

Do corporate carbon emissions affect financial constraints? Evidence from developed markets

Kurumsal karbon emisyonları mali kısıtlamaları etkiler mi? Gelişmiş piyasalardan kanıtlar

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Abstract

This study examines the relationship between carbon emissions and financial constraints, exploring the moderating impact of ownership. We employ a large sample from 24 developed countries for the years spanning from 2002 to 2022. Our sample is composed of 20,774 company-specific observations from 2632 unique companies. We use panel data estimation methodology with the inclusion of fixed effects. Our analysis reveals a significant positive association between carbon emissions and financial constraints. The results indicate that firms with higher carbon emissions experience more significant financial constraints. Moreover, we provide novel evidence that ownership structure has a moderating impact, such that the positive effects of carbon emissions on financial constraints are higher for firms with more institutional and foreign ownership. Conversely, state ownership has a negative moderating impact, suggesting that the positive influence of carbon emissions on financial constraints is less for corporations with higher state ownership. Overall, our findings suggest that environmental performance is an essential factor influencing a firm's financial constraints, and the firm's ownership structure moderates this effect.

Keywords: Carbon Emissions, Financial Constraints, Ownership Structure

Jel Codes: G30, G32, G34

Öz

Bu çalışma kapsamında, karbon emisyonları ile finansal kısıtlamalar arasındaki ilişki ve farklı sahiplik özelliklerinin bu ilişkiyi nasıl etkilediği incelenmektedir. Analizlerde kullanılan örneklem 24 gelişmiş ülkede bulunan 2632 şirketten 2002 ile 2022 yılları arası için toplanan 20,774 şirket-yıl gözlemden oluşmaktadır. Sabit etkiler içeren panel veri tahmin metodolojisini kullanarak yaptığımız analizler, bir firmanın karbon emisyonları ile finansal kısıtları arasında anlamlı ve pozitif ilişki olduğunu ortaya koymaktadır. Sonuçlar, daha yüksek karbon emisyonlarına sahip firmaların daha büyük finansal kısıtlar yaşama olasılığının daha yüksek olduğunu göstermektedir. Ayrıca, farklı mülkiyet özelliklerinin de aracı değişken etkisine dair yeni kanıtlar sunmaktayız: Karbon emisyonlarının finansal kısıtlar üzerindeki pozitif etkisinin, daha fazla kurumsal ve daha fazla yabancı mülkiyete sahip firmalar için daha yüksek olduğunu göstermekteyiz. Buna karşılık, karbon emisyonlarının finansal kısıtlar üzerindeki pozitif etkisinin, daha yüksek devlet mülkiyetine sahip şirketler için daha düşük olduğunu gözlemlenmiştir. Genel olarak, bulgularımız çevresel performansın firmaların finansal kısıtlarını etkileyen önemli bir faktör olduğunu ve firmanın mülkiyet yapısının bu etkiye aracı değişken rolü oynadığını göstermektedir.

Anahtar Kelimeler: Karbon Emisyonları, Finansal Kısıtlar, Sahiplik Yapısı

Jel Kodları: G30, G32, G34

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Introduction

Sustainability issues and environmental concerns have received increasing attention and funding from management and investors in recent decades. Moreover, as one of the twenty-first century's most challenging environmental and human concerns, climate change has been the focus of discussions among academics, professionals, and politicians (Hambira, Saarinen and Moses, 2020). For instance, according to the most recent United Nations (UN) Global Compact-Accenture CEO survey (2019), 71% of CEOs of the biggest companies in the world feel that their organizations' commitments and efforts toward global goals, such as climate change and sustainability, need to be increased. In response to this issue, policymakers worldwide have adopted measures (such as the Paris Agreement) to keep global warming to less than two °C. However, economic and political conditions significantly impact these methods' efficacy and capacity to mitigate climate change.

On the other hand, financial constraints play a pivotal role in companies' growth and survival and, therefore, have been at the centre of empirical research in finance (Farre-Mensa and Ljungqvist, 2016). According to Kaplan and Zingales (1997), a company may face financial constraints if it cannot obtain affordable external funding from investors due to inadequate internal finance. When companies do not have adequate financial alternatives, they may face financial constraints, which might result in underinvestment and be costly for businesses (Gamba and Triantis, 2008). Even though previous research has focused on which kinds of businesses are more prone to have financial constraints, highlighting the impact of the life cycle (Muller and Zimmermann, 2009), size (Carpenter and Petersen, 2002), structure of ownership, and connection with politics (Lin, Liu and Sun, 2017), among others, as main determining factors of financial constraints, only a few studies have focused on the corporate environmental performance as a determinant of financial constraints (Agyei-Boapeah, Ciftci, Malagila, Brodmann and Fosu, 2023). The purpose of this study is to fill this gap in the literature.

The primary purpose of this study is to analyze how environmental performance influences financial constraints. Moreover, we also aim to determine how the companies' ownership structure affects the link between financial constraints and environmental performance. We measure environmental performance with the companies' carbon emissions and employ three different definitions in the analysis to ensure the robustness of our findings. Moreover, to measure financial constraints, we use the Kaplan and Zingales (KZ) index and the Size-Age (SA) index proposed by Hadlock and Pierce (2010). Our findings demonstrate that firms with higher carbon emissions will likely encounter higher financial constraints. Our main finding remains valid when tested with alternative samples, alternative variable measurements, and additional control variables. Furthermore, we reveal new evidence that different ownership attributes moderate the relationship between carbon emissions and financial constraints. While institutional and foreign ownership has a positive moderating impact, state ownership has a negative one. These findings imply that the positive nexus between carbon emissions and financial constraints is higher for firms with higher institutional and foreign ownership but lower for firms with higher state ownership. These findings imply the pivotal role of the firm's ownership structure that shapes how carbon emissions influence financial constraints.

