporate carbon management, and corporate external carbon management, so the items in this study are more comprehensive than those in previous studies. The more disclosed carbon information there is, the more helpful it is for investors to analyze the company's carbon situation in a comprehensive manner. As carbon emission reduction information disclosure becomes an important worldwide accounting management activity, it will be less difficult for investors to discover the climate risks and opportunities hidden in assets. We take the number of carbon information items disclosed in the company's report as the number of carbon information disclosure items (CID). Taking into account the importance and comparability of carbon information, we assigned values to different types of carbon information. Each item of currency, quantity, and qualitative description of carbon information will get three points, two points, and one point, respectively, which are summarized into carbon information disclosure points (CID1).

2.5.2. Independent Variables

Leaders' low-carbon awareness (LLC) includes leaders' low-carbon values, low-carbon commitments, low-carbon performance, and future prospects for low-carbon development. In this study, leaders' low-carbon awareness is measured by whether leaders' speeches involve carbon emission reduction, carbon goals, low-carbon efforts, and so on in the social responsibility report and environmental, social, and governance reports. This study assigns LLC to 1 if there is mention about leaders' low-carbon values, low-carbon commitments, low-carbon performance, and future prospects for low-carbon development in leaders' speeches in CSR and set LLC to 0 if there is no mention.

Table 2. Carbon information disclosure items.

Carbon Information Disclosure Items	Type
Total carbon emissions	Numerical
Carbon emissions of business sectors	
Direct emissions	
Indirect emissions	
Other emissions	
Carbon emissions of production	
Carbon reduction	
Carbon reduction of business sectors	
China certified emission reduction	
Estimated carbon reduction	Qualitative
Disclosing carbon data for more than one fiscal year at the same time	
Methods or standards for calculating carbon emissions and carbon emission targets	
Explanation of the calculation method or scope changed or not changed	
Assurance of carbon emission data	
Note that carbon emissions are not included	Currency
(Unit) Production value carbon emissions	
Revenue from low-carbon products for the reporting year	
The cost of carbon emissions included in the capital expenditure plan	
Low carbon investment amount	
Completed emission reduction	Qualitative
Assessment and description of the impact of climate change risks on financial and business opportunities	
Identification of risks or opportunities related to climate change that may have a substantially financial or strategic impact on the business	
Risks occurred in the value chain risk/types of risk	
Climate change mentioned in the leader's speech or foreword and outlook	
A low-carbon transfer plan that supports long-term business strategies	
Integration of climate-related issues into business goals and strategies	
Emission reduction target	Numerical
Scope 1 emission reduction target	
Scope 2 emission reduction target	
Analyzing the business strategy in the report by applying climate-related scenarios	
CO ₂ emission reductions due to clean energy power generation	
CO ₂ emission reductions caused by equipment modification and elimination of production capacity	Qualitative
Greenhouse gas emission reductions avoided by using waste incineration power generation equipment	
Carbon reduction brought by low-carbon office	
Carbon emissions from travel, etc.	
Green and low-carbon office measures	Qualitative
Special budget for low-carbon product research and development	
Cooperation with the government to formulate policies or standards	
Technical cooperation with universities, etc.	
Investment maturity-academic theoretical research/applied research and development/pilot demonstration/commercial scale/small-scale commercial deployment/large-scale commercial deployment	
The committee or another implementing agency that has overall responsibility for actions related to climate change and its basis	
Establishment of an energy management system	
Multidisciplinary company-wide risk	
Specific climate change risks	

Table 2. Cont.

Carbon Information Disclosure Items	Type
Description of the frequency of carbon risk monitoring and duration of the risk Review and guide strategy, frequency of reporting climate-related issues to the board	Numerical
Carbon asset management committee Measures for carbon asset management Beneficiaries of energy conservation and emission reduction actions Incentive type Incentive carbon reduction activities A business or activity regulated by a carbon pricing system Clean development mechanism projects	Qualitative
Carbon quota Initiate or purchase any project-based carbon credits	Numerical
Carbon trading volume	Currency
A dedicated carbon trading department or subsidiary Attention to climate-related issues in value chain Climate-related strategies with customers/partners Products or services rated as low-carbon or green The basis used to classify products as low-carbon products	Qualitative
Carbon emissions avoided by low-carbon products, product carbon storage, and carbon sinks	Numerical

The establishment of an enterprise energy management system (EME) refers to the specific behavior of an enterprise to construct an enterprise energy management system under the guidance of “Energy-Saving and Low-Carbon Action Implementation Plan for Ten Thousand Enterprises”. This variable is a dummy variable set to 1 if it is established and 0 if it is not established.

