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Cash-rich firms and carbon emissions

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ABSTRACT

We investigate whether corporate cash holdings affect carbon dioxide emissions. Using a sample of 5402 firm-years observations from 943 U.S. firms during 2007–2017, we find that carbon emissions are lower in firms with higher corporate cash holdings. The effect of cash holdings on carbon emissions is more pronounced in firms with low leverage and less financial constraints. Our channel analysis further unveils that renewable energy consumption and carbon abatement investment are higher in cash-rich firms, which transmit lower carbon emissions. Our findings are robust to different identification strategies and alternative measures of cash holdings and carbon emissions. Overall, our paper provides novel evidence on the role of corporate cash holdings in mitigating carbon emissions.

1. Introduction

The existing literature on cash holdings focuses largely on understanding the determinants of cash holdings. For instance, the literature documents that firm size (Al-Najjar, 2013), firm ownership (Gupta & Bedi, 2020; Liu, Mauer, & Zhang, 2014; Loncan, 2020; Megginson, Ullah, & Wei, 2014), corporate diversification (Duchin, 2010), organizational capital (Marwick, Hasan, & Luo, 2020), financial hedging (Sun, Yin, & Zeng, 2021), earnings quality (Farinha, Mateus, & Soares, 2018), labor heterogeneity (Ghaly, Anh Dang, & Stathopoulos, 2017), employee welfare (Ghaly, Dang, & Stathopoulos, 2015) affect cash holdings. There is also evidence that corporate governance (Dittmar & Mahrt-Smith, 2007; Kuan, Li, & Liu, 2012), CEO belief (Deshmukh, Goel, & Howe, 2021) and board gender diversity (Atif, Liu, & Huang, 2019) significantly influence firm cash policies. However, relatively less empirical research (e.g., Benjamin, Regasa, Wellalage, Srikamalaladevi, & Marathamuthu, 2020) has been conducted in exploring the association between firm environmental performance and corporate cash holdings. Anecdotal evidence shows that cash-rich firms intend to engage more in promoting green activities. For example, the *New York Times,* in its 18 August 2011 edition, reports that "*cash-rich companies begin to make renewable energy investments*". In its 4 February 2020 edition, the *Financial Times* reports that cash-rich investors prefer firms with green energy infrastructure. Motivated by the important research gap and the significance of this topic, we conduct a systematic and large-scale empirical analysis to explore the impact of cash holdings on firm-level carbon emissions performance as measured by carbon dioxide emissions such as total, direct, and indirect emissions.

The carbon footprint of business activities has become crucial for corporate policies. The Kyoto Protocol, the Paris Climate Change Agreement, and the very recent Glasgow 2021 UN Climate Change Conference (COP26) are the major driving forces that influence various stakeholders to pressure business enterprises to implement environment-friendly strategies for reducing industrial emissions. In parallel with such pressure, academics and practitioners have ascertained the firm's environmental practice as a 'win-win' strategy that ensures both financial and non-financial benefits. For example, Al-Tuwaijri, Christensen, and Hughes Ii (2004), Clarkson, Li, Richardson, and Vasvari (2011) and Atif, Hossain, Alam, and Goergen (2021) find a positive relationship between environmental and financial performance in U.S. firms. Thus, to comply with external pressures and achieve financial gains, carbon emissions have become a central performance indicator in corporate decision-making where enterprises embark on specific sustainable business practices.

Considering the ever-increasing importance of sustainable business practices, a plethora of literature identifies the determinants of firm-level environmental performance. First, a group of studies investigates the link between firm characteristics and carbon emissions, including firm size (Apergis, Eleftheriou, & Payne, 2013; Bowen, 2002; Lee & Min, 2015); firm location (Cole, Elliott, Okubo, & Zhou, 2013; Ishikawa &

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Okubo, 2017), capital-labour ratio (Cole et al., 2013), ownership structure (Calza, Profumo, & Tutore, 2016; Liu, Zhang, & Liang, 2019), exporting propensity (Jiang, Lin, & Lin, 2014; Richter & Schiersch, 2017) and return on asset (Alam, Atif, Chien-Chi, & Soytaş, 2019). Second, a few studies, such as Cole et al. (2013), Lee and Min (2015) and Alam et al. (2019), examine the impact of firm-level R&D investment on carbon performance. Third, several studies reveal that stronger corporate governance helps to improve firm carbon and environmental performance significantly. These studies include Liao, Luo, and Tang (2015) on board size; Post, Rahman, and McQuillen (2015), Liao et al. (2015) and Atif et al. (2021) on board gender diversity and independent directors; Glass, Cook, and Ingersoll (2016) on women CEOs, Walls and Berrone (2017) on CEO power; Ortiz-de-Mandojana, Bansal, and Aragón-Correa (2019) and Arena, Michelon, and Trojanowski (2018) on CEO's experience and personal traits; Moussa, Allam, Elbanna, and Bani-Mustafa (2020) and Dixon-Fowler, Ellstrand, and Johnson (2017) on board environmental orientation; Kanashiro (2020) on environmental compensation; Zou, Zeng, Lin, and Xie (2015) and Haque and Ntim (2020) on executive compensation; and Kim, Wan, Wang, and Yang (2019) on institutional ownership. While the above literature investigates the impact of firm characteristics and corporate governance variables on firm environmental performance, there is no study available examining the impact of firm cash holdings on carbon performance. Hence, this empirical study is undertaken to narrow this gap by investigating the roles of cash holdings on firm carbon emissions.

Theoretically, cash holdings may influence firms' carbon emissions in two ways. Chief among these reasons is that a cash-rich firm can use its war chest to finance competitive strategies for environmental capital expenditure. According to the natural resource-based view (NRBV), a firm can achieve the competitive advantage by spending its scarce resources (e.g., cash) on environmental activities that create both financial and non-financial benefits for firms (Alam et al., 2019; Atif et al., 2021; Safiullah, Kabir, & Miah, 2021). Considering the inefficiencies in capital markets, cash-rich firms may have the advantage to undertake environmental activities quicker, thereby reducing carbon emissions compared to their cash-poor peers. For instance, a firm may use its cash reserves to fund competitive environmental choices, such as renewable energy consumption, investment in green technologies, the promotion of recycling and reuse, and the arrangement of employee training for environment-friendly activities. The second reason is that cash holdings can impact a firm's carbon performance by promoting innovation. The existing literature suggests that internal cash holdings may significantly impact the likelihood of developing innovations (e.g., Kamien & Schwartz, 1978; Schroth & Szalay, 2010). Notably, such innovations, in turn, increase energy efficiency and promote alternative sources of clean energy production. These will ultimately reduce carbon emissions. Hence, we can view cash holdings as pre-emptive devices that may affect firm carbon performance.

Considering the above theoretical arguments, this study is designed to empirically answer a few important and timely questions. Are cash-rich firms more proactive in reducing carbon emissions than their cash-poor counterparts? Is the relationship between cash holdings and carbon emissions more pronounced in low leverage and high financially constrained firms? Which channels do cash holdings impact carbon emissions? To the best of our knowledge, there is no empirical study that investigate these questions. Thus, we attempt to answer these questions by employing a panel data consisting of firms for 2007–2017 with 5402 firm-year observations from the U.S. Our empirical analysis suggests that carbon emissions are lower in firms with higher corporate cash holdings. The impact of cash holdings is more pronounced in low leverage and financially unconstrained firms. Our analysis further reveals that cash-rich firms emit less carbon through increasing renewable energy consumption and environmental investment. We implement an extensive set of sensitivity tests to further corroborate our baseline estimates.

Our paper makes three contributions to the literature on cash holdings and carbon emissions. First, our paper is positioned at the union of two lines of research in the literature. The first line focuses on corporate cash holdings, and the second line concentrates on the firm carbon performance. By integrating these two lines of research, we provide a novel angle to examine whether corporate cash holdings affect the variation in firm carbon performance. Specifically, most of the earlier studies identify the factors affecting cash holdings, such as growth opportunities and capital expenditure (Kim, Mauer, & Sherman, 1998; Opler, Pinkowitz, Stulz, & Williamson, 1999), product market competition (Haushalter, Klasa, & Maxwell, 2007), corporate diversification (Duchin, 2010; Tong, 2011), R&D smoothing (Brown & Petersen, 2011), customer relations (Itzkowitz, 2013), CEO inside debt (Liu et al., 2014), refinancing risk (Harford, Klasa, & Maxwell, 2014). However, one crucial question is scarcely addressed in the existing literature: what is the environmental implication of having large cash holdings? To the best of our knowledge, this study is the first in this strand of literature and adds that cash holdings help firms reduce carbon emissions.

Second, we examine subsamples of low versus high leverage firms since a firm's leverage level significantly impacts its carbon emissions. We argue that firms with low leverage emit less carbon since they have greater flexibility to utilize their cash for environmental-friendly activities as they have relatively less obligations to their debtholders. Our empirical findings uphold such arguments. We find that the effect of cash holdings on carbon reduction is indeed stronger for firms with low leverage. Moreover, we are also aware that financially constrained firms have limited scope to invest in environmentally sustainable activities since they prioritize their scarce cash in their regular operations. Our empirical findings validate this novel argument.

