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Tangibility of intangibles in the ESG disclosure–carbon intensity nexus for S&P 500 firms

Rupjyoti Saha
Department of Humanities and Social Sciences, Indian Institute of Information Technology Guwahati, Kamrup, India, and
Santi Gopal Maji
Department of Commerce, Tezpur University, Tezpur, India

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Abstract

Purpose – Given the substantial contribution of intangible assets to firms' overall valuation in the present knowledge-based era, this study aims to explore how these non-physical assets influence the effectiveness of ESG disclosure in reducing carbon intensity (CI).

Design/methodology/approach – This study focuses on the S&P 500 firms for the period 2015–2016 to 2022–2023 to study the overall impact of ESG disclosure on CI and investigate the differential impact of the same based on firms' intangible assets by applying the system generalized method of moments (GMM) and two stage least squares (2SLS) regression models.

Findings – This study finds that overall, there is a significant negative impact of ESG disclosure on CI. However, the impact of ESG disclosure on CI varies based on firms' intangible assets. In particular, ESG disclosure leads to significant mitigation of CI for firms with high intangible assets, while the same relationship becomes insignificant for the firms with low intangible assets.

Originality/value – Given the extant ESG literature that largely focuses on its financial outcome, this study makes a novel contribution by studying the impact of ESG disclosure on a sustainability parameter, that is CI in the context of the US. Moreover, this research adds deeper insights into the strategic importance of intangible assets in enhancing corporate sustainability performance.

Keywords ESG disclosure, Carbon intensity, Intangible assets, S&P 500

Paper type Research paper

1. Introduction

The environmental crisis is a global problem, and only global action will resolve it -Barry Commoner

On November 11, 2022, at COP27, US President Joe Biden stated, "the climate crisis is about human security, economic security, environmental security, national security and the very life of the planet. It's more urgent than ever that we double our climate commitments." Given the burgeoning importance of the climate change problem caused by the excessive emission of greenhouse gases, primarily carbon emissions, it is essential to understand the role of corporate environmental, social, and governance (ESG) actions on the environment regarding carbon emission intensity or carbon intensity (CI). CI is the emission rate of a given pollutant relative to the intensity of a specific activity or industrial production process, such as the ratio of greenhouse gas emissions produced to gross domestic product (GDP). On the other hand, ESG reporting indicates how corporations and investors integrate ESG concerns into their business models (Gillan *et al.*, 2021).

According to a recent survey of institutional investors, up to 89% of respondents support making ESG reporting a mandatory requirement (Ferguson *et al.*, 2019). The transition towards sustainability has transformed global economies from traditional industrial patterns to a knowledge-based economy prompting firms to prioritize intangible assets over tangible ones to maintain a competitive edge. Companies with greater intangible assets are more likely to survive in highly competitive environments (Bontis, 2003). Intangible assets have become the crux of present and future business performance. According to Ocean Tomo, the share of intangible asset market value increased from 68% to 84% between 1995 and 2015. By July

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2020, Ocean Tomo reported that intangible assets constituted 90% of the S&P 500 market value. This shift underscores the importance of incorporating relevant and material ESG factors in evaluating a company.

Prior studies have confirmed that ESG practices provide firms with the leverage to enhance their knowledge-based assets, such as human and relational capital, by increasing employee commitment and loyalty, thereby boosting the firm's competitive advantage (Branco and Rodrigues, 2006). These practices also assist businesses in building their reputation with stakeholders and developing their resources and capabilities, which are primarily intangible resources (Quintana García *et al.*, 2022). Moreover, the business legitimacy perspective emphasizes moral principles and a socially aware corporate philosophy, which impact how stakeholders perceive the firm and its integrity as crucial elements in a highly competitive environment (Du and Vieira, 2012). Thus, the potential benefits of ESG investment led to increases in intangible assets and vice-versa, justifying ESG as a value-creation strategy for shareholders (Jun *et al.*, 2022). Furthermore, intangible assets enable firms to CI (Alakkas *et al.*, 2023).

Extant ESG literature can be broadly categorized into three areas: firm characteristics that affect ESG performance, corporate governance as a determinant of ESG disclosure and the financial implications of ESG disclosure. While ESG is the dominant corporate sustainability performance metric in the market, the literature largely focuses on its financial materiality rather than its sustainability impact. Khan (2022), in his bibliometric and meta-analysis study of 199 research articles on ESG from the Scopus database from 2012 to 2022, documents that the study of ESG metrics or ESG disclosure on corporate sustainability in terms of CI is an unexplored area that is gaining attention in both academic research and the business world. Moreover, despite the vital influence of intangible assets in enhancing a firm's ESG capabilities, their role in the environmental performance of ESG practices remains unexplored in the extant literature.

Against this backdrop, we investigate the following questions:

RQ1. How does ESG disclosure impact firms' carbon intensity?

RQ2. Does the impact of ESG disclosure on carbon intensity vary based on firms' intangible assets?