Our primary measure of ownership concentration is the percentage of the total equity owned by the largest shareholder and 10 largest shareholders. Although beyond the five largest shareholders the ownership structures become rather dispersed, we believe that although decision-making is in the hands of minority shareholders, the proportion of the top 10 shareholders’ equity will have a certain rational impact on the top 5 shareholders [105,139].

State-owned shares refer to the state-owned shares of an enterprise. Chinese state-owned shares/enterprises are an important corporate form in China and are responsible for the effective management control of multi-task objectives, such as carbon mitigation and carrying out the political task of serving and repaying the society [140]. Under the constraints of climate policies, SOEs acquire additional credit resources [141]. Moreover, the existence of a party committee could reduce the overinvestment problem of listed large SOEs, and the monitoring effect of the party committee is more pronounced when the CEO is a party member [142]. With the state involved in ownership, enterprises may have an enhanced governance effect and have the advantage of mitigating agency problems [143].

2.5.3. Control Variables

We use the following control variables: company size measured by total assets, liability, profitability (ROA and Sales), and legal persons shares (LPSR). Industry and year effects are also controlled for. All the variables in this study are shown in Table 3.

Environmental information disclosure positively (directly) affects financial performance [144]. Firm size mitigates the positive impact of CSR disclosure on firm performance [145]. In this study, considering the company’s performance in terms of company size and profitability, operating income, assets, liabilities, and ROA are selected as control variables. In terms of corporate control and ownership concentration, we select the propor-

tion of legal person shares and the five largest shareholders (5LOWN) as the corresponding control variables [139].

Table 3. Variables.

Variables	Proxy Variables	Symbol	Description
Voluntary carbon Information disclosure	Carbon information Disclosure items	CID	Information about the amount of corporate carbon emissions, carbon emission reductions, climate change risks and so on
	Carbon information disclosure points	CID1	
Leaders' low-carbon awareness		LLC	
The establishment of an enterprise energy management system		EEM	
Ownership concentration	Ownership concentration 1	1LOWN	The shareholding ratio of the first largest shareholder
	Ownership concentration 10	10LOWN	The sum of the shares held by the top 10 shareholders
State-owned shares		STATESR	
Control variables	SIZE- Asset	Asset	
	SIZE-Liability	Liability	
	Operating income	SALE	
	Return on assets	ROA	
	Ownership concentration 5	5LOWN	The sum of the shareholding ratios of the top five shareholders
	Corporate shares' proportion	LPSR	Corporate shares/the total number of shares multiplied by 100%
	Carbon-intensive industries	Industry dummy	
	AH cross-listing	H-shares dummy	

The Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE) constitute the A-share market. A-shares are common stocks issued by domestic companies for domestic institutions, organizations, or individuals (excluding investors from Taiwan, Hong Kong, and Macao) to subscribe and trade in RMB. Retail investors in the A-share market still account for a large proportion. Chinese cross-listing AH-shares are stocks approved by the China Securities Regulatory Commission, registered in the mainland and listed on the Hong Kong market for foreign investors to subscribe and trade. Different from the mainland's self-contained system and relatively closed operation, international funds can enter and exit freely, transactions are very active, international correlation is high, and fluctuations are large in the Hong Kong Stock Exchange (HKEX) [146]. H-share prices seem to move more consistently with foreign media coverage [147]. Chinese A- and H-share markets operate in different institutional environments, and corporate governance is found

to be important in determining the A-H share premium [148]. A-share and AH-share companies are listed in different markets, and their carbon information disclosure behavior may also be significantly different.

3. Results

3.1. Descriptive Results

Table 4 reports the key descriptive data of the sample. The number of carbon information disclosure items and the average of carbon information disclosure scores are 6.141 and 8.667, respectively. The averages of leaders' low-carbon awareness and energy management system establishment are 0.184 and 0.295, respectively, showing a low trend. The shareholding ratio of the largest shareholder is between 7.84% and 99%, and the shareholding ratio of the top 10 shareholders is between 31.6% and 100%. The averages of the shareholding ratio of the largest shareholder, the top five shareholders, and the top 10 shareholders are 44.1%, 64.9%, and 68.6%, respectively, reflecting the shareholding advantage of the largest shareholder. The highest proportions of A-shares and H-shares in the sample tradable reached 100% and 96.2%, respectively.

