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ORIGINAL PAPER

Moderating effect of carbon accounting systems on strategy and carbon performance: a CDP analysis

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Abstract

Carbon emissions bring significant risks and opportunities, and organisations have responded by adopting different strategies and environmental control systems, such as carbon accounting systems (CASs). However, it remains unclear whether a CAS can help reduce emissions, and what role is played by a CAS in the relationship between carbon strategy and carbon performance. Therefore, this paper analyses the strategy-accounting-performance nexus by drawing on 1672 firm-year observations of firms participating in the CDP in 2014 and 2015. The results suggest that the quality of a CAS is influenced by strategic choices; with a proactive carbon strategy being associated with a higher quality CAS. Further, proactive strategies and CASs are found to be associated with carbon savings and emissions reduction. The results indicate a moderating role of CASs on the strategy-performance relationship, with carbon strategy enabling higher carbon savings and lower emissions intensity in the presence of a high-quality CAS. Our findings suggest that formulation of carbon strategies and establishment of carbon measures can drive effective carbon mitigation.

Keywords Climate change strategy · Carbon accounting · Carbon mitigation · Carbon performance · CDP

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1 Introduction

Climate change is a global issue. Climate emergencies have been declared by more than a thousand cities and local governments (ICEF, 2020). With global recognition of climate emergencies, and the need for rapid carbon mitigation, organisations are under increasing pressure to demonstrate how their climate/sustainability efforts are aligned with organisational strategies, and reflected in management control systems (Ghosh et al., 2019; Harris et al., 2019). Among different sustainability control systems, carbon accounting has received heightened scholarly interest. Carbon accounting enables the quantification of organisations' carbon footprint and carbon-related activities, and the use of this quantified information in organisational decision-making (Hartmann et al., 2013; Stechemesser & Guenther, 2012). Prior literature distinguishes between (reporting-driven) carbon accounting and (internally performance-driven) carbon control, whereby the research that draws upon the CDP is about carbon accounting, and the research that discusses accounting for eco-efficiency, cost savings and material flow accounting, is concerned with carbon control. Despite their differences, carbon accounting and carbon control are intertwined, because the information generated for carbon reporting may also affect carbon management, and vice-versa (Qian & Schaltegger, 2017; Qian et al., 2018). Using this reasoning, we try to understand the link between strategy, carbon accounting and carbon performance by drawing upon externally reported carbon information in the CDP. By doing so, we respond to calls for an exploration of how businesses internalise legitimacy pressures and demands for creating real improvements (Qian & Schaltegger, 2017), and to the need for more empirical studies on sustainability and carbon management accounting (Crutzen et al., 2017; Harris et al., 2019; Hartmann et al., 2013).

Generally, the relevant literature recognises that the effective implementation of a sustainability strategy requires comprehensive environmental management control systems (EMCS) that ensure the integration of sustainability into core businesses, and push organizations towards a sustainable future (Epstein, 1996; Epstein & Wisner, 2005; Gond et al., 2012). Furthermore, previous studies have investigated the design and use of environmental controls, their drivers, and their impacts on organizational performance (Adams et al., 2007; Burritt et al., 2011; Henri & Journeault, 2010).[1] However, few studies have examined how sustainability strategy influences carbon control design, via a large dataset (Harris et al., 2019). Likewise, there is a very limited empirical evidence regarding the impact of carbon accounting on carbon mitigation. Additionally, prior literature often refers to carbon accounting in a limited sense, i.e., the quantification of the carbon footprint and the use of such information in decision making, and does not extend to other controls that also help

[1] It is noted, however, the traditional MCS literature often does not consider the environment or how it should contribute to sustainability (Durden, 2008; Gond et al., 2012). MCS are traditionally established to align organisational behaviour with economic goals, and maximise economic performance (Gond et al., 2012). In contrast, environmental controls in the environmental management literature often consider a small subset of systems and tools for environmental/sustainability management accounting and control (i.e., environmental MCS).

fulfil carbon management objectives. Therefore, following Simons' (1991) concept of 'levers of control', we argue that CASs as a subset of EMCS, encompass carbon-focused environmental controls (eco-controls) that include "formalised procedures and systems" that "maintain or alter patterns in environmental activity" (Henri & Journeault, 2010, p. 64). Hence, CASs include procedures and systems, such as targets and budgets, strategic planning, and reporting systems, working as a package of control (Malmi & Brown, 2008), with the aim of achieving the carbon management objectives of organisations.