This paper makes several contributions to the literature. Primarily, it investigates the nexus between environmental performance, mainly focusing on carbon emissions and financial constraints for an extended sample from 24 developed nations worldwide for an extended time frame, from 2002 to 2022. A recent study by Rehman, Shahzad, Hanif, Arshad and Sergi (2024) also examines the relationship between financial constraints and carbon emissions. However, our study is different from the study of Rehman et al. (2024) in several ways. First, Rehman et al. (2024) investigate how financial constraints affect carbon emissions, whereas our study analyses this association from the opposite direction: how carbon emissions affect financial constraints. Moreover, Rehman et al. (2024) studied only the US market from 2008 to 2019. In contrast, our study investigates a larger sample from 24 developed countries, including the USA, for an extended time frame from 2002 to 2022. Hence, our study differs significantly from the study of Rehman et al. (2024). Our second contribution to the literature is that this study is one of the first attempts to explore the moderating impact of different ownership attributes on the link between carbon emissions and financial constraints. In this context, we present novel empirical evidence that institutional and foreign ownership positively moderates the relationship between carbon emissions and financial constraints. This outcome indicates that firms with more institutional and foreign investors get hurt more when facing more financial constraints if they hurt the environment more. On the contrary, when carbon emissions increase, state-owned firms get less damage in terms of financial constraints.

Literature review and hypothesis development

Over the last couple of decades, key stakeholders' attitudes, including those of lenders, customers, and shareholders, have markedly altered in favour of environmental sustainability and ethical issues. This shift can substantially influence a firm's financial constraints, surpassing the general influence of corporate social responsibility (CSR) as recognized in prior studies (Cheng, Ioannou and Serafeim, 2014). Remarkably, two significant international climate change initiatives – "the 1997 Kyoto Protocol and the 2015 Paris Agreement" – occurred within this period. These environmental actions have increased public knowledge of climate-related issues and put a political strain on authorities and other corporate players to take concrete steps to mitigate climate risk. Accordingly, the association between environmental performance, i.e., carbon emissions specifically, and financial constraints can be analyzed by focusing on three corporate stakeholders: lenders, shareholders, and finally, customers.

Primarily, lenders' environmental concerns may impact companies' degree of financial constraints. Many lenders are now considering environmental factors when making lending choices (Agyei-Boapeah et al., 2023), which is evident in the increasing number of banks adopting the Equator Principles during their lending procedures. Due to rising borrowing costs, these credit market trends have limited credit availability for businesses with a track record of environmental problems. According to Chava's (2014) analysis of a sizable sample of bank credit given to businesses, fewer banks participate in the lending syndicate of borrowers with environmental concerns, particularly emissions. Chava (2014) also demonstrates that companies exhibiting environmental issues experience higher interest rates levied on their bank loans. Similarly, according to Delis, Greiff, Iosifidi and Ongena (2019), a positive association exists between banks' interest rates and borrowing enterprises' fossil fuel reserves (or carbon emission potential). The studies conducted by Attig, El Ghouli, Guedhami and Suh (2013) and Weber, Scholz and Michalik (2010) confirm these findings. Overall, these studies highlight the attention paid by lenders to environmental concerns, which may be preventing environmentally irresponsible businesses from accessing loan money, resulting in higher financial constraints.

Second, financial constraints can be affected by shareholders' environmental concerns stemming from the "cost of equity financing and filing shareholder resolutions" (Agyei-Boapeah et al., 2023). Based on the notion that asset prices are influenced by investors' interests and tendencies (Fama and French, 2007), the inclinations and tastes of shareholders regarding environmentally conscious investments might impact companies' share prices. The expected return of environmentally irresponsible companies is anticipated to rise if many shareholders choose not to invest in them (Gollier and Pouget, 2009). This would make it more challenging and expensive for these companies to acquire funds from the outside equity market. El Ghouli, Guedhami, Kim, and Park (2018) provide evidence supporting this view, showing that companies with lower environmental performance have higher equity capital costs. Likewise, examining a sample exceeding 3000 firms from 1990 to 2013, Ng and Rezaee (2015) illustrate that inadequate sustainability performance amplifies the cost of equity for firms.

Furthermore, direct interaction with management through filing shareholder resolutions, asking questions at meetings, and lobbying is another way current and prospective shareholders can impact corporate environmental policies. These tactics have been more widespread in recent years. For example, according to Landier and Nair (2009), about 30% of shareholder resolutions submitted in 2007 had a social or environmental focus. Overall, Agyei-Boapeah et al. (2023) claim that current shareholders use the chance provided by annual general meetings (AGMs) to pressure the corporation board to consider environmental issues seriously.

Lastly, environmental issues may influence financial constraints by affecting customers and public opinion on the firms' operating cash flow and profitability. Prior research indicates that companies that adopt sustainable practices have better relationships with their customers, staff, and the general public (Albuquerque, Koskinen and Zhang, 2019). Similarly, Tatoglu, Bayraktar, Sahadev, Demirbag and Glaister (2014) argue that companies are more likely to adopt voluntary environmental management methods when they become more stakeholder-oriented and committed to serving their customers. Because they lessen the uncertainty, business risk, strikes, boycotts, lawsuits, and other adverse events, these environmental initiatives increase the firm's profitability and cash flows (Orlitzky and Benjamin, 2001). Concerning climate change, Stanny and Ely (2008) contend that businesses with increasing carbon emissions tend to experience boycotts for their products and increased consumer pressure. According to Albuquerque et al. (2019), companies with superior CSR and sustainable practices get public support and goodwill, which helps them attain consumer loyalty and product distinctiveness. Moreover, companies implementing environmental sustainability policies can increase their export income and profitability (Arora and De, 2020). Hence, an increasing body of research suggests that effective environmental management can protect cash flows (Lins, Servaes and Tamayo, 2017; Chava, 2014;

Albuquerque et al., 2019; Sharfman and Fernando, 2008). Businesses with superior environmental initiatives might reduce their financial constraints to the extent that increased profitability enhances their internal funding. In conclusion, in addition to the overall impact of CSR, a company's environmental performance can also affect its financial constraints through the actions of significant stakeholders such as lenders, shareholders, and the general public.

On the other hand, theoretically, the impact of a firm's carbon emissions on financial constraints is a topic of debate between two opposing schools of thought. Based on neoclassical economic theory, the first viewpoint maintains that maximizing shareholder wealth is a firm's primary objective (Friedman, 1970). Businesses can only support non-shareholder interests, such as protecting the environment, if they are a "means to the end," i.e., boosting corporate profitability (Kabir, Rahman, Rahman and Anwar, 2021). The fundamental principle of this perspective is that a firm's dedication to environmental initiatives might lead to a misallocation of valuable corporate resources and higher costs, potentially diminishing shareholders' wealth (Palmer, Oates and Portney, 1995). Corporations' spending on environmental and social reasons may ultimately advance the personal interests of executives (Krüger, 2015), leading to philanthropic activities. Ineffective managers, for instance, can exploit CSR initiatives to improve their chances of keeping their jobs or to further their brands by merely appeasing stakeholders (Barnea and Rubin, 2010). In light of these potential outcomes, companies' environmental initiatives may raise the risk of a decrease in their overall value.