This study explores the relationship between ESG disclosures and CI using a comprehensive measurement framework based on Scope 1, 2 and 3 emissions, in line with the GHG Protocol, alongside Bloomberg's ESG disclosure scores for S&P 500 firms. The focus on S&P 500 companies is driven by several key considerations. Firstly, as the second-largest global emitter, the United States plays a critical role in the fight against climate change, making it vital to examine the impact of ESG efforts on the CI of its largest 500 companies. These firms represent approximately 80% of the market capitalization of U.S. public companies, with a combined market cap exceeding $43 trillion as of January 2024. Secondly, the ideological divide across U.S. states regarding ESG matters adds complexity to the landscape. While liberal-leaning states embrace ESG principles, conservative states seek to exclude them, leading to ESG activity largely driven by private initiatives rather than regulatory mandates. In this context, voluntary ESG disclosures offer valuable insight into corporate sustainability efforts and their potential to influence CI. Finally, the growing importance of intangible assets in the market value of S&P 500 firms highlights a crucial factor in understanding the ESG-disclosure–CI relationship.

Our findings exhibit a significant negative impact of ESG disclosure on CI. Moreover, our findings unveil the differential impact of ESG disclosure on CI based on firms' intangible assets. Interestingly, outperforming firms in terms of intangible assets valuation makes a significant reduction in CI through their ESG disclosure, while firms with modest level of intangible assets have no significant impact of ESG disclosure on their CI.

Given the significant gaps in the literature, this study makes some novel contributions to the literature. First, while ESG is the dominant corporate sustainability performance metric in the market, the literature largely focuses on its financial materiality rather than its sustainability impact. Hence, departing from the prior literature that is largely focused on the financial outcome of ESG initiatives, this study provides novel empirical evidence on the impact of ESG disclosure on corporate CI in the context of S&P 500 firms. Second, an in-depth review of the literature unveils that despite the vital influence of intangible assets in enhancing a firm's ESG capabilities, their role in the environmental performance of ESG practices remains unexplored in the extant literature. Hence, by studying the differential impact of ESG disclosure on CI based on firms' intangible assets, this study adds novel evidence in the extant literature that the positive effect of ESG disclosure towards reducing CI is more pronounced for firms with high intangible assets. In light of the intangible asset valuation of firms, the linkage between ESG disclosure and corporate CI becomes more evident, with potential policy implications, especially for innovation-driven competitiveness.

The rest of the paper is organized as follows: Section 2 outlines the literature review on the topic; and Section 3 discusses the methodology. Section 4 presents the results; Section 5 concludes the paper and highlights the study's implications, limitations and scope for future research.

2. Review of literature

This section is divided into two sections: Theoretical framework and empirical literature.

2.1 Theoretical framework

The dominant theory encompassing the ESG literature is the stakeholder theory, which contemplates the organization's relationship with its stakeholders. ESG disclosure is a way of communicating an organization's performance in terms of the interests of different stakeholders (Elmghaamez *et al.*, 2024). Likewise, stakeholder theory also substantially explains firms' environmental responsibility (Seroka-Stolka, 2023). Firms reduce CI as part of their responsibility to various stakeholder groups increasingly concerned with sustainability and environmental impact. This theory suggests that firms address carbon emissions to align with stakeholder expectations, which, in turn, can enhance the firm's reputation, mitigate risk and potentially lead to better stakeholder support (Yunus *et al.*, 2020). Prior literature evidenced the financial relevance of ESG disclosure in terms of lower cost of capital (Chen and Yang, 2020), and higher financial and market performance (Nguyen *et al.*, 2022). However, the key motive of undertaking ESG activities or generating ESG reports is not only supposed to focus on developing financial returns but also on environmental and social benefits. Therefore, to justify the sustainability benefits of ESG and its value-creation process, firms make serious efforts to integrate their commitment to the environment into their organizational knowledge and identity to stand out in the competitive, knowledge-driven market (Yang and Shi, 2018).

Similarly, the signaling theory suggests that firms use certain actions to signal positive information to external parties, such as investors and customers, about their quality, capabilities or intentions (Ross, 1978). The theory underlines the importance of ESG disclosure greatly motivates carbon performance as reducing CI can serve as a positive signal to stakeholders, particularly investors, that the firm is forward-thinking, efficient and committed to long-term sustainability (Siddique *et al.*, 2021). On the contrary, a firm's poor carbon performance or high CI can create negative publicity and damage its reputation. It can create a strong adverse reaction among stakeholders, including public shaming, boycotts or the imposition of sustainability restrictions along the supply chain (Dai *et al.*, 2021).

