

Article

Empirically Testing the Relationship Between Natural Capital and Corporate Performance Using CDP Scores

Shoichiro Hosomi *  and Soichiro Yamamoto 

Graduate School of Management, Tokyo Metropolitan University, Tokyo 192-0397, Japan;
yamamoto-soichiro@ed.tmu.ac.jp

* Correspondence: hosomi@tmu.ac.jp

Abstract

Environmental disclosure and environmental, social, and governance assessments are gaining importance, using Corporate Disclosure Project (CDP) scores to evaluate corporate environmental disclosure. However, scarce evidence links CDP scores with performance and value among Japanese manufacturing firms. This study examines these associations using panel data from 2018 to 2023, combining financial data from Nikkei NEEDS Financial QUEST with CDP scores for climate change, water security, and forests. CDP ratings were converted into ordered numerical values, and regression models were estimated with firm-level controls, firm age, applicable fixed effects, and an annual macroeconomic control variable. Robustness checks included categorical score specifications, propensity score matching, and two-step system generalized method of moments estimation. The results indicate that the overall CDP score is positively associated with Tobin's Q, whereas the evidence for return on assets and return on equity is weaker. Improvements in the overall score are also linked to increases in Tobin's Q. By contrast, individual climate change, water security, and forest sub-scores show weak and inconsistent statistical significance. These findings should be interpreted as associations, not definitive causal effects. The study extends environmental accounting research beyond carbon-focused analyses, suggesting that aggregate CDP evaluations are more value-relevant than disaggregated sub-scores.

Keywords: natural capital; IIRC; CDP score; sustainability accounting; corporate performance

1. Introduction

The number of companies issuing integrated reports that combine corporate financial and non-financial information, such as environmental, social, and governance (ESG) indicators, is increasing annually. The [Corporate Value Reporting Lab \(2022\)](#) reported that the number of companies and other entities issuing self-declared integrated reports exceeded 700 in 2021. Reflecting the international climate for corporate sustainability, the Value Reporting Foundation was established in June 2021 through the merger of the UK-based International Integrated Reporting Council (IIRC)¹, which advocated an integrated reporting framework, and the US-based Sustainability Accounting Standards Board.

In Japan, from April 2022, the Tokyo Stock Exchange required companies listed on the Prime Market to disclose information in line with the recommendations of the Task Force on Climate-related Financial Disclosures. In accounting research, natural capital was highlighted as one of the six capitals for value creation (alongside financial, manufactured, intellectual, human, and social/relational capital) in the International Integrated Reporting Framework published by the IIRC in 2013. Although natural capital has been



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extensively discussed in environmental economics within the social sciences, it has rarely been discussed in management and accounting research. This gap highlights the need to advance sustainability accounting beyond the traditional scope of environmental accounting in Japan.

In this study, natural capital is defined, following the International Integrated Reporting Framework, as “all renewable and non-renewable environmental resources and processes that provide goods or services that support the past, present, or future prosperity of an organization” (IIRC, 2013). This concept is consistent with the Natural Capital Protocol, which emphasizes that businesses both depend on and affect natural capital through their activities (Natural Capital Coalition, 2016). Examples of natural capital include air, water, land, minerals, forests, biodiversity, and ecosystem health.

Among recent developments integrating nature into financial and corporate decision-making, the establishment of the Taskforce on Nature-related Financial Disclosures (TNFD)² and the publication of its guidelines, including its final recommendations in September 2023, are especially significant. The TNFD provides a framework for companies to disclose and manage risks and opportunities related to natural capital. Similar to the Task Force on Climate-related Financial Disclosures (see Note 2), its primary aim is to integrate nature-related considerations into investors’ and corporations’ decision-making processes. The Japanese Corporate Governance Code is scheduled for revision in June 2026. Companies are expected to further enhance their sustainability disclosures to improve alignment with the global standards of the International Sustainability Standards Board. The European Union (EU)’s Corporate Sustainability Reporting Directive similarly imposes disclosure obligations based on double materiality on all large and listed companies, and companies operating in the EU must comply with this directive.

Efforts to visualize and quantify the economic value of nature are increasing, especially through to the monetization of ecosystem services such as water purification and carbon sequestration. This growing interest in assigning economic value to ecosystem services is also reflected in the Dasgupta Review, which emphasized that nature should be regarded as an asset and that economic systems should account for the value of natural capital (Dasgupta, 2021). This perspective has strengthened calls for accounting and reporting systems that make corporate dependencies and impacts on nature more visible.

Amid the escalating severity of environmental issues in contemporary society, accounting approaches that support sustainable economic management have gained prominence. In particular, natural capital accounting and environmental accounting are critical frameworks for corporate and governmental decision-making. However, international research requires a clear distinction between these concepts, which are often conflated.

Natural capital accounting defines natural resources and ecosystem services as essential “capital” for economic activity. It systematically quantifies and monetizes this capital and integrates it into national accounting systems and corporate finance. Based on the United Nations-led System of Environmental-Economic Accounting, it aims to assess sustainability by explicitly demonstrating nature’s contributions. Natural capital accounting typically focuses on evaluating the stocks and flows of renewable and non-renewable resources, including forests, freshwater, minerals, and biodiversity (Amaral et al., 2025).

Environmental accounting is a broader concept encompassing methods for measuring and reporting environmental effects, environmental conservation costs, and the effects of environmental policies at both corporate and national levels. Whereas natural capital recognizes the economic value of nature itself as capital, environmental accounting records and reports all economic activities affecting the environment and their associated costs.

Natural capital is frequently applied in policymaking and national fiscal analysis, and international organizations such as the United Nations, World Bank, and OECD

actively promote its adoption. By contrast, environmental accounting is incorporated into corporate sustainability reporting, corporate social responsibility (CSR)³ initiatives, and ESG assessment; it is more closely linked to strategic corporate decision-making.

In summary, although both natural capital and environmental accounting are essential for sustainable development, they differ in their objectives, scope, and applications. Understanding these distinctions and applying each framework appropriately can contribute to more effective environmental policy and sustainable economic management.

Prior studies have shown that environmental performance and disclosure can influence corporate value. Cormier and Magnan (1997) and Konar and Cohen (2001) reported that poor environmental performance and pollution are negatively reflected in stock prices and firm value. Reid and Toffel (2009) reported that pressure from investors and non-governmental organizations (NGOs)⁴ encourages climate-related disclosure, whereas Kim and Lyon (2011) suggested that CDP⁵-related investor activism may affect shareholder value. Luo et al. (2012), Lewandowski (2017), Delmas et al. (2015), and Desai and Raval (2022) further demonstrated that carbon-related disclosure, emissions reduction, and environmental performance are associated with both market-based and accounting-based financial outcomes.

Despite this growing body of research, several important gaps remain. First, many prior studies have focused on firms in Europe, the United States, or emerging markets, whereas empirical evidence from Japan remains limited. Second, existing CDP-related research has concentrated primarily on climate change and carbon emissions, with comparatively less attention devoted to broader natural capital dimensions, such as water security and forests. Third, prior findings regarding the relationship between environmental disclosure and corporate performance remain mixed, particularly with respect to market-based indicators, such as Tobin's Q, and accounting-based indicators, such as return on assets (ROA) and return on equity (ROE). These gaps warrant an examination of whether CDP evaluations are associated with corporate performance in the context of Japanese manufacturing firms.

Japan provides a distinctive institutional setting for examining the relationship between CDP evaluations and corporate performance. Previous studies have shown that superior environmental performance is associated with higher firm value and economic performance among Japanese manufacturing firms (Nishitani & Kokubu, 2012; Fujii et al., 2013). In recent years, Japan has further strengthened its sustainability disclosure framework through the revised 2021 Corporate Governance Code, climate-related disclosure expectations for Tokyo Stock Exchange Prime Market companies based on the Task Force on Climate-related Financial Disclosures recommendations or equivalent frameworks, and the mandatory reporting of greenhouse gas emissions under national legislation. Together with market-based governance through CDP assessments and increasing pressure from institutional investors and global supply chains, these developments suggest that environmental disclosure has become an increasingly important signal of firms' governance and environmental management capabilities. Nevertheless, limited evidence exists regarding whether CDP evaluations are reflected in the market valuation and financial performance of Japanese manufacturing firms.

Accordingly, this study empirically examines whether CDP scores related to climate change, water security, and forests are associated with corporate performance and firm value among Japanese listed manufacturing firms. Manufacturing firms provide an appropriate empirical setting because their operations are closely linked to resource consumption, emissions, water management, supply-chain risk, and other natural-capital-related issues. Using panel data from 2018 to 2023, this study analyzes the relationship between CDP scores and performance measures, including Tobin's Q, ROA, and ROE.