On the contrary, the stakeholder theory claims that companies ought to make choices that reflect the interests of the stakeholders – groups that the company's actions may have an impact (Freeman, 1984). Hence, a company's ability to create long-term value is based on its interactions with different stakeholders. In line with this, stakeholder theory also suggests that a company's environmental initiatives and reduction in carbon emissions can add value to the company by fostering positive relationships with different stakeholders. For example, important stakeholders, such as lenders, suppliers, and investors, favour environmentally conscious businesses (El Ghoul et al., 2018). Therefore, businesses with a minimal carbon footprint may have an edge over rivals in capital, input, and compliance expenses. By integrating environmental sustainability into its operations to the greatest extent feasible, the company will gain the respect of its stakeholders and increase its legitimacy, which is anticipated to open up new avenues for access to essential resources, such as funding (Fernando and Lawrence, 2014). Accordingly, as environmental concerns become significant to key stakeholders (such as lenders, shareholders, customers, and the public) who can influence institutional norms, companies with exemplary environmental performance are expected to gain the legitimacy to secure financing more readily than their counterparts. According to Bansal and Clelland (2004), companies may benefit from corporate environmental legitimacy for at least two reasons: (i) it provides improved access to funding, and (ii) it shields the company from reputational harm and criticism.

New restrictions have been enacted and enforced due to national and international regulatory authorities' recent focus on environmental issues, specifically carbon emissions. Businesses must bear a more significant cost of compliance when adhering to more rules. These costs include waste management, paying fines for breaking environmental standards and producing substantial environmental reporting. This leads to a decrease in the resources that companies have available for investment, which damages their profitability and stock market performance, directly or indirectly. As a result, higher regulatory compliance brought on by excessive carbon emissions may raise businesses' financial constraints.

Second, the financial constraints of corporations with higher carbon emissions are anticipated to increase due to more expensive funding costs (Kabir et al., 2021). The research has extensively established that lenders take into account a company's carbon profile when making a loan decision (Capasso, Gianfrate and Spinelli, 2020; Wang, Feng and Huang, 2021). Similarly, Eliwa, Aboud and Saleh (2021) reveal that lenders reward companies with superior environmental management by tolerating a lesser loan rate and demanding a premium from businesses that emit substantial carbon emissions. High carbon emission companies might have to adhere to strict lending covenants and deadlines for debt payback. The combination of elevated expenses and stringent loan requirements may result in a decline in a company's ability to repay debt within the allotted timeframe. Hence the rise in financial constraints is likely to elevate the likelihood of higher default risk (Wang et al., 2021).

Lastly, stakeholders hold green companies in high respect, contributing to developing a company's social reputation. Consequently, this has a positive impact on businesses' revenue. Companies that align themselves with socially conscious endeavours can win the trust and support of the public and the government, according to research by Branco and Rodrigues (2006). Conversely, companies that produce carbon dioxide are likely to face public backlash. According to Attig et al. (2013), enterprises

that engage in socially irresponsible behaviour risk losing their intangible assets, such as their relationships and reputation, which could then result in a loss of revenue and market share. On the other hand, Grey (2018) claims that corporate environmental performance is perceived as a competitive scheme, which is expected to augment market share and preserve returns when the company has deliberately promoted environmental policies. Furthermore, Zhou, Zhang, Lin, Zeng and Chen (2020) argue that companies that are viewed by the market as "environmentally unsustainable" are more likely to experience serious harm to their brand image, which ultimately lowers their competitiveness. Losing market share and competitiveness may raise future cash-flow uncertainty, increasing the likelihood of higher financial constraints. In light of these arguments, we construct our first hypothesis as follows:

H₁: Firms with higher carbon emissions tend to encounter more financial constraints.

Yang, Chen, Yeh, Chang and Shu (2023) suggest that companies can reduce their carbon emissions in several ways, including decreasing raw material consumption and waste, employing green energy resources, and exposing products' carbon footprint. With the reduction in their carbon emissions, firms are expected to benefit from enhancing their environmental performance in several ways. For example, Cui, Ding, Han and Suardi (2023) suggest that in China, companies with lower carbon emissions are linked with higher innovation and companies with high carbon emissions are financially constrained when they have excessive pollution-related expenses. On the other hand, Shih, Wang, Zhong and Ma (2021) suggest that a significantly negative association exists between environmental performance and corporate default risk, implying the externality of corporate environmental responsibility on a firm's financial risk profile. Similarly, Atif and Ali (2021) suggest that companies with higher ESG performance and disclosure, including environmental performance, encounter lower default risk. These studies highlight the contribution of better environmental performance on companies' financial constraints and default risk. On the other hand, Rehman et al. (2024) analyze this association from a different angle, documenting that financial constraints increase companies' carbon emissions. This association is vital for companies with higher leverage and those not filing their investments in environmental expenses.

On the other hand, the relationship between environmental performance, particularly in terms of carbon emissions, and financial constraints can be significantly influenced by the ownership structure of firms since the owners of a company have influence not only on the environmental-related issues but also on the fundings and consequently financial constraints. Institutional investors, such as pension funds, mutual funds, and insurance companies, often have substantial resources and influence corporate decisions, enabling them to significantly shape firms' strategies and policies. These investors increasingly integrate Environmental, Social, and Governance (ESG) criteria into their investment decisions, motivated by ethical considerations and the financial performance benefits of sustainable practices (Eccles, Ioannou, and Serafeim, 2014).

Research indicates that firms with higher levels of institutional ownership are more likely to adopt robust environmental practices, including reducing carbon emissions, due to the active engagement and pressure from these investors (Safiullah, Alam and Islam, 2022). Dyck, Lins, Roth and Wagner (2019) find that institutional investors play a critical role in enhancing corporate environmental performance by advocating for greater transparency and accountability. This increased scrutiny and demand for improved environmental practices can mitigate financial constraints by boosting investor confidence and improving access to capital markets (Dyck et al., 2019). Hence, we expect firms with higher institutional ownership to have enhanced access to funds, i.e., fewer financial constraints.