Likewise, legitimacy theory is also a relevant theory for explaining the relationship between ESG disclosure and CI. The theory posits that firms operate within a "social contract" and need to align their practices with societal norms and expectations to maintain legitimacy

(Deegan, 2006). Firms consistently disclose non-financial information under social and political pressure to preserve their legitimacy by fulfilling their social contract of disclosing non-financial information (Ng and Rezaee, 2015). Moreover, as public awareness and regulatory standards around climate change grow, firms face pressure to reduce carbon emissions to align with societal expectations and avoid legitimacy threats. Hence, ESG disclosure can be used as a tool by businesses to legitimize their action as the goal of such disclosure is beyond financial materiality but considers ESG activities as a means of demonstrating their corporate citizenship behavior (Odriozola and Baraibar-Diez, 2017). In this regard, firms with higher intangible assets is asserted to have a complementary approach towards ESG disclosure as such voluntary disclosure also accounts for some information on intangible assets, which otherwise mandatory financial disclosure fails to capture (Jun *et al.*, 2022).

2.2 Empirical literature

Based on the theoretical framework, we have discussed the extant empirical literature as presented further in the text.

2.2.1 ESG disclosure and carbon intensity. Extant literature documents the impact of ESG on firms' total factor productivity (Ma *et al.*, 2022), firm value (Bissoondoyal-Bheenick *et al.*, 2023), firm quality development and green innovation (Zheng *et al.*, 2023). However, the relevance of ESG disclosure in terms of CI, particularly in the US context, is barely explored in the existing studies. The US provides a unique platform as the Securities and Exchange Commission (SEC) takes a principles-based, materiality-focused approach to ESG disclosures. Though, the SEC issued guidance from time to time [e.g.: 2010, 2016, 2019, 2020, 2022] on business and financial disclosures, which touched on sustainability themes, a shift to standards that track, for example, the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) is quite unlikely soon [1].

In the absence of a regulatory perspective, ESG disclosure remains discretionary. ESG disclosure is associated with diverse benefits as underlined by theoretical perspectives. Based on the rationale of voluntary disclosure, it can be presumed that firms will opt for more ESG disclosure to reap financial returns and non-financial returns in terms of sustainability performance. While some studies find a positive impact of ESG disclosure on firm performance (Bissoondoyal-Bheenick *et al.*, 2023), the theoretical link between ESG disclosure and CI is barely validated except by Yin *et al.* (2023) for a sample of Chinese heavily polluting companies finds a significant positive impact of ESG disclosure on corporate carbon performance. Based on the theoretical perspectives and contextual factors, we hypothesize the following:

H1. ESG disclosure has a significant negative impact on carbon intensity.

2.3 ESG disclosure and carbon intensity: based on intangible assets

Economies have witnessed a paradigm shift from physical to intangible assets (Harris, 2001). Despite being the primary driver of firms' value creation, intangible assets are not captured in the financial statements, and existing research has predominantly considered profitability, leverage and risk profile as the firm-specific determinants of CSR activities and non-financial disclosure (Khan, 2022). There are significant benefits of ESG investments like approvals and certifications, brand, design, industry expertise, invention, network effects, relationship, software, etc., that can directly increase the value of firms' intangibles assets or vice versa. This parallel association between ESG investments and intangible assets valuation can reduce the bottleneck of ESG investments on the part of management by justifying the return on investment (ROI) of specific ESG initiatives to their shareholders. This complementary relationship between intangible assets and ESG disclosure is supported by multiple theoretical perspectives for having robust stakeholder relationships, talent signaling and confronting

organizational legitimacy by extending superior service to society (Pham *et al.*, 2024). Moreover, extant literature also supports that more intangible assets can assist firms in reducing CI through better technologies, manufacturing and marketing processes and human capital (Alakkas *et al.*, 2023). Given the inseparable role of intangible assets in promoting ESG disclosure and reducing CI, it is imperative to consider the differences in firms' intangible assets while investigating their relationship, which has not yet been addressed in the extant literature. Accordingly, we hypothesize the following:

H2. The impact of ESG disclosure on carbon intensity varies based on firms' intangible assets.

3. Methodology

3.1 Sample selection and data collection

This study selects a sample of the top 500 S&P firms based on market capitalization as of 31st March 2015. This study purposively opted for a sample of top 500 S&P firms, as they are widely used as benchmarks for the global economy's performance, particularly that of the United States, alleviating some external validity issues. Hence, the outcome of researching ESG disclosure and CI in the context of the S&P 500 can be applied to other firms and industries worldwide. The study is based on eight years, from 2015–2016 to 2022–2023. We have particularly selected this period as it is preceded by the Paris Agreement, 2015, which led to the wave of ESG actions at the global level. Our dataset is an unbalanced panel, as continuous information for all the variables over the study period was unavailable. However, to avoid omitted variable biases, and loss of observations, we have considered the entire dataset and used appropriate econometric techniques to handle such datasets.

To understand the differential impact of ESG disclosure on CI based on intangible assets, we have classified our sample firms into panel A and panel B. The median value of intangible assets is used to classify the sample firms as high-intangible assets firms and low-intangible assets firms. The data relating to all variables are obtained from the Bloomberg database.