Table 4. Descriptive analysis of the complete sample (N = 244).

Variable	Mean	Standard Deviation	Min	Max	Percentile (25)	Percentile (75)
CID	6.141	3.669	1	21	1	16
CID1	8.677	0.328	1	30	2	23
LLC	0.184	0.389	0	1	0	1
EEM	0.295	0.457	0	1	0	1
1LOWN	0.441	0.187	0.0784	0.99	0.301	0.549
5LOWN	0.649	0.181	0.241	1.000	0.508	0.785
10LOWN	0.686	0.169	0.316	1.000	0.562	0.822
STATESR	0.090	0.185	0	0.771	0	0.071
Sale (billion)	74.69	256.830	0.367	2825.91	6.362	55.26
ROA	4.129	4.590	−20.021	21.578	1.507	6.529
Asset (billion)	461.687	2155.801	1.819	22124.4	9.989	156.23
Liability (billion)	394.146	1995.636	0.501	20300	5.531	100.756
LPSR	0.045	0.130	0	0.902	0	0.018

In terms of different industries, the carbon information disclosure score (7.052) of enterprises in high-carbon-intensive industries is lower than that of enterprises in low-carbon-intensive industries (10.343), as shown in Table 5.

In low-carbon industries, the number of carbon information disclosure items in the computer, communications, and other electronic equipment manufacturing industries is 8.28, which is higher than the number of carbon information disclosure items in high-carbon industries. On a yearly basis, the average carbon information disclosure score in 2017 was the largest, and the carbon information disclosure scores in 2009 and 2010 were also relatively high. Leaders' low-carbon awareness in the electricity, heat production and supply, coal mining, and washing industries (0.364) is high, while there are established energy management systems for general equipment manufacturing (0.667), electrical machinery and equipment manufacturing (0.545), pharmaceutical manufacturing (0.571), and power and heat production and supply (0.327).

3.2. Correlation Analysis

Carbon information disclosure is significantly correlated with other variables at the 0.05 level, except for ROA, as shown in Table 6. Leaders' low-carbon awareness is significantly related to the establishment of an energy management system, ownership concentration, state-owned shares, and operating income.

Table 5. Descriptive analysis by sector and year.

Sector	D44	C30	D45	B06	C26	C39	C34	C38	C27	
Panel A: Descriptive analysis by sector										
CID	5.418	3.391	4.417	7.091	3.1	8.28	7.167	6.636	6.429	
CID1	7.945	5.478	6.667	9.27	4.7	11.6	9.75	8.455	8	
LLC	0.345	0	0.25	0.364	0.2	0.08	0	0.182	0.143	
EEM	0.327	0.087	0	0.364	0	0	0.667	0.545	0.571	
1LOWN	0.534	0.355	0.474	0.651	0.487	0.0458	0.422	0.233	0.414	
5LOWN	0.68	0.62	0.79	0.858	0.58	0.602	0.614	0.438	0.576	
10LOWN	0.714	0.654	0.809	0.871	0.621	0.653	0.636	0.488	0.612	
STATESR	0.188	0.006	0.191	0.062	0.005	0.013	0.029	0.01	0.052	
Sale	221.983	221.765	67.180	1559.072	81.787	191.415	360.820	767.889	116.277	
ROA	3.616	4.164	4.624	4.579	5.037	3.524	2.131	7.812	9.032	
Asset	1050.177	444.939	122.334	3385.082	107.884	252.027	772.745	989.101	249.231	
Liability	70.620	19.437	6.692	129.147	3.705	15.719	53.651	70.787	10.414	
LPSR	0.02	0.043	0.084	0.005	0.062	0.168	0.031	0.022	0.029	
Variable	2017		2016		2015		2011		2010	2009
Panel B: Descriptive analysis by year										
CID	7.118		6.326		5.079		4.615		6	7
CID1	10.662		9.130		7.474		6.385		8.375	8.5
LLC	0.162		0.217		0.189		0.154		0.375	0
EEM	0.324		0.217		0.270		0.231		0.25	0.5
1LOWN	0.404		0.415		0.446		0.459		0.557	0.301
5LOWN	0.664		0.630		0.645		0.664		0.649	0.460
10LOWN	0.709		0.676		0.679		0.696		0.675	0.522
STATESR	0.061		0.008		0.136		0.124		0.185	0
Sale	1232.064		585.371		379.847		263.589		177.625	247.238
ROA	4.156		3.647		2.937		5.451		4.260	6.659
Asset	10,963.26		3648.483		2453.912		414.435		493.428	366.012
Liability	981.103		307.904		204.624		23.830		33.657	27.416
LPSR	0.038		0.005		0.003		0.005		0.058	0

