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Climate Information Disclosure and Company Financial Performance: Role of The TCFD Framework in China

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ABSTRACT

Motivated by stakeholders' demand for heightened transparency on corporate responsibility to mitigate climate impacts from operations, this study investigates whether Chinese companies utilizing the Task Force on Climate-related Financial Disclosures (TCFD) framework can improve their financial performance through climate information disclosure. It examines how several aspects of climate information disclosure influence corporate financial performance. The study also examines whether signalling or legitimacy incentives within companies influence the relationship. Content analysis was conducted on reports from 2018 to 2021 for 14 Chinese companies that used the TCFD framework and 35 extractive companies as an alternative sample. The findings did not establish a statistically significant relationship between climate information disclosure under the TCFD framework and corporate financial performance. However, climate risk management disclosure is an important determinant of company performance in the extractive industry sample. This result demonstrates that the consequences of corporate disclosure are multifaceted, and that meeting stakeholders' legitimacy demands may not result directly in financial benefits. This study is among the first attempts to assess the relationship between climate information disclosure and financial performance. It offers insights into the potential limitations and complexities of linking climate disclosures to corporate financial performance for policymakers and business managers.

Keywords: Financial performance; climate information disclosure; TCFD framework; extractive companies; machine learning.

INTRODUCTION

In a globalized economic environment, climate change has become one of the most serious challenges facing the world because of its profound impact on natural ecosystems and the economic activities of human society (Palea & Drogo 2020). In 2023, the global annual mean temperature exceeded the pre-industrial 1800s average by approximately 1.45 °C, while ocean warming rates accelerated, resulting in record-high ocean heat content (World Meteorological Organization 2024). Corporate production activities are one of the main causes of pollution (Luo et al. 2022), which has direct effect on carbon emissions and resource utilization (Ma & He 2023), causing climate change. From 1970 to 2021, losses due to climate change in Asia were estimated to amount to USD 1.4 trillion (World Meteorological Organization 2024). Climate change may lead to rising resource costs, supply chain disruptions, and changes in the regulatory environment, which in turn will have an impact on financial performance and market competitiveness (Wang et al. 2020). As the impact of climate change on the economy and society becomes increasingly significant, the responsibility of businesses to adapt and mitigate climate change becomes increasingly important in the eyes of stakeholders.

Following the noticeable demand for corporate transparency from the stakeholders, numerous studies have explored the impacts of environmental, social, and governance (ESG) and environmental information disclosure on corporate performance (Abdullah et al. 2020; Wang et al. 2020; Wang et al. 2021; Chen & Xie 2022). However, few studies have specifically explored the association between climate-related information disclosure and corporate performance (Maji & Kalita 2022). Therefore, this study is motivated by the importance of comprehending and evaluating corporate actions and impacts in response to climate change, particularly in climate information disclosure. Prior studies present mixed results on the relationship between ESG or environmental disclosure and corporate performance. Unlike ESG and environmental disclosure, climate disclosure pertains specifically to the climate risks encountered by a respective company. Consequently, this issue could earn greater concern from stakeholders, including the shareholders. It also addresses the gap in research on the relationship between climate risk disclosure and companies' financial performance. Such understanding is crucial for corporate report preparers and contributes to the decision-making processes of socially responsible investors, consumers, and other stakeholders. Hence, this study examines the impact of Chinese corporate climate information disclosure and its components on financial performance, compares the relationship between TCFD voluntary adopters and extraction industry companies that often disclose such information because of regulatory pressures and maintain legitimacy due to their environmental impacts. These motivations can lead to contradictory outcomes (Hummel

& Schlick 2016; Garcia et al. 2021; Luo et al. 2022). Research on how these motivations affect the relationship between climate disclosure and financial performance have also been limited (Hummel & Schlick 2016).

Corporate climate information disclosure is the process by which companies report their impact on climate change, the risks they face, and their strategies and actions to address climate change to the public. Transparent and comprehensive climate information disclosure is a key component of corporate responsibility to address climate change (Chen & Xie 2022). Climate information disclosure is critical to building public trust, attracting responsible investment and improving market competitiveness (Freedman & Jaggi 2011). Effective information disclosure aids investors and other stakeholders in more accurately evaluating the climate change risks and opportunities that companies encounter (Lin & Wu 2023). Some leading international institutions and initiatives, such as the United Nations' Sustainable Development Goals (SDGs), TCFD and the Paris Agreement, have emphasized the role of companies in disclosing climate-related information (Maji & Kalita 2022).

To address the issue of climate change, the TCFD proposed a detailed disclosure framework in 2017. This framework aims to assist companies in providing climate-related information, enabling investors, lenders, and insurance underwriters to evaluate and manage the associated risks. The TCFD framework emphasizes the importance of governance, strategy, risk management and metrics and targets, providing companies with a systematic approach to disclosing the financial impacts of climate change. Globally, more and more companies and institutions are embracing the TCFD framework. This framework has become a significant global standard for assessing corporate climate-related information disclosures. The latest International Financial Reporting Standards (IFRS) S2 released by the International Sustainability Standard Board also subscribes to the TCFD framework, which aims to emphasize the unified disclosure of climate-related information by enterprises. Currently, more than 4,000 companies and institutions around the world follow the TCFD framework. In the UK, New Zealand, and soon other countries (Maji & Kalita 2022), IFRS S2 will become a mandatory framework for disclosing climate-related information.