Further, the control implications, for a firm adopting a proactive climate change strategy, *versus* another firm adopting a reactive strategy, are unclear in extant literature. As argued by Harris et al. (2019), future sustainability studies need to examine a larger set of controls as driven by, and implicated in, different strategic orientations. With firms being able to adopt different climate change strategies (Boiral, 2006; Kolk et al., 2008; Weinhofer & Hoffmann, 2010), it is critical to understand which carbon strategy is the most (or least) effective in reducing carbon emissions. Overall, this means that the strategic and EMCS mechanisms, through which firms drive carbon mitigation, are poorly understood.

Therefore, this paper aims to address the three-way relationship between carbon strategy-accounting-performance by utilising an international sample of 1672 firm-year responses to the CDP in 2014 and 2015. The CDP is widely perceived as providing the largest and most comprehensive database of voluntary reporting of carbon-related performance and activities of large firms around the world (Luo & Tang, 2014; Matsumura et al., 2014). This paper brings the focus on carbon performance by adopting a resource-based view, whereby CASs and proactive carbon strategies can help develop key resources and capabilities that enable organisations to improve their performance and competitive advantage (Eisenhardt & Martin, 2000; Teece et al., 1997). The proactive carbon strategies include strategic integration, reduction initiatives, policy engagement, value chain engagement, and carbon credit origination (Jeswani et al., 2008; Kolk & Pinkse, 2005; Weinhofer & Hoffman, 2010). Eight CAS components are examined: strategic planning, targets, carbon budget, financial performance measurement, non-financial performance measurement, project management method, incentives, and reporting. Considering eight components allows us to assess the implications of a CAS for carbon performance as a package (e.g., Henri & Journeault, 2010; Tang & Luo, 2014). In this paper, carbon performance is proxied by annual carbon savings and emissions intensity of firms in a given year (Luo & Tang, 2016; Tang & Luo, 2014).

The findings of this study make three contributions to the literature. Firstly, consistent with a resource-based view, and extending prior empirical studies that focus on the carbon disclosure-performance relationship (Clarkson et al., 2015; Kolk et al., 2008; Luo & Tang, 2016; Qian & Schaltegger, 2017; Qian et al., 2018; Schiemann & Sakhel, 2018; Tang & Luo, 2014), our findings suggest that high quality CASs are linked to higher annual carbon savings and lower emissions intensity. Our findings diverge from other studies that question the contribution of CASs, in that carbon accounting on its own is insufficient to achieve carbon reduction (Jackson & Kaesehage, 2020), and that the emissions data may be arranged to present a situation consistent with expectations (Lippert, 2015). Rather than just carbon measurement or reporting, we argue that a comprehensive and formal CAS, that captures different components, can have a meaningful effect on carbon mitigation.

Secondly, this study responds to calls in the literature to determine which strategies improve carbon performance (Qian & Schaltegger, 2017). We provide cross-country evidence of the varying implications of different strategies on performance. Based on prior literature, this study takes into account five different types of proactive strategies. We find that a proactive carbon strategy is effective in improving carbon savings and reducing emissions intensity. This confirms prior literature regarding the positive impact of proactive strategies on environmental performance (Hart, 1995; Kolk & Hoffmann, 2007; Kolk et al., 2008) and argues that this impact applies equally to a climate change context.