Note: According to “Guidelines for Industry Classification of Listed Companies” issued by the China Securities Regulatory Commission, D44 represents electricity and heat production and supply industry, C30 represents nonmetal mineral products, D45 represents Gas production and supply, B06 represents coal mining and dressing, and C26, C39, C34, C38, and C27 represent, respectively, raw chemical materials and chemical products manufacturing, computers, communications, and other electronic equipment manufacturing, ordinary machinery manufacturing, electrical machinery and equipment manufacture, and pharmaceuticals [149].

The establishment of an energy management system is significantly related to the sum of the shares held by the top 10 shareholders and state-owned shares. Ownership concentration (the sum of the previous 10 largest shareholders’ share ratios as an example) is significantly related to state-owned shares, operating income, assets, liabilities, and corporate shares.

3.3. Multivariate Analysis

This study used STATA software to regress the panel data model and cross-sectional time-series Feasible Generalized Least Squares (FGLS) regression to make corresponding revisions to solve heteroscedasticity problems. Multiple linear tests showed that assets and liabilities are linear, and that the top 5 shares and the top 10 shares are linear. The new variables asset-liability ratio (Lia) replaces assets and liabilities, and OC510 (top five shares out of the top 10 shares) replaces the top 10 shares. In addition, the mean vif in the low carbon sample is 1.99, as shown in the Table 7.

Table 6. Correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
(1) CID	1												
(2) CID1	0.961 ***	1											
(3) LLC	0.233 ***	0.163 **	1										
(4) EEM	0.24 ***	0.124 *	0.318 ***	1									
(5) 1LOWN	0.204 ***	0.174 ***	0.223 ***	−0.03	1								
(6) 5LOWN	0.262 ***	0.26 ***	0.206 ***	−0.095	0.759 ***	1							
(7) 10LOWN	0.299 ***	0.3 ***	0.204 ***	−0.109 *	0.716 ***	0.988 ***	1						
(8) STATESR	−0.154 **	−0.192 ***	0.132 **	0.211 ***	0.295 ***	0.227 ***	0.226 ***	1					
(9) SALE	0.253 ***	0.294 ***	0.155 **	−0.047	0.144 **	0.207 ***	0.213 ***	−0.101	1				
(10) ROA	0.061	0.001	0.011	0.101	0.058	0.032	0.024	−0.109 *	0.017	1			
(11) Asset	0.256 ***	0.337 ***	−0.058	−0.102	0.046	0.198 ***	0.212 ***	−0.074	0.309 ***	−0.106 *	1		
(12) Liability	0.247 ***	0.328 ***	−0.065	−0.103	0.035	0.187 ***	0.2 ***	−0.073	0.279 ***	−0.113 *	0.999 ***	1	
(13) LPSR	0.148 **	0.134 **	0.03	−0.099	0.237 ***	0.179 ***	0.193 ***	0.018	−0.072	0.066	−0.068	−0.065	1

* indicates that the Sig value is less than 0.1, ** indicates that the Sig value is less than 0.05, and *** indicates that the Sig value is less than 0.001.

Table 7. VIF.

