



Emissions trading scheme participation and firms' cash holdings

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ABSTRACT

This study investigates the effect of participating in an emissions trading scheme (ETS) on firms' future cash holdings. Using global firm-level data from different continents, our findings show that, notwithstanding the benefits of ETS, its membership has a significant impact on firms' cash holding. Additionally, we document that bankruptcy risk, firm growth potential, corporation tax, and financial constraints mitigate the impact of ETS on corporate cash holdings. Furthermore, we find that the country of operations, continent, and legal origin of the domiciled firm influence the association between ETS and firm cash holdings level. The results are robust to difference in differences (DiD) estimation and a variety of econometric specifications.

1. Introduction

Climate change has come to dominate the global policy landscape as the primary challenge of the 21st century, for which comprehensive international efforts are needed to address. Weather hazards have implications for the financing decisions and investments of firms (Nguyen et al., 2020; Javadi and Masum, 2021; Phan et al., 2022) and pose risks and opportunities for firms. One of the dilemmas facing firms with climate risks is how to enhance their environmental performance without compromising firm value. In this context, emission trading schemes (ETS) have emerged as a prominent market-based mechanism to incentivize corporate emissions reductions and facilitate the transition to net-zero (Talberg, 2013). In navigating the complexities of participating in ETS, the management of cash flows (cash holdings in particular) becomes paramount for firm strategic flexibility in exploiting carbon-market movements, meeting regulatory and compliance obligations, adaptability to regulatory and market uncertainty, as well as investing in emissions reduction technologies and processes (Laurikka and Koljonen, 2006).

This paper investigates the relationship between firm membership in ETS and their level of cash holdings. Previous literature identifies financial flexibility as crucial in enabling firms to capitalize on emerging opportunities (Fresard, 2010; He and Wintoki, 2016; G. Adamolekun et al., 2023). In achieving the goal of shareholder wealth maximization, management needs to determine the

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Table 1**Data Distribution**

This table presents the distribution of the data. Panel A details the spread of the data across years while Panel B reports the continental spread of the data. Panel C reports the yearly distribution of the data.

Panel A: Country Distribution			Panel B: Continental Distribution		
Country	Freq.	Percent	Continent	Freq.	Percent
Argentina	16	0.04	Africa	789	1.87
Australia	2921	6.91	Asia	7136	16.89
Austria	168	0.4	Europe	12,136	28.72
Belgium	207	0.49	North America	18,423	43.6
Bermuda	147	0.35	Oceania	3220	7.62
Brazil	340	0.8	South America	554	1.31
Cambodia	2	0	Total	42,258	100
Canada	2012	4.76	Panel C: Yearly Distribution		
Cayman Islands	33	0.08	Year	Freq.	Percent
Chile	142	0.34	2003	539	1.28
China	917	2.17	2004	553	1.31
Colombia	38	0.09	2005	847	2
Cyprus	26	0.06	2006	997	2.36
Czech Republic	16	0.04	2007	969	2.29
Denmark	224	0.53	2008	1034	2.45
Egypt	22	0.05	2009	1212	2.87
Faroe Islands	3	0.01	2010	1335	3.16
Finland	256	0.61	2011	1897	4.49
France	1323	3.13	2012	2083	4.93
Germany	1048	2.48	2013	2258	5.34
Gibraltar	12	0.03	2014	2457	5.81
Greece	184	0.44	2015	2467	5.84
Hong Kong	993	2.35	2016	2941	6.96
Hungary	18	0.04	2017	3335	7.89
Iceland	2	0	2018	3781	8.95
India	858	2.03	2019	4481	10.6
Indonesia	126	0.3	2020	4788	11.33
Ireland	447	1.06	2021	4284	10.14
Isle Of Man	21	0.05	Total	42,258	100
Israel	121	0.29			
Italy	458	1.08			
Japan	2560	6.06			
Kazakhstan	3	0.01			
Kenya	6	0.01			
Korea (South)	273	0.65			
Kuwait	13	0.03			
Luxembourg	98	0.23			
Malaysia	393	0.93			
Malta	11	0.03			
Mexico	147	0.35			
Monaco	15	0.04			
Morocco	8	0.02			
Netherlands	578	1.37			
New Zealand	274	0.65			
Norway	294	0.7			
Pakistan	4	0.01			
Panama	2	0			
Papua New Guinea	25	0.06			
Peru	14	0.03			
Philippines	101	0.24			
Poland	161	0.38			
Portugal	103	0.24			
Puerto Rico	4	0.01			
Qatar	22	0.05			
Russian Federation	282	0.67			
Saudi Arabia	59	0.14			
Singapore	361	0.85			
Slovenia	4	0.01			
South Africa	750	1.77			
Spain	596	1.41			
Sri Lanka	6	0.01			
Sweden	460	1.09			
Switzerland	646	1.53			
Thailand	83	0.2			
Turkey	153	0.36			
Uganda	3	0.01			

(continued on next page)

Table 1 (continued)

Ukraine	8	0.02
United Arab Emirates	55	0.13
United Kingdom	4493	10.63
United States	16,078	38.05
Uruguay	4	0.01
Vietnam	7	0.02
Total	42,258	100

appropriate level of cash holdings which allows an equilibrium between both marginal costs and marginal benefits (Opler et al., 1999). Firms increase their cash holdings to mitigate the impact of cash demands in the event of unforeseen financial needs (Bates et al., 2009). Since financial flexibility is associated with an increased ability to capitalize on emerging opportunities, we posit that firms that are more financially stable (face less bankruptcy risk) are more likely to raise their cash holdings levels to cope with the potential liquidity pressure of carbon markets as well as better position themselves to take advantage of strategic opportunities. The expectation is that firms with higher financial flexibility are more likely to increase cash holdings in response to ETS membership and its associated investment opportunities. Therefore, we posit that firms that join ETS are concerned with strategic positioning in markets for emissions allowances as well as renewable technologies and processes.