Thirdly, this research suggests a moderating role for CASs in the enactment of strategies for carbon performance. Prior empirical studies reveal a positive impact of CASs on carbon performance, but they do not consider the influence of carbon strategy. This study demonstrates direct effects of carbon strategy on carbon performance, as well as indirect effects as moderated by a CAS. The results are consistent with a resource based view (RBV), that a CAS performs a moderating role on the relationship between carbon strategy and carbon performance, highlighting that a high quality CAS enables strategy to have a stronger impact on carbon performance. The interaction between CASs and carbon strategy has an overall positive relationship with carbon savings and a negative relationship with emissions intensity. Consistent with studies on the CAS-strategy relationship (Bui & de Villiers, 2017; Bui & Fowler, 2019; Ghosh et al., 2019;) we argue that the adoption of both a CAS and strategy rather than each individually, is beneficial for annual carbon savings. This effect is the most pronounced among polluting firms, possibly because the combined effect may drive larger scale operational, behavioural and strategic changes which, in turn, result in significant carbon mitigation.

The rest of the paper proceeds as follows. In Sect. 2, we review the prior literature in order to understand the relationships between carbon strategy, CASs and carbon performance. Section 3 discusses the theory underlying the link between carbon strategy, CASs, and carbon performance, and proposes the hypotheses. In Sect. 4 we explain the research design, and in Sect. 5 we discuss the results. Section 6 summarizes the paper and provides contributions, limitations and practical implications.

2 Literature review

This section reviews the literature on the relationship between carbon strategy and CASs, and between CASs and carbon performance.

2.1 The carbon accounting system (CAS) and carbon strategy

Despite the extensive literature on management control and strategy (e.g., Ferreira & Otley, 2009; Simons, 1990), the insights into how companies design or use management control to support sustainability strategies are only just emerging (Crutzen

& Herzig, 2013; Henri & Journeault, 2010). EMCS can be designed to support sustainability strategies (Crutzen et al., 2017; Figge et al., 2002; Hansen & Schaltegger, 2016), but the role played by EMCS in various sustainability strategies is not well understood (Crutzen & Herzig, 2013; Ghost et al., 2019).

With the global urgency of climate change, carbon emissions pose significant risks and provide (improvement) opportunities to organisations (Bebbington & Larrinaga-González, 2008; Cadez & Czerny, 2016) and the focus on carbon emssions has facilitated the growth of a plethora of private standards to guide carbon accounting and disclosure, such as the Greenhouse Gas (GHG) Protocol (Sundin & Ranganathan, 2002) and other standards (Green, 2010). Corollary there is an increasing integration of carbon accounting into corporate strategic management and EMCS (Engels, 2009; Hopwood, 2009; Luo & Tang, 2016). Carbon-focused management accounting can facilitate cross-departmental communication and increase the efficiency and effectiveness of information processing (Burritt et al., 2011; Kumarasiri & Jubb, 2016). Similarly, performance measurement systems enable organisations to maintain transparent accounts of carbon emissions, and identify reduction potential (Schaltegger & Csutora, 2012; Schaltegger & Zvezdov, 2015). Appropriate design and use of CASs can help develop key organisational capabilities and implement a proactive carbon strategy that helps achieve a competitive advantage (Bui & de Villiers, 2017; Henri & Journeault, 2010; Menguc et al., 2010). The carbon strategy and accounting link has been examined in different sectors, such as the automotive industry (Lee, 2012), forestry (Ellison et al., 2011) and agriculture (Huang & Mi, 2011), as well as in a cross-sectional context (Bui et al., 2020). While these studies suggest that carbon accounting is useful in mitigating carbon emissions and implementing carbon strategies, it is unclear which form of carbon accounting is useful, and for what type of carbon strategy.