Variable	VIF	1/VIF
1LOWN	3.79	0.263761
5LOWN	3.51	0.284918
OC510	2.66	0.376314
ROA	1.57	0.635064
LPSR	1.52	0.656306
Lia	1.51	0.663675
EEM	1.41	0.708981
STATESR	1.31	0.765582
LLC	1.30	0.771464
SALE	1.30	0.771773
Mean VIF	1.99	

The regression of the fixed-effects model for leaders' low-carbon awareness in low-carbon industries and carbon information disclosure shows that $F(10,57) = 5.89$ and $p = 0.0000$, and the sequence is stable. The result of the F test is $F(60, 57) = 4.64$ and $p = 0.0000$, indicating that the fixed-effects model is significant. The random-effects model is established, and Wald $\chi^2(10) = 24.60$ and $p = 0.0062$. In the Breusch and Pagan Lagrange multiplier test for random effects (BreuschP), $\chi^2(10) = 17.20$ and $p = 0.0000$. The result of Hausman test is $\chi^2(9) = 93.83$ and $p = 0.0000$, and the hypothesis that fixed effects are more appropriate is accepted (see Table 8). After performing the heteroscedasticity test and cross-sectional time-series FGLS regression (to modify heteroscedasticity), it was found that leaders' low-carbon awareness positively affects carbon information disclosure, with a coefficient of 0.752, which is significant at the 0.05 level. Thus, Hypothesis 1 is verified.

Similarly, the establishment of an energy management system for enterprises in high-carbon industries has a positive impact on carbon information disclosure, with a coefficient of 2.546, which is significant at the 0.01 level. Thus, Hypothesis 2 is verified. The shareholding ratios of the largest shareholder and the top 5 shareholders play a role in promoting voluntary carbon information disclosure. Therefore, Hypothesis 3 is verified. The proportion of state-owned shares of listed companies that issue AH shares has a positive impact on voluntary carbon information disclosure, with a coefficient of 0.024, which is significant at the 0.01 level. In addition, the regression results are opposite in samples other than AH-shares samples. Thus, Hypothesis 4 is verified.

This study uses Models 3 and 4 to test Hypotheses 5 and 6. Considering that the moderating variables in this study are category variables, there is no need for decentralization of moderating variables. The regression results show that leaders' low-carbon awareness of high-carbon industries or low-carbon industries has no moderating effect on the relationship between the establishment of an energy management system and voluntary carbon information disclosure, as shown in Table 9. Therefore, Hypothesis 5 is not verified. In addition, leaders' low-carbon awareness in enterprises with AH shares has a positive regulatory effect on the relationship between the establishment of an energy management system and voluntary carbon information disclosure. The coefficient of $LLC \times EEM$ is 3.981, which is significant at the 0.01 level. Thus, Hypothesis 6 is verified.

3.4. Robustness Test

First, we take the carbon information disclosure score as another proxy variable for the dependent variable in robustness testing. The results show that the coefficients of leaders' low-carbon awareness, the establishment of an energy management system are 1.317 and 2.623, respectively, which are significant at the 0.05 level, as shown in Table 10. The higher the ownership concentration is, the more the carbon information is disclosed. The more the state-owned shares in A-share companies are, the less the carbon information is disclosed by companies. The moderating effect test results show that $LLC \times EEM$ is a significant factor, and the coefficients are 6.562 for H-share samples, as shown in Table 11. The results of the

robustness test of the main effect and the moderating effect are consistent with the original regression results.

Table 8. Hypothesis testing.

Variables	Model 1 (Low-Carbon Industries)	Model 1 (High-Carbon Industries)	Model 2 (A-Shares)	Model 2 (AH-Shares)
LLC	0.752 ** (2.05)	1.023 ** (2.48)	0.420 ** (2.07)	1.887 *** (6.90)
EEM	1.329 *** (3.86)	2.546 *** (5.27)	3.168 *** (11.43)	2.147 *** (6.03)
1LOWN	6.820 *** (5.62)	3.278 ** (2.04)	5.620 *** (7.02)	7.698 *** (6.82)
5LOWN	6.422 *** (5.56)	6.685 *** (3.64)	3.983 *** (3.43)	4.311 ** (2.03)
OC510	−21.084 *** (−6.12)	−33.785 *** (−5.77)	−20.871 *** (−6.54)	−23.512 *** (−4.67)
STATESR	−0.029 ** (−2.23)	−0.042 *** (−4.43)	−0.054 *** (−9.20)	0.024 *** (2.92)
SALE	1.16×10^{-6} * (1.86)	1.00×10^{-5} (4.43)	2.25×10^{-5} (1.45)	4.21×10^{-7} (0.70)
Lia	2.152 * (1.93)	2.436 * (1.89)	1.943 ** (2.23)	2.729 * (1.80)
ROA	0.024 (0.58)	−0.058 (−1.23)	0.065 ** (2.18)	−0.216 *** (−3.17)
LPSR	0.028 (1.63)	−0.026 (−1.24)	0.029 ** (2.35)	−0.103 ** (−2.31)
C	17.809 *** (5.99)	29.013 *** (5.36)	17.711 *** (6.69)	1.50 *** (5.15)
Obs	128	116	160	84
F	—	—	2.44 **	—
BreuschP	17.20 ***	0.00	29.09 ***	8.83 ***
Hausman	93.83 ***	3.88	24.46 ***	13.77
FGLS	380.95 ***	218.72 ***	8690.91 ***	8999.03 ***
Model	Fixed-effects model	Random-effects model	Fixed-effects model	Random-effects model