Third, we examine the channel through which a firm's cash holdings influence its carbon emissions. We provide empirical evidence that cash holdings reduce carbon emissions by promoting renewable energy consumption and carbon abatement investment. Hence, our paper also contributes to the emerging literature, which suggests that cash-rich firms invest more in renewable energy and green innovation (e.g., Alvarez & Lippi, 2009; Lyandres & Palazzo, 2016; Zhang, Tong, & Li, 2020) to reduce carbon emissions. Our pathway analysis offers important insights for firms as well as policymakers aiming to reduce carbon emissions.

In using a causal interpretation of the relations between cash holdings and carbon emissions, potential endogeneity may be an issue. For example, unobservable factors may also affect firms' cash holdings leading to a spurious outcome. By controlling for firm and industry fixed effects in our baseline regressions, we address one source of endogeneity that may lead to potential firm and industry heterogeneity bias. Another vital source of endogeneity could be the reverse causality. A firm's cash holdings may be affected by its ability to reduce carbon emissions, implying causality from carbon emissions to cash holdings. We address these endogeneity concerns through two different strategies. First, following Fresard (2010), we employ the instrumental variable (IV) approach by using asset tangibility as an IV for cash holdings. After controlling exogenous components from cash holdings, we report that our baseline results remain valid. Second, we use propensity score matching (PSM) and identify subsamples of industries and firms with reasonably similar characteristics. Post-matching, we still find that cash holdings have a significant negative association with carbon emissions.

The remainder of this paper is organized as follows. The next section of the paper provides a brief review of the literature and develops the testable hypotheses. This is followed by a description of the data, variable construction, and descriptive statistics in Section 3. Section 4 presents empirical findings on the relationship between cash holdings and carbon emissions. Section 5 highlights the channel analysis, while Section 6 reports the robustness of the results. Finally, section 7 concludes the paper.

2. Literature review and hypothesis development

We begin this section by reviewing the extant literature on cash holdings. We then develop our hypotheses by discussing why cash holdings are crucial for improving firm carbon performance and through which channels higher cash holdings affect carbon emissions.

2.1. Extant literature on cash holdings

Do excess cash holdings increase or decrease firm value? The trade-off and the agency theories provide fundamental motives to determine corporate cash policies (Chen, Ye, Jebran, & Majeed, 2020). These theories highlight corporate cash holdings have both positive and negative effects on firms' value creation. The trade-off theory, originated from Keynes (1936), argues that firms hold cash to meet the expenses for daily business activities (transaction motive), to manage unexpected circumstances (precautionary motive), and to make investments in future business opportunities (speculative motives). Many empirical studies support the fundamental argument of the trade-off theory that holding large cash enhances firms' values both financially and non-financially. For example, Opler et al. (1999) and Almeida, Campello, and Weisbach (2004) show that the cash reserves tend to be positively associated with future investment prospects. Similarly, Faulkender and Wang (2006) and Denis and Sibilkov (2010) suggest that the marginal value of cash seems to be greater in financially constrained firms. Harford et al. (2014) examine whether cash holdings allow firms to minimize the adverse impact of refinancing risk. Their findings suggest that larger cash holdings are valuable for firms with shorter maturity debt. Cash can also be used to fund product-market choices (e.g., aggressive pricing, targeted advertising, securing plant locations, building distribution networks) that increase the cash-rich firms' market share (Campello, 2006 and Fresard, 2010).

Among direct non-financial benefits, Brown and Matsa (2016) report that firms should adopt conservative financial policies to reduce the probability of distress as well as the labour-related costs of retaining and recruiting high-quality employees. In distressed situations, conservative cash holdings lower unemployment risk, particularly in firms with a high layoff propensity (Devos & Rahman, 2018). In this connection, Ghaly et al. (2015) show a positive relation between employee-friendly practices and cash holdings.

Conversely, the agency theory argues that managers prefer to keep cash in hand as ample cash offers managers with greater discretion without being scrutinized by external investors when they require capital. The excess cash holdings would then help the self-interested managers to generate personal gains, including empire building (Harford, 1999). Consequently, cash holdings would have a negative impact on a firm's financial performance (Dittmar & Mahrt-Smith, 2007; Gao, Harford, & Li, 2013). Dittmar and Mahrt-Smith (2007) show that firms with poor governance experience the lower value of cash. Similarly, Harford, Mansi, and Maxwell (2008) report that poorly governed firms keep less cash than others as managers of these firms are likely to spend their cash reserves rapidly on capital expenditures and acquisitions. Finally, Gao et al. (2013) show that public firms reserve higher cash than their private counterparts because they have lower precautionary motives compared to private firms.

2.2. Why do cash holdings affect carbon emissions?

Following an interdisciplinary approach suggested in Benjamin et al. (2020), we develop theoretical arguments based on stakeholder theory, legitimacy theory and signaling theory that highlight the importance of the firm investment in carbon abatement projects. For example, stakeholder theory emphasizes that firms manage their stakeholders' expectations by adopting a particular locus on environmental trajectory and adjusting its activities and policies to deliver such promises (Chan, Watson, & Woodliff, 2014; Liu & Anbumozhi, 2009). Connectedly, a firm's financial policy should not only focus on its shareholders, but also emphasize non-financial stakeholders such as customers, employees, and society (Titman, 1984). Cornell and Shapiro (1987) argue that a firm should adopt a conservative financial policy to reassure its stakeholders that it can invest for the welfare of employees and society. Thus, cash-rich firms with a greater latitude of strategic choices can adapt such environmental strategies at ease.

The legitimacy theory extends stakeholder theory to argue that firms should go beyond merely complying with laws and regulations and meet the expectations of the community as well as stakeholders (Luo & Tang, 2014). To appear legitimate to their stakeholders, firms should undertake environment-friendly policies that demonstrate their commitment towards such community and stakeholders' expectations (Braam, de Weerd, Hauck, & Huijbregts, 2016). In a world where decarbonatization is now central to world leaders' forums such as the Glasgow 2021 UN Climate Change Conference (COP26), firms' management of carbon emissions could be regarded as instrumental in shaping their perceived legitimacy. Therefore, cash-rich firms would try to use their cash into carbon abatement projects. Moreover, in line with the signaling theory, firms prefer to disclose carbon emissions information and other environmental performance parameters to minimize the asymmetric information between them and their external stakeholders and differentiate themselves from other firms (Belkaoui & Karpik, 1989; Benjamin et al., 2020). Cash-rich firms can effectively do this signaling through deploying their resources in carbon abatement projects.

Considering the fundamental arguments of the above theories, we argue that firms need to hold more cash to invest in environment-related projects, which are expected to improve firm carbon performance. Examples of these costs include the green product or service development cost, operational costs (e.g., recycling cost, employee training cost), research and development costs, and capital expenditure (e.g., green, and energy-efficient technology). Therefore, the practice of adopting environmental-friendly policies is required to incur operational and capital expenditure in both the short- and long-term.

Initiating and maintaining such environmental costs is challenging for most firms. As briefly discussed at the outset, there are at least two reasons why a firm should accumulate cash reserves to overcome such challenges. First, cash acts as a buffer against external shocks. Firms with a high level of cash holdings can absorb the adverse shocks from outside and smoothly veer the daily operations. Therefore, managers have fewer concerns about maintaining daily operations and are more likely to focus on long-term investment (e.g., environmental investment), enhancing firm value and reputation. Second, cash reduces the likelihood of seeking external financing (Easterbrook, 1984), thereby helping management avoid frequent scrutiny from outside public investors who are generally myopic and short-term profit oriented. In the absence of pressure from public investors, managers can demonstrate their commitment to reducing the firm's carbon footprint and protecting the environment. Furthermore, green manufacturing and environmental investment can be strategic decisions for firms. If managers do not have to raise funds from public markets, they are not required to release proprietary information of their strategic choices to the public. There could be a substantial cost in revealing their strategic decision to the market as it risks exposing valuable information to their competitors (Bhattacharya & Ritter, 1983). Based on the above reasons, cash holdings increase the incentives for managers to invest more in the environment, which is formalized in our first hypothesis:

H_1. *: Higher cash holdings lead to lower carbon emissions,* ceteris paribus.

2.3. How do cash holdings affect carbon emissions?

If cash holdings significantly reduce carbon emissions, the follow-up question is through which channels higher cash holdings affect carbon emissions. We argue that cash holdings decrease carbon emissions substantially through two channels. First, cash affluent firms generally

Table 1
Sample distribution.

Panel A: Year-wise sample distribution			Panel B: GICS industry sector-wise sample distribution		
Year	Observations	% of observations	GICS Sector	No of firms	% of Sample firms
2007	291	5.39%	Energy	83	8.80%
2008	372	6.89%	Materials	80	8.48%
2009	418	7.74%	Industrials	57	6.04%
2010	447	8.27%	Consumer Discretionary	261	27.68%
2011	456	8.44%	Consumer Staples	36	3.82%
2012	465	8.61%	Health Care	34	3.61%
2013	452	8.37%	Financials	172	18.24%
2014	468	8.66%	Information Technology	67	7.10%
2015	591	10.94%	Communication Services	29	3.08%
2016	715	13.24%	Utilities	61	6.47%
2017	727	13.46%	Real Estate	63	6.68%
Total	5402	100.00%	Total	943	100.00%

This table presents sample distribution of our study. Panel A reports year-wise sample distribution and Panel B shows industry-sector wise sample distribution. Our full sample covers 2007–2017, 2106 firms and 5402 firm-year observations.