China is one of the G20 countries and has also signed the Paris Agreement, which aims to reduce the impact of climate change on human society. In 2020, President Xi Jinping of the Chinese People's Government proposed the dual-carbon plan[1], further emphasizing China's determination to reduce carbon emissions and reduce the impact of climate pollution (Wang et al. 2021). As one of the world's largest developing countries and carbon dioxide emitters, Chinese companies play an important role in addressing global climate change (Liu et al. 2021). As an important part of the global supply chain, Chinese companies' performance in climate change information disclosure is related to their sustainable development and affects the decision-making of global investors and consumers (Lin & Wu 2023).

In China, although companies have been paying increasing attention to climate change information disclosure, the extent and level of information disclosure are still low and unsatisfactory (Wang et al. 2021). According to data from the TCFD official website, as of June 2023, China only had 78 TCFD adopters compared with more than 500 TCFD adopters in the UK and the US. Inconsistent climate information disclosure requirements, low practicality, and a lack of understanding of the consequences for companies may contribute to their inadequate and poor-quality climate information disclosure (Ane 2012; Wang et al. 2020). The TCFD framework guides companies to disclose climate information (Demaria & Rigot 2021; Maji & Kalita 2022; Braasch & Velte 2023). As the Chinese government and stakeholders focus more attention to corporate climate information, the pressure on companies to disclose such information also increases. China is the world's second-largest economy and largest developing country. It is particularly important to study the relationship between climate information disclosure and corporate financial performance in China. Therefore, this context has been used in this study, in view of the global importance of the framework and the unique challenges faced by Chinese companies in climate change information disclosure.

Against this background, the promotion of the TCFD framework through the new IFRS standards has great prospects in China. However, adopting the TCFD framework presents unique challenges that can affect companies' performance. This study aims to investigate the importance of climate disclosure under the TCFD framework, covering its four components, and analyze its relationship with corporate financial performance. Additionally, it seeks to examine whether the association between climate information disclosure and financial performance varies for companies that comply voluntarily with TCFD (signalling incentive) compared to companies in the extractive industry that encounter legitimacy pressures from stakeholders.

This study makes important contributions to the literature. First, although studies on ESG have been conducted, sustainability, environmental information and company performance, this study is one of the first to examine the impact of Chinese corporate climate information disclosure and its components on financial performance. Second, this study is also among the few that have investigated the differing motivations, namely, signalling and legitimacy, that can influence climate information disclosure. Third, diverging from most of the literature on climate disclosure, this study is among the select few to employ a machine learning approach to measure climate information disclosure. Finally, while much of the literature on ESG, sustainability or environmental information and company performance relies on data from developed countries, this study contributes to the scarce body of literature focusing on emerging countries.

To achieve our research objective and address the research question, we utilize content analysis of reports from 2018 to 2021 for 14 Chinese companies utilizing the TCFD framework, along with 35 extractive companies as an alternative sample. Panel regression analysis is also employed. The results did not indicate a statistically significant association between climate information disclosure, whether in compliance with the TCFD framework, and corporate financial performance. This result questions the usefulness of the framework to the stakeholders.

The following sections will detail the literature review and research hypotheses of the study. Subsequent chapters will describe the study sample and variable measurements, followed by empirical analysis and discussion. Finally, the paper will summarize the main findings and conclusions and provide suggestions for future research and practical implications.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

SUSTAINABILITY DISCLOSURE AND PERFORMANCE

Companies, as major environmental polluters, are shouldering more environmental responsibilities in view of global climate change and ecological deterioration. Previous studies suggest generally positive effects of sustainability disclosure in the form of corporate social responsibility (Liu & Zhang 2017), ESG (Chen & Xie 2022; Chen et al. 2022), environmental information disclosure (Qiu et al. 2016; Wang et al. 2020; Abdullah et al. 2020; Wang et al. 2021) and carbon information disclosure (Yan et al. 2020) on company financial performance or long term value. Although many studies have been conducted on the relationship between multiple perspectives of sustainability disclosure and corporate performance, no unified conclusion has been reached. These studies reported that the relationship is contingent on other factors, such as differences in company characteristics, research samples, research methods, and institutional backgrounds in different countries (Abdullah et al. 2020). Therefore, focusing on climate information disclosure in relation to company performance is imperative because of the momentum it has gained in recent years due to the issuance of IFRS S2 and the increasing importance of addressing climate issues in companies.

CLIMATE INFORMATION DISCLOSURE

Climate information disclosure is part of the environmental issues discussed within CSR, ESG, or sustainability disclosures. As the international community's attention to climate change continues to increase (Costello et al. 2009; Chen et al. 2022), the role of companies in the global climate agenda has also received increasing attention. Thus, climate information disclosure is emerging as a focal research area (Maji & Kalita 2022). Currently, few studies have focused\on climate information disclosure (Demaria & Rigot, 2021). A stream of climate information disclosure studies is concentrated on the measurement of climate change information disclosure (Demaria & Rigot 2021; Moreno & Caminero 2022; Braasch & Velte 2023). Results obtained using the self-constructed model and indicators suggest an increasing trend of compliance in climate information disclosure in France (Demaria & Rigot 2021), Spain (Moreno & Caminero 2022) and Germany (Braasch & Velte 2023).

Studies on the measurement of climate information disclosure are divided into three methods. One is the traditional content analysis method (Bowman & Haire 1975), which has received criticism from many scholars (Ng 1985). The second is manual content analysis, which has the disadvantage of being highly subjective (Luo et al. 2022). The third is the third-party agency rating (Chen et al. 2022). However, the rating indicators of various agencies differ, and no unique rating for agencies that disclose corporate climate information is available. The latest approach is to use machine learning to measure corporate climate disclosures. However, guidance specific on this matter remains lacking in the literature.