A few studies have looked at the organisational strategic responses in a climate-change-sensitive business environment (Bui & de Villiers, 2017; Cadez & Czerny, 2016; Kolk et al., 2008; Weinhofer & Hoffmann, 2010). For instance, Cadez and Czerny (2016) propose three strategic priorities, ranging from internal carbon reduction (i.e., combustion emissions reduction, process or product emissions reduction) to external carbon reduction (mainly through supply chains), and carbon compensation. Similarly, Weinhofer and Hoffman (2010) classify climate change strategies as focusing on either CO_2 compensation, CO_2 reduction, or carbon independence. Further, firms can adjust their climate change strategy from stable to reactive, anticipatory, proactive, or creative, hinging on the degree of uncertainty of regulatory requirements (Bui & de Villiers, 2017). However, it remains unclear how different climate change strategies can influence CASs.[2]

[2] There could be an interactive relationship between strategy and CASs.

2.2 CASs and carbon performance

This section discusses the use of CASs in carbon management, as well as some limitations of CASs. Prior studies have examined the relationship between carbon emissions and disclosure and financial performance using proxies such as market value of equity (Matsumura et al., 2014; Saka & Oshika, 2014), cost of equity and cost of debt (Li et al., 2014). These studies support the view that carbon accounting and reporting enhance firms' financial performance. Another stream of literature examines CASs from a managerial perspective, and emphasises the impact of using CAS information on carbon performance, albeit with inconclusive evidence. Henri and Journeault (2010) provide empirical evidence for the positive impacts of eco-controls on various aspects of environmental performance, such as reduction in material costs, increased productivity, better relationships with stakeholders, or overall company reputation. Wijethilake et al. (2018) study of 175 manufacturing firms in Sri Lanka and find that EMCS moderates the relationship between environmental innovation strategy and organisational performance. In addition, studies have utilized CDP data to understand the association between carbon accounting and performance (Clarkson et al., 2015; Kolk et al., 2008; Luo & Tang, 2016; Qian & Schaltegger, 2017; Qian et al., 2018; Schiemann & Sakhel, 2018; Tang & Luo, 2014). Tang and Luo's (2014) study of 45 Australian firms indicates that a firm can mitigate its carbon footprint through a high-quality carbon management system. Qian and Schaltegger (2017) analyse Global 500 companies, and find that change in carbon disclosure levels is associated positively with subsequent change in carbon performance. However, they do not examine components of carbon accounting and controls but, rather, the extent of disclosure. Differently, Qian et al., (2018) draw on the Corporate Sustainability Barometer (CSB) and CDP database of 114 large companies across the US, Germany, Australia and Japan, and find that the application of environmental accounting has a significant positive impact on both corporate carbon management and disclosure quality. Ott and Endrikat (2022), using CDP database of S&P 500, find that financial carbon-related incentives are associated with superior carbon performance, while non-financial incentives are not. This indicates the differing impacts of incentive design on carbon performance. Summing up, CDP based studies have not explored the impact of a comprehensive CAS on carbon performance.

3 Hypothesis development

This study adopts the lens of the natural resources-based view (RBV) as proposed by Hart (1995) to develop hypotheses. The RBV suggests that firms maintain their competitive advantage by utilising and nurturing resources that are not easily imitated by competitors. The RBV conceptualizes firms as bundles of resources heterogeneously distributed across firms, and suggests that these resource differences persist over time (Amit & Schoemaker, 1993; Wernerfelt, 1984). Resources must satisfy the key criteria of being valuable, rare, inimitable, and non-substitutable, if they are to lead to the achievement of sustainable competitive advantage (Barney, 2001). Resources enable the implementation of value-creating strategies via elements, such as physical assets, human resources, organizational assets, and competencies (Eisenhardt & Martin, 2000; Teece et al., 1997). Capabilities enable the interaction between these resources and their effective deployment. They are defined as "The firm's processes that use resources – specifically, the processes to integrate, reconfigure, gain and release resources-to match, and even create, market change" (Eisenhardt & Martin, 2000, p.1107). Prior research has suggested innovation, organizational learning, market orientation and entrepreneurship are among the primary capabilities needed to reach competitive advantage (Bhuian et al., 2005; Henri, 2006).