3.2 Measurement of variables

3.2.1 Dependent variable. The dependent variable in this study, CI, is calculated as the total in thousand metric tons of greenhouse gases in carbon dioxide equivalent (CO2e) emitted from three sources of classification as per the GHG protocol, that is Scope 1, 2 and 3 per millions of sales revenues in the company.

3.2.2 Independent variable. The prime explanatory variable in this study is ESG disclosure. To capture it, we have used the Bloomberg ESG Disclosure Scores to rate companies on their ESG data disclosure level. Their values range from 0 to 100.

3.2.3 Control variables. This study selects the control variables mentioned in previous works, such as firm size, financial leverage, board size, board independence, CEO duality and board gender diversity (Yin *et al.*, 2023). In addition, we have also introduced some novel corporate governance variables that can influence the relationship between ESG disclosure and CI such as boards' young directors' age, GRI compliance, sustainability/CSR committee, audit committee size and nomination committee size. These new control variables are included based on certain reasoning. For instance, the literature suggests that the age of a director, which ultimately leads to experience is relevant in strategic issues that affect the firm's ESG disclosure and CI (Mantia *et al.*, 2018). Similarly, the GRI standards are globally applicable guidelines that enable organizations to voluntarily disclose the environmental, social and economic dimensions of their activities to a level equivalent to that of generally accepted accounting principles for financial reporting (Willis, 2003). The GRI compliance is linked with ESG disclosure and CI as an entity doing such compliance is more committed to sustainability than an entity that does not (Luo and Tang, 2023). Moreover, firms doing GRI

compliance reflect their motive reducing CI and better sustainability performance (Dhanda, 2022).

Likewise, the board committee's involvement is critical in shaping how CI is reported and managed, ensuring that a company's environmental impact is appropriately disclosed, and taking steps to reduce emissions in line with broader ESG goals (Arif *et al*., 2021; Oyewo, 2023). In particular, the existence of a CSR or sustainability committee and audit committee are responsible for ensuring that a company discloses accurate and meaningful ESG information, including its efforts in reducing its environmental footprint (Elmghaamez *et al.*, 2024). These committees also ensure investment in energy-efficient technologies and processes to reduce energy consumption and emissions (Orazalin *et al*., 2024). Lastly, the nomination committee has a subsidiary impact on ESG disclosure and CI relationship as its primary focus is on appointing board members and determining executive compensation, its decisions can impact how the company addresses ESG issues, including carbon emissions and CI (Moisello *et al.*, 2024). The variable names and their metrics are shown in Table 1.

3.2.4 Econometric models. We have used a two-step system generalized method of moments (system GMM) based on the work of Blundell and Bond (1998) to examine the dynamic linkage between ESG disclosure and CI. The two-step system GMM model is used for the following reasons. First, the alternative panel data models like fixed effects or random effects provide biased and inconsistent estimation under a dynamic setup and possible endogeneity issues (Arellano, 2002). As CI tends to persist over the periods specifically after the Paris Agreement of 2015, the previous year's CI will influence the current year's CI, and a dynamic GMM model can successfully handle such issues. Second, coefficient estimates of the GMM model are consistent in the presence of endogeneity, that is when the covariates are not strictly exogenous, autocorrelation and unobserved heterogeneity (Arellano, 2002). GMM provides reliable estimates even when some factors are influenced by unobserved factors or past values, which is a common issue in this study. Third, the use of system GMM against difference GMM is justified on the grounds it is more efficient than other methods because it can handle the unbalanced panels (where some data points are missing) while giving more

Table 1. Measurement of variables

Variable	Acronyms	Definition
Carbon Intensity	CI	Total of Scope 1, Scope 2 and Scope 3 GHG emissions divided by total assets
ESG Disclosure	ESGD	Bloomberg ESG Disclosure Scores range from 0 to 100; 100 is best
Intangible Assets	INTG	Ratio of net intangibles assets to total assets
Firm Size	LnTA	Natural logarithm of total assets
Financial Leverage	LEV	Ratio of total debt to total assets
GRI Compliance	GRIC	A dummy variable coded as "1" if a company has used the Global Reporting Initiative (GRI) framework, otherwise "0"
Board Size	BS	Total number of members on board
Youngest Director Age	YDA	Age of the youngest director
Audit Committee	ACM	Total number of members in the audit committee
Nomination Committee	NCM	Total number of members in the nomination committee
Corporate Social Responsibility Committee	CSRC	A dummy variable coded as "1" for having CSR or sustainability committee, otherwise "0"
Board Independence	BI	The ratio of non-executive directors to total board size
Board Gender Diversity	GD	The ratio of female directors to total board size
Role Duality	DUA	A dummy variable is coded as "1" if the same person acts as a chief executive officer and chairperson of the board, otherwise "0"