Another stream of literature focuses on the factors associated with climate information disclosure. Factors positively associated with climate information disclosure include carbon emissions, environmental performance, carbon-intensive industries, support for TCFD, and company characteristics, such as size, leverage, stability and capital expenditure (Ding et al. 2023). Similar results for factors related to climate change exposure have been confirmed in conference calls (Sautner et al. 2023). This finding aligns with other studies investigating environmental or ESG disclosure. One important contribution of Ding et al. (2023) is their suggestion that legitimization incentives (carbon emissions) influence climate information disclosure. Their study is also one of the first to use the TCFD framework as a measurement for climate information disclosure. However, evidence to show that corporate governance mechanisms, such as board gender diversity, board size and board independence, and company performance have a negative relationship with climate information disclosure is weak (Ding et al. 2023).

Additionally, only limited studies have concentrated on the impact of climate information disclosure or climate change exposure on stock price crash risks (Lin & Wu 2023), options market risks (forward-looking risks), risk premiums and returns (Sautner et al. 2023) and corporate performance (Maji & Kalita 2022). Maji and Kalita (2022) used India from 2019 to 2020, taking energy companies as a sample, and found a positive relationship between corporate climate change financial disclosures and corporate performance.

THEORY AND HYPOTHESIS

Most studies use the signalling theory that information disclosure can reduce information asymmetry between companies and external stakeholders (Siddique et al. 2021), lower perceived risks, increase investor and consumer trust, attract more capital, enhance corporate visibility and improve corporate performance. Signalling theory posits that in markets with asymmetric information, companies disclose high-quality environmental information to send positive signals and differentiate themselves from competitors (Spence 1978).

However, corporate climate disclosures might negatively impact financial performance. According to legitimacy theory, companies must align their actions with societal norms and values. If environmental disclosures reveal behaviour that contradicts these norms, it can harm a company's social legitimacy, reduce public trust, and damage its market reputation. Ren et al. (2020) argue that companies face higher compliance costs to meet legal and societal expectations, often diverting resources to environmental protection at the expense of economic performance. Liu and Zhang (2017) found that social responsibility disclosures can hurt short-term profits, especially for heavily polluting industries, due to the high costs of environmental and public relations efforts. Although these actions foster good stakeholder relationships, the benefits may take time to materialize, justifying the potential short-term performance decline.

Recent studies have found mixed results due to these differences. Studies have found corporate environmental-related information disclosure to be positively related to corporate performance (Wang et al. 2020; Abdullah et al. 2020; Yan et al. 2020; Wang et al. 2021; Chen & Xie 2022; Maji & Kalita 2022). Several other studies reveal that corporate environment-related information disclosure is not related to corporate financial performance (Aupperle et al. 1985; Aras et al. 2010; Qiu et al. 2016). This view holds that although environmental disclosure may be attractive to certain stakeholders (such as environmental organizations and social activists), its direct impact on a firm's overall financial performance may be limited. From this perspective, a company's financial performance is more affected by market demand (Aras et al. 2010), internal management efficiency, industry characteristics and macroeconomic factors (Abdullah et al. 2020).

Climate information disclosure is a specific type of environmental information disclosure related more directly to business risks than general environmental disclosure. According to signalling theory, the internal arrangements within companies regarding initiatives to address climate risks impact the incentive to disclose climate-related information. Therefore, the assumption is that what is disclosed reflects actual practices. When companies have clear strategies to reduce climate-related business risks and implement appropriate risk management initiatives with defined metrics and targets, it is expected that corporate performance will consequently improve. Based on the theory and conclusions of previous relevant literature, this study puts forward the following hypotheses:

H_1 A significant relationship exists between corporate climate information disclosure and corporate financial performance.

This study substantiates the results according to different components of climate information disclosure, i.e., governance, strategy, risk management, and metrics and targets by testing study each component separately.

H_{1a} A significant relationship exists between corporate climate information (governance) disclosure and corporate financial performance.

H_{1b} Corporate climate information (strategy) disclosure and corporate financial performance have a significant relationship.

H_{1c} A significant relationship exists between corporate climate information (risk management) disclosure and corporate financial performance.

H_{1d} A significant relationship between corporate climate information (metrics and targets) disclosure and corporate financial performance.

TCFD adopters may span a variety of industries and represent companies that voluntarily choose to follow specific guidance on climate-related financial disclosures, which is consistent with the signalling theory. This adoption demonstrates their commitment to transparency on climate risks and strategies. In contrast, companies in extraction industries may face legitimacy pressures due to their significant environmental impacts, which are often driven by regulatory requirements rather than voluntary commitments. These motivations can result in conflicting results (Hummel & Schlick 2016; Garcia et al. 2021; Luo et al. 2022).

The two sets of companies operate under different market dynamics and stakeholder expectations. TCFD adopters may disclose climate-related information to attract sustainability-focused investors and improve market perception, while extraction industry companies may disclose more for legitimacy reasons. Thus far, studies that compare the effect of these explanations on the strength of the relationship between climate information disclosure

and financial performance have been very limited (Hummel & Schlick 2016). Therefore, the following hypothesis is proposed:

H_2 A significant difference exists in the corporate climate information disclosure and corporate financial performance relationship between TCFD adopters and non-TCFD adopters.