* indicates that the Sig value is less than 0.1, ** indicates that the Sig value is less than 0.05, and *** indicates that the Sig value is less than 0.001.

Table 9. Moderating effect model.

Variables	Model 3 (Low-Carbon Industries)	Model 3 (High-Carbon Industries)	Model 4 (A-Shares)	Model 4 (AH-Shares)
LLC	−0.729 (−0.56)	0.676 (1.32)	0.372 (1.02)	−0.760 (−0.54)
EME	1.183 *** (3.26)	2.165 *** (3.67)	2.916 *** (7.84)	1.1 (1.58)
LLC*EEM	1.650 (1.18)	1.080 (1.19)	0.239 (0.45)	3.981 ** (2.43)
1LOWN	6.760 *** (5.61)	3.007 * (1.89)	5.874 *** (6.96)	8.64 *** (2.76)
5LOWN	6.373 *** (5.48)	7.02 *** (3.84)	3.306 *** (2.59)	5.936 * (1.78)

Table 9. Cont.

Variables	Model 3 (Low-Carbon Industries)	Model 3 (High-Carbon Industries)	Model 4 (A-Shares)	Model 4 (AH-Shares)
510	−20.845 *** (−6.09)	−33.047 *** (−5.80)	−20.621 *** (−6.34)	−33.834 *** (−4.63)
STATESR	−0.02 ** (−2.20)	−0.040 *** (−4.06)	−0.051 *** (−8.32)	0.025 (1.05)
SALE	1.40×10^{-6} ** (2.18)	1.61×10^{-5} (4.53)	2.66×10^{-6} * (1.65)	1.20×10^{-6} (1.46)
Lia	1.874 (1.64)	2.20 * (1.72)	1.749 * (1.78)	1.284 (0.57)
ROA	0.025 (0.58)	−0.061 (−1.29)	0.071 ** (2.35)	−0.238 *** (−3.02)
LPSR	0.027 (1.55)	−0.029 (−1.53)	0.024 * (1.83)	−0.054 (−0.83)
C	17.847 *** (6.03)	28.369 *** (5.38)	17.840 (6.61)	30.854 *** (4.68)
Obs	128	116	160	84
F	5.26 ***	-	2.20 **	-
BreuschP	17.28 ***	0.00	27.20 ***	0.00
Hausman	54.34 ***	5.40	22.98 **	8.13
FGLS	412.10 ***	226.95 ***	1103.72 ***	112.61 ***
Model	Fixed-effects model	Random-effects model	Fixed-effects model	Random-effects model

* indicates that the Sig value is less than 0.1, ** indicates that the Sig value is less than 0.05, and *** indicates that the Sig value is less than 0.001.

Table 10. Hypothesis testing with a new measurement for the dependent variable.

Variables	Model 1 (Low-Carbon Industries)	Model 1 (High-Carbon Industries)	Model 2 (A-Shares)	Model 2 (AH-Shares)
LLC	1.317 ** (2.20)	1.146 * (1.91)	0.005 (0.01)	1.708 (1.26)
EEM	0.391 (0.75)	2.623 *** (3.68)	3.300 *** (7.75)	0.673 (0.66)
1LOWN	7.911 *** (3.53)	4.412 * (1.80)	7.927 *** (7.21)	7.152 (1.53)
510	−35.739 *** (−5.66)	−34.014 *** (−3.51)	−17.824 *** (−3.60)	−39.549 *** (−3.62)
STATESR	−0.037 ** (−2.01)	−0.064 *** (−4.72)	−0.073 *** (−8.34)	0.01 (0.51)
SALE	6.43×10^{-7} (0.62)	1.97×10^{-5} (3.73)	2.48×10^{-6} (1.11)	1.44×10^{-6} (1.37)
Lia	7.026 *** (4.32)	5.164 *** (2.61)	2.938 ** (2.33)	6.884 ** (2.00)
ROA	0.055 (0.94)	−0.003 (−0.05)	0.084 ** (2.23)	−0.264 ** (−2.03)

Table 10. Cont.