The study also has practical implications. For corporate managers, the findings provide evidence that improving the overall quality of environmental disclosure and management, as reflected in the aggregate CDP score, is associated with higher market valuation. For investors, the results clarify how the overall CDP score may serve as a non-financial signal of environmental risk management and future value creation, while indicating that individual sub-scores should be interpreted cautiously. For policymakers and standard setters, the findings provide evidence relevant to the ongoing development of sustainability disclosure requirements and natural-capital-related reporting frameworks.

The principal findings are as follows. The overall CDP score is positively associated with corporate performance and firm value, particularly market-based firm value measured by Tobin's Q, and this relationship remains robust after controlling for firm age and other factors. Improvements in the overall CDP score are also positively associated with changes in Tobin's Q. In contrast, the individual CDP sub-scores for climate change, water security, and forests do not exhibit consistently significant associations after additional controls and robustness checks are applied. These findings suggest that capital markets may evaluate the aggregate quality of environmental disclosure and management more consistently than individual natural-capital dimensions.

The remainder of this paper is organized as follows. Section 2 reviews the relevant accounting literature and develops the hypotheses. Section 3 describes the analytical methodology. Section 4 presents the analysis results. Section 5 discusses the findings. Section 6 concludes the paper.

2. Theoretical Framework and Hypotheses Development

This study primarily adopts signaling theory as the theoretical lens for explaining the relationship between CDP scores and corporate performance. Signaling theory suggests that, under conditions of information asymmetry, observable signals can convey otherwise unobservable firm quality to external market participants (Spence, 1973). In management research, signals are understood as observable firm attributes or actions that reduce information asymmetry between firms and external stakeholders (Connelly et al., 2011). External investors cannot directly observe the quality of a firm's environmental risk management, natural-capital dependency management, or long-term sustainability strategy. CDP scores provide publicly observable and externally comparable information regarding disclosure quality, governance, risk assessment, target setting, and environmental management practices. Therefore, higher CDP scores may serve as credible non-financial signals that reduce information asymmetry between firms and capital market participants.

Within this framework, CDP scores may influence corporate performance through three channels. First, the information channel suggests that higher CDP scores improve transparency and reduce uncertainty regarding environmental risks. Second, the risk-management channel suggests that firms with higher CDP scores are perceived as better prepared for climate change, water security, forest-related supply chain risks, and future environmental regulations. Third, the stakeholder-confidence channel suggests that higher CDP scores enhance legitimacy and trust among investors, customers, creditors, regulators, and other stakeholders. These effects are expected to be reflected particularly in market-based valuation measures such as Tobin's Q because such measures incorporate investors' expectations regarding future risks and opportunities.

In the literature on CDP and CO₂ emissions, early valuation studies indicate that capital markets incorporate environmental liabilities and environmental performance into firm valuation. Cormier and Magnan (1997) found that investors discount firms with greater implicit environmental liabilities, whereas Konar and Cohen (2001) showed that poorer environmental performance, measured by toxic emissions, is negatively associated

with intangible firm value. Building on this perspective, more recent CDP-focused studies have examined whether standardized environmental disclosure and management scores provide value-relevant information to investors.

The relationship between corporate responses to climate change and financial performance has been widely examined in the literature (Boiral et al., 2012; Busch & Hoffmann, 2011). However, this relationship is not uniformly positive and appears to depend on contextual factors.

Reid and Toffel (2009) analyzed the determinants of voluntary climate-related disclosure. Using CDP data for S&P 500 companies, they employed logistic regression to identify key determinants of disclosure behavior. They found that firms targeted by NGOs or investors were significantly more likely to disclose climate-related information and that firm size, industry characteristics, and governance structures also influenced disclosure behavior. Their findings suggest that external pressure can promote corporate disclosure and stimulate substantive changes in environmental strategies, indicating that disclosure functions not only as a reporting mechanism but also as a catalyst for organizational change.

Kim and Lyon (2011) examined whether institutional investor activism through the CDP enhances shareholder value. Using an event-study approach, they found that firms participating in the CDP tended to exhibit higher firm value, suggesting that transparency regarding environmental performance can increase corporate value. The effect was stronger among firms facing greater reputational risk and those with lower prior disclosure levels. They argued that investor activism is most effective when aligned with stakeholder interests, coupled with meaningful scope for improvement. Their study provides important insights into ESG investing and the conditions under which activism influences financial outcomes. It also provides evidence for the role of environmental risk management in corporate evaluations.

Luo et al. (2012) and Lewandowski (2017) provide empirical evidence that carbon-related corporate activities, including emissions reduction and carbon disclosure, are associated with firm value and financial performance. Both studies identify stakeholder and market pressures as critical drivers that incentivize firms to adopt and advance carbon strategies, encompassing both mitigation efforts and disclosure practices. Collectively, these findings suggest that carbon management is not merely a matter of environmental compliance but is increasingly embedded within firms' broader economic and strategic decision-making processes.

Delmas et al. (2015) examined the relationship between corporate greenhouse gas (GHG) emission reductions and financial performance from both short- and long-term dynamic perspectives. Using data from 1095 U.S. firms between 2004 and 2008, they found that environmental improvements may impose short-term financial costs, reflected in lower ROA. However, investors appear to recognize the long-term benefits of environmental initiatives, leading to higher firm value as measured by Tobin's Q. These findings suggest that environmental investments may reduce short-term profitability while generating long-term market rewards.

From a signaling-theory perspective, CDP-related disclosure may serve as a credible signal of a firm's environmental risk exposure and management quality. Matsumura et al. (2014) showed that carbon emissions disclosed through the CDP are negatively associated with firm value, whereas disclosure itself is value relevant. Similarly, Griffin et al. (2017) found that investors price greenhouse gas emissions as a negative component of equity value. These findings imply that environmental information influences capital market valuation by reducing information asymmetry and enabling investors to assess firms' exposure to climate-related risks.

The signaling role of CDP is particularly relevant in Japan because environmental disclosure operates through multiple institutional mechanisms rather than a single mandatory disclosure regime. Besides legal requirements for greenhouse gas reporting, Japanese firms are increasingly subject to market-oriented governance through the Corporate Governance Code, institutional investor engagement, and disclosure expectations based on the TCFD recommendations. Consequently, superior CDP ratings may signal not only environmental performance but also stronger governance structures, more sophisticated risk management, and higher disclosure quality, all of which may influence investors' assessments of firm value (Nishitani & Kokubu, 2012).

Compared with neighboring East Asian economies, Japan places greater emphasis on stock-exchange governance, investor engagement, and market-based reputational incentives. These institutional differences suggest that the economic implications of CDP disclosure may vary across countries depending on how environmental reporting is encouraged and enforced (Singhania & Saini, 2023).

Desai and Raval (2022) examined the relationship between environmental performance and market value using Indian firms. Their study focused on how the market incorporates environmental burden information, particularly CO₂ emissions, into firm valuation. Using 230 firm-year observations derived from CDP data and annual reports, they employed Tobin's Q as a proxy for firm value. The results showed that higher CO₂ emissions have a statistically significant negative effect on firm value. This finding is consistent with evidence from developed markets and suggests that investors incorporate environmental risk into valuation decisions by recognizing potential future regulatory and reputational costs.

Asghar et al. (2024) provide macro-level evidence that natural capital is economically relevant for sustainable development. Building on this perspective, the present study focuses on firm-level natural-capital disclosure and management by examining CDP scores for climate change, water security, and forests.

Early studies demonstrated that high levels of pollution reduce stock prices and corporate value, suggesting that investors incorporate environmental risks into pricing. Subsequent analysis using CDP data has shown that external pressure from NGOs and investors, combined with firm size, industry, and governance factors, drives voluntary disclosure, which itself acts as a catalyst for strategic transformation. More recent research on natural capital has demonstrated how synergistic innovation enhances sustainability. As CDP reporting has evolved and the number of disclosing firms has increased, the relationship between natural capital and corporate performance warrants re-examination using established methodology. Based on signaling theory, firms with higher overall CDP scores are expected to send stronger signals of environmental transparency, risk-management capability, and strategic preparedness. Because the overall CDP score summarizes multiple dimensions of environmental governance and disclosure quality, investors may interpret it as an indicator of lower long-term environmental risk and higher future value-creation potential. Therefore, the overall CDP score is expected to be positively associated with corporate performance, particularly market-based firm value. Thus, we propose Hypothesis 1:

Hypothesis 1. *Higher CDP score ratings have a more positive effect on corporate performance.*

This study examines the need for empirical analysis of the effect of natural capital on financial performance. Using CDP data with evolving content and an increasing number of disclosing firms, this study empirically tests whether CDP-based evaluations are associated with corporate performance.

The empirical analysis is based on the framework proposed by Desai and Raval's (2022) model. Whereas their study used CO₂ emissions as the primary explanatory variable, the present study employs CDP scores. To reflect the rating-based nature of CDP assessments,

CDP scores are conceptualized as ordinal measures similar to Likert-type scales. Although CDP scores are ordinal, they are treated as approximately continuous variables in this study because the scoring categories are ordered and they comprise multiple levels. This approach is consistent with methodological literature suggesting that Likert-type or ordinal scales with several categories are often analyzed using parametric methods when justified by the research objectives and underlying assumptions (Carifio & Perla, 2008; Sullivan & Artino, 2013).