RESEARCH DESIGN

SAMPLE AND DATA

This study selects Chinese companies listed on the Shanghai and Shenzhen stock markets in China from 2018 to 2021 as a sample. Since TCFD released its first disclosure framework and related recommendations in mid-2017, the number of TCFD adopters in China gradually increased beginning in 2018. The sample screening process is as follows. First, companies in mainland China that adopted TCFD are obtained from the TCFD official website. Next, TCFD adopters of unlisted companies are excluded because such companies may not disclose annual reports. Hence, to ensure consistency with the sample scope, this study excluded companies that became TCFD adopters after 2021 because they did not comply with the framework throughout the sample timeframe. This approach ensures the completeness and continuity of the sample, allowing for the collection of complete panel data for analysis. Finally, 14 companies or 56 companies' annual observations were obtained. This study obtained climate-related information and related data from annual reports published by companies. Other data for this study came from the Wind database[2]. Previous scholars have found that differences in the industries of the research sample may affect the research results (Braasch & Velte 2023). Hence, to ensure the reliability of the research results, we also selected Chinese extractive industry companies as a sample of climate-sensitive industries for robustness testing. Although these companies have not become TCFD adopters, we use the machine learning method to obtain climate information consistent with the TCFD framework (Gao et al. 2024). The resource extraction industry is one of the most important drivers of carbon dioxide emissions (Wu et al. 2023).

Therefore, the listed extractive industry companies from 2018 to 2021 were also selected, with ST/PT and companies lacking key data excluded. Finally, 35 extractive industry sample companies were obtained with 140 annual observations. ST companies are those designated as "special treatment" due to consecutive losses over two years. Similarly, PT marks are for companies at risk of delisting. Stocks of such companies can experience higher uncertainty and volatility in the market. Although the sample sizes in the two panels were unbalanced, the purpose of this study was to examine differences between different subgroups rather than to obtain an overall balanced sample. In fact, the larger the sample, the more representative it is. Previous related studies have adopted similar research designs (Braasch & Velte 2023; Zhao et al. 2024).

VARIABLE MEASUREMENT

DEPENDENT VARIABLE

Corporate financial performance serves as the dependent variable in this study. This study uses return on assets (ROA) and return on equity (ROE) as its measurement indicators. Previous related studies have widely used ROA and ROE to measure financial performance related to ESG disclosure, environmental disclosure, and carbon information disclosure (Yan et al. 2020; Wang et al. 2021; Chen & Xie 2022; Chen et al. 2022) because these metrics have become the focal point for most investors. Therefore, for the dependent variable, this study uses ROA to measure corporate financial performance and ROE for robustness testing.

INDEPENDENT VARIABLE

Climate information disclosure is used as the independent variable of this study. Lin and Wu (2023) used computer text processing of high-frequency words reported by the Chinese government to construct keywords. Then, they measured climate risk information by the ratio of the frequency of these keywords appearing in company annual reports to all terms. However, this method does not consider the TCFD framework and cannot consider comprehensive climate information. These scholars have used different machine learning methods to measure climate information disclosure based on the TCFD framework (Bingler et al. 2022; Moreno & Caminero 2022; Ding et al. 2023). This study uses machine learning methods to measure corporate climate information disclosure under the TCFD framework and avoids the subjectivity of manual content analysis. The TF-IDF method[3] is used to construct climate keywords to avoid the inconsistency of corporate climate information disclosure under the TCFD framework so that the status of corporate climate information disclosure can be understood more accurately.

This study is the first to use machine learning methods to study the relationship between climate information disclosure and corporate financial performance. According to Luo et al. (2022), manual content analysis is

criticized for its subjectivity. Scholars, including Chen & Xie (2022) for ESG, Luo et al. (2022) for EID and Yan et al. (2020) for CID, often rely on third-party rating data for empirical analysis. Notably, China lacks TCFD rating agencies due to limited TCFD adopters, with less than a hundred adopting companies before its disbandment. Consequently, studies such as Lin and Wu (2023), Ding et al. (2023) and Sautner et al. (2023) resort to various machine-learning methods to assess climate-related disclosures. We obtained climate information disclosure values in four different dimensions under the TCFD framework based on the method of Ding et al. (2023). Finally, according to Cao et al. (2022), the entropy method is used to obtain the value of climate information disclosure. In short, this study identified China's TCFD Adopters (Training Sample), extracted climate-related information consistent with the TCFD framework from the sample, cleaned up the document (removing irrelevant words and punctuation marks), used the Python program and uploaded the sample annual report and climate keywords under each TCFD dimension, employed an algorithm to calculate the similarity of climate-related disclosures and obtained the similarity values in the four dimensions of each observation sample, and the final values of the four dimensions obtained in the fifth step were combined into the final climate-related disclosure value using the entropy weight method. Further explanation can be found in Gao et al. (2024).

CONTROL VARIABLE

This study considered a wider range of control variables, which are commonly used in previous studies and have been confirmed to have an impact on corporate financial performance, including company age (Zeng et al. 2012; Wang et al. 2020; Chen & Xie 2022), financial leverage (Wang et al. 2020; Abdullah et al. 2020; Wang et al. 2021; Chen & Xie 2022; Maji & Kalita 2022), corporate revenue growth rate (Abdullah et al. 2020; Chen et al. 2022), number of staff (Eng & Mak 2003), and board size (Liu & Zhang 2017; Abdullah et al. 2020) to eliminate possible confounding effects .