Source(s): Created by authors

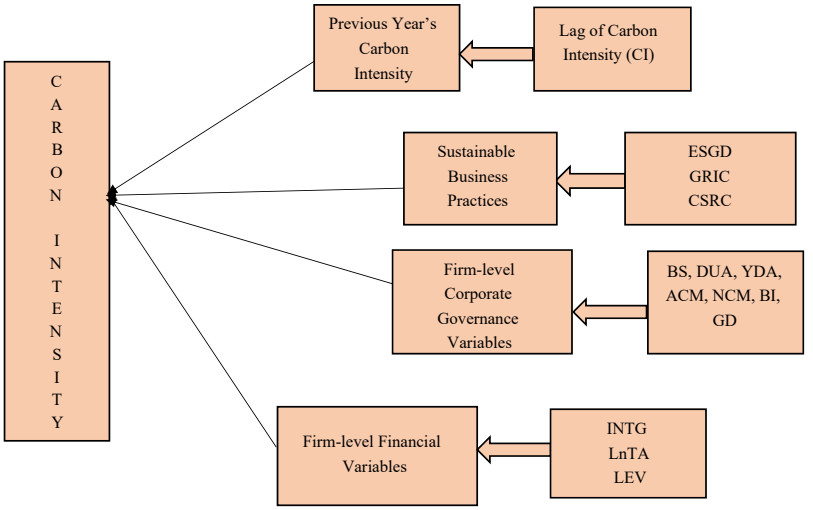
accurate results by merging regression levels and differences (Blundell and Bond, 1998). As the present dataset is an unbalanced panel, GMM is a reliable model to provide tenable results. Finally, we have adopted a two-step system GMM instead of a one-step as the asymptotic variance is small for the former (Hwang and Sun, 2018; Maji and Saha, 2021). The following form of the model is employed in the present study.

$$\pi_{i,t} = \alpha + \delta\mu_{i,t-1} + \sum_{J=1}^{J} \beta_J S_{i,t}^{J} + \sum_{C=1}^{C} \beta_C F_{i,t}^{C} + \sum_{Y=1}^{Y} \beta_C G_{i,t}^{Y} + \nu_{i,t} + \varepsilon_{i,t} \ldots \quad \text{(A)}$$

where i is firm and t is time. $\pi_{i,t}$ is the is the carbon emission intensity and $\mu_{i,t-1}$ is the one-year lag of π. $S_{i,t}^{J}$ denotes sustainability related variables such as ESGD, GRIC and CSRC, $F_{i,t}^{C}$ represents firm-specific variables such as INTG, LnTA and LEV and $G_{i,t}^{Y}$ indicates governance related variables viz., BS, DUA, YDA, ACM, NCM, BI and GD. $\nu_{i,t}$ and $\varepsilon_{i,t}$ are the latent time-invariant firm-specific effect and idiosyncratic error respectively. Accordingly, the following specific models are used in this study to test the hypotheses.

$$\begin{aligned} CI_{i,t} = {} & \alpha + \delta CI_{i,t-1} + \beta_1 ESGD_{i,t} + \beta_2 GRIC_{i,t} + \beta_3 CSRC_{i,t} + \beta_4 INTG_{i,t} \\ & + \beta_5 LnTA_{i,t} + \beta_6 LEV_{i,t} + \beta_7 BS_{i,t} + \beta_8 DUA_{i,t} + \beta_9 YDA_{i,t} + \beta_{10} ACM_{i,t} \quad \text{(Model 1)} \\ & + \beta_{11} NCM_{i,t} + \beta_{12} BI_{i,t} + \beta_{13} GD_{i,t} + \nu_{i,t} + \varepsilon_{i,t} \ldots \end{aligned}$$

The conceptual framework of the Model (1) is presented in Figure 1, which depicts that CI is the dependent variable under consideration, which is influenced by a set of independent variables such as firms' previous year's CI (LagCI), sustainable business practices such as ESGD, GRIC, CSRC, firm-level corporate governance variables such as BS, DUA, YDA, ACM, NCM, BI and GD and firm-level financial variables such as INTG, LnTA and LEV. Model 1 is employed to examine the impacts of ESG disclosure on carbon emission intensity for the whole sample as well as for the sub-samples based on firms' intangible assets. The reliability of the system GMM estimation was tested by two specification tests – Sargan test for



Source(s): Developed by authors

Figure 1. Conceptual framework of the empirical Model (1)

the validity of instruments and over-identifying restrictions, and the Arellano–Bond autocorrelation (AR) tests for serial correlation in the random errors (Arellano, 2002) and the results fulfills such requirements, which purports for the tenability of the system GMM estimation.

Further, to ensure the robustness of the results obtained, we have employed a two-stage least squares (2SLS) simultaneous regression model, which is widely used in the literature to account for potential endogeneity issues.