A company's financial performance is influenced by various factors beyond carbon emissions; these include economic conditions, industry competition, and corporate strategies (Desai & Raval, 2022). Although Desai and Raval focused on the relationship between CO₂ emissions and financial performance, they also stated that other factors, such as market conditions and firm-specific characteristics, may significantly affect financial outcomes. More detailed analysis incorporating these additional variables provides a deeper understanding of the determinants of financial performance.

The overall CDP score comprises evaluations across three areas. First, "climate change" assesses companies' efforts to reduce GHG emissions and the effectiveness of their plans, including policies for climate change mitigation, energy efficiency, and the use of renewable energy. Second, "water security" evaluates water-resource management practices, water conservation and quality preservation efforts, with evaluation criteria such as water usage and responses to local water scarcity issues. Third, "forests" assesses efforts to reduce deforestation, including sustainable sourcing of raw materials and supply chain management. From the same theoretical perspective, the three CDP sub-scores represent more specific signals of firms' management of natural-capital-related risks. Climate change scores reflect preparedness for transition and physical climate risks; water security scores reflect exposure to water scarcity, operational continuity, and resource-use efficiency; and forest scores reflect supply chain management and biodiversity-related concerns. If investors regard these issue-specific scores as financially material and comparable across firms, higher sub-scores should also be associated with stronger corporate performance. Therefore, the following hypothesis is proposed.

Hypothesis 2. *Higher climate change, water security, and forest scores have more positive effects on corporate performance.*

This study adopts a similar approach to Delmas et al. (2015)'s panel data analysis. Panel data contain observations on cross-sectional units (i.e., firms) over time and are widely regarded as an efficient framework because they exploit variation across both dimensions. CDP scores are reported annually and can be observed repeatedly for the same firm, thereby generating a panel-data structure that captures both temporal variation and cross-sectional heterogeneity. Consequently, panel-data analysis is well suited for examining the relationship between CDP scores and corporate performance. Signaling theory further suggests that changes in CDP scores may convey value-relevant information. Improvements in CDP scores may signal enhancements in environmental governance, disclosure systems, target setting, and natural-capital risk management. Such improvements may be particularly relevant to investors because they reflect not only the current quality of environmental management but also the direction of organizational development. Therefore, improvements in CDP scores are expected to be associated with improvements in market-based corporate performance.

Hypothesis 3. *Improvements in CDP scores can enhance long-term benefits.*

The same signaling logic applies to changes in individual CDP sub-scores. Improvements in climate change, water security, and forest scores may signal progress in managing specific natural-capital-related risks, including emissions reduction, water-resource management, sustainable sourcing, and supply chain risk mitigation. If investors perceive these improvements as financially material, they should be associated with stronger long-term corporate performance.

Hypothesis 4. *Improvements in climate change, water security, and forest scores can enhance long-term benefits.*

3. Materials and Methods

3.1. Data Sources and Period of Analysis

This study uses an unbalanced panel dataset of Japanese listed firms covering fiscal years 2018–2023. This period was selected because CDP disclosures became increasingly available and comparable across Japanese firms, while the scope of CDP evaluations expanded beyond climate-related disclosure to include water security and forests. Financial statement and stock market data were obtained from the Nikkei NEEDS Financial QUEST database, and CDP scores were collected from publicly available CDP disclosures. Financial variables include market capitalization, book value of net assets, current-year profit, expected profit for the subsequent fiscal year, total assets, debt ratio, ROA, ROE, and the market-to-book ratio. Environmental variables include the overall CDP score and the three CDP sub-scores for climate change, water security, and forests.

3.2. Sample Selection

The target population consists of companies listed on the Tokyo Stock Exchange for which financial data were available from Nikkei NEEDS Financial QUEST and CDP-related information could be identified from publicly available sources. Consistent with prior studies, the empirical analysis was restricted to manufacturing firms as defined by the Nikkei Industry Classification codes. This restriction is theoretically and empirically justified for three reasons. First, manufacturing firms are more directly exposed to natural-capital-related challenges, including energy consumption, GHG emissions, water use, raw material procurement, waste generation, and environmental risks throughout the supply chain. Second, the manufacturing sector exhibits relatively comparable production processes and performance measures, enhancing the validity and reproducibility of inter-firm comparisons. Third, CDP scores related to climate change, water conservation, and forests are likely to be more economically relevant in manufacturing than in many service industries.

3.3. Data Cleaning and Missing Data Treatment

The dataset was processed using the following procedures. First, firm-year observations were matched by firm identifier and fiscal year across the Nikkei NEEDS Financial QUEST database and publicly available CDP disclosure data. Second, observations with missing values for dependent variables, key explanatory variables, or required control variables were excluded from the relevant regression models. Because each model specification requires complete information, missing observations were handled through listwise deletion. Consequently, the number of observations varies across models depending on the availability of overall CDP scores and the three CDP sub-scores. Third, to reduce the influence of extreme observations, continuous financial variables were trimmed at the top and bottom 1% of their distributions. Fourth, market capitalization and selected financial variables were scaled by year-end total assets where appropriate to improve comparability across firms of different sizes. Fifth, market capitalization, book value of net assets, current-

year profit, expected profit for the subsequent fiscal year, and CDP scores were transformed as described below for the regression analysis.

CDP scores are derived from detailed corporate questionnaires comprising numerous qualitative and quantitative items. These questionnaires cover governance, strategy, risk management, metrics and targets, emissions or resource-use data, verification, and supply chain management. Responding organizations are evaluated across four progressive stages of environmental stewardship in an organization: Disclosure, Awareness, Management, and Leadership. After a responder is assessed against the scoring methodology for a given environmental issue area, a final percentage score is calculated for each scoring level. For Disclosure and Awareness, the score is based on the percentage of points awarded relative to the points available. For the Management and Leadership levels, a weighted percentage score is calculated. To account for differences in environmental exposure and management across sectors, CDP applies sector-specific weighting adjustments at the Management and Leadership levels. Organizations are ultimately assigned a letter grade ranging from A to D for each environmental issue area (CDP, 2025).

CDP scores are reported as ordinal letter ratings. For the baseline regression analysis, these ratings were coded numerically as follows: A = 4, B = 3, C = 2, D = 1, and F or “No Rating/Not Disclosed” = 0. The same coding rule was applied to the overall CDP score and the three sub-scores for climate change, water security, and forests. To address the ordinal nature of CDP ratings, additional robustness checks were conducted using categorical score specifications.

The use of a quasi-continuous specification is motivated by the fact that CDP categories represent progressively higher levels of disclosure quality, governance, risk management, target setting, and environmental strategy. Nevertheless, because CDP ratings are ordinal, the baseline specification should be interpreted as an ordered approximation rather than as evidence that adjacent rating categories are equally spaced. To address this measurement issue, additional robustness checks were conducted using dummy variables for each CDP rating category, with score category with CDP score 2 used as the reference category.

3.4. Analysis Sample

The target companies included those listed on the Tokyo Stock Exchange. Data from Nikkei NEEDS, handled by the Nihon Keizai Shimbun, were used. Financial and stock price data were extracted from Nikkei NEEDS Financial Quest. Recurring profit was used as the profit figure (net profit and forecast profit for the next period), as it serves as a proxy variable for future performance.

Consistent with prior studies, the analysis was limited to manufacturing firms based on the Nikkei Industry Classification code. This restriction reflects the sector’s relatively standardized production processes, performance metrics, and availability of quantitative data. Moreover, relationships among operational indicators, production efficiency, and firm performance are generally more clearly defined in manufacturing industries, thereby enhancing the validity and reproducibility of the empirical analysis.

Stock market capitalization and financial data were scaled by year-end total assets. To accommodate this, a scaling factor based on total assets was applied. Turnover for the following year was used to calculate per-unit turnover. Market capitalizations, book value of net assets, current-year profits, and expected profits for the next year were log-transformed.

3.5. Variable Definitions

To improve transparency and address variable interpretation, Table 1 summarizes the definitions, measurement procedures, transformations, and data sources of the variables used in the regression analyses and robustness checks.

Table 1. Variable definitions and measurement.