Moreover, institutional investors often seek to mitigate risks associated with poor environmental performance, such as regulatory fines, litigation, and reputational damage, which can exacerbate financial constraints (Clark and Hebb, 2005). Institutional investors help firms avoid these risks by promoting environmentally responsible behaviours and capitalizing on the growing market for green investments and sustainable finance. Eccles et al. (2014) provide evidence that companies with high institutional ownership tend to have better sustainability disclosures, which can enhance their market valuation and lower their cost of equity. Overall, we expect institutional ownership to significantly moderate the relationship between environmental performance and financial constraints by fostering improved corporate governance, reducing environmental risks, and enhancing access to capital.

Like institutional ownership, foreign ownership is also anticipated to influence the nexus between financial constraints and environmental performance. According to Kampouris, Mertzanis, and Samitas (2022), foreign ownership is crucial to a company's ability to obtain financing. Foreign investors often bring different standards, practices, and expectations than domestic investors, significantly influencing corporate behaviour and performance. Foreign ownership can bring additional scrutiny and higher environmental standards due to differing regulatory environments and investor expectations, which can mitigate financial constraints through enhanced reputational benefits and access to international

capital markets. In short, foreign ownership is anticipated to moderate the linkage between financial constraints and environmental performance by imposing higher environmental standards, introducing advanced technologies and management practices, enhancing transparency and disclosure, and improving access to international financial markets. These factors collectively enable firms to improve their environmental performance, specifically in reducing carbon emissions, and alleviate financial constraints, underscoring the beneficial role of foreign investors in promoting corporate sustainability.

On the other hand, state ownership may present a dual-edged sword; while state-owned enterprises might benefit from preferential financing conditions and policy support, they may also face less stringent environmental scrutiny. On the one hand, state-owned enterprises often benefit from preferential treatment regarding access to financing and regulatory support, which can alleviate financial constraints (Li and Xia, 2008). However, state ownership also presents potential drawbacks. The lack of stringent profit motives can sometimes result in less efficient management practices, which may hamper environmental performance and financial efficiency. While it can provide financial stability and policy-driven incentives for environmental improvement, potential inefficiencies and conflicting objectives might hinder the optimal realization of these benefits.

Based on the above arguments, we build our second hypothesis as follows:

H₂: Different ownership attributes moderate the association between carbon emissions and financial constraints.

Data and methodology

Data

The primary purpose of this paper is to explore the impact of corporate environmental performance on financial constraints. We build our sample to test our premise, employing the Morgan Stanley Capital International (MSCI) market classification index. Accordingly, we incorporate 24 developed nations listed in the MSCI classification for the Americas, Europe, the Middle East and Africa (EMEA), and Asia-Pacific (APAC) regions. We specifically focus on developed countries because they play a crucial role in global climate discussions and policymaking. Publicly traded companies from these 24 developed nations are included in our sample for 2002–2021. We start with 2002 because Refinitiv also reported carbon emission scores in 2002. We gather data using the Datastream database to obtain a list of all publicly traded corporations in developed countries. First, we exclude financial firms (standard industrial classification (SIC) codes 6000 to 6999) because their financial statements are not comparable to those of non-financial firms. Refinitiv extracts the carbon emissions data from the firms' disclosures on environmental performance or media coverage. If firms do not make any non-financial disclosures on their environmental performance and there is no media coverage, then carbon emissions data can be missing for some firms and observations. Since this study's primary variable of interest is carbon emissions, we omit the observations for which the data is missing. Our final sample comprises an unbalanced panel of 20,774 company-year observations, corresponding to 2632 separate companies.

We provide the allocation of observations across the 24 nations in Table 1 – Panel A. As can be depicted from Table 1 – Panel A, the observations from the USA occupy the most significant portion of the sample (27.9%), followed by Japan, which possesses 17% of the sample. Moreover, Table 1 Panel B presents the sample distribution by industry, categorized using SIC groups. The manufacturing sector dominates the sample, with a portion of 47.48%.

We compile our sample from multiple sources: Primarily, data on carbon emissions and ownership is extracted from Refinitiv Eikon. Second, we download all the financial and accounting data from Thomson Reuters Datastream. Finally, the country-level control variables are obtained from World Development Indicators from the World Bank.

Variables

In this study, since we aim to assess how carbon emissions influence financial constraints at the firm level, our primary variable of interest is carbon (CO₂) emissions. To extract data on CO₂ emissions, we utilize the Refinitiv EIKON database. Our baseline estimations employ the natural logarithm of “total CO₂ and CO₂ equivalents emission in tonnes” as the primary independent variable following Benlemlih and Yavas (2023). In robustness tests, we employ two separate proxies to measure carbon emissions: The natural logarithm of “total CO₂ and CO₂ equivalents emission in tonnes divided by net sales or revenue” and the natural logarithm of “Scope 1 direct emissions and Scope 2 indirect emission in tonnes divided by net sales or revenue”. The definitions of all variables employed in the analysis are provided in Table 2.

Table 1: Distribution of the Sample Across Countries and Industries

Panel A: Country	Number of observations	Number of firms	%
USA	5793	887	27.9%
Japan	3596	353	17.3%
UK	2311	204	11.1%
Canada	1346	188	6.5%
Hong Kong	1037	194	5.0%
Australia	976	142	4.7%
France	841	81	4.0%
Germany	786	91	3.8%
Sweden	545	72	2.6%
Switzerland	440	56	2.1%
Italy	411	49	2.0%
Spain	351	36	1.7%
Denmark	294	30	1.4%
Finland	292	22	1.4%
Netherlands	293	30	1.4%
New Zealand	229	37	1.1%
Norway	232	26	1.1%
Singapore	198	32	1.0%
Belgium	186	24	0.9%
Russia	187	25	0.9%
Austria	165	19	0.8%
Portugal	116	13	0.6%
Ireland	95	13	0.5%
Israel	54	8	0.3%
Total	20774	2632	100.0%