3.1 Carbon strategy and the CAS

Consistent with an RBV, the design and practice of EMCS should be tailored to the corporate strategic intent, in order to optimise organisational performance (Chenhall, 2003; Henri, 2006) and gain competitive capabilities (Henri, 2006; Widener, 2007). While sustainability strategy provides high-level direction and policy with regards to environmental issues, EMCS provide the specific tools for coordinating and aligning the resources and processes needed to turn such strategy into actual performance outcomes (Ghost et al., 2019; Lee, 2012).

A proactive environmental strategy requires certain capabilities to allow the collective deployment of multiple resources, ensuring that they work in sync to improve organisational performance. For example, a pollution prevention strategy would require the monitoring and management of environmental impacts, over and beyond minimum regulatory requirements (Hart, 1995). This is achieved via an EMCS using performance measures and monitoring systems. Proactive environmental strategies require the provision of physical and monetary information regarding the ecological cost of organisational product, process, or activities (Adams & Frost, 2008). Indeed, long-term-oriented physical and monetised carbon accounts are used extensively when firms adopt creative or proactive strategies, as opposed to other strategies (Bui & Fowler, 2019). Consequently, changes in carbon strategies require modification of CASs to support the new strategic intents and objectives (Bui & de Villiers, 2017).

A proactive environmental strategy would also require a good reporting system, so environmental issues are forwarded to relevant managers, and elevated to senior levels if they present significant risks to the organisation. Interactive controls allow top management's focused attention and intervention with regard to environmental issues of strategic importance (Simons, 1991). Furthermore, a proactive strategy involves a high organisational commitment to managing environmental performance (Hart, 1995). This inevitably requires some form of formal environmental target, and associated budgets and processes to ensure performance is monitored and corrected against the target (Bui et al., 2020).

Accordingly, a more proactive climate change strategy is associated with more formal environmental controls (Pondeville et al., 2013), in order to affect various organisational decisions (Christ & Burritt, 2013). Therefore, we hypothesise the following.

Hypothesis 1 *A more proactive carbon strategy is associated with a higher quality carbon accounting system.*

3.2 CAS and carbon performance

In accordance with RBV, we argue that *CASs* incorporate processes that ultimately provide a source of competitive advantage. Prior studies have documented the direct performance benefits of environmental controls, such as quality enhancement, cost savings, more accurate product pricing, and retention of skilled personnel (Dunk, 2007; Gunarathne & Lee, 2015). Indirect benefits include organisational learning, continuous innovation, stakeholder integration, and shared vision and goal congruence capabilities (Adams et al., 2007; Journeault, 2016).

There are different types of controls, such as diagnostic controls and interactive controls. Diagnostic controls, such as managerial incentives, carbon targets and investment modelling, motivate organisational members to align their behaviour with carbon management objectives and, hence, lead to performance improvement. Extant literature provides conflicting evidence regarding the relationship between incentives and performance, from no relationship (Tang & Luo, 2014), to a negative relationship found between monetary incentives and carbon mitigation (Ioannou et al., 2016). In contrast, setting carbon targets enables firms to monitor emissions, set benchmarks for performance assessment, and control negative deviations from pre-determined targets (Adams et al., 2007; Tang & Luo, 2014). Prior studies indicate that more difficult targets are more likely than less difficult ones to be accomplished, thus, supporting the impact of target setting on performance (Ioannou, et al., 2016; Larrinaga-González et al., 2001). The use of carbon measures in investment modelling can provide a platform for discussion and dialogue, and for encouraging innovation within the organisation (Bui & Fowler, 2019).