Variable	Symbol	Definition and Measurement
Dependent Variables		
TQ (Tobin's Q)	Y	Market-based firm value indicator; Δ TQ denotes the year-to-year change in Tobin's Q.
ROA	Y	Return on assets; accounting-based corporate performance indicator.
ROE	Y	Return on equity; accounting-based corporate performance indicator.
Independent Variables		
Net asset book value	X_1	Book value of net assets; scaled by total assets and log-transformed where appropriate.
Net profit for the year	X_2	Current-year recurring profit; scaled by total assets and log-transformed where appropriate.
Profit forecast for next financial year	X_3	Expected profit for the following fiscal year; proxy for future performance; scaled/log-transformed where appropriate.
CDP Score (climate change, water security, forest)	X_4, X_5, X_6, X_7	CDP letter score coded as highest rating was assigned a value of A = 4, followed by B = 3, C = 2, D = 1, and F or "No rating/Not disclosed" = 0.
Control Variables		
Market value book value ratio	X_8	Market-to-book ratio; controls for valuation characteristics affecting stock returns.
Debt ratio	X_9	Financial leverage; proxy for financial capacity to undertake investments.
Return on assets (lagged ROA)	X_{10}	ROA in the previous year; proxy for operating performance capacity.
Scale	X_{11}	Firm size, measured as the natural logarithm of total assets.
Firm Age	X_{12}	Number of years from the firm's establishment year to the observation year.
GNI	X_{13}	Gross national income; annual macroeconomic control variable.

3.6. Analysis Model

Following the Ohlson (2001) valuation framework, firm value can be expressed as the sum of the discounted present value of future residual earnings. This framework incorporates four key elements: (i) current-year residual earnings, (ii) the persistence of residual earnings, (iii) other information affecting future residual earnings, and (iv) the persistence of that "other information."

The inclusion of CDP scores is consistent with both the Ohlson framework and the signaling-theory perspective developed above. In the Ohlson framework, "other information" refers to value-relevant non-accounting information that affects expectations of future residual earnings. CDP scores may be interpreted as such information because they provide observable signals regarding environmental disclosure quality, natural-capital risk management, and long-term strategic preparedness. Accordingly, CDP scores are included as key explanatory variables to examine whether corporate performance and

market valuation reflect these non-financial signals. Hypotheses 1 and 2 are supported if the estimated coefficients on the CDP variables are positive and statistically significant.

Analysis Model 1:

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon_i,$$

Analysis Model 2:

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon_i,$$

where Y is Tobin's Q (TQ), ROA, and return on equity (ROE); X_1 is net asset book value; X_2 is net profit for the year; X_3 is expected profit for the next financial year; X_4 is the CDP score; X_5 is the climate change score; X_6 is the water security score; and X_7 is the forest score.

To test the effect of changes in CDP scores on stock returns (changes in TQ), year-to-year differences are calculated based on the above specification. Capital investment and R&D investment are considered necessary to improve CDP score ratings, and the availability of financing for such investments may influence the level of CDP scores. Therefore, the debt ratio is included as a proxy for financial capacity, and lagged ROA is included as a proxy for operating performance capacity.

As the explained variable is share price return, firm size (natural logarithm of total assets) and the market-to-book ratio, which may affect share price returns, are included in the model. To address potential omitted-variable bias, extended specifications also include firm age and an annual macroeconomic control variable, gross national income (GNI)⁶. Firm age is measured as the number of years from the year of establishment to the observation year. GNI is included as an annual macroeconomic control variable to account for macroeconomic conditions at the year level (World Bank, n.d.).

Corporate performance may also be influenced by ownership structure, corporate governance characteristics, and industry competition. However, including these variables would substantially reduce the usable sample because consistent firm-year observations are unavailable for all firms. Accordingly, the baseline and extended specifications control for observable firm characteristics through financial controls, industry indicators, firm age, fixed effects where applicable, and the annual macroeconomic control variable. The remaining risk of omitted-variable bias is discussed as a limitation of the study.

Although lagged explanatory variables help establish temporal ordering between CDP-related variables and corporate performance, they do not establish causality. Therefore, propensity score matching (PSM) was conducted as an additional robustness test for Models 1 and 2, while two-step system generalized method of moments (GMM) estimation was applied to Models 3 and 4. These approaches are intended to mitigate, rather than eliminate, concerns regarding selection bias, endogeneity, and omitted-variable bias.

Analysis Model 3:

$$Y_{it} = \alpha_{it} + \beta_1 X_{1(t-1)} + \beta_2 X_{2i(t-1)} + \beta_3 X_{3i(t-1)} + \beta_4 X_{4i(t-1)} + \beta_8 X_{8i(t-1)} + \beta_9 X_{9i(t-1)} + \beta_{10} X_{10i(t-1)} + \beta_{11} X_{11i(t-1)} + \beta_{12} X_{12i(t-1)} + \beta_{13} X_{13i(t-1)} + \varepsilon_{it},$$

Analysis Model 4:

$$Y_{it} = \alpha_{it} + \beta_1 X_{1i(t-1)} + \beta_2 X_{2i(t-1)} + \beta_3 X_{3i(t-1)} + \beta_5 X_{5i(t-1)} + \beta_6 X_{6i(t-1)} + \beta_7 X_{7i(t-1)} + \beta_8 X_{8i(t-1)} + \beta_9 X_{9i(t-1)} + \beta_{10} X_{10i(t-1)} + \beta_{11} X_{11i(t-1)} + \beta_{12} X_{12i(t-1)} + \beta_{13} X_{13i(t-1)} + \varepsilon_{it},$$

where Y is the Δ Tobin's Q (TQ); X_1 is the Δ Net asset book value; X_2 is the Δ net profit for the year; X_3 is the Δ projected profit for the next fiscal year; X_4 is the Δ CDP score; X_5 is the Δ climate change score; X_6 is the Δ water security score; X_7 is the Δ forest score; X_8 is the

market-to-book ratio; X_9 is the debt ratio; X_{10} is return on assets in the previous year; and X_{11} is firm size.

For Models 3 and 4, a series of specification tests were conducted to determine the appropriate econometric model. Specifically, an F-test for individual effects was used to compare fixed-effects and pooled OLS models, a Breusch–Pagan Lagrange multiplier test was used to compare random-effects and pooled OLS models, and a Hausman test was used to compare fixed-effects and random-effects estimators. The results, reported in Appendix C, indicate that firm-specific effects were not statistically significant and that the random-effects specification was not preferred to pooled OLS. Although the Hausman test did not reject the consistency of the random-effects estimator, the Breusch–Pagan test indicated that random effects did not provide a statistically superior fit relative to pooled OLS. These findings are also consistent with the change-based structure of Models 3 and 4 because differenced variables partially account for time-invariant firm-specific heterogeneity. Consequently, pooled OLS was adopted as the primary estimation method for Models 3 and 4.

4. Results

4.1. Descriptive Statistics

Descriptive statistics are first reported for the dataset. For Hypotheses 1 and 2, 422 companies are included in the analysis. For the panel data analysis (Hypotheses 3 and 4), 120 companies are analyzed. Table 2 shows the descriptive statistics for each variable. Table 3 presents correlations. Some combinations exhibit relatively high correlation coefficients, such as net profit and expected profit for the following period; however, the variance inflation factor remains below 5, suggesting that multicollinearity is not a serious concern.

Table 2. Descriptive statistics.

	TQ	Net Asset Book Value	Net Profit for the Year	Profit Forecast for the Next Financial Year	CDP Score
Average	3.28	0.72	2.69	3.26	2.34
SE	0.34	0.11	0.32	0.28	0.24
Median	3.07	0.91	2.78	3.53	2.07
Standard deviation	1.65	1.01	0.64	0.75	1.15
Minimum	−3.21	−2.13	−5.87	−6.37	0
Maximum	10.28	1.02	6.95	5.31	4

Table 3. Correlation coefficients.

	TQ	Net Asset Book Value	Net Profit for the Year	Profit Forecast for the Next Financial Year	CDP Score	Debt Ratio	Return on Assets	Scale	Market Value Book Value Ratio
TQ	1								
Net asset book value	0.33	1							
Net profit for the year	0.62	0.32	1						
Profit forecast for the next financial year	0.53	0.35	0.25	1					
CDP Score	0.25	0.08	0.31	−0.34	1				
Debt ratio	−0.45	−0.09	−0.21	−0.06	−0.42	1			
Return on assets	−0.23	0.01	0.08	−0.11	−0.07	0.14	1		
Scale	−0.2	−0.02	0.11	−0.14	0.03	0.09	0.01	1	
Market value book value ratio	−0.18	0.09	0.04	−0.29	0.02	0.21	0.22	0.27	1
Firm Age	0.01	−0.06	0.20	0.20	−0.07	−0.03	0.01	−0.03	0.11
GNI	0.02	−0.01	0.65	−0.01	0.03	0.05	0.22	−0.05	−0.37

4.2. Main Findings

Desai and Raval (2022) showed that CO₂ emissions have a significant negative effect on both measures of corporate value. Companies that reduce CO₂ levels are rewarded with higher market values. Although the present study measures environmental performance using CDP scores rather than emissions levels, the overall findings are broadly consistent with those of Desai and Raval.

Before estimating the models, the Ramsey regression equation specification error test (RESET) was conducted to assess the adequacy of the linear functional form. The results indicate that the null hypothesis of correct model specification cannot be rejected for either the full sample or the subsample analyses. Therefore, the use of linear regression specifications is considered appropriate. Estimation results are reported in Tables 4–11, while additional robustness checks addressing CDP score measurement, endogeneity, and omitted-variable bias are presented in Section 4.3 and Tables 12–16.