Panel B: Industry	Number of observations	Number of firms	%
Manufacturing	9851	1138	47.48%
Transportation, communications, electric & gas	3885	420	18.72%
Services	2068	377	9.97%
Mining	1995	269	9.61%
Retail Trade	1497	215	7.21%
Construction	714	78	3.44%
Wholesale trade	643	106	3.10%
Agriculture, forestry, fishing	96	23	0.46%
Total	20749	2626	100.00%

Table 2: Variable Descriptions

Variables	Description	Source
Independent variables		
CO2	Natural logarithm of "total CO2 and CO2 equivalents emission in tonnes"	Refinitiv Eikon
CO2_v2	Natural logarithm of "total CO2 and CO2 equivalents emission in tonnes divided by net sales or revenue."	Refinitiv Eikon
CO2_v3	Natural logarithm of "Scope 1 direct emissions and Scope 2 indirect emission in tonnes divided by net sales or revenue."	Refinitiv Eikon
Dependent variables		
Kaplan-Zingales Index (KZ score)	Proxy for financial constraints. Higher KZ Index values indicate that a company is more financially constrained. Calculated as follows: "KZ Index _t = -1.002 × (Cash Flow _t /Total Assets _{t-1}) + 0.283 × Q _t + 3.139 × leverage _t - 39.368 × (Dividends _t / Total Assets _{t-1}) - 1.315 × (Cash Holdings _t / Total Assets _{t-1})"	Thomson Reuters Datastream
Size-Age index (SA index)	Proxy for financial constraints. Higher SA index values reveal that a company is more financially constrained. Calculated as follows: "SA index = (-0.737 × Size) + (0.043 × Size ²) - 0.04 × Age"	Thomson Reuters Datastream
Firm-level controls		
Firm Size	Ln (Total assets)	Thomson Reuters Datastream
Leverage	Total liabilities over total assets	Thomson Reuters Datastream
Profitability	ROA (Net income to total assets)	Thomson Reuters Datastream
Tangibility	Net property plant and equipment over total assets	
Country level controls		
Inflation	Annual consumer price index	World Development Indicators from the World Bank
GDP growth	Annual growth of Gross Domestic Product	World Development Indicators from the World Bank
Moderating variables		
Institutional ownership	"Percentage of ownership held by institutions (hedge funds, mutual funds, pension funds, insurance companies, banks, etc.)"	Refinitiv Eikon
Foreign ownership	"Percentage of ownership held by foreign parties"	Refinitiv Eikon
State ownership	"Percentage of ownership held by the State in respective countries."	Refinitiv Eikon

On the other hand, the primary dependent variable is financial constraints at the firm level. A company's incapability to obtain financing at a cheaper cost indicates the extent of its financial constraints (Gamba and Triantis, 2008). Financial constraints refer to the inadequate financial resources a company has. In the baseline regressions, we employ two separate proxies to measure financial constraints following relevant literature (Agyei-Boapeah et al., 2023; Cheng et al., 2014; Rehman et al., 2024): Kaplan and Zingales index (Kaplan and Zingales, 1997) and Size-Age index (Hadlock and Pierce, 2010). Kaplan and Zingales (1997) present a structural framework for understanding financial constraints and introduce an index based on company characteristics associated with financial constraints. The KZ index is computed as follows:

$$\begin{aligned} \text{"KZ Index}_t = & -1.002 \times \left(\frac{\text{Cash Flow}_t}{\text{Total Assets}_{t-1}} \right) + 0.283 \times \left(\frac{\text{Market Value}_t}{\text{Total Assets}_{t-1}} \right) + 3.139 \times \left(\frac{\text{Total Debt}_t}{\text{Total Assets}_{t-1}} \right) - 39.368 \\ & \times \left(\frac{\text{Dividend}_t}{\text{Total Assets}_{t-1}} \right) - 1.315 \times \left(\frac{\text{Cash}_t}{\text{Total Assets}_{t-1}} \right) \end{aligned} \quad (1)$$

We also employ the Size-Age (SA) index as an alternative proxy to measure financial constraints. Higher KZ or SA index values indicate that a firm faces greater financial constraints than firms with no financial constraints. The SA index is calculated as follows:

$$\text{"SA index} = (-0.737 \times \text{Size}) + (0.043 \times \text{Size}^2) - 0.04 \times \text{Age} \quad (2)$$

On the other hand, in line with the previous research (Kabir et al., 2021), we incorporate a list of control variables in our empirical model to thoroughly examine the linkage between CO₂ emissions and financial constraints. Given that larger organizations are often assumed to be more stable than smaller firms and to have lower financial constraints, we primarily control for firm size, which is assessed as the natural logarithm of assets. Leverage, expected to raise businesses' financial constraints, is predicted to influence financial constraints positively. A firm's profitability is anticipated to negatively impact financial constraints (measured by return on assets (ROA)). It is assumed that a thriving business will have a greater capacity to obtain financing. Therefore, ROA and financial constraints are anticipated to be negatively associated (Kabir et al., 2021). Next, we control for tangibility. The impact of tangibility on financial constraints can be positive or negative. On the one hand, it may be easier for firms with higher tangibility to find financing; hence, tangibility and financial constraints may be negatively associated. On the other hand, tangible assets may be recovered more quickly in the event of financial constraints. Hence, there may be a positive relationship between tangibility and financial constraints. We also control for country-level variables by employing an international sample of 23 nations globally (Benlemlih and Yavas, 2023). Countries' economic conditions are expected to influence corporate financial constraints. Accordingly, we include GDP growth and inflation as country controls.

Finally, we hypothesize that a firm's ownership structure will impact the firm's environmental performance and financial constraints. Accordingly, within the scope of this study, we have the purpose of analyzing the moderating impact of ownership on the association between corporate carbon emissions and financial constraints. To measure ownership, we employ three different proxies: institutional, foreign, and finally, state ownership. The definitions of all variables are provided in Table 2.

Research design

To explore whether and how carbon emissions affect firms' financial constraints, we employ the following baseline regression model, following Agyei-Boapeah et al. (2023)

$$\text{Financial Constraints}_{i,t} = \alpha_0 + \beta \text{CO2}_{i,t} + \gamma' X_{it} + \theta' Y_{ct} + \eta_t + \eta_i + \eta_c + v_{itc} \quad (3)$$

In our baseline estimation, the dependent variable is financial constraints. We employ two proxies for financial constraints: the KZ index and the SA index, the details of which have been given in the variables section. On the other hand, our primary independent variable is carbon emissions (CO₂). For CO₂, we use the natural logarithm of "total CO₂ and CO₂ equivalents emission in tonnes". In robustness tests, we use different carbon emissions data. To prevent biased results, we add several company-level and country-level control variables. Within the firm-level control variables, firm size, leverage, profitability, and tangibility are added to the estimations. Within the country-level control variables, inflation and GDP growth are added. In Model 3, X_{it} represents company-level, and Y_{ct} stands for country-level controls.