Reporting systems and strategic planning often serve as interactive controls in carbon management (Bui et al., 2020; Simon, 1995). Reporting systems, notably more frequent communications on risk management and strategy from lower-to top-management levels, allow the detection of risks before they become real problems and threaten the achievement of organisational objectives (Simons, 1995; Van der Stede, 2001). Differently, a strategic planning process ensures the review of current strategies, evaluation of the risks and opportunities, and the formulation of new strategies. Prior studies have found that the board of directors plays a critical role in monitoring and reporting carbon information and ensuring climate change accountability to firm stakeholders (Ben-Amar & McIlkenny, 2015; Prado-Lorenzo & Garcia-Sanchez, 2010). Hence, frequent reporting of carbon risk information to the board will feed into the strategic planning process and the development of climate change strategies. Further, active scrutiny by the board is likely to result in intensive monitoring at lower management levels and the promotion organisational learning on carbon issues (Bui, 2011; Bui & de Villiers, 2017). Through these different processes and resulting capabilities, we expect that comprehensive CASs with diagnostic and interactive controls, that embed climate change issues, will lead to stronger carbon performances. The following hypothesis is, thus, formed:

Hypothesis 2 *A higher quality carbon accounting system is associated with stronger carbon performance.*

3.3 Carbon strategy and its effect on carbon performance (both directly and moderated by the CAS)

Though it has been theoretically implied, the relationship between proactive carbon strategy and carbon performance has not been adequately investigated. For example, Clarkson et al. (2011) document a positive relationship between environmental and financial performance, where environmental performance is driven by a proactive environmental strategy. Using a S&P 500 sample, Moussa et al. (2020) report a positive link between carbon strategy and carbon performance and a mediating role for carbon strategy on the relationship between board environmental orientation and carbon performance.

Prior literature based on the RBV has argued that a proactive environmental strategy can provide a source of competitive advantage. For example, a proactive strategy can improve environmental performance through investing in end-of-pipe pollution treatment or prevention, developing greener products, or pursuing sustainable development through low-impact technologies (Hart, 1995). Environmental proactivity can result in capabilities such as stakeholder integration, organizational learning, and continuous improvement (Sharma & Vredenburg, 1998). Firms can innovate on their own, or in collaboration with stakeholders and industry partners (Kolk & Hoffmann, 2007; Kolk et al., 2008) and, hence, they can enhance potential carbon savings or innovation outcomes. A proactive strategy also emphasises organisational changes, such as behaviour shifts towards more sustainable resource consumption and, thus, reduce negative environmental impacts (Aragón-Correa & Sharma, 2003). A carbon strategy that takes climate change issues seriously, also encourages risk-taking and entrepreneurship. This is because effective carbon mitigation goes beyond energy efficiency and requires technological transformation, which does not occur without significant investment with high risk, while the returns are realised only in the long term. Accordingly, a proactive climate change strategy results in capabilities that will lead to stronger carbon performance. Hence, we formulate the following hypothesis:

Hypothesis 3a *A more proactive carbon strategy is associated with stronger carbon performance.*

Further, we argue that this relationship is also moderated by the quality of the *CAS*. The RBV suggests that a sustainable competitive advantage relies on organisational "organizing", i.e., the ability to exploit the rare, valuable, or non-imitable capability or resources of an organisation (Barney, 2001). *CASs* help to organize resources and, hence, to implement carbon strategy through various mechanisms (Crutzen & Herzig, 2013). For instance, targets facilitate efficient resource allocation into areas that can result in the highest carbon reduction (Ioannou & Serafeim, 2012). Similarly, incentive systems can reinforce manager and staff motivation towards achieving carbon plans and initiatives as part of the carbon strategy (Bui et al., 2020). The integration of carbon indicators into investment modelling enables the reorientation of organisational resources towards lower carbon technologies and, hence, the achievement of a lower-carbon business strategy (Bui & Fowler, 2019). Further, the reporting of carbon information to the board allows top management monitoring of carbon performance, and timely action to correct deviations against the planned strategy (Moussa et al., 2020). Overall, by facilitating strategy implementation, *CASs* allow the mobilisation of organisational financial and non-financial resources in alignment with carbon strategies, leading to better carbon performance.