Prior studies on ETS and corporate finance have focused on investigating the factors which influence participation in emission trading schemes such as firm characteristics and regulatory incentives (Denis and Sibilkov, 2010; Lv and Bai, 2021; Nguyen and Phan, 2020). However, the literature is mute on the impact of ETS membership on firm liquidity. Understanding the relationship between cash holdings and ETS membership is crucial for an in-depth comprehension of the financial and strategic decision-making processes of firms operating in emissions trading markets. Climate risk introduces increased pressure on firm cash holdings. An increase in cash holdings in response to corporate climate initiatives is essential to meet required capital investments and mitigate the challenges associated with external constraints (Nguyen and Phan, 2020; Liu et al., 2023). Accordingly, increased costs of operations and investments in corporate climate initiatives through the reduction in energy-intensive operations and increase in green innovation require significant corporate liquidity. Furthermore, an increase in climate risks enhances the vulnerability of firms to regulatory requirements and their associated costs.

Another proposition is that corporate climate initiatives could reduce cash holdings. However, Porter's hypothesis posits that although corporate innovation introduces significant costs, increases in environmental performance and competitiveness can offset the costs associated with such innovation (Porter and van der Linde, 1995). For instance, due to the capital requirements for partaking in ETS, the profitability of firms and ultimately their cash flow from operations would be adversely impacted (Sun et al., 2021). In addition, the costs of ETS membership introduce an increased need for cash flow to meet operational and regulatory uncertainty. Considering the foregoing dilemma posed by ETS participation, our study contributes to the broader understanding of the financial implications of sustainability initiatives and offers insights into the management of cash reserves in the context of emissions trading. Specifically, we demonstrate the corporate finance implications of carbon mitigation initiatives.

We investigate the nexus between ETS membership and firm cash holdings levels to shed more light on the financial dimension of environmental stewardship. We argue that increased climate risks and the associated costs of ETS membership positively impact firms' decisions to increase cash holdings. We find that membership in an ETS is associated with an increase in the level of cash holdings. This result implies that firms that join ETS increase their cash holding levels to mitigate financial risks, exploit investment opportunities and meet regulatory costs. To examine the mediating effect of firm characteristics, we differentiate our sample based on bankruptcy risk, the level of growth opportunities, the level of financial constraints, corporate tax rates, legal environment, and geographic location.



Fig. 1. Membership of ETS and Cash Holdings

This figure presents the cash holdings level for firms that are members of an emission trading scheme and their counterparts that are non-members.

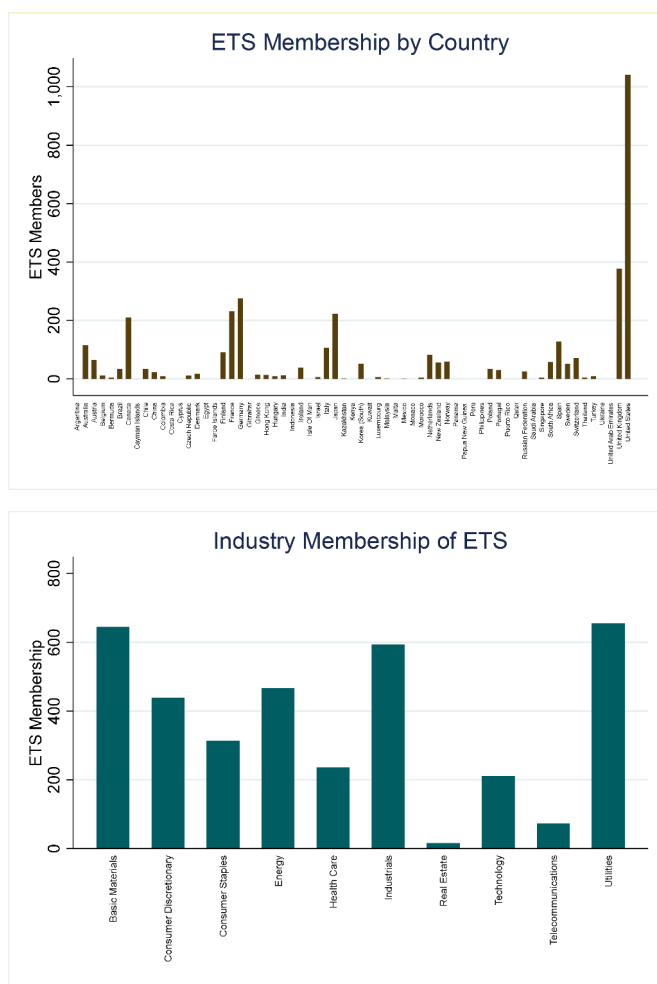


Fig. 2. ETS Membership by Country and Industry
The figures depict membership of ETS by country (Fig. 2a) and by industry (Fig. 2b).

Our evidence indicates that the positive association between ETS membership and cash holdings varies with firm-specific characteristics and macro-level differences in the legal and geographical environments in which firms operate. Our results indicate that the positive relation between ETS membership and cash holdings is more pronounced for firms that face high bankruptcy risk, low growth opportunities, constrained, and high corporate tax. Put together, the findings indicate that firms that face capital market and saving impediments tend to increase their cash holdings in response to membership in ETS. Other factors such as the law of origin, continent, and industry are important considerations.

Our study is most closely related to the study of Li et al. (2022). Unlike Li et al. (2022) who employ the staggered implementation of the China CO2 ETS which is still in its infancy as a quasi-natural experiment to investigate the effects of ETS on firm cash holdings. Contrastingly, we use a global sample of corporate ETS participation. The global setting of our study offers several advantages. In general, ETS vary in size, coverage of industries as well as their design. For instance, the EU ETS is the most mature in the world, having been established in 2005, and encompasses over 40 % of total EU emissions (Osorio et al., 2021). In contrast, the Regional Greenhouse Gas Initiative (RGGI) in the northeastern United States is focused only on emissions from the electricity utility sector (Green, 2021), while the Korean ETS, launched in 2015, applies to over 60 % of the nation’s emissions (Noh, 2012). Similarly, Other emissions trading schemes such as the New Zealand ETS, the Western Climate Initiative and several others also vary in their scope and focus (Parker, 2019). This heterogeneity in ETS worldwide, encompassing scope, targets, and allocation methods underscores the need for a comprehensive analysis using global data to understand the nuanced relationship between ETS and cash holdings. The setting of our study offers a unique opportunity to understand how carbon mitigation initiatives affect corporate strategic decisions all over the world.