Table 4. Model 1 estimation results.

Model Statistics				
	TQ	ROA	ROE	
CDP Score	0.054 **	0.005 **	0.013 ***	
R-squared	0.46	0.11	0.19	
Adjusted R-squared	0.45	0.10	0.18	
F-statistic	71.41	10.50	19.05	
p (F-statistic)	0.001 ***	0.001 ***	0.001 ***	
RESET Tests				
	Statistic	p	df1	Statistic
Model 1	0.623	0.536	2	0.623

** Significance at the 5% level. *** Significance at the 1% level.

Table 5. Estimation results for each explanatory variable in Model 1.

	Coefficient	t-Statistic	p
Net asset book value	0.420	8.61	0.0001 ***
Net profit for the year	0.229	5.36	0.0001 ***
Profit forecast for the next financial year	0.293	9.15	0.0001 ***
Firm Age	−0.003	−1.86	0.064 *
CDP Score	0.054	2.43	0.015 **

* Significance at the 10% level. ** Significance at the 5% level. *** Significance at the 1% level.

Although the Breusch–Pagan tests generally do not reject the null hypothesis of homoskedasticity at conventional significance levels, heteroskedasticity-robust standard errors are reported as a precautionary measure.

Table 4 shows that the coefficients on the overall CDP score are positive for all three corporate performance indicators. Specifically, the coefficient of the CDP score is 0.054 for TQ, 0.005 for ROA, and 0.013 for ROE. These coefficients are statistically significant, indicating that firms with higher overall CDP ratings tend to exhibit higher market-based and accounting-based performance. The adjusted R² values are 0.45 for TQ, 0.10 for ROA, and 0.18 for ROE, indicating relatively strong fit for Tobin's Q but more modest fit for ROA and ROE. Overall, these results support Hypothesis 1.

Table 6. Model 2 estimation results.

Model Statistics				
	TQ	ROA	ROE	
Climate Change	0.007	0.002	0.004	
Water Security	0.029	0.002	0.006	
Forest	−0.007	0.001	0.004	
R-squared	0.46	0.11	0.18	
Adjusted R-squared	0.45	0.10	0.17	
F-statistic	49.85	7.41	13.12	
<i>p</i> (F-statistic)	0.001 ***	0.001 ***	0.001 ***	
RESET Tests				
	Statistic	Value	df1	df2
Model 2	0.57	0.19	2	47

*** Significance at the 1% level.

Table 7. Estimation results for each explanatory variable in Model 2.

	Coefficient (TQ)	t-Statistic	p
Climate Change Scores	0.007	0.290	0.776
Water Security Scores	0.029	1.176	0.240
Forest Scores	−0.007	−0.343	0.732

Table 8. Model 3 estimation results.

Model Statistics (Δ TQ)				
R-squared	0.78			
Adjusted R-squared	0.75			
F-statistic	18.68			
p (F-statistic)	0.001 ***			
RESET Tests				
	Statistic	p	df1	df2
Model 3	0.79	0.45	2	52

*** Significance at the 1% level.

Table 9. Estimation results for each explanatory variable in Model 3.

	Coefficient	Std. Error.	t-Statistic	p
Intercept	0.200	0.066	3.054	0.003 ***
Δ Net asset book value	0.031	0.027	1.152	0.252
Δ Net profit for the year	0.604	0.018	33.973	0.001 ***
Δ Profit forecast for the next financial year	0.514	0.017	29.891	0.001 ***
Δ CDP Score	0.059	0.005	12.299	0.001 ***
Debt ratio	−0.017	0.028	−0.626	0.532
Return on assets	0.164	0.129	1.276	0.205
Scale	0.001	0.003	0.409	0.683
Firm Age	0.000	0.000	1.895	0.061 *
GNI	−0.002	0.008	−0.260	0.795
Market value book value ratio	0.008	0.010	0.783	0.435

* Significance at the 10% level. *** Significance at the 1% level.

Table 10. Model 4 estimation results.

Model Statistics (ΔTQ)				
R-squared		0.67		
Adjusted R-squared		0.63		
F-statistic		15.22		
<i>p</i> (F-statistic)		0.001 ***		
RESET Tests				
	Statistic	<i>p</i>	df1	df2
Model 4	1.07	0.340	2	46

*** Significance at the 1% level.

Table 11. Estimation results for each explanatory variable in Model 4.

	Coefficient (TQ)	t-Statistic	<i>p</i>
Δ Climate Change Scores	0.007	0.006	0.328
Δ Water Security Scores	−0.007	−0.977	0.328
Δ Forest Scores	0.011	2.308	0.023 **

** Significance at the 5% level.

Economically, the coefficient of 0.054 for the overall CDP score indicates that, holding the book value of net assets, current earnings, and expected future earnings constant, a one-point increase in the coded CDP score is associated with a 0.054 increase in Tobin's Q. The CDP score is coded from 0 to 4; therefore, movement from a lower to a higher category is associated with higher market valuation, even after controlling for conventional financial information. Although the coefficient is numerically modest, its implication is meaningful: CDP scores appear to provide incremental value-relevant information to investors beyond accounting-based fundamentals.

Prior studies have focused on CDP reports for information on CO₂ emission efficiency and disclosure of CO₂-related information. Currently, the scope of investigation has been expanded to include climate change, water security, and forests. Therefore, we include these scores, which are not analyzed in prior studies, as variables. The coefficients of the climate change score, water security score, and forest score are not statistically significant for Tobin's Q, ROA, or ROE. For Tobin's Q, the coefficients are 0.007 for the climate change score, 0.029 for the water security score, and −0.007 for the forest score. For ROA, the corresponding coefficients are 0.002, 0.002, and 0.001, respectively. For ROE, they are 0.004, 0.006, and 0.004, respectively. Although most coefficients are positive, none of them is statistically significant. Table 6 shows that the adjusted R² values are 0.45 for TQ, 0.10 for ROA, and 0.17 for ROE, indicating that the model fit is relatively stronger for Tobin's Q than for the accounting-based indicators. These results indicate that the disaggregated CDP sub-scores do not provide robust evidence of a direct association with corporate performance. Accordingly, the main results do not support Hypothesis 2 (Tables 6 and 7).

These results are based on panel data analysis, addressing an issue identified in Desai and Raval (2022). With an adjusted R² of 0.75, the model fit is high; furthermore, *p* = 0.001, indicating that Model 3 is statistically significant.

Table 9 shows that the coefficient of the change in the CDP score is 0.059, which is small but positive and significant at the 1% level. The results in Table 9 show that, despite controlling for net asset book value, current profits, and next period's expected profits, the coefficient of change in the CDP score is significantly positive, supporting Hypothesis 3.

The Analytical Model 4 results are weaker than those for Analytical Model 3. The coefficients of Delta Climate Change and Delta Water Security are not statistically significant, and Delta Water Security is negative. Delta Forest is positive and weakly significant at

the 5% level; however, this evidence is insufficient to support a broad conclusion that improvements in individual sub-scores consistently increase firm value. Thus, support for Hypothesis 4 is weak and limited (Tables 10 and 11).

4.3. Robustness Checks

To address concerns regarding CDP score measurement, endogeneity, and omitted-variable bias, several supplementary robustness checks were conducted. These analyses provide additional supporting evidence but do not establish definitive causal relationships because unobservable firm characteristics may continue to affect both CDP scores and corporate performance.

Comparisons between the baseline and extended specifications indicate that the overall CDP score remains positive and statistically significant in Model 1, while the change in the CDP score remains positive and statistically significant in Model 3. In contrast, the results for the individual sub-scores in Models 2 and 4 are not consistently significant. This pattern indicates that the strongest evidence relates to the aggregate CDP measure rather than the individual climate change, water security, and forest dimensions.

First, to address concerns regarding the ordinal nature of CDP ratings, Model 1 was re-estimated using a categorical dummy-variable specification. CDP score category 2 served as the reference category. Table 12 reports the results for Tobin's Q, ROA, and ROE using the same format as the main regression analyses. The highest CDP category is positively associated with Tobin's Q, whereas lower CDP categories are negatively associated with certain accounting-based performance measures. Overall, these findings are broadly consistent with the baseline interpretation that higher CDP evaluations are associated with higher market valuation.

Table 12. Categorical specification for CDP scores.

Variable	Tobin's Q	ROA	ROE
CDP score = 0	−0.102 (0.095)	−0.015 * (0.008)	−0.055 *** (0.014)
CDP score = 1	−0.043 (0.060)	−0.010 * (0.005)	−0.018 ** (0.009)
CDP score = 3	0.056 (0.053)	0.004 (0.005)	−0.003 (0.008)
CDP score = 4	0.119 * (0.072)	0.001 (0.006)	0.021 * (0.011)
Controls	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Num. Obs.	422	422	422
Adj. R ²	0.452	0.101	0.185

Standard errors are reported in parentheses. * Significance at the 10% level. ** Significance at the 5% level. *** Significance at the 1% level. CDP score 2 is used as the reference category. Controls include current net profit, profit forecast, market-to-book ratio, and firm age.