MODEL

We use a balanced panel data model to study the impact of climate-related financial disclosures on firm financial performance (Abdullah et al. 2020; Maji & Kalita 2022). The traditional OLS model is more suitable for cross-sectional and time series data. Previous related studies have almost always applied the fixed effects model because of unobservable individual-specific effects, and these effects may be related to the explanatory variables. Fixed effects models reduce omitted variable bias by controlling for these invariant individual-specific effects. After the Hausman test, the results show this study is suitable for the fixed effects model ($p = 0.0007$). This study also controlled individual and year effects to reduce bias in statistical results. Controlling individual enterprise and year effects reduces estimation bias and improves the accuracy of regression analysis. Firm-individual effects involve characteristics unique to each firm, such as management style or corporate culture.

In contrast, year effects involve common factors in a particular year, such as economic cycles or policy changes. Failure to consider these effects may result in the omission of important variables, thereby affecting the explanatory power of the model and the reliability of the results. The impact of other variables on firm financial performance can be analysed more accurately by controlling for these effects (Yan et al. 2020; Chen & Xie 2022). Therefore, the following regression model was used to test the hypotheses of the study:

$$CFP_{i,t}=\beta 0 +\beta 1\ Cid\ i,t + \sum \beta i,t\ (controls+Firm+Year)+\varepsilon\ i,t\ , \quad (1)$$

where $\beta 0$ is a constant term, $\beta 1$ represents the regression coefficient, i represents the company, t represents the year and ε is the error term. The dependent variable CFP represents corporate financial performance represented by Roa or Roe; the independent variable Cid is climate information disclosure that includes Cid (gove), Cid (strat), Cid (Rm) and Cid (Mt); controls represent a series of factors that have been proven to affect corporate financial performance, including Age, Leverage, Growth, Board size, and Labor; Firm represents the control of individual corporate effects, and Year represents the control of year effects. Finally, outliers were screened to improve the stability of the study results. Table 1 outlines the main variable definitions.

TABLE 1. Main variables

Variable	Measurement
Roa	Net profit/total assets
Roe	Net profit/total equity
Cid	Entropy method used to form a Cid indicator for the four-dimensional indicators.
Cid (gove)	TF–IDF is used to obtain Cosine Similarity score1 (Governance)
Cid (strat)	TF–IDF is used to obtain Cosine Similarity score1 (Strategy)
Cid (Rm)	TF–IDF is used to obtain Cosine Similarity score1 (Risk management)
Cid (Mt)	TF–IDF is used to obtain Cosine Similarity score1 (Metrics and Targets)
Age	Logarithm of the company's listing age
Leverage	Total liabilities at the end of the year/Total assets at the end of the year
Growth	Operating income this year/Operating income last year -1

Board size	Number of directors
Labour	Logarithm of the number of employees

RESULTS AND DISCUSSION

DESCRIPTIVE STATISTICS

Table 2 provides descriptive statistics of 2018–2021 data for 14 TCFD adopter companies in China. The table shows the core indicators of corporate financial performance, Roa and Roe, and the various dimensions of climate information disclosure. Table further shows that the overall score of climate information disclosure (Cid) varies widely across the sample, with a mean of 47.21%, indicating that although some companies perform outstandingly in climate information, overall, a large room for improvement still exists. Among the four core elements of climate information disclosure, climate governance (Cid (Gove)) is the most fully disclosed, with an average value of 60.56%, indicating that companies respond more actively to climate change at the governance level. However, the average disclosure scores for climate strategy (Cid (Strat)) and climate risk management (Cid (Rm)) are low at 34.26% and 38.32%, respectively, indicating that corporate disclosure practices in these areas need to be strengthened. The average disclosure score of climate indicators and targets (Cid (Mt)) is relatively good, with an average value of 50.64%, reflecting that companies have exerted certain efforts in setting climate-related goals and measurement indicators. Consistent with Bingler et al. (2022), the minimum score for Cid is 0. In terms of control variables, the average value of company age (Age) is 3.19, which shows that the sample enterprises have a certain history and maturity. The average values of the company's financial leverage (Leverage) and annual revenue growth (Growth) are 79.25% and 10.55%, respectively, showing the status of the company's financial structure and growth potential. Overall, these descriptive statistics provide the basis for our subsequent in-depth analysis of the relationship between climate information disclosure and corporate financial performance.

TABLE 2. Descriptive statistics

Variables	Obs	Mean	Std. dev.	Min	Max
Roa	56	0.030	0.056	0.004	0.287
Roe	56	0.120	0.074	0.027	0.501
Cid	56	0.472	0.200	0.000	0.861
Cid (Gove)	56	0.606	0.407	0.000	1.000
Cid (Strat)	56	0.343	0.248	0.000	0.927
Cid (Rm)	56	0.383	0.275	0.000	0.943
Cid (Mt)	56	0.506	0.291	0.000	1.000
Age	56	3.191	0.357	2.197	3.638
Leverage	56	0.792	0.220	0.247	0.926
Growth	56	0.105	0.157	-0.326	0.733
Boardsize	56	12.304	2.854	7.000	18.000
Labour	56	10.954	1.960	6.990	13. 068