Fazzari, & Petersen, 2009; Brown & Petersen, 2011). As a result, in an imperfect market, higher liquid assets, including cash, assist firms in raising external capital with lower costs and mitigate the future cash flow risk, which encourages them to spend more on innovation. Thus, we postulate our second hypothesis:

H_2. *: Cash-rich firms lead to lower carbon emissions through increasing renewable energy consumption and carbon abatement investment,* ceteris paribus.

3. Sample, data, and descriptive statistics

3.1. Sample and data

We obtain U.S. firm-level data from four sources. All financial variables related to cash holdings and carbon emissions are from the Thomson-Reuters Eikon database, which also includes the ASSET4 database. We use total, direct, and indirect - all three available measures of carbon emissions data from the ASSET4 database. Our search for all firms in the New York Stock Exchange from the Thomson-Reuters Eikon database for 2007–2017 provided us with 32,022 firm-year observations. Since carbon emissions disclosure is still voluntary, a significant proportion of the firms do not report their carbon emissions data.[1] We exclude those firm-year observations which do not have their carbon emissions data. This procedure leaves the dataset with 6833 firm-year

Table 2
Summary statistics results.

Variables	Mean	Std. Dev.	Min	Max
Panel A: Carbon emissions related variables				
Total carbon emissions (in tons)	4,077,875	17,300,000	2	336,000,000
Direct carbon emissions (in tons)	6,535,239	19,900,000	0	336,000,000
Indirect carbon emissions (in tons)	1,166,369	2,795,422	0	39,600,000
Renewable energy consumption (thousand MWHs)	11,800,000	53,200,000	8.14	1,780,000,000
Environmental investment (in USD)	1,010,000,000	49,800,000,000	0	5,210,000,000,000
Panel B: Corporate cash holdings variables				
Cash holdings	0.108	0.146	0	1
Cash holdings1	0.877	94.950	0	1667.5
Panel C: Control variables				
Sales growth (%)	7.712	23.279	−85.2	192.52
Firm size (log of total assets in million USD)	16.165	1.726	10.203	22.049
Capital expenditure (log in million USD)	0.218	1.50	−6.90	9.18
Leverage (%)	0.2935	0.202	0	3.781
R&D Intensity	3.255	5.364	0	16.172
ROA (%)	5.482	8.090	−90.17	45.79
Annual payout ratio	0.0785	7.892	−571.56	352.30
Board independence	75.553	18.433	0	100
CEO duality``	0.250	0.433	0	1
Board size	10.667	2.883	1	29
Institutional ownership (%)	0.393	0.417	0	1

This table presents summary statistics results for all variables used in this paper. Panels A-C report our carbon emissions related variables, cash holdings variables and control variables, respectively. The descriptive statistics are calculated based on 5402 firm-year observations for the period 2007–2017.

finance renewable energy projects in the U.S. to enjoy tax equity firms (Kirkland, 2011). For example, all cash-rich firms, including Google, General Electronics, Exxon, and Wal-Mart, are few of the largest clean energy investors. At the same time, these cash-rich firms also enjoy competitive advantage in purchasing clean energy compared to their cash-poor peers, which make them largest consumers of renewable energy. Second, cash-affluent firms have unparallel flexibility to invest in carbon abatement projects, such as green R&D. Since R&D investment is generally linked to the success of new and untested technologies and hence are highly unpredictable (Chan, Lakonishok, & Sougiannis, 2001), firms with high innovation tend to have high information asymmetry, highly uncertain cash flows, and a lack of collateral (Brown,

observations. We then merge institutional ownership data from the Thomson-Reuters Institutional Holdings database (13-F institutions filing with the Securities and Exchange Commission) and the FactSet database. At this stage, we find 5402 firm-year observations from 943 unique firms listed on the New York Stock Exchange having all three measures of carbon emissions data, cash holdings, institutional

[1] While more and more firms disclose their carbon emission information in recent times, the U.S. SEC Chair Gary Gensler hinted in the July 2021 webinar on 'Climate and Global Financial Markets' that firms may be required to file climate disclosures through the Form 10-K. See more here: https://corpgov.law.harvard.edu/2021/09/01/the-secs-upcoming-climate-disclosure-rules/.

Table 3
The impact of corporate cash holdings on carbon emissions.

	TCE	DCE	INDEC	TCE	DCE	INDEC
	(1)	(2)	(3)	(4	(5)	(6
Cash holdings	−0.2971**	−0.4118*	−0.7029**			
	(−2.05)	(−1.66)	(−2.22)			
Cash holdings1				−0.1722**	−0.3947**	−0.4982**
				(−2.46)	(−2.53)	(−2.53)
Firm size	0.4789***	0.2628***	0.4826***	0.4791***	0.2563***	0.4824***
	(16.88)	(5.29)	(7.47)	(16.89)	(5.16)	(7.47)
Sales growth	0.0007***	0.0000	−0.0006	0.0007***	0.0001	−0.0006
	(2.94)	(0.06)	(−0.75)	(2.94)	(0.10)	(−0.76)
Capital expenditure	0.0369**	0.0434	−0.0211	0.0372**	0.0455	−0.0209
	(2.21)	(1.38)	(−0.53)	(2.24)	(1.45)	(−0.53)
Leverage	−0.0810	−0.2352	−0.6532***	−0.0824	−0.2194	−0.6437***
	(−0.85)	(−1.53)	(−3.36)	(−0.86)	(−1.43)	(−3.32)
R & D intensity	−0.0096*	0.0176*	−0.0354***	−0.0097*	0.0183*	−0.0354***
	(−1.69)	(1.85)	(−2.80)	(−1.70)	(1.93)	(−2.80)
Profitability	0.0009	0.0013	0.0015	0.0008	0.0011	0.0016
	(0.65)	(0.60)	(0.51)	(0.62)	(0.52)	(0.54)
Institutional ownership	−0.0356***	−0.0133	−0.0047	−0.0357***	−0.0124	−0.0047
	(−5.30)	(−1.24)	(−0.34)	(−5.32)	(−1.15)	(−0.34)
Board independence	−0.0005	−0.0043**	−0.0033*	−0.0005	−0.0042**	−0.0033
	(−0.43)	(−2.28)	(−1.68)	(−0.43)	(−2.23)	(−1.36)
Board size	−0.0440	0.1144	0.0599	−0.0437	0.0940	0.0576
	(−0.63)	(1.11)	(0.45)	(−0.63)	(0.91)	(0.43)
CEO duality	−0.0315	−0.0252	−0.1005*	−0.0320	−0.0296	−0.0984*
	(−1.12)	(−0.60)	(−1.84)	(−1.14)	(−0.70)	(−1.81)
Constant	5.2706***	8.5221***	5.3045***	5.2624***	8.6699***	5.2997***
	(11.87)	(10.70)	(5.13)	(11.86)	(10.86)	(5.13)
R-squared	0.090	0.042	0.058	0.090	0.045	0.059
F-statistics	40.13***	6.77***	8.83***	40.31***	7.12***	8.97***
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5402	2041	1926	5402	2041	1926

This table shows the coefficients from a fixed effects regression estimates of cash holdings on carbon emissions controlling for firm size, sales growth, capital expenditure, leverage, R&D intensity, profitability, institutional ownership, board independence, board size and CEO duality, year, and industry fixed effects. The dependent variables are the natural logarithm of total carbon emissions (TCE), direct carbon emissions (DCE) and indirect carbon emissions (INDCE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

ownership, and other control variables. Finally, we merge board gender diversity data from BoardEx. We use firms' ISIN identifiers to merge the data from these sources. Our final sample covers the period between 2007 and 2017[2] based on data availability. To overcome the outliers' effect, we winsorize all control variables at the 1st and 99th percentiles. All variables are defined in Appendix Table A1.

3.2. Sample description

Table 1 illustrates the distribution of our sample. Panel A of Table 1 reports the sample distribution on a yearly basis during 2007 to 2017. The panel shows an increasing trend in firm-year observations during our sample period, which can be ascribed to the higher disclosure of carbon emissions in recent periods. In Panel B, the number of firms across industry sectors is reported, and it suggests that our sample is representative of all GICS sectors.

Table 2 presents the summary statistics of the selected variables in our model. Panel A reports the means of total carbon emissions, direct carbon emissions and indirect carbon emissions that are 4,077,875 tons, 6,535,239 tons, and 1,166,369 tons, respectively. As expected, these statistics indicate that direct carbon emissions are higher than indirect carbon emissions in U.S. firms.[3] Panel B shows descriptive statistics of corporate cash holdings where the average cash holdings stand at 0.108 million and the mean of cash holdings net of assets is 0.877 million.

In Panel C, descriptive statistics of control variables show that firms experience an annual steady sales growth of 7.7% while their average firm size is 16.17. The means for capital expenditure and leverage are 0.22 and 29%, respectively. Among others, the R&D intensity is 3.255. The average total institutional investor ownership is 39.3%. Among corporate governance variables, the mean for board independence, CEO duality and board size are 75.55, 0.250 and 10.667, respectively. These statistics are qualitatively similar to prior research.