Variables	Model 1 (Low-Carbon Industries)	Model 1 (High-Carbon Industries)	Model 2 (A-Shares)	Model 2 (AH-Shares)
5LOWN	14.736 *** (6.56)	4.575 * (1.68)	3.214 * (1.75)	8.386 * (1.70)
LPSR	−0.005 (−0.16)	−0.033 (−1.02)	−0.003 (−0.12)	−0.08 (−0.89)
C	25.902 *** (4.91)	30.68 6 *** (3.46)	15.912 *** (3.85)	35.663 *** (3.60)
Obs	128	116	160	84
F	4.50 ***	-	2.11 **	-
BreuschP	18.21 ***	0.00	26.17 ***	0.00
Hausman test	53.25 ***	5.08	20.36 **	7.87
FGLS	283.94 ***	133.29 ***	542.80 ***	85.93 ***
Statistical models	Fixed-effects model	Random-effects model	Fixed-effects model	Random-effects model

* indicates that the Sig value is less than 0.1, ** indicates that the Sig value is less than 0.05, and *** indicates that the Sig value is less than 0.001.

Table 11. Moderating effect model with a new measurement for the dependent variable.

Variables	Model 3 (High-Carbon Industries)	Model 3 (Low-Carbon Industries)	Model 4 (A-Shares)	Model 4 (AH-Shares)
LLC	0.615 (0.82)	−0.425 (−0.37)	−0.105 (−0.19)	−2.331 (−1.16)
EEM	2.094 ** (2.48)	0.072 (0.13)	3.180 *** (6.61)	−0.431 (−0.40)
LLC*EEM	1.687 (1.27)	2.310 * (1.70)	0.327 (0.38)	6.562 *** (2.73)
1LOWN	3.800 (1.54)	8.602 *** (3.76)	8.099 *** (7.30)	7.615 * (1.69)
510	−32.644 *** (−3.39)	−37.415 *** (−5.82)	−18.061 *** (−3.65)	−38.899 *** (−3.69)
STATESR	−0.060 *** (−4.23)	−0.035 * (−1.92)	−0.07 *** (−8.26)	0.025 (0.76)
SALE	1.98×10^{-6} *** (3.80)	1.17×10^{-6} (1.08)	2.64×10^{-6} (1.16)	2.71×10^{-6} ** (2.45)
Lia	4.700 ** (2.29)	6.132 *** (3.53)	2.775 ** (2.12)	6.212 * (1.84)
ROA	−0.012 (−0.18)	0.052 (0.89)	0.084 ** (2.20)	−0.311 ** (−2.29)
5LOWN	5.183 * (1.92)	14.476 *** (6.41)	2.930 (1.58)	8.481 * (1.79)
LPSR	−0.036 (−1.13)	−0.010 (−0.28)	−0.003 (−0.13)	−0.05 (−0.64)
C	29.581 *** (3.37)	27.991 *** (5.11)	16.321 *** (3.95)	35.437 *** (3.69)

Table 11. Cont.

Variables	Model 3 (High-Carbon Industries)	Model 3 (Low-Carbon Industries)	Model 4 (A-Shares)	Model 4 (AH-Shares)
Obs	116	128	160	84
F	-	4.04 ***	1.90 **	-
BreuschP	0.00	18.30 ***	25.60 ***	0.00
Hausman test	7.30	39.92 ***	18.82 **	5.49
FGLS	140.85 ***	292.25 ***	636.77 ***	99.23 ***
Statistical models	Random-effects model	Fixed-effects model	Fixed-effects model	Random-effects model

* indicates that the Sig value is less than 0.1, ** indicates that the Sig value is less than 0.05, and *** indicates that the Sig value is less than 0.001.

4. Conclusions

This study combines stakeholder theory and organizational legitimacy theory, starting from the management decision-making perspective and the perspective of the implementation of voluntary carbon information disclosure. Furthermore, this study divides the factors that affect management's carbon information disclosure decision-making into leaders' low-carbon awareness, major shareholder pressure, and state-owned shares, and then it constructs a research framework for the factors influencing voluntary carbon information disclosure in the two market scenarios of the mainland China market and HKEX.