CORRELATION ANALYSIS

Table 3 reveals the analysis of climate risk information disclosure (Cid) and its correlation with corporate financial performance (Roa). The results show a significant negative correlation between Roa and Cid ($r = -0.275^{**}$), implying that a higher degree of climate information disclosure may not be related directly to an increase in return on assets. This relationship is statistically significant, suggesting that firms with higher climate disclosure scores in the sample may translate into decreased financial performance in the short term. At the same time, a significant negative correlation between Roa and the company's financial leverage (Leverage) ($r = -0.689^{***}$), which may reflect the potential adverse impact of high financial leverage on the company's financial performance. In contrast, the company's annual revenue growth rate (Growth) shows a positive correlation with Roa ($r = 0.327^{**}$), indicating that companies with faster revenue growth tend to achieve higher returns on assets. The significant negative correlation between board size (Boardsize) and Roa ($r = -0.508^{***}$) may indicate that a larger board structure may have an adverse impact on decision-making efficiency and corporate performance. In addition, the negative correlation ($r = -0.426^{***}$) of company employee size (Labour) provides preliminary evidence of a possible negative association between employee number and financial efficiency. These findings have implications for subsequent empirical research and provide a basis for in-depth exploration of the relationship between climate information disclosure and corporate financial performance. Notably, correlation analysis can only reveal the degree of association between variables and cannot determine causality. After the VIF test, the VIF values are all lower than 5, which avoids the problem of multicollinearity. Therefore, further verification of the nature and direction of these relationships through multiple regression analysis methods is necessary.

TABLE 3. Correlation Matrix

	Roa	*Cid*	*Age*	*Leverage*	*Growth*	*Boardsize*
Cid	-0.275**					
Age	0.036	0.056				
Leverage	-0.689***	0 .414***	0.059			
Growth	0. 327**	0. 105	-0.045	-0.253*		
Boardsize	-0.508***	0.346 ***	0. 065	0.643 ***	-0.029	
Labour	-0.426***	0. 286**	0.034	0.774***	-0.320**	0.345***

Note: *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels, respectively.

BASELINE REGRESSION AND ROBUSTNESS CHECKS

Table 4 shows the regression results, which are divided into Panels A and B[4]. Panel A uses data from 14 companies in China that are TCFD adopters. This is to assess whether corporate climate information disclosure by TCFD adopters can promote corporate financial performance. Panel B uses an alternative sample for robustness testing using panel data from 35 extractive industry companies in China. There are also 140 observations in four years, from 2018 to 2021. Excavation enterprises include oil and natural gas mining, coal mining and mineral mining enterprises (Wu et al. 2023). Although the companies in Panel B are not adopters of TCFD, we can use the machine learning method in this study to obtain climate information disclosure consistent with the TCFD framework for testing. Roa is the dependent variable in the two-panel data, and Roe is the dependent variable that replaces Roa in the robustness test.

In Panel A, from the results in column (1), the fixed effects regression model shows that the relationship between Roa and Cid is not significant. This result implies that in this sample, the extent of climate information disclosure does not significantly affect firms' return on assets. The results in column (2) show that using the alternative variable Roe, the relationship between climate information disclosure and Roe is also not significant, which further supports that a direct strong association between climate information disclosure and corporate financial performance may not exist. The relationship between Leverage and Roa and Roe is not significant in both models, indicating that financial leverage may not be the main factor affecting financial performance in these samples of TCFD adopters. Employee size (Labour) has a significant positive impact in the Roa model but is not significant in the Roe model, indicating that employee size may have a positive impact on return on assets, but the impact on return on equity is not necessarily obvious.

In Panel B, according to the results of (3) and (4), the relationship between Cid and Roa and Roe is still not significant. This result reinforces the idea that climate disclosure may not directly impact corporate financial performance. Leverage shows a significant negative impact in the Roa model, and this impact is more significant in the Roe model. This result is consistent with the traditional hypothesis that high financial leverage may have a negative impact on corporate financial performance. Annual revenue growth rate (Growth) has a significant positive impact on Roa and Roe in both models, indicating that revenue growth plays a significant role in improving corporate financial performance.

Hence, based on the existing statistical analysis, we can conclude that no significant positive or negative relationship exists between climate information disclosure and corporate financial performance. This study is more inclined to support the hypothesis that climate information disclosure is not related to corporate financial performance. However, this view does not mean that climate disclosure is unimportant or does not have other potential non-financial benefits. Climate disclosures may have positive impacts on corporate reputation, investor relations, and long-term sustainability, and these are areas that future research may explore.

TABLE 4. Regression results

Panel A	(1)	(2)	Panel B	(3)	(4)
TCFD sample	*Roa*	*Roe*	Extractive industry sample	*Roa*	*Roe*
Cid	0.012	0.028	*Cid*	0. 007	0.009
	(0.011)	(0.025)		(0.013)	(0.026)
Age	0.019	0.145	*Age*	0. 096	0.140
	(0.047)	(0.146)		(0. 088)	(0.147)
Leverage	0.106	0.426	*Leverage*	-0. 238***	-0.367 **
	(0.136)	(0.304)		(0.068)	(0.151)
Growth	0.020	0.018	*Growth*	0. 024***	0.048***
	(0.025)	(0.036)		(0.008)	(0.017)
Boardsize	0.00l	0.004	*Boardsize*	0. 00l	0.000
	(0.002)	(0.005)		(0. 002)	(0.005)
Labour	0.124*	0.242**	*Labour*	-0.021	-0.027
	(0.066)	(0.115)		(0. 021)	(0.038)
Cons	-1.495*	- 3.390**	*Cons*	0.072	0.130
	(0.769)	(1.341)		(0. 282)	(0.491)
Fixed effects	YES	YES	Fixed effects	YES	YES
R^2	0.962	0.896	R^2	0.812	0.759
R-adj	0.937	0.826	R-adj	0.728	0.651

N	56.000	56.000	N	140.000	140.000

Previous related studies have used lagged terms of corporate information disclosure as instrumental variables to solve the endogeneity problem caused by reverse causality (Ding et al. 2023; Gao et al. 2024). This study follows previous practice in using lagged terms of lagged climate information disclosures as instrumental variables. In both models in Table 5, the coefficients of Lag_cid (-0.0192 and -0.0369) are shown to be statistically insignificant (p-values are 0.674 and 0.712, respectively). Climate information disclosure still has no significant impact on a company's return on total assets (Roa) and return on equity (Roe) even after adjusting for potential endogeneity issues, thus rejecting H1. These 2SLS regression results are consistent with the baseline regression results, indicating the absence of a significant link between climate disclosure and corporate financial performance.