In order to determine whether the fixed effects model or the random effects model is more appropriate for our panel data analysis, we conducted a Hausman test. The null hypothesis of the Hausman test states that the preferred model is the random effects model, while the alternative hypothesis suggests that the preferred model is the fixed effects model. The results of the Hausman test are provided in the Appendix. Since the p-value is less than the conventional significance level of 0.05, we reject the null hypothesis, indicating that the fixed effects model is more appropriate for our data. Accordingly, panel data estimation techniques with fixed effects are employed to test Model 3. In order to account for the effects of fluctuating macroeconomic conditions, we include time-fixed effects. Second, industry-fixed effects are integrated to address sector-specific attributes. Finally, we employ country-fixed effects to alleviate possible heterogeneity across countries and capture any missing variables at the macro level. In Model 3, " η_t " stands for year-fixed effects, " η_i " for industry-fixed effects, " η_c " for country-fixed effects, and finally, " v_{itc} " stands for the error terms.

Descriptive statistics

Table 3 presents the summary statistics for all variables, incorporating the number of observations, mean, minimum, p25, median, p75, maximum, and standard deviation. The mean values of the KZ and SA indexes are harmful, at -7.89 and -0.13, respectively. On the other hand, the mean value of carbon emissions is 12.7, with a standard deviation of 2.6. Finally, the mean level of institutional and foreign ownership is 43% and 30%, respectively, as opposed to the mean level of state ownership at 9.8%. These summary statistics indicate that institutional ownership has the highest mean within the three ownership attributes. On the other hand, we display the Pearson correlation coefficients in Table 4. As

can be depicted from the table, the coefficients are not high, and therefore, there are no multicollinearity issues in the analysis.

Table 3: Summary Statistics

	N	Mean	min	p25	Median	p75	max	Std. Dev.
KZ Index	19,794	-7.891	-607.553	-5.364	-.534	2.058	273.178	47.368
SA Index	19,292	-.132	-3.234	-1.482	-.606	.851	3.482	1.766
CO2	20,774	12.733	5.805	11.099	12.759	14.436	18.197	2.562
Firm Size	20,716	16.748	9.579	15.029	16.417	18.278	21.065	2.336
Leverage	20,716	.568	.008	0.431	.568	.697	11.934	.252
ROA	20,716	.042	-2.365	0.016	.042	.077	.402	.099
Tangibility	20,712	.35	0	0.150	.301	.51	.969	.241
GDP growth	20,774	1.448	-11.167	0.754	1.936	2.779	24.475	3.114
Inflation	20,774	1.912	-4.478	0.717	1.64	2.493	15.534	1.868
Institutional Ownership	20,153	43.905	0	15.958	40.162	70.603	105.948	30.704
Foreign Ownership	20,206	30.26	0	9.622	20.606	47.219	95.371	26.379
State Ownership	19,281	9.771	0	0.789	1.459	7.906	99.364	16.973

Table 4: Correlation Table

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) KZ Index	1.000											
(2) SA Index	0.102*	1.000										
(3) CO2NewVar_w	0.204*	0.419*	1.000									
(4) Firm Size	0.108*	0.988*	0.476*	1.000								
(5) Leverage	0.053*	-0.006	0.144*	0.003	1.000							
(6) ROA	-0.125*	-0.002	-0.001	0.012	-0.176*	1.000						
(7) Tangibility	0.230*	0.017*	0.443*	0.033*	0.016*	-0.105*	1.000					
(8) GDP growth	-0.010	-0.128*	-0.011	-0.110*	-0.012	0.104*	0.008	1.000				
(9) Inflation	-0.015*	-0.282*	-0.090*	-0.257*	0.010	0.062*	0.022*	0.359*	1.000			
(10) Institutional Own	-0.049*	-0.403*	-0.035*	-0.355*	0.039*	0.034*	0.005	0.073*	0.171*	1.000		
(11) For Own	-0.107*	-0.238*	-0.149*	-0.236*	-0.027*	0.025*	-0.053*	-0.013	0.033*	0.195*	1.000	
(12) State Own	0.037*	0.466*	0.035*	0.439*	-0.079*	-0.028*	-0.012	-0.119*	-0.221*	-0.379*	-0.019*	1.000

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Results

Baseline findings: Impact of carbon emissions on financial constraints

This study investigates the association between environmental performance and financial constraints and explores the moderating influence of different ownership attributes. We employ corporate carbon emissions to proxy for firms' environmental performance. Employing panel data estimate techniques, we carry out the estimations taking into account time, industry, and country fixed effects. In the baseline estimations, we first analyze the effect of carbon emission on financial constraints. The findings are displayed in Table 5. We employ the KZ index as our dependent variable in Columns 1-3, whereas we use the SA index in Columns 4-6. Columns 1 and 3 consider only carbon emissions as the explanatory variable, without including any firm or country-level control variables. Columns 2 and 4 include firm-level controls, and finally, Columns 3 and 6 incorporate country-level controls and firm-level control variables.