4. Findings

4.1 Descriptive statistics

Table 2 present descriptive statistics for Panel A and Panel B, respectively. In Panel A, the mean value of CI is 0.53, while in Panel B, it is 1.43, indicating a significant difference in CI levels based on firms' intangibles. Moreover, the ESGD for Panel A firms is 48.91, substantially higher than the ESGD of 32.88 for Panel B firms, supporting the observation that firms with more intangible assets are more engaged in ESG activities. Similar variations are observed in other sustainability variables such as GRIC and CSRC, highlighting diverse sustainability practices based on intangible assets.

Table 2. Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max	*p*1	p99
Panel A: high intangibles							
CI	1,148	0.53	1.02	0.00	5.06	0.00	4.85
ESGD	1,115	48.91	12.23	28.92	79.29	30.66	75.36
GRIC	1,161	0.49	0.50	0.00	1.00	0.00	1.00
CSRC	1,158	0.48	0.38	0.00	1.00	0.00	1.00
INTG	1,161	0.58	0.17	0.35	0.85	0.36	0.82
LnTA	1,161	9.69	1.20	5.54	13.26	7.10	12.63
LEV	1,161	6.09	2.73	1.09	17.04	1.24	15.91
BS	1,158	10.86	2.16	6.00	23.00	5.00	15.00
DUA	1,158	0.47	0.30	0.00	1.00	0.00	1.00
YDA	1,158	50.07	6.04	39.00	64.00	33.00	62.00
ACM	1,158	4.19	1.24	2.00	9.00	2.00	7.00
NCM	1,158	4.12	1.60	2.00	10.00	2.00	9.00
BI	1,158	0.88	0.06	0.67	1.00	0.67	0.93
GD	1,158	0.25	0.10	0.00	0.67	0.00	0.61
Panel B: low intangibles							
CI	1,142	1.43	4.71	0.00	12.28	0.00	11.86
ESGD	1,144	32.88	12.21	22.40	64.95	23.52	63.90
GRIC	1,158	0.48	0.50	0.00	1.00	0.00	1.00
CSRC	1,157	0.26	0.44	0.00	1.00	0.00	1.00
INTG	1,162	0.16	0.10	0.09	0.35	0.10	0.34
LnTA	1,162	11.87	1.56	6.07	15.09	6.16	14.48
LEV	1,131	9.68	7.55	1.13	16.25	1.21	15.63
BS	1,162	10.85	2.32	6.00	23.00	6.00	17.00
DUA	1,149	0.44	0.50	0.00	1.00	0.00	1.00
YDA	1,160	50.22	5.83	35.00	64.00	35.00	61.00
ACM	1,157	4.22	1.21	2.00	9.00	2.00	8.00
NCM	1,157	4.17	1.59	2.00	11.00	2.00	9.00
BI	1,160	0.88	0.06	0.63	1.00	0.67	0.94
GD	1,157	0.25	0.10	0.00	0.63	0.00	0.54

Source(s): Computed by authors

4.2 Multicollinearity analysis

To test multicollinearity among the independent variables under consideration, we have calculated the Variance Inflation Factor (VIF). The highest VIF value obtained is 2.35, which is far below the threshold value of 10. Hence, multicollinearity is not a severe issue in the dataset.

4.3 Regression results

The regression analysis (specifically using the system GMM model in columns (2) and (3) of Table 3) indicates a statistically significant negative relationship between ESG disclosure (ESGD) and CI among S&P 500 firms. This implies that firms with higher ESG disclosure tend to have lower CI, supporting hypothesis H_1. This finding aligns with previous research by Yin *et al.* (2023) which found similar results in the context of Chinese heavily polluting enterprises. Sustainability variables such as GRIC and CSRC also exhibit inverse relationships with CI.

To validate the findings' robustness, the 2SLS (Two-Stage Least Squares) model is employed, and the results in columns (3) and (4) of Table 3 largely support the GMM model results.

4.4 Further analysis

To know the differential impact of ESG disclosure on CI based on firms' intangible assets, we have employed model (1) for sub-samples of high-intangibles firms and low-intangibles firms, and the results are presented in Table 4. The findings align with hypothesis H_2, which suggests that the impact of ESGD varies depending on the level of firms' intangible assets. Firms with high intangible assets experience a statistically significant negative impact of ESGD on CI. In

Table 3. Regression results for all firms

	System GMM model (model 1)		2SLS model (robustness check)	
Variables	Coefficient	*t*-statistic	Coefficient	*t*-statistic
Lag of CI	0.519	2.41**		
ESGD	−0.01	−1.96**	−0.012	−3.24***
GRIC	−0.195	−1.74*	−0.096	−1.84*
CSRC	−0.618	−1.69*	−0.201	−1.91*
INTG	−0.383	−2.13**	−0.937	−4.92***
LnTA	−0.271	−2.16**	−0.087	−2.06**
LEV	−0.001	−1.76***	−0.011	−1.53
BS	−0.028	−0.71	−0.006	−0.21
DUA	0.003	0.02**	0.266	2.77***
YDA	−0.007	−0.61	−0.009	−1.14
ACM	0.015	0.31	0.049	1.12
NCM	−0.044	−1.03	0.034	1.15
BI	0.502	0.37	1.89	2.01
GD	−0.485	−0.78	−0.308	−0.62
Constant	4.118	2.07**	1.117	1.26
Wald χ^2	44.615***			
AR(1)[1]	−1.078			
AR(2)[2]	0.926			
Sargan test[3]	7.863			
R-Square			0.257	
F-Statistics			19.78***	