In support of this view, previous research documents that firm cash-holding behavior differs with legal traditions. For instance, Das Gupta & Pathak (2020) find that firms in common law countries hold higher levels of cash relative to their civil law counterparts. Further, Yung and Nafar (2014) find that firms domiciled in countries of common law origin tend to hold lower cash levels owing to stronger creditor rights, which increases the availability of credit. As such, differences in the legal environment in which firms operate

Table 2
Summary Statistics

This table presents the summary statistics of the data across the sample of ETS members and non-members. The table also reports a *t*-test of the difference in mean between both sub-samples. ** implies a significance level below 5 %.

	Members					Non-Members					
	count	mean	SD	p25	p75	count	mean	SD	p25	p75	Diff
Cash Holdings	4953	0.10	0.10	0.04	0.14	47,419	0.18	0.20	0.05	0.23	-0.08**
Size	4954	24.32	2.40	22.75	25.20	47,436	22.27	2.56	20.58	23.53	2.05**
Leverage	4954	0.29	0.15	0.19	0.39	47,429	0.26	1.70	0.09	0.37	0.03
ROA	4954	0.04	0.09	0.00	0.07	47,435	-0.13	17.98	0.00	0.07	0.17
MTB	4948	0.84	1.16	0.16	1.10	47,310	1.50	4.12	0.28	1.77	-0.66**
Market Share	4513	0.05	3.02	-0.13	0.07	37,759	1.06	74.95	-0.12	0.13	-1.01
Dividend	4954	0.88	0.32	1.00	1.00	47,436	0.65	0.48	0.00	1.00	0.23**
Working Capital	4954	0.07	0.13	-0.01	0.15	47,436	0.14	6.21	0.03	0.29	-0.07
CAPEX	4951	0.05	0.04	0.03	0.07	47,325	0.07	4.70	0.01	0.06	-0.02
R & D	4954	1.10	7.15	0.00	0.03	47,436	2.60	83.09	0.00	0.05	-1.49

Table 3
Baseline

This table presents the baseline regression that examines the relationship between ETS membership and cash holdings. Column 1 reports the results of an OLS regression. Column 2 reports the results of a Driscoll Kraay estimation. Columns 3 & 4 report the results based on a generalized linear model (GLM) and a random effect (RE) model respectively. Details of the variable description are presented in the Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses.

	(1) OLS	(2) Driscoll Kraay	(3) GLM	(4) RE
Main				
Emission Trading	0.0170*** (9.74)	0.0170*** (5.37)	0.0170*** (9.76)	0.0055*** (2.94)
Size	-0.0102*** (-9.41)	-0.0102*** (-7.57)	-0.0102*** (-9.43)	-0.0250*** (-12.79)
Leverage	-0.0399*** (-3.48)	-0.0399*** (-5.01)	-0.0399*** (-3.49)	-0.0206 (-1.31)
ROA	-0.2209*** (-17.68)	-0.2209*** (-13.18)	-0.2209*** (-17.70)	-0.1083*** (-8.66)
Market to Book	0.0152*** (11.77)	0.0152*** (9.09)	0.0152*** (11.79)	0.0064*** (2.94)
Industry Sales Growth	0.0000*** (4.01)	0.0000*** (4.73)	0.0000*** (4.02)	-0.0000 (-0.14)
Dividend	-0.0326*** (-17.40)	-0.0326*** (-7.26)	-0.0326*** (-17.43)	-0.0124*** (-5.17)
Working Capital	0.2661*** (17.63)	0.2661*** (13.14)	0.2661*** (17.66)	0.1302*** (8.63)
Capex	-0.1192*** (-4.77)	-0.1192*** (-12.89)	-0.1192*** (-4.78)	-0.1478*** (-4.00)
R&D	0.0002*** (3.91)	0.0002*** (3.14)	0.0002*** (3.91)	0.0001*** (2.48)
Constant	0.4188*** (11.25)	0.0000 (0.00)	0.4188*** (11.27)	0.7739*** (13.46)
Industry Effect	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes
Observations	34,816	34,816	34,816	34,816
Adj R-Squared	0.50	0.47		0.43

may produce differences in the way firm cash holding and financing policies are affected by ETS membership.

Furthermore, previous research documents the effects of differences in competition intensity between industries on firm cash holdings behavior. Accordingly, [Ma et al. \(2014\)](#) find that the intensity of industry competition affects firms' cash holdings, which increase with the level of first-mover advantage in the industry. Similarly, research has shown that industry-level differences in uncertainty of input prices have strong effects on firm cash holdings, and that the predictive power of various firm characteristics in regressions of cash holdings differ amongst industries ([Baum, Schafer & Talavera, 2006](#)). Complementing this view, [Xi and Luo \(2020\)](#) find that US firms in the technology and healthcare sectors increased their cash holdings significantly more than similar firms in other industries between 1980 and 2015. Further, the authors find significant differences in the effects of the global financial crises on cash holdings between the healthcare and technology sectors. These findings suggest that firms in different industries may react in divergent ways to ETS membership in their cash holdings behavior.

Our study contributes to the literature on firm carbon-reduction initiatives and cash holdings. Prior studies examine the nexus

Table 4**ETS Membership, Cash Holdings and Bankruptcy Risk**

This table presents the panel regression result of splitting the ETS sample into firms with high and low bankruptcy risk. Details of the variable description are presented in the Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses. Standard errors are clustered at continent level.