PSM was conducted for Models 1 and 2 as an additional robustness check. The treatment variable equals one when the corresponding CDP-related score is above the sample median and zero otherwise. The high overall CDP score is positively associated with Tobin's Q in the matched sample, providing partial support for the overall CDP result. However, for Model 2, the PSM results are weaker: the climate change and water security treatments are not statistically significant, and the forest treatment is only weakly significant for Tobin's Q. Therefore, the PSM evidence should be interpreted as supplementary rather than conclusive causal evidence.

Table 13. PSM results: Key treatment coefficients.

Treatment Variable	Tobin's Q	ROA	ROE	Matched N
High CDP	0.095 ** (0.045)	0.006 (0.004)	0.011 (0.007)	348
High Climate	0.066 (0.048)	0.006 (0.004)	0.007 (0.008)	278
High Water	0.015 (0.046)	0.008 ** (0.004)	0.019 *** (0.007)	330
High Forest	0.110 * (0.058)	0.001 (0.005)	0.021 ** (0.009)	202

Standard errors are reported in parentheses. * Significance at the 10% level. ** Significance at the 5% level. *** Significance at the 1% level. PSM uses 1:1 nearest-neighbor matching without replacement. Matching covariates include current net profit, profit forecast, market-to-book ratio, and firm age.

Table 14 reports the covariate balance and matched sample sizes. The PSM procedure generally improves the balance of the matching covariates, although some imbalance remains for the overall CDP score. This reinforces the need to interpret PSM as a robustness check rather than as definitive causal identification.

Table 14. Covariate balance and matching sample sizes.

Model	SMD After Matching	Control All	Treated All	Control Matched	Treated Matched
CDP	0.076–0.263	248	174	174	174
Climate	0.012–0.082	283	139	139	139
Water	0.087–0.126	257	165	165	165
Forest	0.008–0.058	321	101	101	101

SMD denotes standardized mean difference. The table reports the range of post-matching SMDs across the four matching covariates. The columns “Control all” and “Treated all” refer to the original sample used for matching, while “Control matched” and “Treated matched” refer to the sample retained after 1:1 nearest-neighbor matching.

Two-step System GMM estimation was conducted for Models 3 and 4 to address dynamic endogeneity. For Model 3, the change in the overall CDP score remains positively and significantly associated with the change in Tobin's Q, supporting the primary pooled OLS finding that improvements in the overall CDP score with higher market valuation. However, for Model 4, the coefficients for changes in climate change, water security, and forest scores are not statistically significant in the System GMM specification. Thus, the dynamic robustness evidence supports Hypothesis 3 but not Hypothesis 4.

Table 15. Two-step System GMM results for Models 3 and 4.

Variable	Model 3: Δ CDP Score	Model 4: Disaggregated Scores
lag(Delta_TQ, 1)	0.014 (0.031)	0.036 (0.036)
Delta_CDP_Score	0.052 *** (0.007)	
Delta_Climate_Change		0.010 (0.010)
Delta_Water_Security		−0.013 (0.009)
Delta_Forest		0.009 (0.007)

Table 15. *Cont.*

Variable	Model 3: Δ CDP Score	Model 4: Disaggregated Scores
Debt_Ratio	−0.050 (0.038)	−0.080 ** (0.040)
ROA_Lag	0.225 (0.163)	0.219 (0.160)
Scale_InAssets	0.010 *** (0.003)	0.011 *** (0.003)
Market_to_Book	0.016 (0.014)	0.007 (0.015)
Delta_Net_Asset_Book_Value	−0.028 (0.035)	−0.014 (0.037)
Delta_Net_Profit	0.593 *** (0.026)	0.601 *** (0.027)

Standard errors are reported in parentheses. ** Significance at the 5% level. *** Significance at the 1% level. The dependent variable is Delta_TQ.

Table 16. Dynamic GMM diagnostic tests.

Model	AR(1) <i>p</i> -Value	AR(2) <i>p</i> -Value	Sargan <i>p</i> -Value
Model 3-GMM	<0.001	0.082	0.057
Model 4-GMM	<0.001	0.131	0.174

AR(1) and AR(2) are Arellano–Bond tests for serial correlation. The overidentification test reports the Hansen statistic when available; otherwise, the Sargan statistic is reported.

Overall, the robustness checks provide additional, although not uniform, support for the main findings. The evidence is comparatively strong and consistent for the overall CDP score, particularly in relation to Tobin’s Q and changes in Tobin’s Q. In contrast, evidence for the disaggregated climate change, water security, and forest scores remains weak and unstable across the main specifications, PSM analyses, and system GMM estimations. Accordingly, the findings should be interpreted as evidence of associations between CDP-related evaluations and corporate performance rather than as definitive causal effects.

5. Discussion

This study’s findings should be interpreted in relation to both the proposed hypotheses and the broader literature on environmental disclosure, environmental performance, and firm value. Overall, the findings indicate that the aggregate CDP score functions as value-relevant non-financial information in the Japanese manufacturing sector. The individual CDP sub-scores have weaker evidence, suggesting that capital markets may evaluate the overall quality of environmental disclosure and management more consistently than each separate natural-capital dimension. From the perspective of signaling theory, CDP scores can be interpreted as credible non-financial signals through which firms communicate their environmental governance quality, risk management capability, and preparedness for future natural-capital-related risks to external investors.

5.1. Hypotheses 1 and 2

The results for Hypothesis 1 indicate that the overall CDP score is positively and significantly associated with Tobin’s Q. This finding is consistent with [Cormier and Magnan \(1997\)](#) and [Konar and Cohen \(2001\)](#), which showed that environmental liabilities and poor environmental performance are negatively reflected in stock prices and firm value. Although those studies focused on pollution and environmental performance rather than CDP scores, the underlying implication is similar: capital markets appear to incorporate environmental information into valuation because it signals future regulatory costs, reputational risks, and managerial capability.

The findings are also consistent with those of Kim and Lyon (2011), Luo et al. (2012), Lewandowski (2017), Delmas et al. (2015), and Desai and Raval (2022), who reported that carbon disclosure, emissions reduction, and environmental performance are associated with market valuation and financial outcomes. In particular, Desai and Raval (2022) found that higher CO₂ emissions are associated with lower firm value, whereas the present study finds that higher CDP scores are associated with higher firm value. Taken together, these findings suggest that investors reward firms perceived to manage environmental risks more effectively.

However, this study differs from much of the prior literature because it uses CDP scores as a broader proxy for environmental disclosure and management quality rather than focusing exclusively on emissions levels. This distinction is important because CDP scores capture not only environmental outcomes but also governance, risk assessment, strategy, target setting, and disclosure quality. Consequently, the positive association between CDP scores and Tobin's Q suggests that investors may value the managerial and informational attributes reflected in CDP evaluations, rather than environmental outcomes alone.

With respect to Hypothesis 2, the results do not provide statistically significant evidence that the climate change, water security, and forest scores are individually associated with corporate performance. This finding differs from the expectation that each natural-capital dimension would be independently value relevant. One possible explanation is that investors may interpret the aggregate CDP score as a more comprehensive and accessible signal of environmental governance and disclosure quality, whereas individual sub-scores may be more difficult to evaluate because of differences in industry materiality, data comparability, and investor awareness.

The weak and inconsistent results for the individual sub-scores further suggest that the value relevance of natural-capital information depends on the extent to which each issue is perceived as financially material. Although climate change, water security, and forests are all important environmental dimensions, their economic relevance may vary across manufacturing subsectors. Accordingly, the results suggest that the disaggregated sub-scores should be interpreted cautiously, and Hypothesis 2 is not supported.

5.2. Hypotheses 3 and 4

The results for Hypothesis 3 indicate that changes in CDP scores are positively associated with changes in Tobin's Q, suggesting that investors value not only the level of environmental disclosure and management quality but also improvements in these dimensions over time. The result is consistent with Delmas et al. (2015), who argued that investors may recognize environmental improvements as a source of long-term value, even when they involve short-term costs.

The result also complements those of Desai and Raval (2022), who reported that increases in CO₂ emissions are associated with lower firm value. Whereas their study focused on deterioration in environmental performance, the present study examines improvements in environmental evaluations. Taken together, the findings suggest that capital markets respond negatively to increasing environmental risk and positively to improvements in environmental disclosure and management.

The results for Hypothesis 4 are considerably weaker compared to those for Hypothesis 3. In the primary panel-data specification, the change in the forest score exhibits only weak statistical significance, whereas changes in climate change and water security scores are not statistically significant. Furthermore, none of the three sub-score changes remains statistically significant in the two-step system GMM analysis. Consequently, Hypothesis 4 receives only limited support. These findings suggest that improvements in the aggregate

CDP score are more robustly associated with firm value than improvements in individual environmental dimensions.