TABLE 5. 2SLS test

	(1)	(2)
Variables	*Roa*	*Roe*
Lag_cid	-0.0192	-0.0369
	(0.0520)	(0.0878)
Firmsize	0.0173***	0.0267***
	(0.00408)	(0.00727)
Leverage	-0.410***	-0.477***
	(0.0691)	(0.116)
Age	0.0121*	0.0178
	(0.00689)	(0.0132)
Growth	0.0740	0.0566
	(0.0547)	(0.0919)
Constant	-0.169	-0.300
	(0.115)	(0.203)
R^2	0.592	0.267
N	42.000	42.000

FURTHER ANALYSIS

Different dimensions of climate information disclosure may have different research impacts. Following previous related research ((Maji & Kalita 2022; Ding et al. 2023), in the multi-dimensional analysis in Table 6, we examined the impact of four dimensions of climate information disclosure on corporate financial performance under the TCFD framework influence. The model in columns (1), (2), (3) and (4) shows that the impact of climate information disclosure in the four dimensions on Roa is not significant, thus rejecting hypotheses 1a–1d. Hence, the four dimensions of corporate climate information disclosure under the TCFD framework have no significant relationship with corporate financial performance. Similarly, to avoid the influence of sample size and industry nature, we continued to use Panel B data to conduct another test. In the models of (5), (6), (7) and (8), we found that climate information disclosure consistent with TCFD has an insignificant impact on Roa in the governance, strategy, indicator and target dimensions, which also supports previous findings. It also suggests that they may not be the key driver of financial performance. Climate information disclosure in the risk management dimension in the extractive industry sample has a significant positive relationship with corporate financial performance, which may suggest that in the extractive industry, disclosure of risk management is critical to improving corporate financial performance. This effect may be because this dimension of climate information disclosure emphasizes how companies identify and manage corporate climate-related risks. Stakeholders may have such concerns. The impact of these companies on climate pollution is clear, especially in the extractive industry. Corporate information on climate-related risks may attract stakeholders, enhance corporate stock liquidity, and promote corporate financial performance.

TABLE 6. Multi-dimensional analysis

Panel A	(1)	(2)	(3)	(4)
TCFD Sample	*Roa*	*Roa*	*Roa*	*Roa*
Cid (Gove)	-0.003			
	(0.007)			
Cid (Strat)		0.004		
		(0. 005)		
Cid (Rm)			0. 011	
			(0.012)	
Cid (Mt)				0. 009
				(0.007)
Age	0.030	0 .024	0. 026	0. 0l0
	(0.052)	(0.052)	(0.043)	(0.047)
Leverage	0.092	0.095	0. 109	0. Il0
	(0.142)	(0. 140)	(0.139)	(0. 133)

Growth	0.027	0. 024	0. 024	0. 020
	(0.024)	(0.023)	(0.023)	(0.023)
Boardsize	0.00l	0.00l	0.00l	0. 00l
	(0.002)	(0. 002)	(0. 002)	(0.002)
Labour	0.129*	0. 127*	0. 126*	0. 123*
	(0.068)	(0.068)	(0.065)	(0.065)
Cons	-1.568*	-1.534*	-1.542*	-1.455*
	(0.800)	(0.805)	(0. 762)	(0. 744)
Fixed effects	YES	YES	YES	YES
R^2	0.962	0.962	0.963	0.963
R-adj	0.936	0.936	0.938	0.938
N	56.000	56.000	56.000	56.000

Panel B Extractive industry sample	(5) Roa	(6) Roa	(7) Roa	(8) Roa
Cid (Gove)	0.003			
	(0.008)			
Cid (Strat)		-0.018		
		(0.011)		
Cid (Rm)			0. 042 ***	
			(0.0ll)	
Cid (Mt)				-0.011
				(0.009)
Age	0. 096	0. 097	0. 075	0. 090
	(0.087)	(0.083)	(0.076)	(0.084)
Leverage	-0. 243***	-0 .257***	-0. 249***	-0. 263***
	(0.070)	(0. 070)	(0.058)	(0.070)
Growth	0. 024***	0 .024 ***	0. 024 ***	0. 024 ***
	(0. 008)	(0.008)	(0.007)	(0.008)
Boardsize	0.002	0. 002	0. 00l	0. 002
	(0.002)	(0.002)	(0.002)	(0.002)
Labour	-0.020	-0.018	-0. 018	-0.017
	(0.021)	(0.021)	(0. 021)	(0.021)
Cons	0.071	0. 050	0.104	0. 067
	(0. 281)	(0. 271)	(0. 255)	(0.273)
Fixed effects	YES	YES	YES	YES
R^2	0.812	0.817	0. 846	0.815
R-adj	0. 728	0. 735	0. 776	0. 732
N	140.000	140.000	140.000	140.000

DISCUSSION OF RESULTS

This study deeply explores the relationship between climate information disclosure and corporate financial performance under the TCFD framework through the empirical analysis of company data of TCFD adopters (Panel A) and extractive industry companies (Panel B). In Panel A, our results do not find a significant correlation between climate information disclosure and corporate financial performance. This finding means that although TCFD adopters may be active in climate disclosure, this disclosure behaviour does not translate into significant improvements in financial performance.