	(1) Low Risk	(2) High Risk
Emission Trading	0.0069*** (2.69)	0.0052*** (2.11)
Size	-0.0167*** (-7.99)	-0.0254*** (-11.20)
Leverage	-0.0041 (-0.28)	-0.0242 (-1.14)
ROA	-0.0305*** (-2.97)	-0.0797*** (-5.94)
Market to Book	0.0037** (1.74)	0.0155*** (6.21)
Industry Sales Growth	0.0000** (1.89)	-0.0000 (-0.35)
Dividend	-0.0208*** (-6.42)	-0.0102*** (-3.67)
Working Capital	0.2804*** (22.03)	0.0960*** (5.95)
Capex	-0.1885*** (-7.27)	-0.1223*** (-3.11)
R&D	0.0003*** (6.11)	0.0001*** (2.46)
Constant	0.6104*** (12.76)	0.7664*** (11.11)
Industry Effect	Yes	Yes
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Observations	18,951	15,865
Adj R-Squared	0.44	0.13

between environmental performance and cash holdings, particularly studies on the relationship relating to the cost of innovation (He and Wintoki, 2016), climate risk (Lee et al., 2023) and carbon policy (Gao and Gao, 2023). We extend the existing literature by examining the effect of the country and continent of firms on the relationship between cash holdings and ETS memberships. In particular, we contribute to the nascent conversation on the corporate finance implications of carbon mitigation initiatives. Following the signing of the Paris Agreement in 2015, countries across several continents have committed to engaging in climate initiatives that reduce carbon emissions. The EU ETS is the first and largest market aimed at minimizing carbon emissions (Oestreich and Tsiakas, 2015). ETS membership is characterized by increased regulatory risks and compliance costs (Egenhofer et al., 2011) and country level factors have implications for the level of awareness and investments into climate initiatives. There are substantial changes in carbon pricing across markets such as China, New Zealand, South Korea and EU (Wei et al., 2022) and differences in corporate governance systems and allocation of capital across countries (Reidl, 2022). Cash holdings can serve as a precautionary measure to undertake investments to minimize compliance costs and the incentive to undertake climate initiatives increases the need for more cash holdings (Nguyen and Phan, 2020). Country and continent's specific responses to climate initiatives poses significant implications for firm cash holdings in response to ETS membership. To the best of our knowledge, our study is the first to examine this. Furthermore, we provide a novel understanding of the moderating effect of firm-specific characteristics such as growth opportunities, financial constraints, and level of corporate taxes on the link between ETS membership and cash holdings level. Our findings highlight that carbon mitigation initiatives have profound implications on corporate finance and firm and country-level characteristics could exacerbate or mitigate the consequences.

The rest of the paper is presented as follows. In Section 2, we have the literature and hypothesis section; Section 3 details the data and methodology; Section 4 reports the Empirical results and analyses. Section 5 presents the robustness analysis and Section 6, concludes the study.

2. Research design

2.1. Sample selection and data sources

We use global firm-level data from World Scope and Rifinitiv Eikon to investigate the relationship between ETS membership and cash holdings. Our sample for this study includes both ETS-participating and non-participating firms from 2003 to 2021. Based on the ISIN codes, the two databases were merged, and this criterion led to the collection of 42,258 firm-year observations. The sample distribution is reported in detail in Table 1. Notably, our sample is fairly distributed across country, year, and continent.

Table 5**ETS Membership, Cash Holdings, and Growth Opportunities**

This table presents the result of dividing our sample of firms into growth opportunities. Details of the variable description are presented in the Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses. Standard errors are clustered at continent level.

	(1) Low	(2) High
Emission Trading	0.0117*** (3.39)	0.0027 (1.32)
Size	-0.0318*** (-8.58)	-0.0154*** (-9.82)
Leverage	0.0173 (0.64)	-0.0214** (-1.82)
ROA	-0.0600*** (-5.08)	-0.1174*** (-10.94)
Market to Book	0.0042*** (2.01)	0.0089*** (4.27)
Industry Sales Growth	0.0000 (1.31)	-0.0000*** (-3.55)
Dividend	-0.0168*** (-4.55)	-0.0129*** (-4.83)
Working Capital	0.2189*** (6.29)	0.1411*** (10.92)
Capex	-0.7042*** (-3.38)	-0.1058*** (-2.66)
R&D	0.0001*** (2.25)	0.0003*** (3.38)
Constant	1.0223*** (11.42)	0.5109*** (9.78)
Industry Effect	Yes	Yes
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Observations	13,859	20,957
Adj R-Squared	0.27	0.21

2.2. Variable selection

2.2.1. Dependent variable

The dependent variable in our model is the future cash holding of firms. To measure this, we collect data from World Scope and follow the approach of previous cash-holding studies (see for example, Opler et al., 1999; Fresard 2010; Jones et al., 2022; Adamolekun et al., G. 2023; Pan and Lei., L. 2023). Firms' cash holding is calculated by dividing total cash and cash equivalents by total assets.

$$\text{Cash holding} = \frac{\text{cash and cash equivalents}}{\text{Total assets}} \quad (1)$$

Total assets

In Fig. 1, we report the pictorial representations of the cash holdings level for firms that are members of an emissions trading scheme compared to their counterparts that are non-members of the scheme. In general, the cash holdings level of both groups trends upwards and appears to have accelerated at the same time. As regards the degree of cash holdings, the graph indicates that non-members hold more cash than their peers that are members of an emission trading scheme.

2.2.2. Explanatory variables

Our main explanatory variable is ETS participation and sourced from Rifinitiv Eikon. This proxy follows a binary structure, with a value of one (1) for firms that engage in ETS and a value of zero (0) for those that do not. A company's decision to join (or not) an ETS shows its dedication to cutting carbon emissions and investing in low-carbon technologies, despite the associated costs. Prior studies (such as Makridou et al., 2019; Ren et al., 2022; Wei et al., 2022) have used firm ETS participation as a proxy for climate action and have found that the proxy has a considerable impact on firm performance.