The weak and inconsistent results for the individual sub-scores may indicate that issue-specific natural-capital risks are not uniformly material across manufacturing subsectors. They may also reflect lower investor awareness or lower comparability of issue-specific disclosures relative to aggregate CDP evaluations. Therefore, the findings suggest that the financial relevance of natural-capital information depends on the perceived materiality, comparability, and maturity of each disclosure dimension. This represents an important contribution of the study because previous CDP-related research has focused primarily on carbon emissions and climate-related information, whereas the present study compares multiple environmental dimensions within a common empirical framework.

The robustness checks provide additional, although not uniform, support for these interpretations. In particular, the categorical CDP specification and the two-step system GMM analysis support the conclusion that the overall CDP score is positively associated with market-based firm value. In contrast, the results for the climate change, water security, and forest sub-scores are generally weaker in both the PSM and system GMM analyses. These findings suggest that investors may evaluate the overall quality of environmental disclosure and management more consistently than individual natural-capital dimensions.

This distinction is important for understanding the study's contribution. The findings indicate that the overall CDP score may function as an aggregate signal of environmental governance, disclosure quality, and risk-management capability. By contrast, the value relevance of individual natural-capital dimensions appears to depend on industry-specific materiality, data comparability, and investor awareness. Consequently, the results for the individual sub-scores should be interpreted as less robust and less conclusive compared to those for the overall CDP score.

5.3. Interpretation of the Results in Relation to the Hypotheses

Prior studies reported that increases in CO₂ emissions per unit of sales are associated with lower stock market valuations, whereas decreases in emissions are associated with higher valuations. Our findings suggest a related pattern. Improvements in CDP scores may reflect investments in environmental initiatives, environmental management systems, disclosure processes, and governance mechanisms. Although such activities may require additional resources, they may also enhance corporate reputation, strengthen stakeholder confidence, and improve perceptions of long-term sustainability. Consequently, higher CDP scores are associated with higher firm value, suggesting that investors incorporate CDP-related information into valuation decisions.

5.3.1. Short-Term Accounting Effects

The results for ROA and ROE indicate that the association between CDP scores and short-term accounting performance is weaker than the association with Tobin's Q. This finding suggests that environmental disclosure and management practices may not immediately translate into higher accounting profitability. One possible explanation is that improving CDP scores often requires investments in environmental initiatives, monitoring systems, data collection processes, governance reforms, and disclosure activities. These expenditures may generate short-term costs or may affect earnings only gradually. Therefore, the weaker associations observed for ROA and ROE should not be interpreted as evidence that CDP scores lack economic relevance; rather, they suggest that the benefits of environmental management may emerge over a longer time horizon.

5.3.2. Long-Term Market Valuation Effects

By contrast, the positive association between CDP scores and Tobin's Q suggests that capital markets may interpret CDP evaluations as indicators of long-term value creation. Tobin's Q reflects investor expectations regarding future profitability, risk reduction, and growth opportunities. Higher CDP scores may reduce uncertainty related to future regulatory costs, reputational risks, supply-chain disruptions, and resource constraints. Accordingly, the findings suggest that CDP scores are more closely associated with forward-looking market valuation than with contemporaneous accounting profitability.

5.3.3. Changes in CDP Scores as Improvement Signals

The positive association between changes in CDP scores and changes in Tobin's Q further suggests that investors respond not only to the level of environmental evaluation but also to improvements over time. An increase in a CDP score may signal improvements in environmental governance, risk management, disclosure quality, and strategic preparedness. Accordingly, the panel-data results suggest that improvements in environmental management quality are associated with higher market valuation, particularly from a long-term perspective.

6. Conclusions

6.1. Summary of the Main Findings

This study empirically examined the relationship between CDP scores and corporate performance among Japanese listed manufacturing firms. The primary objective was to investigate whether environmental disclosure and management quality, as reflected in CDP evaluations, are associated with firm value and financial performance. Specifically, the study examined both overall CDP scores and the three CDP dimensions of climate change, water security, and forests. Using panel data covering fiscal years 2018–2023, four hypotheses were tested regarding both the level of CDP scores and changes in CDP scores over time.

The empirical results provide several key findings. First, the overall CDP score is positively and significantly associated with corporate performance, particularly market-based firm value measured by Tobin's Q. This finding supports Hypothesis 1 and suggests that firms with higher CDP evaluations tend to receive higher market valuations. Second, the individual climate change, water security, and forest scores are not statistically significant in the main specification. Accordingly, Hypothesis 2 is not supported. These findings suggest that capital markets may place greater weight on aggregate environmental evaluations than on individual environmental dimensions.

Third, the panel regression analysis showed that improvements in overall CDP scores are positively associated with changes in Tobin's Q. This finding supports Hypothesis 3 and indicates that investors value not only firms that already have high environmental disclosure and management quality, but also firms that improve their CDP evaluations over time. Fourth, the results regarding changes in individual sub-scores are weak. Climate Change (Delta Climate Change) and Water Security (Delta Water Security) are not statistically significant, whilst Forest (Delta Forest) shows only weak significance in the fixed-effects model and is not significant in the robustness check using System GMM. Therefore, Hypothesis 4 receives only weak and limited support.

Additional robustness checks were conducted using categorical CDP score specifications, propensity score matching (PSM), and two-step system GMM estimation. These analyses provide relatively stronger support for the positive association between the overall CDP score and market-based firm value, whereas the evidence for the individual CDP sub-scores remains weaker and less conclusive. Therefore, the results for climate change,

water security, and forest scores should be interpreted as supplementary evidence rather than as evidence of robust and consistent associations.

6.2. Theoretical Implications

This study contributes to the literature on environmental accounting, ESG disclosure, and natural capital-related corporate evaluation in several ways. First, it provides empirical evidence from Japanese listed manufacturing firms, a setting that has received relatively limited attention in prior CDP-related research. Much of the existing literature has focused on firms in the United States, Europe, or emerging markets and has concentrated primarily on carbon emissions and climate-related disclosure. By focusing on Japan, this study extends the geographical scope of research on the relationship between environmental disclosure and firm value.

Second, this study broadens the analytical focus beyond carbon emissions by incorporating multiple CDP dimensions, namely climate change, water security, and forests. This extension is important because natural capital is inherently multidimensional and environmental risk extends beyond GHG emissions alone. At the same time, the results indicate that the individual sub-scores are not consistently associated with firm value. These findings provide a more nuanced understanding of CDP evaluations. Specifically, whereas the overall CDP score appears to function as a robust signal of environmental disclosure and management quality, the value relevance of individual natural-capital dimensions remains less certain.

Third, this study distinguishes between the level of CDP scores and changes in CDP scores. This distinction enables the examination of both accumulated environmental management quality and improvements in such quality over time. The results indicate that both higher CDP scores and improvements in CDP scores are positively associated with market valuation. These findings suggest that CDP evaluations may function not only as indicators of current disclosure quality but also as signals of future risk-management capability and long-term value-creation potential.

A notable contribution of this study lies not only in extending research on the CDP to Japanese companies, but also in analyzing individual CDP sub-scores to identify which scores are most closely correlated with corporate value. Prior studies have primarily analyzed individual indicators such as emissions, environmental performance (Desai & Raval, 2022) and CDP participation (Kim & Lyon, 2011). In contrast, this study compares overall scores with individual CDP sub-scores and examines both score levels and year-to-year changes within a common framework. The results show that, among the CDP measures examined, the overall CDP score and improvements in that score exhibit the most consistent associations with market valuation.

6.3. Practical Implications

The magnitude of the estimated coefficients should be interpreted as evidence of incremental market valuation rather than large immediate accounting benefits. The findings also have several practical implications for corporate managers, investors, and policymakers.

For managers, the relatively robust results for the overall CDP score suggest that firms should treat CDP disclosure as part of an integrated environmental management process rather than as an isolated reporting or score-improvement exercise. The findings suggest that improving CDP scores may help reduce information asymmetry regarding environmental risk management, regulatory preparedness, and long-term resilience. However, because the results for the individual sub-scores are weak and inconsistent, managers should be cautious in assuming that improvements in a single CDP dimension will necessarily be associated with higher market valuation. In addition, other findings suggest that

improving environmental disclosure and management practices may be associated with higher market valuation. Rather than treating CDP disclosure as a compliance-oriented reporting exercise, firms may benefit from integrating environmental disclosure into broader strategic processes for identifying, managing, and communicating environmental risks and opportunities across multiple natural-capital dimensions.

For investors, the findings indicate that CDP scores may serve as useful non-financial indicators when evaluating firms. Higher CDP scores may signal stronger environmental governance, more comprehensive risk management, and greater preparedness for future sustainability-related challenges. However, because the evidence for the individual sub-scores is weaker, investors should interpret climate change, water security, and forest scores cautiously and in conjunction with industry materiality and firm-specific circumstances.