Table 5: Baseline Findings: Impact of Corporate Carbon Emissions on Financial Constraints

	(1)	(2)	(3)	(4)	(5)	(6)
	KZ Index	KZ Index	KZ Index	SA Index	SA Index	SA Index
CO2	2.694*** (13.405)	2.446*** (9.205)	2.455*** (9.252)	.281*** (90.903)	.295*** (88.945)	.295*** (88.941)
Firm Size		-1.095*** (-3.156)	-1.102*** (-3.179)			
Leverage		6.071** (2.436)	6.13** (2.46)		.039 (1.383)	.04 (1.397)
ROA		-42.302*** (-7.322)	-42.477*** (-7.353)		.39*** (6.39)	.389*** (6.359)
Tangibility		42.332*** (12.714)	42.352*** (12.72)		-.991*** (-27.068)	-.991*** (-27.062)
GDP growth			-.181 (-.8)			.001 (.175)
Inflation			1.088*** (2.888)			.006 (.947)
Constant	-41.696*** (-15.334)	-36.585*** (-7.759)	-38.084*** (-7.887)	-3.707*** (-92.944)	-3.578*** (-86.892)	-3.589*** (-83.811)
Observations	18549	18549	18549	17990	17983	17983
R-squared	.128	.159	.16	.399	.435	.435

t-values are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

The findings in all six columns demonstrate that carbon emissions positively and significantly (at a 1% level) affect both proxies of financial constraints. This result implies that as companies incur higher carbon emissions, they are likely to face higher financial constraints. Hence, firms with better environmental performance tend to enjoy fewer financial constraints. Firms with reduced carbon emissions will likely enjoy higher revenue and market share, possibly due to a rise in reputation, brand image, trust, and public support. This leads to more favourable conditions from the financial institutions and reduced financial constraints.

On the other hand, within the control variables, firm size has a negative and significant (at 1% level) impact on financial constraints, which aligns with the literature (Kabir et al., 2021). More giant corporations, likely to be more stable than smaller ones, tend to have lower financial constraints. Please note that we do not include firm size as one of the control variables in the regressions, where the SA index is the dependent variable (Columns 4 – 6), because the SA index is constructed from the variable size. Hence, there is high multicollinearity between these two variables. On the other hand, leverage has a positive effect in all four estimations, yet the effect is significant only in estimations where the dependent variable is the KZ index. This finding implies that firms with more bank debt in their balance sheets will likely encounter a higher KZ index. The findings with ROA are contradictory: The impact is significantly negative in estimations where the KZ index is the dependent variable, suggesting that more profitable firms are likely to face fewer financial constraints. This aligns with our anticipation that a thriving business will have a greater capacity to obtain financing. Notwithstanding this, in columns 5 and 6, we observe that profitability positively and significantly affects the SA index. This contradictory finding may stem from measuring the SA index, which only incorporates companies' size and age. On the other hand, the impact of tangibility on the KZ score is significantly positive, implying that tangible assets may be recovered more quickly in the event of financial constraints. On the contrary, the impact of tangibility on the SA index is significantly negative, suggesting that firms with higher tangibility tend to find financing easier and, therefore, encounter fewer financial constraints. Finally, within the country-level control variables, only the impact of inflation on the KZ score is significantly positive, indicating that firms in countries with higher inflation are likely to face higher financial constraints.

Robustness tests

We conduct several robustness tests to confirm that our baseline finding regarding the positive impact of carbon emissions on financial constraints is robust. The findings are displayed in Table 6. In columns 1 and 2, we employ two definitions to proxy for carbon emissions. In column 1, we employ the natural logarithm of "total CO2 and CO2 equivalents emission in tonnes divided by net sales or revenue." In column 2, we use the natural logarithm of "Scope 1 direct emissions and Scope 2 indirect emission in tonnes divided by net sales or revenue". The coefficient of the alternative versions of carbon emissions loads positively and significantly, confirming our baseline finding that carbon emissions increase financial constraints even when we change the definition of the primary variable of interest.

Then, we construct alternative samples. Our sample comprises publicly listed companies from 24 developed nations, where the USA occupies the largest share, with a portion of almost 28%. To rule out

that our findings are not biased due to the USA, we exclude the USA from our sample and re-run the baseline model. The findings are presented in Column 3 in Table 6. CO₂ continues to load positively and significantly, which aligns with our main findings. Then, we construct another sample by excluding the manufacturing sector, which has a share of almost 48%, and re-estimate the baseline model. The findings, displayed in Column 4, confirm our result. Finally, we incorporate additional board-related variables into the analysis, anticipating that companies' boards of directors are influential in environmental initiatives and issues related to financial constraints. We incorporate two board-related variables: board size and independent board members. The findings presented in Column 5 show that higher carbon emissions are likely to result in higher financial constraints even when we consider firms' board-related attributes.

Table 6: Robustness Tests

	Alternate Independent variables		Alternative sample: excluding the USA	Alternative sample: excluding the manufacturing sector	Additional board-level control variables
	(1) KZ Index	(2) KZ Index	(4) KZ Index	(5) KZ Index	(6) KZ Index
CO ₂			2.638*** (8.01)	3.137*** (7.634)	2.506*** (9.059)
CO ₂ _v2	1.628*** (4.931)				
CO ₂ _v3		1.724*** (3.884)			
Firm Size	1.125*** (4.699)	1.112*** (4.242)	-.939** (-2.117)	-.691 (-1.326)	-1.157*** (-3.028)
Leverage	7.421*** (2.919)	10.988*** (3.835)	13.032*** (3.447)	8.368*** (2.58)	5.781** (2.282)
ROA	-46.243*** (-9.29)	-52.849*** (-9.668)	-45.321*** (-5.728)	-38.377*** (-5.236)	-42.934*** (-7.237)
Tangibility	41.717*** (11.885)	45.399*** (10.288)	53.366*** (12.989)	49.449*** (10.853)	43.384*** (12.423)
GDP growth	-.258 (-1.179)	-.371 (-1.441)	-.129 (-0.547)	-.305 (-0.831)	-.211 (-0.906)
Inflation	1.188*** (3.193)	.981** (2.247)	1.272*** (2.714)	1.322** (2.128)	1.045*** (2.706)
Board Size					1.734 (1.46)
Ind. Board Member					-.046*** (-3.04)
Constant	-38.418*** (-7.56)	-41.078*** (-7.063)	-51.219*** (-8.34)	-64.523*** (-9.154)	-39.488*** (-7.786)
Observations	18509	14246	13446	9635	17583
R-squared	.161	.173	.208	.188	.161

t-values are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

The moderation effect of ownership

Next, we investigate whether and how several ownership traits influence the nexus between carbon emissions and financial constraints. The findings are displayed in Table 7. Column 1 presents the findings for institutional ownership. We observe that the influence of institutional ownership on financial constraints is negative and significant (at the 1% level), which aligns with the relevant literature (Farooq, Humayon, Khan, and Ali, 2022). This finding suggests that firms with higher institutional ownership are likely to access funds quickly and, hence, are obliged to encounter fewer financial constraints. On the other hand, the interaction term between carbon emissions and institutional ownership is significantly positive, indicating that the positive impact of carbon emissions on financial constraints is more significant for firms with higher institutional ownership. Since these firms prioritize environmental issues, they are hampered more when their carbon emissions increase. Firms with higher institutional ownership are expected to be affected more when their carbon emissions increase in terms of increasing financial constraints than other firms.