Fig. 2 presents the distribution of ETS membership by country and by industry. Fig. 2a demonstrates that according to the sample, membership in ETSs is popular among firms in USA, UK, Germany, France, Japan, and Canada. As regards industry, Fig. 2b suggests that membership is popular among firms from the utility industry, basic materials industry, and industrials (manufacturing). Put together, this implies that firms from carbon-intensive industries are favourably disposed to join such schemes.

2.2.3. Control variables

Following prior studies in the literature (see Opler et al., 1999; Fresard, 2010; Adamolekun et al., G. 2023), we control for firm-specific variables such as size, leverage, return on assets, market to book value, industry sales growth, dividend, working capital, capital expenditure (CAPEX) and research and development (R&D). Data for these variables are obtained from Refinitiv Eikon. Further

Table 6**ETS, Cash Holdings, and Financial Constraints**

This table presents the result of dividing our sample of firms into their levels of financial constraint. Details of the variable description are presented in the Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. Standard errors are clustered at continent level.

	(1) Unconstrained	(2) Constrained
Emission Trading	0.0021 (1.09)	0.0130*** (3.85)
Size	-0.0116*** (-7.30)	-0.0261*** (-11.30)
Leverage	-0.0086 (-1.03)	-0.0264 (-1.25)
ROA	-0.0186** (-1.67)	-0.0942*** (-6.48)
Market to Book	0.0016 (1.01)	0.0110*** (8.63)
Industry Sales Growth	-0.0004*** (-5.99)	0.0000 (0.02)
Dividend	0.3479*** (8.74)	-0.0111*** (-4.53)
Working Capital	0.2703*** (20.57)	0.1132*** (6.47)
Capex	-0.1230*** (-5.39)	-0.1649*** (-4.47)
R&D	0.0003 (0.98)	0.0001*** (2.66)
Constant	0.0000 (0.00)	0.8036*** (12.03)
Industry Effect	Yes	Yes
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Observations	18,383	16,433
Adj R-Squared	0.39	0.17

information on the variable definition is presented in Appendix 1.

2.3. Empirical model

To measure the influence of ETS participation on firms' future cash holdings, we start by estimating an ordinary least square (OLS) regression, followed by a series of robustness checks which include Driscoll-Kraay regression, generalised linear model (GLM) and random effect (RE) model. Our baseline empirical model is specified below:

$$Y_{it+1} = \alpha + \beta'X_{it} + \beta'Y_{it} + \delta_i + \lambda_c + Q_j + \mu_t + u_{it} \quad (2)$$

where Y_{it+1} refers to the future cash holding of firms. X_{it} is the set of explanatory variables, Y_{it} represents the control variables, α denotes the constant term, β stands for the coefficient, δ_i , λ_c , Q_j and μ_t denote firm, country, industry, and time effects while u_{it} is the error term.

Furthermore, an endogeneity problem may occur in our model due to the nature of our sampling. For instance, the choice to participate in ETS is discretionary, and in certain instances, there are restrictions on the types of industries or businesses participating in the ETS. In addition, some countries limit participation to specific sectors to align with their emission reduction goals. Consequently, the potential concern of endogeneity arises due to the presence of the participation variable. Hence, we employ propensity score matching and Average Treatment Effect on the Treated (ATET) methodology within a Difference-in-Differences (DID) framework to mitigate concerns of endogeneity. These methods are employed to obtain more robust causal estimates by accounting for potential endogeneity bias when studying the effect of a treatment (ETS participation) on firm's cash holding. Moreover, we include relevant control variables in the model to help account for potential confounding factors that might drive ETS participation and the firm's cash holding.

3. Findings and discussion

In Table 2, we present the summary statistics of our sample. We split the sample into firms that are members and non-members of emissions trading schemes. We also report a t -test of the difference between the means of both sub-samples. Markedly, firms that are members of emission trading schemes hold less cash when compared to their counterparts that are not members of an ETS. Furthermore, ETS member firms have a lower market-to-book ratio than non-member firms. Firms that are members of an emission trading scheme are typically bigger and a high proportion of them pay dividends when compared to non-members. This may imply that

Table 7

ETS Membership, Cash Holdings and Tax Regime

This table reports the result of splitting our sample into the corporate tax rate in their country of incorporation. Details of the variable description are presented in Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses. Standard errors are clustered at continent level.

	(1) Low Tax	(2) High Tax
Emission Trading	0.0045** (1.79)	0.0090*** (4.01)
Size	-0.0093*** (-5.50)	-0.0247*** (-12.68)
Leverage	-0.0290*** (-2.46)	-0.0190 (-1.09)
ROA	0.0348 (1.61)	-0.0992*** (-7.42)
Market to Book	0.0018 (0.91)	0.0110*** (8.19)
Industry Sales Growth	0.0001 (1.24)	-0.0000 (-0.17)
Dividend	-0.0213*** (-5.46)	-0.0148*** (-6.02)
Working Capital	0.2984*** (16.91)	0.1191*** (7.39)
Capex	-0.0558 (-0.94)	-0.2055*** (-8.20)
R&D	-0.0002*** (-2.22)	0.0001*** (2.58)
Constant	0.4028*** (6.30)	0.7687*** (13.58)
Industry Effect	Yes	Yes
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Observations	11,732	23,084
Adj R-Squared	0.41	0.17

firms that are members of ETS are typically more mature than non-members.

In Table 3, we report the results of the empirical analyses. We commence by specifying a simple OLS regression which is reported in column 1. Next, to circumvent potential cross-sectional dependence in our sample, we estimate a Driscoll Kraay model and report the results in column 2 of Table 3. In columns 3 & 4 respectively we present the results of a generalized linear model (GLM) and a random effect (RE) model. Across the 4 estimations, the results indicate that members of emission trading schemes increase their cash holdings. One potential explanation for this finding is that membership in ETS prompts liquidity pressure which forces member firms to build up their cash holdings. The results confirm the proposition that the green transition has profound implications for firm finances. In particular, the evidence suggests that carbon mitigation initiatives have liquidity implications that could potentially affect firm valuation. Accordingly, joining emission trading schemes could reduce corporate profitability due to the inherent cash flow risk (Sun et al., 2021). Our findings lend support to the position of Li et al. (2022) who propose that ETS could exacerbate operational uncertainties thereby forcing member firms to build up cash as a hedge. To ensure our specification is robust, we specify our model using a difference in difference regression and document consistent results. The findings from this analysis is reported in Appendix 2.