Note(s): ***, ** and * indicate significant at 1%, 5% and 10%, respectively; [1]Arellano–Bond first-order autocorrelation test. [2]Arellano–Bond second-order autocorrelation test. [3]Test for over-identifying restrictions
Source(s): Computed by authors

Table 4. Results of the two-step system GMM model

Variables	High intangibles Coefficient	*t*-statistic	Low intangibles Coefficient	*t*-statistic
Lag of CP	0.622	6.43***	0.327	1.19
ESGD	−0.027	−1.89**	−0.016	−1.38
GRIC	−0.678	−2.43***	−0.015	−0.18
CSRC	−2.628	−2.61***	−1.269	−1.06
LnTA	−0.633	−1.72*	−0.879	−3.42***
LEV	−0.001	−1.73*	0.001	−0.38
BS	−0.106	−1.54	0.115	2.09**
DUA	0.412	1.31	0.732	2.08**
YDA	−0.023	−0.67	0.009	0.18
ACM	−0.116	−1.69*	−0.079	−0.87
NCM	−0.051	−0.71	−0.118	−1.49
BI	2.642	1.08	2.159	1.27
GD	−2.129	−0.58	−1.476	−1.53
Constant	7.129	1.49	8.467	2.31***
Wald χ^2	97.29***		48.78***	
AR(1)[1]	−1.665*		−1.248	
AR(2)[2]	1.154		0.794	
Sargan test[3]	15.106		13.665	

Note(s): ***, ** and * indicate significant at 1%, 5% and 10%, respectively; [1]Arellano–Bond first order autocorrelation test. [2]Arellano–Bond second order autocorrelation test. [3]Test for over-identifying restrictions
Source(s): Computed by authors

contrast, firms with lower levels of intangible assets do not show a significant impact of ESGD on CI. The potential structural or operational differences between high and low-intangible firms and how these influence the effectiveness of ESG disclosures in reducing CI are stated in the following points. *First*, firms with lower intangible assets often possess a more capital-intensive business model, which may involve significant investments in physical infrastructure. The high upfront costs associated with adopting carbon-reducing technologies are often a substantial barrier to achieving quick reductions in CI. Even with strong ESG disclosures, these firms may not see immediate reductions in CI because the changes required are costly, involve long timelines and necessitate substantial operational overhauls (Yang and Shi, 2018). This delayed technological adaptation can make it harder for firms with lower intangible assets to rapidly lower their carbon emissions, even if they report ESG efforts. *Second*, firms with high intangible assets have more opportunities to leverage their intangible resources to innovate and reduce carbon footprints (Alakkas *et al.*, 2023). For instance, they may be able to shift to cloud computing, implement digital solutions that optimize energy consumption or reduce physical resource use (Sroufe and Jernegan, 2020). Firms with fewer intangible assets lack these avenues for innovation, making it harder to achieve the same reductions in CI through ESG efforts alone.

Third, firms with low intangible assets often allocate a higher proportion of their capital to maintaining and improving their physical infrastructure, which leaves less flexibility for investing in sustainability initiatives (Teece, 2015). As a result, ESG disclosures may not be backed by sufficient financial investment in carbon-reducing initiatives, leading to slower reductions in CI. *Finally*, in firms with lower intangible assets, ESG disclosures may be primarily driven by compliance requirements or market pressures rather than a strategic priority (Lanzalonga *et al.*, 2025). These firms may publish ESG reports as a way to meet investor demands or regulatory standards, but their commitment to actual carbon reduction efforts may be less robust, particularly if reducing CI involves high upfront costs or operational disruptions. On the other hand, firms with higher intangible assets may view ESG disclosure as

part of their overall strategy to maintain a competitive advantage, attract investment and build consumer loyalty (Rohendi *et al.*, 2024). As a result, they are more likely to invest in initiatives that drive actual reductions in CI, using their intangible resources to identify and implement sustainable solutions. The results of the system GMM is supported by the 2SLS model. The results are not reported owing to the limitation of word count.

5. Rationalization and conclusion

As ESG has become a widely recognized metric for sustainability, this study investigates the role of ESG disclosure in reducing CI among S&P 500 firms. It also explores how the impact of ESG disclosure on CI varies depending on the level of firms' intangible assets. Our findings reveal a significant reduction in CI for firms that actively engage in ESG disclosure, highlighting the environmental relevance of these practices.