3.3. Estimation models

We use the following baseline model to investigate the impact of cash holdings on carbon emissions.

$$CE_{it} = \alpha + \beta_1 (Cash\ holdings)_{it-1} + \beta_2 \sum (FLC)_{it-1} + \beta_4 \sum (Industry\ effects)_i + \beta_5 \sum (Year\ effects)_t + \varepsilon_{it} \quad (1)$$

where CE_{it} refers to the total, direct and indirect carbon emissions. We use cash holdings as our main variable of intertest. Following Fresard (2010) and Cheung (2016), we use two proxies for cash holdings. Our primary measure of cash holdings is calculated as cash and short-term investment scaled by total assets. Our alternative measure of cash holdings is the cash holdings to net assets, which is measured by cash and short-term investment scaled by the difference between total assets and cash and short-term investment. FLC_{it-1} stands for firm-level control variables, which includes both firm characteristics and board-level

[2] Although the Thomson-Reuters Eikon (ASSET4) database started reporting carbon emissions data since 2004, only a few observations were found in the initial years from 2004 to 2006. Thus, we start our sample period from 2007.

[3] The mean for total carbon emissions may not be equal to the summation of direct and indirect carbon emissions because all firms do not disclose three components of carbon emissions in all years.

Table 4
The impact of corporate cash holdings on carbon emissions: subsample analysis of the impact of financial leverage.

	Panel A: High leverage			Panel B: Low leverage		
	TCE	DCE	INDEC	TCE	DCE	INDEC
	(1)	(2)	(3)	(1)	(2)	(3)
Cash holdings	−0.7932***	−2.3051***	−1.3877**	0.0712	−3.4161***	−1.7585***
	(−2.58)	(−2.75)	(−2.29)	(0.33)	(−5.95)	(−3.46)
Firm size	0.7177***	0.6528***	0.8044***	0.7542***	0.6064***	0.5855***
	(27.77)	(11.02)	(18.75)	(35.45)	(12.64)	(13.72)
Sales growth	−0.0011*	−0.0084**	−0.0020	−0.0039***	−0.0052**	−0.0065***
	(−1.84)	(−2.41)	(−0.78)	(−3.76)	(−2.26)	(−3.18)
Capital expenditure	0.4079***	0.5479***	0.1467***	0.3133***	0.3683***	0.1851***
	(18.15)	(8.81)	(3.24)	(13.53)	(6.63)	(3.70)
Leverage	0.3710**	−0.1721	0.2221	2.1256***	1.2647**	0.5376
	(2.36)	(−0.40)	(0.70)	(7.61)	(2.11)	(1.02)
R & D intensity	0.0218***	−0.0435***	0.0168	−0.0048	0.0319**	0.0244**
	(3.07)	(−2.95)	(1.55)	(−0.78)	(2.58)	(2.18)
Profitability	0.0024	−0.0139	0.0051	0.0195***	0.0268***	0.0182**
	(0.66)	(−1.57)	(0.78)	(5.41)	(3.26)	(2.44)
Institutional ownership	−0.0294	−0.0273	−0.0104	−0.0232	0.0120	−0.0752**
	(−1.59)	(−0.67)	(−0.35)	(−1.35)	(0.33)	(−2.33)
Board independence	0.0111***	0.0064	0.0024	0.0019	0.0046	−0.0009
	(5.53)	(1.45)	(0.77)	(1.02)	(1.16)	(−0.25)
Board size	0.3842***	0.2201	−0.8372***	−0.0966	0.8700***	0.5706**
	(2.77)	(0.69)	(−3.57)	(−0.83)	(3.26)	(2.40)
CEO duality	0.0600	0.0882	0.0809	0.2222***	0.3654***	0.0344
	(1.13)	(0.76)	(0.94)	(4.50)	(3.51)	(0.37)
Constant	−1.8610***	0.2259	0.9005	−4.0765***	−1.3193	1.8662**
	(−3.55)	(0.15)	(0.84)	(−4.75)	(−1.33)	(2.16)
R-squared	0.688	0.646	0.500	0.746	0.789	0.563
F-statistics	171.25	57.98	28.98	212.91	101.53	34.13
	0.000	0.000	0.000	0.000	0.000	0.000
Observations	2749	1081	992	2653	960	934

This table reports subsample analysis of the impact of leverage on the relationship between cash holdings and carbon emissions. The dependent variables are the natural logarithm of total carbon emissions (TCE), direct carbon emissions (DCE) and indirect carbon emissions (INDCE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

corporate governance variables. We control the firm size, sales growth, capital expenditure, leverage, R&D intensity and profitability. Firm size is measured as the natural log of total assets, while sales growth is calculated as the net sales in year *t* minus net sales in year *t-1* divided by net sales in year *t-1*. Capital expenditure is measured as the total capital expenditures for the year, Leverage is calculated as the total of long term and short-term debt divided by total assets. We measure R&D intensity as the ratio of R&D expenses to net sales. Following the literature, we set R&D intensity to zero if R&D expense is missing. Finally, profitability is proxied by return on assets (ROA).

Existing literature (e.g., Chen, Harford, & Lin, 2017; Harford et al., 2008) suggests that corporate governance plays a vital role in shaping corporate policies, including environmental issues. Thus, we include four variables from corporate governance: institutional ownership, board independence, board size and CEO duality. We measure institutional ownership as the total institutional ownership ratio, while board independence is measured by the ratio of independent directors on the board. We capture board size as the total number of board members, and the CEO duality is an indicator variable captured as the separation between the CEO and chairman of the board. The definitions for all variables are provided in Appendix Table A1.

4. Empirical results

4.1. Cash holdings and carbon emissions: Baseline results

In Table 3, we present the baseline results between cash holdings and carbon emissions. The independent variable of interest in columns 1—3 is cash holdings. The result shows that firms with higher cash holdings emit significant less total, direct, and indirect carbon. The results are also economically meaningful as a one standard deviation increase in corporate cash holdings (0.146) is associated with a 4.33(= 0.146× 0.2971) percentage point reduction in total carbon emissions and a 6.01 (= 0.146× 0.4118) percentage point decrease in direct carbon emissions, and a 10.26 (= 0.146 × 0.7029) percentage point reduction in indirect carbon emissions. In columns 4—6, we use an alternative measure of cash holdings. Our results are robust, indicating that cash-rich firms emit less carbon. The extent of the impact in columns (4) — (6) is slightly reduced, however, the impact remains economically significant. For example, in column (4), an increase of one standard deviation in the cash holdings is linked with a decrease of 2.51 percentage point in total carbon emissions. Taken together, our baseline regression unmasks the importance of holding higher cash on reducing carbon emissions. Our findings support the fundamental arguments of stakeholder theory that a firm's conservative financial policy (such as holding higher cash) is better for the social well-being of stakeholders. Our results are consistent with similar studies in existing literature, which report that cash holdings are crucial for innovation and employment (Campello, Giambona, Graham, & Harvey, 2011; Duchin, 2010). Overall, the empirical evidence supports our first hypothesis (H_1).

We next present the impact of control variables. First, our results depict that larger firms, firms with higher sales growth and capital expenditure emit higher carbon. Second, we find that institutional ownership and board independence are significantly negatively associated with carbon emissions. Third, our results indicate that leverage and R&D intensity reduce carbon emissions, but the results are not robust across different model specifications. Finally, we find that the effect of profitability and board size on carbon emissions is statistically insignificant.

4.2. Cash holdings and carbon performance: The role of financial leverage

In this section, we examine whether the effect of cash holdings on

Table 5
The impact of corporate cash holdings on carbon emissions: subsample analysis of the impact of financial constraints.