We further introduce extractive industry data as an alternative sample (Panel B) to evaluate whether legitimacy motives could drive company performance. In this sample, disclosure of the risk management dimension exhibits a positive relationship with corporate financial performance, which may suggest that in certain industries, such as the extractive industry, transparency in risk management may be viewed by the market as adding value to the business. However, the analysis in Panel B also fails to confirm a broad positive relationship between climate disclosure and financial performance.

These results challenge signalling theory, which assumes that firms gain economic benefits by disclosing more information. In both samples of this study, climate disclosure does not appear to be linked directly to financial performance (Wang et al. 2020). This finding may be because market participants consider a variety of factors when assessing corporate value rather than just the extent of climate information disclosure. It may also reflect that companies' motivations for disclosing climate information are not just for financial benefits but may also be in response to social responsibilities, regulatory requirements or industry best practices. This view supports the perspective of legitimacy theory (Braasch & Velte 2023).

Taken together, this study provides evidence of the limited impact of climate information disclosure on corporate financial performance, which may prompt managers and policymakers to rethink the strategies and purposes of promoting climate information disclosure, especially in the long-term sustainability of companies' strategies.

CONCLUSION

Driven by corporate production activities, climate change has become a significant challenge that has been profoundly impacting ecosystems and economic activities globally. As the effects of climate change on the economy and society grow, the demand for corporate transparency has been increasing, prompting studies on the impact of climate-related information disclosure on corporate performance. However, specific studies on the latter remain limited. Hence, this study examines how climate information and each of its components affect financial performance. It also compares the impact of signalling versus legitimacy incentives between companies adopting the TCFD framework and those in the extraction industry.

Through the analysis of two samples, the results that generally, climate information disclosure and corporate financial performance are not related. This finding is similar to the results of previous related studies (Guidry & Patten 2012; Qiu et al. 2016; Baboukardos et al. 2021). This finding shed new light on understanding the economic impact of climate disclosures, particularly in the extractive industry, which is an area with high environmental concerns. Although disclosure of risk management dimensions shows a positive relationship in the extractive industry sample, this phenomenon is not observed in the sample of TCFD adopters. This observation may suggest that the impact of climate disclosures varies depending on industry and firm characteristics or that the depth and quality of disclosures may be key factors in determining their impact. Although this study did not find a direct positive relationship between climate information disclosure and financial performance, it does not mean that climate information disclosure is not important. Conversely, transparency and accountability may bring value to companies in other non-financial ways, such as increased brand reputation and investor confidence. Companies should view climate disclosure as part of their long-term sustainability strategy rather than as a direct driver of short-term financial performance.

At present, research on climate information in China is still in its preliminary stages. Previous research has focused on the impact of climate information on the stock market (Lin & Wu 2023; Zhao et al. 2024). This study is one of the first to explore the relationship between corporate climate information disclosure and corporate financial performance in China. It provides empirical evidence on the significance of climate disclosures, which is particularly important for understanding and assessing the practical aspects of the TCFD recommendations. Furthermore, by comparing data from different industries and different dimensions of climate information disclosure, this study improves understanding of the multi-dimensional impact of climate information disclosure. From a practical perspective, this study highlights the need for a deeper understanding of the multifaceted value of climate disclosures when developing relevant policies and corporate strategies. It reminds managers and policymakers that they should focus on the quality and depth of climate information disclosure and how to effectively use this information to promote the long-term sustainable development of enterprises.

A limitation of this study is that it focuses primarily on Chinese firms, and these findings may not be applicable to other countries with various levels of development or cultural backgrounds. Future research could enhance the generalizability of these results by expanding the sample scope, introducing different industries and firm sizes and exploring other potential mediating variables. Future research should consider expanding the sample scope to include diversity across countries, industries and company sizes to verify the generalizability of the results of this study. Future research should also explore how to measure the quality and impact of climate information disclosure more accurately and how it affects the decision-making of investors and other stakeholders. In addition, future research could explore the impact of climate information disclosure on corporate non-financial performance, such as brand value and corporate social responsibility. Finally, although climate information disclosure did not show a direct positive impact on corporate financial performance in the current study, our study provides new insights into understanding the challenges and opportunities that companies face with climate information disclosure.

NOTES

1. China’s dual-carbon plan aims to limit the peak of carbon emissions by 2030 and achieve carbon neutrality by 2060.
2. Comparable to the globally recognized Bloomberg Terminal, the Wind database offers extensive data, information, and analytical tools with particular focus on China and other Asian markets to financial professionals.
3. TF–IDF, which stands for term frequency–inverse document frequency, is a metric that assesses the significance of a word within a document relative to its occurrence in a larger collection or corpus, considering the fact that some words are generally more common.
4. Comparing the two samples can take one of two forms: (1) combining both samples in one regression, with TCFD as a dummy variable and testing an interaction between Cid and TCFD. (2) Alternatively, the samples can be tested separately. We chose the second approach, which is not incorrect from a statistical standpoint

because the intercepts (representing the level of performance when Cid is 0) for both samples could be different. Additionally, the number of observations between the two categories is not the same.

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