Next, in Table 4, we examine how the bankruptcy risk of a firm could affect its ability to build up cash to cope with the liquidity and operational uncertainty that arise as a result of its membership in ETS. Drawing on the Z score measure, we identify firms below the critical value (i.e., 1.81) as those with high bankruptcy likelihood. Alternatively, those with a Z score above the value are regarded as having a low likelihood of bankruptcy. The results of the analysis indicate that firms with a low risk of bankruptcy build up their cash at a faster pace than their counterparts with a high risk of bankruptcy. This suggests that taking up climate mitigation poses different risks to different firms based on their bankruptcy risk exposure.

We also investigate if growth opportunities mediate the relationship between ETS membership and firm cash holdings. We report the results of this procedure in Table 5. The result suggests that only firms with low growth opportunities increase their cash holdings after joining ETS. A plausible explanation for this finding is that firms with low growth are mature and as such, can respond to the additional liquidity pressure they face by building up their cash. Contrastingly, firms with high growth opportunities need internal finances to fund their growth opportunities and as such cannot afford to build up their coffers to cater for the liquidity demand. For high-growth firms, increasing their cash holdings could imply passing up growth opportunities.

Drawing on the KZ index, we split firms in our sample according to the level of their financial constraint and report the results of this analysis in Table 6. The result indicates that firms with easy access to the capital market do not build up their cash as a result of joining an ETS. However, constrained firms build up their cash holdings level after joining emission trading schemes. Put together, the results indicate that capital market imperfections could exacerbate the corporate finance implications of climate mitigation initiatives.

Since the corporation tax rate could disincentivize firm savings (Opler et al., 1999), we examine how this affects firm cash holdings

Table 8

ETS Membership, Cash Holdings and Law of Origin

This table presents the result of splitting our sample of firms into common law and civil law countries. Details of the variable description are presented in the Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses. Standard errors are clustered at continent level.

	Civil Law	Common Law
Emission Trading	0.0030 (0.74)	0.0088*** (3.73)
Size	-0.0151*** (-4.56)	-0.0279*** (-9.49)
Leverage	-0.0273 (-1.32)	0.0296** (1.73)
ROA	-0.0470*** (-2.48)	-0.0524*** (-5.97)
Market to Book	0.0079*** (3.58)	0.0042*** (2.02)
Industry Sales Growth	0.0017 (1.20)	0.0000 (0.99)
Dividend	-0.0145*** (-3.01)	-0.0113*** (-3.92)
Working Capital	0.1843*** (6.77)	0.2124*** (6.39)
Capex	-0.2030*** (-5.14)	-0.1620*** (-6.76)
R&D	0.0011*** (9.54)	0.0001*** (2.16)
Constant	0.4345*** (5.34)	0.7269*** (7.37)
Industry Effect	Yes	Yes
Year Effect	Yes	Yes
Country Effect	Yes	Yes
Observations	6499	20,978
Adj R-Squared	0.23	0.31

Table 9

ETS, Cash Holdings, and Continental Differences

This table reports the result of splitting our sample of firms into continents. Details of the variable description are presented in Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses. Standard errors are clustered at continent level.

	(1) Africa	(2) Asia	(3) Europe	(4) North America	(5) Oceania	(6) South America
Emission Trading	0.0168 (1.05)	-0.0018 (-0.42)	0.0056** (1.88)	0.0077*** (2.79)	0.0012 (0.18)	-0.0161 (-1.22)
Size	-0.0192 (-1.50)	-0.0275*** (-6.84)	-0.0171*** (-5.75)	-0.0221*** (-11.37)	-0.0263*** (-6.48)	-0.0290*** (-2.36)
Leverage	-0.1217*** (-2.12)	0.0574*** (6.16)	0.0021 (0.14)	-0.0120 (-0.80)	-0.0807*** (-4.55)	-0.0076 (-0.16)
ROA	-0.1128 (-0.44)	-0.0386*** (-3.52)	-0.0130 (-1.33)	-0.0748*** (-6.81)	-0.0869*** (-5.19)	-0.0566 (-0.37)
Market to Book	-0.0056 (-0.14)	0.0186*** (5.15)	0.0015 (0.87)	0.0080*** (6.94)	0.0099*** (2.51)	0.0094 (0.74)
Industry Sales Growth	-0.0017 (-0.10)	0.0004*** (5.15)	-0.0002*** (-3.00)	0.0000 (0.68)	-0.0000*** (-12.46)	0.0003 (0.46)
Dividend	-0.0095 (-0.66)	0.0063 (1.03)	-0.0156*** (-4.08)	-0.0096*** (-2.92)	-0.0302*** (-3.68)	-0.0118 (-0.78)
Working Capital	0.0995*** (3.23)	0.1422*** (3.67)	0.1878*** (8.97)	0.2808*** (18.72)	0.1046*** (5.21)	0.1772*** (3.60)
Capex	-0.1533** (-1.76)	-0.2208*** (-4.73)	-0.1422*** (-4.48)	-0.1515*** (-7.08)	-0.1032 (-1.26)	-0.2077** (-1.75)
R&D	-0.0273 (-0.28)	0.0001*** (8.07)	0.0012*** (6.44)	0.0001 (1.48)	0.0000 (0.19)	0.0019 (0.89)
Constant	0.0000 (0.00)	0.0000 (0.00)	0.3459*** (5.17)	0.6699*** (16.04)	0.0000 (0.00)	0.0000 (0.00)
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	676	5738	10,027	15,229	2719	427
Adj R-Squared	0.26	0.19	0.26	0.45	0.28	0.33