	Panel A: Financially constrained firms			Panel B: Financially unconstrained firms		
	TCE	DCE	INDEC	TCE	DCE	INDEC
	(1)	(2)	(3)	(1)	(2)	(3)
Cash holdings	−0.3342	−1.7972	2.3373	−0.2031	−2.5955***	−1.3824***
	(−0.73)	(−0.36)	(0.71)	(−0.61)	(−4.14)	(−3.09)
Firm size	0.3890***	0.2512	−1.5266*	0.6041***	0.5237***	0.5930***
	(2.74)	(0.24)	(−2.17)	(20.10)	(9.98)	(15.73)
Sales growth	−0.0029	0.0218*	0.0064	−0.0021***	−0.0086***	−0.0046***
	(−1.61)	(2.07)	(0.91)	(−3.61)	(−3.71)	(−2.73)
Capital expenditure	0.2345***	−0.2427	0.0034	0.4437***	0.4024***	0.1235***
	(4.18)	(−0.63)	(0.01)	(19.07)	(8.19)	(3.49)
Leverage	0.7546***	0.3490	−0.7286	1.0154***	0.3707	1.1626***
	(3.91)	(0.14)	(−0.43)	(6.31)	(1.19)	(5.19)
R & D intensity	−0.0001	0.0595	0.0665	0.0109	−0.0348***	0.0127
	(−0.00)	(0.55)	(0.92)	(1.54)	(−3.03)	(1.52)
Profitability	0.0049	−0.0295	0.0099	0.0253***	0.0135*	0.0305***
	(0.93)	(−1.56)	(0.78)	(5.44)	(1.69)	(5.17)
Institutional ownership	−0.1551***	0.3342	−0.0506	−0.0244	−0.0195	−0.0527**
	(−3.36)	(1.67)	(−0.38)	(−1.22)	(−0.58)	(−2.14)
Board independence	−0.0148**	−0.0110	−0.1418***	0.0140***	0.0073**	0.0067***
	(−2.41)	(−0.29)	(−5.53)	(7.09)	(2.14)	(2.77)
Board size	0.3308	−0.4919	−0.0268	−0.1716	0.4912*	−0.4563**
	(0.93)	(−0.24)	(−0.02)	(−1.31)	(1.96)	(−2.51)
CEO duality	0.1815	−3.8168**	1.5798	0.1658***	0.3068***	0.1147
	(1.29)	(−3.13)	(1.94)	(2.99)	(3.21)	(1.63)
Constant	5.3224***	9.9918	42.0750***	−1.7486*	1.8768*	3.3002***
	(2.72)	(0.67)	(4.25)	(−1.78)	(1.74)	(4.27)
R-squared	0.636	0.943	0.989	0.743	0.693	0.503
F-statistics	13.92	5.21	27.49	202.20	96.36	39.87

This table reports subsample analysis of the impact of financial constraints (annual payout ratio based) on the relationship between cash holdings and carbon emissions. The dependent variables are the natural logarithm of total carbon emissions (TCE), direct carbon emissions (DCE) and indirect carbon emissions (INDCE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

Table 6
The impact of corporate cash holdings on carbon emissions: subsample analysis of the impact of financial constraints.

	Financially constrained firms			Financially unconstrained firms		
	TCE	DCE	INDEC	TCE	DCE	INDEC
	(1)	(2)	(3)	(1)	(2)	(3)
Cash holdings	−1.2353	3.8443*	1.1969	−0.2489	−3.8388***	−1.9704***
	(−1.05)	(1.91)	(0.66)	(−1.30)	(−7.30)	(−4.56)
Firm size	0.6945***	0.0859	0.9719***	0.7121***	0.7527***	0.6847***
	(5.62)	(0.38)	(4.85)	(39.65)	(18.11)	(20.06)
Sales growth	0.0075	0.0143	0.0038	−0.0049***	−0.0073***	−0.0050***
	(1.45)	(1.49)	(0.45)	(−5.51)	(−3.48)	(−2.85)
Capital expenditure	0.7325***	0.6543***	0.7807***	0.4276***	0.4783***	0.1973***
	(5.40)	(2.80)	(3.75)	(24.50)	(10.55)	(5.24)
Leverage	−0.7246	−1.5490	1.2394	1.0994***	0.5155*	0.9694***
	(−0.89)	(−1.41)	(1.27)	(10.95)	(1.90)	(4.37)
R & D intensity	0.2204***	0.3089***	0.0116	0.0022	−0.0265**	0.0211**
	(7.94)	(6.65)	(0.28)	(0.42)	(−2.48)	(2.36)
Profitability	0.0239	−0.0760**	0.0436	0.0150***	0.0131*	0.0130**
	(1.60)	(−2.42)	(1.56)	(5.27)	(1.96)	(2.29)
Institutional ownership	0.1994**	0.0693	−0.0410	−0.0383***	−0.0428	−0.0279
	(2.35)	(0.59)	(−0.39)	(−2.78)	(−1.43)	(−1.13)
Board independence	−0.0133	−0.0559***	0.0354**	0.0071***	0.0059*	−0.0001
	(−1.25)	(−3.21)	(2.27)	(4.67)	(1.74)	(−0.03)
Board size	−0.7510	−3.0003***	−2.7596***	−0.0356	0.2151	−0.3517*
	(−1.32)	(−3.56)	(−3.66)	(−0.37)	(0.96)	(−1.89)
CEO duality	−0.0033	0.7625**	−0.4963	0.2091***	0.3520***	0.0482
	(−0.01)	(2.21)	(−1.61)	(5.20)	(4.05)	(0.66)
Constant	6.3244**	22.3380***	1.1326	−3.5615***	−1.4448	2.0390***
	(2.27)	(4.68)	(0.27)	(−3.92)	(−1.62)	(2.83)
R-squared	0.903	0.956	0.848	0.710	0.723	0.475
F-statistics	32.04***	45.77***	11.70***	312.11***	124.43***	40.48***

This table reports subsample analysis of the impact of financial constraints (Firm size based) on the relationship between cash holdings and carbon emissions. The dependent variables are the natural logarithm of total carbon emissions (TCE), direct carbon emissions (DCE) and indirect carbon emissions (INDCE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

Table 7
The impact of cash holdings on carbon emissions: Instrumental variable (IV) approach.

Panel A: First-stage estimation DV: Cash holdings		Panel B: Second-stage estimation			
			Total carbon emissions	Direct carbon emissions	Indirect carbon emissions
Tangibility	−0.0026***	Cash holdings—predicted	−0.5427**	−3.0963***	−2.3514***
	(−12.47)		(−2.52)	(−5.38)	(−5.23)
Cash holdings$_{t-1}$	0.7245***	Firm size	0.7096***	0.7167***	0.7231***
	(110.87)		(39.88)	(17.96)	(23.29)
Cash holdings$_{t-2}$	0.1543***	Sales growth	−0.0023***	−0.0089***	−0.0076***
	(23.70)		(−4.29)	(−4.02)	(−4.32)
		Capital expenditure	0.4004***	0.5424***	0.1602***
			(22.89)	(12.46)	(4.67)
		Leverage	0.8761***	0.2276	0.3087
			(8.56)	(0.84)	(1.47)
		R & D intensity	0.0182***	−0.0003	0.0333***
			(3.68)	(−0.03)	(4.24)
		Profitability	0.0086***	0.0006	0.0069
			(3.23)	(0.10)	(1.38)
		Total institutional blockholder ownership	−0.0031	0.0201	−0.0354
			(−0.22)	(0.67)	(−1.51)
		Board independence	0.0081***	0.0059*	0.0015
			(5.42)	(1.76)	(0.58)
		Board size	0.0572	0.3394	−0.2234
			(0.59)	(1.54)	(−1.29)
		CEO duality	0.1169***	0.1052	−0.0300
			(3.01)	(1.29)	(−0.46)
Constant	0.0304***	Constant	−3.3523***	−0.2997	1.7222**
	(19.54)		(−3.67)	(−0.31)	(2.17)
R-squared	0.776	R-squared	0.711	0.707	0.533
F-statistics	23,253.40***	F-statistics	256.66***	91.63***	40.51***

This table presents two-stage least squares regression results from Eq. 1. The instrumental variable is the assets tangibility. Panel A reports the results from the first-stage ordinary least square (OLS) regressions with the Cash holdings as the dependent variable. Panel B presents the second-stage regression results, where the dependent variable is carbon emissions and key independent variable of interest is the cash holdings-predicted. All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

carbon emissions is affected by firm leverage levels. We argue that this association is likely to be stronger for low leveraged firms. This is because firms with low leverage have less obligations to debtholders, and hence these firms enjoy more flexibility to use cash reserves for carbon-reducing projects. Following prior literature (Li & Zhang, 2019), we use the median value of leverage for our sample to classify firm-year observations into high leverage and low leverage. Panels A and B of Table 4 present our empirical results. Panels A and B show that the effect of cash holdings on carbon emissions is negative and significant for firms with high and low leverage. However, the effect size is larger for firms with low levels of leverage (Panel B) when we use direct carbon emissions and indirect carbon emissions as our proxies for carbon emissions. Overall, our results suggest that leverage levels have significant effects on the association between cash holdings and carbon emissions.

4.3. Cash holdings and carbon performance: The role of financial constraints

In this section, we examine the impact of financial constraints on the relationship between cash holdings and carbon emissions. We argue that this association is weaker for firms that have higher financial constraints. This is because higher financial constraints are likely to induce firms to hold more cash reserves for regular business activities. Hence, financially constrained firms have a limited scope of investing in carbon-mitigating projects. We employ two measures of financial constraints. The first one is the annual payout ratio. Following Denis and Sibilkov (2010), we assign those firms in the bottom (top) three deciles of the annual cash payout ratio distribution to the financially constrained (unconstrained) firms. This is consistent with the argument of Fazzari, Hubbard, and Petersen (1987) that unconstrained firms are more likely to have higher payout ratios, while constrained firms are likely to have lower payout ratios.

We present our results in Table 5. Panels A and B report results for financially constrained and unconstrained firms' sample groups, respectively. Our results in Panel A show that the effect of cash holdings on carbon emissions is not significant for financially constrained firms. Conversely, Panel B depicts that the effect is negative and statistically significant at the 1% level in the case of both direct and indirect measures of carbon emissions. This result indicates that the impact of cash holdings is more pronounced for firms with fewer financial constraints.