This study used A-share listed companies that disclosed important carbon information (such as carbon emissions or carbon emission reductions) in their social responsibility reports or environmental, social, and governance reports from 2009 to 2017 as a research sample and identified 62 carbon information items. In addition, panel data fixed-effects and random-effects models are used for regression analysis. The results show that leaders' low-carbon awareness has a positive impact on the carbon information disclosure of industry enterprises; the establishment of an energy management system positively affects the carbon information disclosure of enterprises in high-carbon industries, which is consistent to Grosbois's results [150]. Similar to the results of [7,8,12], ownership concentration positively affects the voluntary carbon information disclosure of enterprises. In line with the expectations of [12,28], state-owned shares negatively affect the voluntary carbon information disclosure of A-share listed companies other than AH-share listed companies. The moderating effect test found that low-carbon awareness has no significant moderating effect on the relationship between the establishment of an energy management system and the carbon information disclosure of high-carbon industries, but a positive moderating effect in companies listed on the Hong Kong Stock Exchange.

This research establishes a link between low-carbon-related policies, low-carbon and energy-saving actions of enterprises, and voluntary carbon information disclosure, confirming the effect of the negative relationship between leaders' low-carbon awareness and the establishment of an energy management system on voluntary carbon information disclosure in high-carbon industries. Furthermore, state-owned shares in HKEX have shaped a pioneer image when showing their own social responsibility in the low-carbon economy. In contrast, companies owning state-owned shares (rights) have an inhibitory effect on voluntary carbon information disclosure in the mainland securities market, indicating that state-owned shares are less willing to show detailed corporate carbon information to the public in the mainland market and strive to play a responsible role granted by society instead of playing a pioneer role in low-carbon development. A stock exchange that has issued carbon information disclosure regulations plays a significant role in the low-carbon awareness of corporate leaders and state-owned shares in voluntary carbon information disclosure, demonstrating that a sound and standardized stock market plays a certain role in guiding corporate voluntary carbon information disclosure.

Therefore, based on the theory of organizational legitimacy and the results of this study, we suggest that the Chinese government expand the application of energy management systems to enterprises, and actively accelerate the development and follow-up implementation of low-carbon management systems to enhance the disclosure of corporate carbon information. In addition, proceeding from the information needs of stakeholders, we suggest the Chinese government formulate standardized guidelines for listed companies to disclose carbon information and urge companies with state-owned shares to timely fulfill their information disclosure obligation in order to better play their leading role.

5. Discussion

This study verifies the hypothesis that the establishment of a corporate energy management system promoted by the government's "Energy Conservation and Low-Carbon Action Plan for Ten Thousand Enterprises" has a positive effect on voluntary carbon information disclosure and clarifies the different mechanisms for leaders' low-carbon awareness as well as the establishment of a corporate energy management system (action) in voluntary carbon information disclosure of enterprises in high-carbon and low-carbon industries. This study has expanded the research on the factors affecting enterprises' voluntary carbon information disclosure. However, this study is still an exploratory research on the relationship between leaders' low-carbon awareness and the establishment of corporate energy management systems and voluntary carbon information disclosure by listed companies, and the measurement method is relatively basic. The chairman of a listed company is the highest representative of shareholders' interests, but it is common for the chairman and CEO to serve concurrently in China. It is expected that future research can fully distinguish the functional differences and leadership differences between the chairman and CEO of Chinese listed companies, explore other proxy variables other than leaders' low-carbon awareness reflected in the chairman's oration, elaborate on leaders' low-carbon awareness, and refine corporate energy management systems. Considering that the research on the relationship between carbon performance and carbon information disclosure has been mature, and that this relationship is often affected by other characteristics of enterprises, as well as the availability, authenticity, and verifiability of the carbon emission data of Chinese enterprises (or whether they have passed the third verification), future research can incorporate carbon performance as a control variable to explore more comprehensive related research. In addition, the nature of the mechanism for the influence of ownership concentration on carbon information disclosure still needs to be made clear through management decision-making, and further exploration of the role of ownership concentration in management and the issue of manager agency is conducive to a deeper understanding of the corporate carbon information disclosure behavior, providing a foundation for strengthening corporate global leadership in climate action.

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