Table 10**ETS Membership, Cash Holdings, and Industrial Classification**

This table reports the result of splitting our sample of firms into industries. Details of the variable description are presented in the Appendix 1. ** & *** indicates significance level below 10 % and 5 % respectively. T stats are reported in parentheses. Standard errors are clustered at continent level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Basic Materials	Consumer Discretionary	Consumer Staples	Energy	Health Care	Industrials	Real Estate	Technology	Telecommunications	Utilities
Emission Trading	0.0003 (0.08)	0.0155*** (5.21)	-0.0012 (-0.33)	0.0019 (0.51)	-0.0023 (-0.33)	-0.0003 (-0.06)	0.0239 (1.64)	0.0035 (0.51)	0.0194*** (3.44)	0.0036*** (2.09)
Size	-0.0133*** (-1.98)	-0.0176*** (-24.09)	-0.0095 (-1.07)	-0.0169*** (-5.55)	-0.0222*** (-9.21)	-0.0181*** (-3.06)	-0.0350*** (-3.51)	-0.0252*** (-10.66)	-0.0044 (-1.01)	-0.0043 (-1.02)
Leverage	-0.0650*** (-4.19)	-0.0044 (-0.34)	0.0679*** (2.51)	0.0856*** (6.41)	0.0288*** (3.32)	0.0707** (1.68)	-0.0612 (-0.81)	0.0734*** (3.28)	0.0409*** (4.84)	-0.0334*** (-2.68)
ROA	-0.1354*** (-5.34)	-0.0478** (-1.65)	-0.1185*** (-11.92)	-0.0280 (-1.44)	-0.0621*** (-10.93)	-0.0008 (-0.04)	-0.0238 (-0.83)	-0.0000 (-0.02)	-0.0206 (-0.55)	-0.0491 (-1.07)
Market to Book	0.0140*** (9.64)	0.0117*** (6.79)	0.0085*** (4.35)	0.0170*** (6.54)	0.0028*** (4.29)	0.0107*** (3.84)	-0.0010** (-1.84)	0.0078*** (7.90)	0.0005 (0.22)	-0.0140*** (-2.52)
Industry Sales Growth	-0.0000*** (-8.72)	-0.0000*** (-10.79)	0.0049*** (2.08)	0.0000 (0.54)	0.0000** (1.94)	0.0015 (0.40)	-0.0005*** (-4.75)	-0.0083*** (-2.69)	-0.0132 (-1.34)	0.0006*** (1.96)
Dividend	-0.0089 (-1.57)	-0.0028 (-0.79)	-0.0103 (-1.07)	-0.0038 (-0.44)	-0.0134*** (-4.36)	-0.0084 (-1.05)	0.0112 (0.91)	-0.0101 (-1.23)	-0.0202*** (-2.77)	-0.0164*** (-2.51)
Working Capital	0.1628*** (5.31)	0.2918*** (6.64)	0.3383*** (5.98)	0.2424*** (5.16)	0.6685*** (21.64)	0.2210*** (3.61)	0.2318*** (3.14)	0.5618*** (66.18)	0.5638*** (3.80)	0.4819*** (7.36)
Capex	-0.1218*** (-3.41)	-0.1564*** (-2.54)	-0.2414 (-1.61)	-0.0967*** (-3.47)	-0.5004*** (-4.28)	0.0057 (0.07)	-0.0674*** (-2.26)	-0.3535*** (-8.14)	-0.1291*** (-2.54)	-0.1261** (-1.68)
R&D	-0.0010 (-1.12)	0.0010*** (6.72)	0.0002 (0.90)	0.0041 (0.72)	0.0000 (0.19)	0.0005*** (8.87)	-0.0000*** (-2.52)	0.0000** (1.80)	0.0040*** (2.78)	0.0007 (1.12)
Constant	0.3984*** (3.18)	0.3753*** (26.46)	0.2911 (1.11)	0.0000 (.)	0.4101*** (11.20)	0.4838*** (3.60)	1.0906*** (3.92)	0.0000 (.)	0.2143*** (2.28)	0.2234*** (2.02)
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4396	8030	3134	3491	4386	9113	1044	3983	1246	2561
Adj R	0.29	0.35	0.31	0.21	0.51	0.19	0.24	0.53	0.53	0.37

Table 11

Propensity Score Matching

The Table presents the result of the propensity score matching estimation. Panel A reports the pre-estimation test of bias reduction. Panel B reports the result of the After Treatment Effect on Treated (ATT). The estimation in panel B accounts for year, and country effect.

Panel A: Pre-Estimation Test						
Variable	Category	Treated	Control	t stat	P Value	Bias Reduction
Size	Unmatched	24.27	22.416	48.39	0.000	97.8
	Matched	24.26	24.301	-0.82	0.415	
Leverage	Unmatched	0.294	0.259	10.41	0.000	98.5
	Matched	0.294	0.295	-0.16	0.869	
ROA	Unmatched	0.038	-0.025	0.52	0.604	97.3
	Matched	0.038	0.039	-0.81	0.417	
MTB	Unmatched	0.867	1.412	-14.27	0.000	98.1
	Matched	0.87	0.86	0.43	0.665	
Sales Growth	Unmatched	0.046	1.077	-0.91	0.361	97
	Matched	0.046	0.015	0.69	0.493	
Dividend	Unmatched	0.885	0.679	28.75	0.000	98.3
	Matched	0.884	0.881	0.52	0.600	
Working Capital	Unmatched	0.072	0.131	-0.58	0.559	97.9
	Matched	0.073	0.074	-0.4	0.688	
Capital Expenditure	Unmatched	0.054	0.047	7.07	0.000	88.4
	Matched	0.054	0.055	-0.71	0.476	
R & D	Unmatched	1.05	1.782	-0.98	0.329	70.6
	Matched	1.054	1.27	-1.04	0.297	
Panel B: After Treatment Effect on the Treated (ATT)						
Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Cash Holdings	Unmatched	0.104	0.166	-0.062	0.003	-22.97
	ATT	0.104	0.111	-0.007	0.003	-2.47

around membership of ETS. Similar to [Pinkowitz et al. \(2012\)](#), we split our sample according to the corporation tax rate in a country in a year and we present our findings in [Table 7](#). The result indicates that ETS member firms domiciled in countries with high tax rates build up their cash at a higher intensity than their counterparts situated in countries with low corporation tax rates. One reason why firms in countries with high tax rates may build up cash at a faster rate may be to circumvent future increases in corporate tax rates which may reduce their rate of savings and as such exacerbate the financial risk of such carbon mitigation initiatives.