We construct our second measure of financial constraints based on firm size. Following Denis and Sibilkov (2010), we assign those firms in the bottom (top) three deciles of the firm size distribution to the financially constrained (unconstrained) firms. This approach is consistent with prior studies in the literature (Acharya, Almeida, & Campello, 2007; Almeida et al., 2004). Table 6 reports our results in Panels A and B. We find consistent results, as reported in Table 5, that the effect of cash holdings is stronger for firms with fewer financial constraints compared to their financially constrained counterparts. Taken together, we find robust evidence that financial constraints affect the relationship between cash holdings and carbon emissions.

4.4. Cash holdings and carbon performance: Addressing endogeneity

Our study depicts that cash holdings have significant impact on carbon emissions. However, a firm's cash policy may be endogenously related to its carbon emissions; thus, it is difficult to establish a causal link going from cash holdings to carbon emissions. To address this identification challenge, we use two different empirical techniques. First, we use an instrumental variable approach. More specifically, we use asset tangibility as an instrument to force the exogenous portion of cash to explain carbon emissions. While a firm's asset tangibility correlates with its cash reserves, there is little reason to believe that the tangible attributes of a firm's assets have a direct influence on its carbon emissions.

To test this assertion, we use the two-stage least square (2SLS)

Table 8
The effect of corporate cash holdings on carbon emissions: Propensity score matching estimates.

Panel A: Pre-match propensity score regression and post-match diagnostic regression

	Pre-match	Post-match
Firm size	0.1807***	−0.0465
	(6.63)	(−0.33)
Sales growth	0.0009	0.0059
	(0.92)	(0.85)
Capital expenditure	0.1668***	−0.0183
	(7.14)	(−0.14)
Leverage	1.3845***	0.1404
	(8.64)	(0.15)
R & D intensity	−0.1218***	−0.0021
	(−17.32)	(−0.08)
Profitability	−0.0266***	−0.0489
	(−5.75)	(−1.13)
Institutional ownership	0.0093	−0.0624
	(0.40)	(−0.67)
Board independence	0.0055**	−0.0051
	(2.39)	(−0.37)
Board size	0.1021	0.5430
	(0.66)	(0.73)
CEO Duality	0.1111*	0.1364
	(1.75)	(0.43)
Constant	−4.9139***	0.1289
	(−10.45)	(0.05)
Pseudo R2	0.1044	0.0123
F-statistics	768.32***	0.8016***
Observations	7011	586

Panel B: Quality of propensity score matching (PSM)

Variable	Treated	Control	Diff	t -statistics
Total carbon emissions	13.762	14.189	−0.427	2.55**
Direct carbon emissions	12.643	13.267	−0.624	2.84***
Indirect carbon emissions	12.624	12.695	−0.071	0.54
Firm size	16.839	16.921	−0.082	0.81
Sales growth	6.5679	4.1258	2.4421	−1.08
Capital expenditure	0.82009	0.78724	0.03285	−0.36
Leverage	0.30463	0.30632	−0.00169	0.13
R&D intensity	2.8048	2.8404	−0.0356	0.09
Profitability	4.6988	4.6335	0.0653	−0.15
Institutional ownership	2.7676	2.6575	0.1101	−0.97
Board independence	83.954	84.035	−0.081	0.10
Board size	2.398	2.4132	−0.0152	0.98
CEO Duality	0.737	0.73089	0.00611	−0.18

Panel C: Cash holdings and carbon emissions – PSM regression

	Panel A: Total carbon emissions	Panel B: Direct carbon emissions	Panel C: Indirect carbon emissions
Cash holdings	−2.7440***	−4.2258***	−1.7634**
	(−3.73)	(−4.39)	(−2.40)
Firm size	0.6183***	0.6657***	0.5654***
	(9.15)	(7.53)	(8.39)
Sales growth	−0.0074**	−0.0122***	0.0044
	(−2.14)	(−2.69)	(1.27)
Capital expenditure	0.3921***	0.5788***	0.1244**
	(6.55)	(7.38)	(2.08)
Leverage	1.6015***	0.4739	2.3191***
	(4.10)	(0.93)	(5.95)
R & D intensity	0.0120	−0.0204	0.0457***
	(0.73)	(−0.95)	(2.80)
Profitability	0.0080	0.0078	0.0048
	(0.66)	(0.49)	(0.40)
Institutional ownership	0.0080	0.0190	−0.0375
	(0.18)	(0.32)	(−0.83)
Board independence	−0.0051	0.0033	−0.0011
	(−0.77)	(0.38)	(−0.16)

Table 8 (*continued*)

Panel C: Cash holdings and carbon emissions – PSM regression

	Panel A: Total carbon emissions	Panel B: Direct carbon emissions	Panel C: Indirect carbon emissions
Board size	−0.3621	−0.1087	−0.0462
	(−1.14)	(−0.26)	(−0.15)
CEO duality	0.0095	0.1223	0.0291
	(0.07)	(0.71)	(0.22)
Constant	3.7308**	0.9729	2.4953*
	(2.58)	(0.51)	(1.73)
R-squared	0.705	0.704	0.518
F-statistics	28.67***	28.55***	12.89***
Observations	586	586	586

This table presents PSM estimates results. Panel A reports the results from pre-match propensity score regression and post-match diagnostic regression. The dependent variable is an indicator variable set to one if a firm's cash holdings in a given year is in bottom quartile, and zero if otherwise. Panel B presents the results on the quality of matching. Panel C presents PSM regression results. All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

regression approach. Table 7 presents our results. In the first stage, we check the relevance of our instrument. Following Fresard (2010), we obtain the exogenous portion of cash holdings by regressing them on asset tangibility and their lagged values, where tangibility is a function of receivables, inventory, and fixed capital defined as in Berger, Ofek, and Swary (1996). Our result in column (1) suggests that our instrument is negatively associated with the cash holdings, consistent with the literature (Capkun, Hameri, & Weiss, 2009; Fresard, 2010). Moreover, since the *F*-test of the first-stage regressions is reasonably large, we can reject the null hypothesis that the instrument is weak (Larcker & Rusticus, 2010). We present the second-stage regression results in columns (2) and (3). We find that the instrumental variable, the predicted value of cash holdings, provides strong evidence that a firm's cash holdings are associated with lower carbon emissions, indicating that firms with higher cash holdings invest more in carbon abatement projects and hence emit less carbon compared to their rivals.

Second, firms' choice to disclose carbon emissions is not random but can be a function of a firm's observable characteristics. Matching can significantly alleviate asymptotic biases arising from endogeneity or self-selection (Roberts & Whited, 2013). To address such biases, we use propensity score matching (PSM) estimates, in which we compare two matched samples of firms with and without high cash holdings. Specifically, we identify a control sample of firm-year observations with relatively high cash holdings that exhibit no significant differences in observable characteristics compared to treatment firms, which refer to firms with low cash holdings measured by cash holdings in the lower quartile. We use the nearest neighbor matching approach with replacement to ensure that both groups of firms are comparable, and no significant differences are detected between them. We report the results in Table 8. In Panels A and B, we report pre-match PSM regression and post-match diagnostic regression, and univariate mean comparisons between treatment and control firms' characteristics, respectively. The results suggest no statistically significant differences exist in firms' characteristics, but carbon emissions measures appear to be significant at the 5% level between both groups. Overall, the univariate comparisons suggest that the matching process has successfully removed observable differences between these two groups except that of carbon emissions measures. This result confirms that the difference in carbon emissions is stemmed from the level of corporate cash holdings. Panel C of Table 8 provides OLS regression results using the matched sample. We find, across all models, a negative and economically meaningful impact of cash holdings on carbon emissions. Thus, our findings from PSM analysis suggest that our baseline results presented in Table 3 are not driven by endogeneity issues.

Table 9
The impact of corporate cash holdings on carbon emissions: Renewable energy consumption channel.

	Panel A: Dependent variable: Total renewable energy consumption		Panel B: Dependent variable: Total carbon emissions	
Cash holdings	3.3722**		−0.7561**	
	(2.16)		(−2.15)	
Cash holdings1		1.6440*		−0.3717**
		(1.66)		(−1.99)
Total renewable energy consumption			−0.0374*	−0.0370*
			(−1.78)	(−1.76)
Firm size	0.4943	0.4817	−0.2306	−0.2278
	(1.37)	(1.33)	(−1.39)	(−1.36)
Sales growth	0.0049	0.0046	0.0031	0.0032
	(1.05)	(0.98)	(1.34)	(1.37)
Capital expenditure	0.2009	0.1830	−0.0554	−0.0534
	(1.06)	(0.97)	(−0.67)	(−0.64)
Leverage	−0.6140	−0.6289	0.4877	0.5208
	(−0.77)	(−0.79)	(1.03)	(1.09)
R & D intensity	−0.0311	−0.0350	0.1816	0.1806
	(−0.21)	(−0.23)	(0.98)	(0.98)
Profitability	0.0064	0.0077	0.0035	0.0033
	(0.43)	(0.52)	(0.43)	(0.41)
Institutional ownership	−0.0130	−0.0128	−0.0354	−0.0354
	(−0.22)	(−0.22)	(−1.32)	(−1.32)
Board independence	0.0140	0.0144	0.0061	0.0061
	(1.47)	(1.51)	(1.16)	(1.17)
Board size	−0.4113	−0.4248	0.3285	0.3299
	(−0.68)	(−0.70)	(1.28)	(1.28)
CEO duality	−0.3647*	−0.3801**	−0.0668	−0.0606
	(−1.94)	(−2.02)	(−0.42)	(−0.38)
Constant	4.7423*	5.0992*	16.9718***	16.8800***
	(1.80)	(1.86)	(6.42)	(6.38)
R-squared	0.040	0.036	0.047	0.046
F-statistics	1.83***	1.65***	1.25*	1.22*
Year and Industry fixed effects	Yes	Yes	Yes	Yes
Observations	5402	2041	5402	2041