We find a similar finding with foreign ownership (column 2). While the individual impact of foreign ownership on financial constraints is significantly negative, suggesting that firms with higher foreign ownership face fewer financial constraints than firms with lower foreign ownership, the interaction term is positive. This result suggests that when firms with higher foreign ownership increase their carbon emissions, the impact on financial constraints is more significant than those with less foreign

ownership. Finally, we investigate the moderation impact of state ownership (Column 3). The findings show that the impact of state ownership on the KZ score is significantly positive, suggesting that it is more difficult for state-owned enterprises to find financing. Hence, they face higher financial constraints. On the other hand, the interaction term between state ownership and carbon emissions loads negatively and significantly. This finding shows that state-owned firms are likely to be less affected by increased carbon emissions. Overall, our findings highlight the significance of companies' ownership structure on the nexus between financial constraints and environmental performance.

Table 7: Further Analysis: Moderation Effect of Ownership on the Association Between Corporate Carbon Emissions and Financial Constraints

	(1) KZ Index	(2) KZ Index	(3) KZ Index
CO2	1.525*** (4.36)	.925*** (3.137)	3.035*** (10.311)
Ins Own	-.333*** (-4.937)		
CO2 * Ins Own	.025*** (4.873)		
For Own		-.677*** (-8.075)	
CO2 * For Own		.053*** (8.497)	
State Own			.511*** (4.445)
CO2 * State Own			-.039*** (-4.481)
Firm Size	-1.278*** (-3.598)	-1.269*** (-3.577)	-1.415*** (-3.874)
Leverage	6.377** (2.48)	6.709*** (2.659)	6.336** (2.401)
ROA	-44.587*** (-7.44)	-45.706*** (-7.558)	-60.188*** (-10.567)
Tangibility	42.148*** (12.441)	42.777*** (12.545)	41.891*** (12.106)
GDP growth	-.168 (-.734)	-.253 (-1.096)	-.243 (-1.032)
Inflation	1.099*** (2.878)	1.032** (2.477)	1.251*** (3.204)
Constant	-22.723*** (-4.004)	-15.217*** (-2.779)	-39.4*** (-7.508)
Observations	18016	18065	17340
R-squared	.163	.170	.169

t-values are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

Conclusion

Environmental challenges, climate change, and CO2 emissions have grown significantly in the last decades and are now at the forefront of academic, practitioner, and political arguments. Financial constraints, on the other hand, play a pivotal role in shaping businesses' survival and growth prospects. This paper investigates the nexus between environmental performance, i.e., carbon emissions and financial constraints. We hypothesize that firms with better environmental performance, i.e., lower carbon emissions, will have fewer financial constraints. Employing a large sample of 20,774 company-year observations from 24 developed nations, we provide empirical evidence of a positive and significant association between carbon emissions and financial constraints. Our finding is robust to alternative definitions of variables, alternative samples, and additional control variables. Our findings align with Agyei-Boapeah et al. (2023), who document that superior environmental performance, shown with lower carbon emissions, is significantly associated with lower financial constraints. Our findings also confirm the results of Alsaifi, Elnahass, Al-Awadhi and Salama (2022), who examine corporate carbon disclosure and firm risk in the UK context, demonstrating that enhanced voluntary carbon disclosure reduces corporate risk.

In additional analyses, we assess three different ownership traits, state, institutional, and foreign ownership, in moderating the relationship between carbon emissions and financial constraints. Primarily, we observe that the impact of institutional ownership on financial constraints is significantly negative, aligning with the relevant literature (Farooq et al., 2022). This outcome implies that companies with institutional owners have more access to funds and must encounter fewer financial constraints.

We obtain similar findings for the direct impact of foreign ownership on financial constraints. Furthermore, we provide novel empirical evidence that institutional and foreign ownership has a positive moderating effect, whereas state ownership has a negative one. These outcomes imply that corporations with foreign and institutional ownership should care about their environmental performance and reduce their carbon emissions to the greatest extent possible since they will encounter higher financial constraints if their carbon emissions rise. Companies with institutional owners are anticipated to be affected more when their carbon emissions increase in terms of increasing financial constraints than other firms. On the contrary, state-owned companies have less impact from a possible deterioration in their environmental performance.

This study contributes to the literature in several ways. First, it studies the association between a specific perspective of environmental performance and financial constraints for a considerable sample of 20,774 company-year observations from 24 developed nations around the globe. Second, and more importantly, this study is the first to investigate whether and how ownership structure moderates the link between carbon emissions and financial constraints. Hence, this study provides companies with management-specific implications regarding how their financial constraints would be affected by a potential decline in their carbon emissions for different types of ownership.

Overall, this study's findings significantly affect company policy and managerial management. From a managerial perspective, firms must prioritize the environment among other stakeholders. Investing in environmental issues and reducing their carbon emissions will help enhance the environmental standards surrounding them, and accordingly, they will benefit from fewer financial constraints. Moreover, considering the different impacts generated by the different attributes of the ownership structure, management can take action accordingly. For policymakers, developing investment and climate policies that facilitate swift and extensive environmental changes is necessary to shift funding away from projects with high emissions, assisting the projects with lower emissions. These initiatives are anticipated to motivate companies to invest more in environmental actions.

The limitation of this study is that, in this paper, we only focus on the impact of carbon emissions on financial constraints. However, other considerations also affect firms' financial constraints, including the economic environment, countries' banking system and credit availability in the financial system. Hence, our study covers only a portion of factors that may impact corporate financial constraints. Future studies should also consider these other dimensions to comprehend corporate financial constraints. Furthermore, this study does not cover implicit and explicit factors that would affect corporate carbon emissions, like countries' culture and policy toward environmental issues, which also constitutes a limitation of this study. Since countries' attitudes, culture, and policies towards environmental factors will ultimately affect corporate performance regarding environmental issues, these factors can also be examined in future studies.

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Appendix:

Appendix 1:

Test	Test Statistic (Chi-squared)	p-value
Hausman test	1414.46	0.0000