For policymakers and standard setters, the results provide evidence that environmental disclosure is relevant to capital-market evaluation. As sustainability disclosure requirements continue to evolve in Japan and internationally, the findings support efforts to enhance the consistency, comparability, and reliability of environmental disclosure frameworks. The weak and inconsistent results for the individual sub-scores further suggest that additional efforts may be needed to improve the visibility, comparability, and interpretability of issue-specific environmental information, including information related to water resources, forests, biodiversity, and supply-chain risks.

6.4. Limitations and Future Research

This study has several limitations that provide directions for future research. First, CDP scores are derived partly from corporate responses and disclosure practices and may therefore be subject to measurement bias. Firms with greater sustainability-related resources, stronger reporting capabilities, or more sophisticated disclosure systems may receive higher scores even when their underlying environmental performance is not proportionately superior. Conversely, firms with weaker disclosure capabilities may receive lower evaluations despite implementing substantive environmental practices. Accordingly, CDP scores should be interpreted as indicators of environmental disclosure and management quality rather than as direct measures of environmental outcomes.

Furthermore, because CDP evaluations rely on firm-disclosed information, the scores may be influenced by strategic disclosure, selective reporting, and variation in the completeness and comparability of responses. Although CDP applies a standardized scoring framework, some degree of disclosure-related bias may remain. Therefore, the findings should be interpreted as evidence that capital markets respond to CDP-based environmental evaluations rather than as evidence that actual environmental performance directly determines firm value. Future research could address this limitation by combining CDP scores with objective environmental outcome measures, such as GHG emissions, water withdrawal, waste generation, third-party assurance data, or environmental violation records.

Second, caution is warranted when interpreting the empirical results. Although the categorical specifications, PSM analyses, and system GMM estimations help mitigate concerns regarding measurement error and endogeneity, they do not fully eliminate potential omitted-variable bias or establish definitive causal relationships. Future research could further investigate these relationships using richer data on ownership structures, corporate governance, and industry competition, as well as more refined measures of environmental performance.

Third, the empirical analysis focuses on Japanese listed manufacturing firms. Although this setting is appropriate because manufacturing firms are closely connected to emissions, resource use, water management, and supply-chain risks, the findings may not be directly generalizable to non-manufacturing industries or firms operating in other countries. Future

research could compare manufacturing and non-manufacturing sectors or conduct cross-country analyses to examine whether institutional environments influence the relationship between CDP scores and firm value.

Fourth, the results indicate that the individual CDP sub-scores are less consistently associated with market valuation than the overall CDP score. Future research should investigate why climate change, water security, and forest-related information are not consistently value-relevant in the revised specifications. Possible explanations include differences in materiality across industries, lower investor awareness, weaker comparability of issue-specific disclosures, and the relatively early stage of market understanding regarding biodiversity- and ecosystem-related risks. Further examination of industry-specific materiality and supply-chain exposure may help clarify these issues.

In conclusion, this study demonstrates that CDP scores are positively associated with corporate performance, particularly market-based firm value, among Japanese listed manufacturing firms. The findings indicate that environmental disclosure and management quality are relevant to investors' valuation decisions and that improvements in CDP evaluations are associated with higher market valuation. By contrast, the evidence for the climate change, water security, and forest sub-scores is weak when robustness checks are considered and should therefore be interpreted cautiously. By showing that aggregate CDP evaluations are more consistently associated with firm value than disaggregated environmental sub-scores, this study contributes to the literature on environmental accounting, ESG evaluation, and natural-capital-related corporate disclosure.

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Abbreviations

The following abbreviations are used in this manuscript:

CDP	Corporate Disclosure Project
IIRC	International Integrated Reporting Council
CSR	Corporate social responsibility
NGO	Non-governmental organization
TNFD	Taskforce on Nature-related Financial Disclosures
ESG	Environmental, Social, and Governance
ROA	Return on assets
ROE	Return on equity

GHG	Greenhouse Gas
GNI	Gross National Income
PSM	Propensity Score Matching

Appendix A

Table A1. Sample distribution by fiscal year for Hypotheses 1 and 2.

Fiscal Year	Models 1 and 2 Sample: Firm-Year Observations
2023	422
Total	422

Table A2. Sample distribution by fiscal year for Hypotheses 3 and 4.

Fiscal Year	Models 3 and 4 Sample: Firm-Year Observations
2018	120
2019	120
2020	120
2021	120
2022	120
2023	120
Total	720

Table A3. Analysis of manufacturing companies for Hypotheses 1 and 2.

Industry Category	Manufacturing Companies	Company Ratio
Food manufacturing	34	8%
Plastic products manufacturing	42	10%
General machinery manufacturing	38	9%
Electrical machinery manufacturing	38	9%
Transport equipment manufacturing (including motor vehicles)	59	14%
Steel and non-ferrous metal manufacturing	21	5%
Chemical products manufacturing (including basic chemicals and petroleum)	55	13%
Textile products manufacturing	34	8%
Paper and printing-related industries	42	10%
Other manufacturing	59	14%
Total	422	100%

Table A4. Analysis of manufacturing companies for Hypotheses 3 and 4.

Industry Category	Manufacturing Companies	Company Ratio
Food manufacturing	5	4%
Plastic products manufacturing	13	11%
General machinery manufacturing	10	8%
Electrical machinery manufacturing	11	9%
Transport equipment manufacturing (including motor vehicles)	20	17%
Steel and non-ferrous metal manufacturing	6	5%
Chemical products manufacturing (including basic chemicals and petroleum)	16	13%
Textile products manufacturing	7	6%
Paper and printing-related industries	16	13%
Other manufacturing	16	13%
Total	120	100%

Appendix B

Table A5. Covariate Balance Diagnostics.

Model	Variable	SMD_Before	SMD_After
CDP	Firm_Age	0.142	0.076
CDP	Market_to_Book	0.220	0.169
CDP	Net_Profit_Current_Year	0.512	0.263
CDP	Profit_Forecast_Next_Year	0.512	0.220
Climate	Firm_Age	0.011	0.012
Climate	Market_to_Book	0.054	0.082
Climate	Net_Profit_Current_Year	0.278	0.041
Climate	Profit_Forecast_Next_Year	0.431	0.051
Water	Firm_Age	0.088	0.093
Water	Market_to_Book	0.143	0.087
Water	Net_Profit_Current_Year	0.386	0.126
Water	Profit_Forecast_Next_Year	0.335	0.111
Forest	Firm_Age	0.011	0.009
Forest	Market_to_Book	0.053	0.051
Forest	Net_Profit_Current_Year	0.383	0.008
Forest	Profit_Forecast_Next_Year	0.323	0.058

SMD denotes standardized mean difference. SMDs are reported before and after matching. Values below 0.10 are generally considered indicative of satisfactory covariate balance.

Appendix C

Table A6. Panel Model Selection Tests.

Model	Test	Null Hypothesis	Statistic	p-Value
Model 3	F test for individual effects	No firm effects	0.899	0.758
Model 3	Breusch–Pagan LM test	No random effects	0.671	0.413
Model 3	Hausman test	RE is consistent	8.459	0.584
Model 4	F test for individual effects	No firm effects	0.917	0.713
Model 4	Breusch–Pagan LM test	No random effects	0.473	0.492
Model 4	Hausman test	RE is consistent	10.663	0.558

The F test examines whether firm fixed effects are jointly significant relative to pooled OLS. The Breusch–Pagan LM test examines whether random effects are preferred to pooled OLS. The Hausman test examines whether the random effects estimator is consistent relative to the fixed effects estimator.

Notes

- ¹ The IIRC is a non-profit organization based in the UK that establishes guidelines for integrated reporting.
- ² The TNFD provides an international framework that helps companies and financial institutions identify, assess, disclose, and manage risks and opportunities related to natural capital, such as biodiversity and ecosystems. It was established in 2021 as the nature-focused counterpart to the Taskforce on Climate-related Financial Disclosures. In September 2023, the final framework was released, aiming to support the integration of nature-related dependencies and impacts—such as forests, water resources, and land use—into corporate decision-making and investment strategies.
- ³ CSR can be understood as a managerial philosophy and set of organizational practices through which firms acknowledge and manage their responsibilities toward society and the environment, beyond the mere pursuit of profit, by incorporating stakeholder concerns into corporate strategy and operations.
- ⁴ NGOs can be understood as voluntary, non-profit, and self-governing organizations that function outside direct governmental control and seek to promote public or collective interests through activities such as service delivery, advocacy, community development, policy engagement, and humanitarian assistance.
- ⁵ CDP is a UK charity-controlled NGO that operates a global disclosure system to help investors, companies, nations, regions, and cities manage their environmental impacts. However, as the project now covers water security and forestry as well as carbon, the abbreviated name “CDP” has become its official name.
- ⁶ GNI is defined according to the System of National Accounts framework as income received by resident institutional units from domestic and foreign sources.

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