This table shows the mechanism through which cash holdings affect carbon emissions. Panel A reports the coefficients from a fixed effects regression estimates of cash holdings on total renewable energy consumption. Panel B reports the coefficients from a fixed effects regression estimates of cash holdings on carbon emissions controlling for renewable energy consumption, firm size, sales growth, capital expenditure, leverage, R&D intensity, profitability (ROA), institutional ownership, board independence, board size and CEO duality, year, and industry fixed effects. All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

5. Cash holdings and carbon performance: Channel analysis

Our results thus far suggest that an increase in cash holdings leads to a decrease in carbon emissions. Now a follow-up question asks through which channels cash holdings impact carbon emissions. We conjecture that cash holdings affect carbon emissions through two channels: (i) increasing renewable energy consumption and (ii) increasing carbon abatement investment. To empirically examine our channels, we follow two steps. In the first step, we examine the relationship between cash holdings and renewable energy consumption as well as cash holdings and carbon abatement investment. In the second step, we investigate the impact of cash holdings on carbon emissions controlling for total renewable energy consumption and carbon abatement investment in their respective regressions.

Table 9 presents our channel analysis based on renewable energy consumption. In Panel A, we find that the relationship between cash holdings and the renewable energy consumption is positive and significant at the 5% level, indicating that cash holdings promote firm renewable energy consumption. This association is similar when we use the alternative measure of cash holdings. Panel B of Table 9 presents the regression results of cash holdings on carbon emissions after controlling renewable energy consumption. According to our expectation, the result shows that cash holdings reduce carbon emissions significantly. This result suggests that the carbon emissions are lower for firms with higher corporate cash holdings, even after controlling for total renewable energy consumption.

Table 10
The impact of corporate cash holdings and earnings predictability on carbon emissions: Carbon abatement investment channel analysis.

	Panel A: Dependent variable: Carbon abatement investment		Panel B: Dependent variable: Total carbon emissions	
Cash holdings	0.0687**		−0.8179***	
	(2.14)		(−2.87)	
Cash holdings1		0.0432**		−0.5199***
		(2.15)		(−2.83)
Carbon abatement investment			−0.0052	−0.0057**
			(−0.38)	(−2.42)
Firm size	0.3112***	0.3115***	0.1493**	0.1558**
	(2.73)	(2.75)	(2.11)	(2.21)
Sales growth	0.0020	0.0020	0.0011	0.0011
	(1.40)	(1.39)	(1.39)	(1.44)
Capital expenditure	0.1167*	0.1165*	0.0017	0.0025
	(1.70)	(1.70)	(0.05)	(0.07)
Leverage	−0.1641	−0.1638	0.0083	0.0340
	(−0.38)	(−0.38)	(0.04)	(0.15)
R & D intensity	0.0023	0.0023	−0.0270**	−0.0266**
	(0.11)	(0.11)	(−2.57)	(−2.52)
Profitability	0.0014	0.0014	0.0060**	0.0058**
	(0.27)	(0.27)	(2.33)	(2.26)
Institutional ownership	0.0024	0.0026	−0.0221*	−0.0221*
	(0.10)	(0.11)	(−1.67)	(−1.67)
Board independence	0.0064	0.0064	0.0022	0.0023
	(1.44)	(1.44)	(0.98)	(0.99)
Board size	0.1514	0.1528	0.1683	0.1664
	(0.68)	(0.68)	(1.46)	(1.45)
CEO duality	0.0144	0.0143	−0.0581	−0.0563
	(0.14)	(0.14)	(−0.95)	(−0.92)
Constant	11.1071***	11.1015***	11.9071***	11.7841***
	(6.38)	(6.39)	(10.42)	(10.35)
R-squared	0.037	0.037	0.063	0.062
F-statistics	3.08***	3.08***	3.63***	3.61***
Year and Industry fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	5402	2041	5402	2041

This table shows the mechanism through which cash holdings affect carbon emissions. Panel A reports the coefficients from a fixed effects regression estimates of cash holdings on carbon abatement investment. Panel B reports the coefficients from a fixed effects regression estimates of cash holdings on carbon emissions controlling carbon abatement investment, firm size, sales growth, capital expenditure, leverage, R&D intensity, profitability (ROA), institutional ownership, board independence, board size and CEO duality, year, and industry fixed effects. All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

To further substantiate our baseline argument that cash holdings help reduce carbon emissions, we conduct a second channel analysis using the carbon abatement investment variable. Our findings in Panel A of Table 10 confirm a positive relationship between cash holdings and carbon abatement investment. The result is significant at the 5% level, suggesting cash holdings promote the carbon abatement investment. Panel B of Table 10 reports that the coefficient of cash holdings is negative and significant at the 1% level, referring that cash-rich firms have a lower carbon emission. This result suggests that carbon emissions are lower for firms with higher corporate cash holdings, even after controlling for carbon abatement investment. Overall, our channel analysis confirms that cash holdings improve firm carbon performance through investing its cash in harnessing renewable energy consumption

Table 11
The impact of corporate cash holdings on carbon emissions controlling for board gender diversity.

	TCE	DCE	INDEC	TCE	DCE	INDEC
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Controlling for female directors' dummy						
Cash holdings	−0.296**	−0.429*	−0.845***			
	(−2.04)	(−1.72)	(−2.67)			
Cash holdings1				−0.172**	−0.266*	−0.578***
				(−2.46)	(−1.73)	(−2.97)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.090	0.033	0.054	0.090	0.033	0.055
F-statistics	36.78***	4.47***	7.03***	36.95***	4.47***	7.18***
Observations	5402	1914	1825	5402	1914	1825
Panel B: Controlling for the proportion of female directors						
Cash holdings	−0.2830*	−0.4192*	−0.8321***			
	(−1.95)	(−1.68)	(−2.62)			
Cash holdings1				−0.1671**	−0.2630*	−0.5773***
				(−2.39)	(−1.71)	(−2.95)
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.090	0.037	0.047	0.091	0.037	0.048
F-statistics	37.05***	4.97***	6.09***	37.22***	4.97***	6.25***
Observations	5402	1914	1825	5402	1914	1825
Panel C: Controlling for the proportion of female independent directors						
Cash holdings	−0.443***	−0.359	−1.091***			
	(−2.98)	(−1.31)	(−3.02)			
Cash holdings1				−0.245***	−0.211	−0.767***
				(−3.41)	(−1.23)	(−3.38)
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.102	0.044	0.057	0.103	0.043	0.059
F-statistics	33.92***	4.68***	5.95***	34.18***	4.66***	6.16***
Observations	4456	1564	1500	4456	1564	1500

This table shows the coefficients from a fixed effects regression estimates of cash holdings on carbon emissions controlling for firm size, sales growth, capital expenditure, leverage, R&D intensity, profitability, institutional ownership, board independence, board size, CEO duality and board gender diversity, year, and firm fixed effects. The dependent variables are the natural logarithm of total carbon emissions (TCE), direct carbon emissions (DCE) and indirect carbon emissions (INDCE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parenthesis.

and other carbon abatement projects.

6. Robustness checks

In this section, we employ several additional tests to check the robustness of our baseline results that cash holdings negatively influence firm-level carbon emissions.

6.1. Board gender diversity

In our previous estimations, we control firm-level financial and governance characteristics, including the board of directors' attributes. However, our models are independent of board gender diversity. Female directors are considered better monitors and advisors (Adams & Ferreira, 2009). The literature also documents the positive role of female directors with regards to firm financial and environmental performance (Atif et al., 2021, 2019; Liao et al., 2015). We therefore re-estimate our baseline results controlling for board gender diversity to check whether our results are driven by female directors. Empirically, we control for three proxies for female directors (female directors' dummy, the proportion of female directors, and the proportion of female independent directors) and estimate our models separately.

Our results are presented in Table 11: Panel A for female directors' dummy, Panel B for the proportion of female directors and Panel C for the proportion of female independent directors. In all three panels, we also use three alternative proxies of carbon emissions and two alternative proxies of cash holdings. Our results report that cash holdings are associated with lower total carbon emissions, lower direct carbon emissions and lower indirect carbon emissions in all three panels. These results are similar when we use alternative proxies of cash holdings in columns 4–6. These findings are also consistent with our main results reported in Table 3. Furthermore, the magnitudes of the coefficient of both proxies of cash holdings remain similar to those presented in Table 3, indicating that our findings are not driven by board gender diversity.