The value of ESG disclosure lies in its ability to hold firms accountable for their environmental impacts. By providing transparent information about carbon emissions and sustainability practices, ESG disclosure enhances the information environment for investors, regulators and stakeholders. This transparency encourages firms to adopt more proactive measures to reduce their carbon footprint, effectively turning ESG disclosure into a monitoring tool that drives continuous improvement in environmental practices. Additionally, as consumer and investor awareness of environmental issues grows, firms that enhance their ESG disclosures gain a competitive edge in the marketplace. Although ESG disclosure remains voluntary in the U.S., it offers significant benefits for regulatory agencies. By encouraging firms to disclose their environmental practices, regulators can better monitor corporate behavior and ensure that firms are taking meaningful steps to address their environmental impacts.

Our findings also exhibit that out-performing firms in terms of intangible assets make significant reductions of CI through their ESG disclosure while firms with modest levels of intangibles fail to do so. It suggests that firms rich in intangible assets are better equipped and more motivated to engage in robust ESG activities. These firms are able to leverage their intangible resources to drive effective sustainability initiatives, resulting in a meaningful reduction in their carbon footprint. In contrast, firms with fewer intangible assets often lack the necessary resources and capacity to implement comprehensive ESG strategies, leading to limited progress in mitigating their carbon emissions.

Our findings offer several key insights with important implications for regulators, practitioners and other stakeholders. The study reveals that ESG activities significantly mitigate corporate CI. This is particularly impactful as it highlights the role of ESG disclosure in fostering transparency, trust and accountability among stakeholders. In a country like the US, where there is considerable debate surrounding the role of ESG, these results underscore the importance of ESG as a legitimate and effective sustainability metric. This should serve as a wake-up call for regulators, reinforcing the need to embrace ESG as a tool for driving meaningful environmental change.

The analysis further emphasizes the importance of intangible assets in enhancing the effectiveness of ESG practices. Firms with higher intangible assets are better able to leverage ESG efforts to reduce CI. This suggests that managers should recognize the value of intangible assets when developing ESG strategies, focusing not just on financial outcomes but also on how these assets can drive sustainability. For firms with lower intangible assets, the study highlights the need to invest in building these resources to improve their ESG performance and, ultimately, their environmental impact. In this respect, regulators could encourage firms to strengthen their intangible assets as part of their broader commitment to sustainability, particularly in fostering innovation-driven competitiveness.

This study makes several novel contributions to the literature. While ESG has been widely studied in terms of its financial materiality, much less attention has been paid to its direct sustainability impact. By focusing on the relationship between ESG disclosure and corporate

CI, this research offers new empirical evidence on how transparency in ESG practices can directly reduce emissions. Furthermore, it highlights the previously unexplored role of intangible assets in shaping the environmental outcomes of ESG efforts, revealing that firms with higher intangible assets experience more pronounced reductions in CI through their ESG disclosures. This contribution not only advances the understanding of ESG's environmental impact but also provides valuable insights for future sustainability practices, particularly in policy development aimed at enhancing innovation and competitiveness.

There are some limitations associated with this study, which also suggests pathways for future research. First, this study focused on intangibles, as ESG is a voluntary disclosure in the US context, future studies can investigate the role of corporate governance variables in analyzing the impact of ESG disclosure on CI. Second, the scope of the impact of ESG disclosure is extensive, and there may be additional sustainability factors being influenced by ESG disclosure. Third, we recognize that voluntary ESG disclosures may introduce self-selection bias, as companies that choose to disclose are likely those with stronger ESG practices. However, given that the study focuses on publicly listed S&P 500 companies, we believe this sample is representative of the largest and most influential firms in the US, which are often at the forefront of ESG practices and disclosure. The study's focus on the US context was intentional, as the voluntary nature of ESG disclosures in the US presents a unique opportunity to examine how firms choose to engage with ESG practices. While we agree that the findings might differ in regions with mandatory ESG disclosures, such as the European Union, the focus on the US context allows for a deeper understanding of voluntary disclosure behavior, which could vary significantly from mandatory disclosure regimes. Therefore, while the generalizability to non-US settings is an important consideration, it falls outside the primary scope of this research and thus it opens an avenue for future in this direction for a sample with mandatory ESG disclosure.

Finally, the exclusion of smaller firms from the S&P 500 sample does limit the applicability of the findings to smaller firms, which might have different challenges and incentives around ESG reporting. However, the focus on large, publicly traded firms is consistent with much of the existing literature, which often centers on larger corporations due to their prominence and resources in sustainability efforts. We recognize this limitation but believe the findings are valuable in the context of large firms, which are more likely to set trends for ESG disclosure practices that could eventually influence smaller firms.

Note

1. https://www.paulweiss.com/insights/esg-thought-leadership/publications/the-us-regulatory-framework-for-esg-disclosures?id=37633

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Corresponding author

Rupjyoti Saha can be contacted at: rupjyoti.1122@rediffmail.com, saharupjyoti@gmail.com