In [Table 8](#), we report the results of splitting our sample into common law and civil law countries. We find that firms situated in civil law countries that join ETS do not build up their cash. The result, however, demonstrates that firms in common law countries that are typically market-based economies build up their cash holdings' levels after joining emission trading schemes.

In [Tables 9 & 10](#) we split the sample of firms into continents and industries and report how this dynamic affects the relationship between ETS and firm cash holdings level. In [Table 9](#) we look at how the continent of a firm affects outcome; the result indicates that only firms situated in Europe and North America build up their cash in response to joining ETS. One explanation for this is that these continents house some of the most mature carbon markets. The carbon market in Asia and Oceania to a large extent is still in its infancy and as such the corporate finance implications may still be unraveling. Our assertions are robust to the findings in [Table 8](#), as most firms in Europe and North America are situated in countries that practice common law. Consequently, Europe and North America tend to have more mature and stringent environmental regulations than other regions. Companies in these areas anticipate higher compliance costs associated with emissions trading schemes and, as a result, strategically increase their cash reserves to cover these costs. Similarly, the pricing of emission rights differs in this regard which could affect the liquidity pressure that emanates from membership in ETS. We also report how the relationship between ETS, and cash holdings varies by industry. Notably, firms in manufacturing and energy industries do not change their cash holdings in response to membership of ETS. In contrast, firms in the telecommunications industry, utility industry, and consumer discretionary industry build up their cash levels.

3.1. Robustness test

To ensure our results are robust, we run our baseline using a quasi-experimental method. To achieve this, we employ the propensity score matching estimation, a procedure that matches the treated group (i.e., ETS member firms) and control groups (i.e. Non ETS member firms). The result of this procedure is presented in [Table 11](#). The findings from the specification indicate even after considering the treatment effect, members of emissions trading schemes hold more cash than their counterparts who are non-members.

4. Conclusion

Motivated by the growing number of studies in the carbon emission literature ([Ren et al., 2022](#); [Azar et al., 2021](#); [Pan et al., 2022](#); [Ahmad et al., 2023](#)), we provide fresh insights by exploring the effect of firms' ETS participation on their future cash holdings. Although ETS participation offers some benefits to firms, our baseline results in this study indicate that joining emission trading schemes have profound implications on firm cash holdings and potential firm valuation. Further empirical results indicate that

bankruptcy risk, growth opportunities of firms, corporation tax and financial constraints may mediate the impact of ETS on cash holdings of firms. Additionally, we find that the relationship between ETS and firm cash holdings level is moderated by the country of operations, continent, and legal origin of the domiciled country.

The findings of this study provide significant policy guidance to government and industry practitioners. Whilst contributing to the academic literature, our findings are also vital for the risk management strategies of market participants, particularly sustainable investors who are conscious of protecting both the quality of their investments and the environment. In spite of the findings documented in this study, we believe there are further avenues to be explored by future studies. Such research avenues include examining the effect of ETS participation on firms' credit ratings and market valuation.

Authors' statement

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Data availability

Data will be made available on request.

Appendix 1. Variable Definition

This table presents the definition of the key variables used in this study.

Variable	Definition
Cash Holdings	This refers to the cash and cash equivalence of a firm deflated by total assets.
ETS	This identifies if a firm is a member of an emission trading scheme or not.
Working Capital	This is the working capital of a firm divided by total assets.
CAPEX	This measures the capital expenditure of a firm in a year.
R & D	This is the amount spent by a firm on research and development deflated by total assets.
RoA	This refers to the EBITDA (earnings before interest, tax, depreciation, and amortization divided by the total assets
Industry Sales Growth	This is a firm's sales growth adjusted by industry growth.
Size	This refers to the log of total assets.
Leverage	This is defined as the total debt of a firm divided by total assets
Market to Book	Market-to-book (MTB) ratio refers to the market value of equity deflated by the book value of equity.
Dividend	This captures whether or not a firm pays dividends in a year.

Appendix 2. : Difference in Differences Regression

This table reports the result of the panel difference in differences regression. ATET is defined as the after-treatment effect on the treated. Details of the variable description are presented in Appendix 1. The *t*-statistics are reported in parentheses. *, **, and *** indicates significance level at less than 10 %, 5 %, and 1 % respectively. The difference in differences regression approximates the after-treatment effect on the treated. Model 1 reports the result without accounting for industry and country effects. Model 2 accounts for industry, year and country effects.

	(1)	(2)
ATET		
Emission Trading	0.0027** (2.24)	0.0027** (2.24)
Controls		
Size	-0.0275*** (-26.06)	-0.0275*** (-26.06)
Leverage	-0.0085 (-0.60)	-0.0085 (-0.60)
ROA	-0.0717*** (-5.86)	-0.0717*** (-5.86)
Market to Book	0.0035*** (2.75)	0.0035*** (2.75)
Industry Sales Growth	-0.0000 (-1.30)	-0.0000 (-1.30)
Dividend	-0.0045	-0.0045

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(continued)

	(1)	(2)
ATET		
	(-1.85)	(-1.85)
Working Capital	0.0860***	0.0860***
	(5.83)	(5.83)
Capex	-0.1236***	-0.1236***
	(-7.79)	(-7.79)
R&D	0.0000***	0.0000***
	(3.76)	(3.76)
Constant	0.7638***	0.7638***
	(32.50)	(32.50)
Firm Effect	Yes	Yes
Industry Effect	No	Yes
Year Effect	Yes	Yes
Country Effect	No	Yes
Observations	34,817	34,816

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