6.2. Estimated carbon emissions

Since carbon emissions disclosure is voluntary for U.S. firms, a substantial number U.S. listed firms do not report their carbon emissions. Such nondisclosure motives may raise the concern of sample selection bias as the sample may not represent the population. To address self-selection and disclosure bias, we follow Griffin, Lont, and Sun (2017) and estimate carbon emissions for non-disclosing firms. Griffin et al. (2017) highlight that their estimation model "*potentially removes a key source of selection bias from the results*". To estimate carbon emissions for a non-disclosing firm, we first employ a linear model for a disclosing firm combining the scale of operations, asset composition, investment, sector, and other emission producing financial variables (revenues, leverage, profitability, and intangibles). Thus, we follow the empirical

Table 12
The impact of corporate cash holdings on estimated carbon emissions.

	DV: Natural logarithm of estimated total carbon emissions (ETCE)			
	(1)	(2)	(3)	(4)
Cash holdings	−0.264***	−0.305***		
	(−11.81)	(−12.25)		
Cash holdings1			−0.121***	−0.148***
			(−11.50)	(−12.67)
Firm size	0.383***	0.389***	0.384***	0.392***
	(88.99)	(78.30)	(89.28)	(78.90)
Sales growth	0.000***	0.000***	0.000***	0.000***
	(9.90)	(3.36)	(9.93)	(3.57)
Capital expenditure	0.045***	0.041***	0.045***	0.041***
	(17.66)	(14.49)	(17.95)	(14.63)
Leverage	−0.119***	−0.124***	−0.118***	−0.123***
	(−8.55)	(−8.40)	(−8.45)	(−8.34)
R & D intensity	0.001	0.001	0.001	0.001
	(1.30)	(0.96)	(1.26)	(0.90)
Profitability	0.002***	0.002***	0.002***	0.002***
	(9.10)	(8.48)	(8.82)	(8.17)
Institutional ownership	−0.006***	−0.007***	−0.006***	−0.007***
	(−5.53)	(−6.32)	(−5.52)	(−6.35)
Board independence	0.001***	0.001**	0.001***	0.001**
	(3.20)	(2.54)	(3.17)	(2.47)
Board size	0.057***	0.060***	0.057***	0.060***
	(5.42)	(5.15)	(5.39)	(5.15)
CEO duality	0.001	0.001	0.001	0.001
	(0.33)	(0.38)	(0.27)	(0.32)
Proportion of female directors		−0.040***		−0.039***
		(−3.14)		(−3.07)
Constant	6.331***	6.270***	6.304***	6.227***
	(93.79)	(78.69)	(93.55)	(78.45)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
R-squared	0.724	0.709	0.724	0.709
F-statistics	1235.83***	854.02***	1233.54***	856.96***
Observations	6121	6121	6121	6121

This table shows the coefficients from a fixed effects regression estimates of cash holdings on estimated carbon emissions controlling for firm size, sales growth, capital expenditure, leverage, R&D intensity, profitability, institutional ownership, board independence, board size and CEO duality and proportion of female directors, year, and firm fixed effects. The dependent variable is the natural logarithm of estimated total carbon emissions (ECE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

model (without subscripts i and t for firm and year) below:

$$logECE = \alpha_0 + \sum_j \alpha_{1j} SEC_j + \alpha_2 logREV + \alpha_3 logCAPEX + \alpha_4 logGPPED + \alpha_5 logINTAN + \alpha_6 PROF + \alpha_7 LEV + \varepsilon \quad (2)$$

where *ECE* is the estimated carbon emissions; *SEC* is one for each of the *j* GICS industry sectors, otherwise zero; *REV* is total revenues; *CAPEX* is capital expenditures; *GPPED* is gross property, plant and equipment to depreciation expense; *INTAN* is intangibles; *PROF* is profitability (return on assets); *LEV* is long-term debt over total assets; and ε is random error.

We then use the coefficients from Eq. (2) to estimate carbon emissions for a non-disclosing firm. This method allows us to estimate carbon emissions for 6121 firm-year observations for non-disclosing firms. Table 12 presents the regression results of the impact of corporate cash holdings on estimated carbon emissions. The results show that cash holdings have significant and negative relationships with carbon emissions in models 1 to 4, confirming that our baseline results (presented in Table 3) are robust against self-selection and disclosure bias.

Table 13
The impact of corporate cash holdings on carbon emissions: S&P 1500 sample.

	(1)	(2)
Cash holdings	−0.533***	
	(−2.86)	
Cash holdings1		−0.339***
		(−3.67)
Firm size	0.458***	0.459***
	(12.16)	(12.22)
Sales growth	0.001***	0.001***
	(3.13)	(3.10)
Capital expenditure	0.008	0.007
	(0.38)	(0.30)
Leverage	−0.249*	−0.254*
	(−1.91)	(−1.96)
R & D intensity	−0.007	−0.007
	(−1.10)	(−1.13)
Profitability	−0.000	−0.000
	(−0.26)	(−0.28)
Institutional ownership	−0.030***	−0.030***
	(−3.34)	(−3.36)
Board independence	−0.001	−0.001
	(−0.77)	(−0.75)
Board size	0.138	0.136
	(1.47)	(1.46)
CEO duality	−0.025	−0.027
	(−0.69)	(−0.75)
Constant	5.279***	5.261***
	(9.00)	(9.01)
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
R-squared	0.126	0.129
F-statistics	22.32***	22.87***
Observations	2061	2061

This table shows the coefficients from a fixed effects regression estimates of cash holdings on carbon emissions in S&P 1500 sample. We control for firm size, sales growth, capital expenditure, leverage, R&D intensity, profitability, institutional ownership, board independence, board size and CEO duality, year, and industry fixed effects. The dependent variables are the natural logarithm of total carbon emissions (TCE). All independent variables are lagged by one-year. One, two and three asterisks denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively; and t-statistics are reported in parentheses.

6.3. S&P 1500 sample

One may argue that small and medium firms have less motivation to report carbon emissions as such disclosure requires significant resource endowments. To support this argument, extant empirical literature (e.g., Liao et al., 2015; Rankin, Windsor, & Wahyuni, 2011) provides evidence that large firms have a higher propensity to disclose carbon emissions. Therefore, our sample could be driven by large firms. To avoid such sample selection bias, following Atif et al. (2021), we further run our baseline regressions on S&P 1500 index firms,[4] which consist of the S&P 500 (large), S&P MidCap 400 (medium), and S&P SmallCap 600 (small) firms. Table 13 reports the results of the impact of corporate cash holdings on carbon emissions in the S&P1500 sample. Our results suggest that cash holdings significantly decrease carbon emissions. Thus, we confirm our baseline results presented in Table 3 in a representative sample of large, medium, and small firms.

7. Conclusion

While a plethora of literature investigates the determinants of cash holdings, relatively less empirical research has been conducted on the implications of holding such large cash. Particularly, there is scarce research on the relationships between corporate cash holdings and carbon emissions. We circumvent this vital research gap by examining

[4] We restrict our analysis for S&P 1500 sample only to total carbon emissions due to limited firm-year observations for direct and indirect carbon emissions.

the association between cash holdings and carbon emissions. Employing a sample of 5402 firm-year observations from 943 U.S. listed firms, we find that corporate cash holdings have a significant positive impact on improving carbon performance. We also find that the relationship is stronger in firms with low leverage and less financial constraints. Our results further indicate that cash-rich firms exhibit higher renewable energy consumption and employ more resources in carbon abatement investment, which transmit to lower carbon emissions. Our results are robust to a range of tests to buttress against endogeneity concerns, including industry and year fixed-effects, instrumental variable estimations and propensity score matching estimates.

This study provides imperative policy implications for firms' investors, managers, and policymakers. First, we provide evidence suggesting that a firm's cash holdings help reduce its carbon footprint. Hence, investors and managers concerned about the negative impact of business activities on the environment may emphasize holding more cash. Second, our study may provide insight for regulators and policymakers in developing sustainable business practices as our study unveils an input factor of carbon emissions.

Appendix A

Table A1
Variable definitions.

Variable names	Measures
Total carbon emission (TCE)	Measured as total carbon emitted in tonnes as reported by firms
Direct carbon emissions (DCE)	Measured as the direct carbon emitted in tonnes as reported by firms
Indirect carbon emissions (INCE)	Measured as the indirect carbon emitted in tonnes as reported by firms
Cash holding	Cash and short-term investment scaled by total assets
Cash holding1	Cash and short-term investment scaled by the difference between total assets and cash and short-term investment
Sales Growth	Measured as (Net sales in year t minus Net sales in year t-1 divided by Net sales in year t-1
Firm Size	Measured as the natural log of total assets
Capital expenditures	Measured as the total capital expenditures for the year
Leverage	Measured as the total of long term and short-term debt divided by total assets
R&D intensity	Measured as the ratio of R&D expenses to Net Sales. Set to zero if R&D expense is missing.
Return on assets (ROA)	Return on assets
Total institutional ownership (Total IO)	Total institutional ownership ratio in percentage of market capitalization
Board independence	The number of independent directors as a percentage of board size
CEO duality	A dummy variable equaling one if the CEO is also the chairman of the board, and zero otherwise
Board size	The total number of directors on the board
Renewable energy consumption	Total renewable energy consumption as a percentage of total energy use
Environmental Investment	Total investment in environmental activities (in USD)

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