Hence, in accordance with the RBV, we argue that a *CAS* strengthens the relationship between a proactive carbon strategy and carbon performance. Thus, the following hypothesis is formed:

Hypothesis 3b *A higher quality carbon accounting system moderates positively the relationship between a proactive carbon strategy and carbon performance.*

4 Methods

4.1 Sample selection

This study utilises the information obtained from the CDP 2014–2015 database, in conjunction with firms' financial information obtained from the Thomson Reuters DataStream. Information captured in CDP is faithfully represented and reliable, as CDP questionnaires and scoring methodology are well-constructed, leaving little opportunity for managers to provide misleading information (Depoers et al., 2016). The disclosures to CDP, according to some studies (Luo & Tang, 2014, 2016), are indicative of the underlying carbon performance. Furthermore, the CDP database is regarded as the largest source of primary climate change information (Andrew & Cortese, 2011; Luo & Tang, 2014; Matsumura et al., 2014) and, therefore, is able to cover various aspects of corporates' climate change activities.

We choose 2015 and 2014 as our years of investigation, owing to the consistency in the structures and content of the CDP questionnaires,[3] and the inclusion of two years allows us to control for change over time. After omission of observations with missing dependent and independent variables and zero emissions, and winzorizing of financial variables, we arrive at final sample of 1672 observations, as shown in Table 1.

[3] The need to limit to only two years' data was driven by the manual coding of all strategy and CAS variables. Furthermore, since 2016, CDP has changed their questionnaire format and scoring methods, including changes to Scope 2 emissions measurement, science-based targets and the movement from separate disclosure and performance scores to one single-letter performance score (DFGE, 2016). This has led to inconsistencies in the way CASs are measured and scored.

Table 1 Sample selection

	Firm year observations
Firms that submitted 2014—2015 CDP questionnaires and made their responses available and retrievable from the CDP database	2349
Less: Eliminated observations where either independent variable and dependent variables are missing	308
Less: Zero values of dependent variables	369
Final sample	1672

4.2 Regression models

To test the hypotheses, the following regression models are employed:

$$\begin{aligned} CAS = {} & \alpha_0 + \alpha_1 PROACT + \alpha_2 SIZE + \alpha_3 ROA \\ & + \alpha_4 TOBINSQ + \alpha_5 NEW + +\alpha_6 GDP \\ & + \alpha_7 LAW + \alpha_8 ETS + Industry\_FE \\ & + Year\_FE + \varepsilon \end{aligned} \tag{1}$$

$$\begin{aligned} \Sigma CP = {} & \beta_0 + \beta_1 CAS + \beta_2 SIZE + \beta_3 ROA \\ & + \beta_4 TOBINSQ + \beta_5 NEW + \beta_6 GDP \\ & + \beta_7 LAW + \beta_8 ETS \\ & + Industry\_FE + Year\_FE + \varepsilon \end{aligned} \tag{2}$$

$$\begin{aligned} \Sigma CP = {} & \gamma_0 + \gamma_1 PROACT + \gamma_2 SIZE + \gamma_3 ROA \\ & + \gamma_4 TOBINSQ + \gamma_5 NEW + +\gamma_6 GDP \\ & + \gamma_7 LAW + \gamma_8 ETS + Industry\_FE \\ & + Year\_FE + \varepsilon \end{aligned} \tag{3}$$

$$\begin{aligned} \Sigma CP = {} & \delta_0 + \delta_1 CAS + \delta_2 PROACT + \delta_3 CAS * PROACT \\ & + \delta_4 SIZE + \delta_5 ROA + \delta_6 TOBINSQ + \delta_7 NEW \\ & + \delta_8 GDP + \delta_9 LAW + \delta_{10} ETS + Industry\_FE \\ & + Year\_FE + \varepsilon \end{aligned} \tag{4}$$

The main variables of interest are *CAS* (carbon accounting system), *ΣCP* (carbon performance i.e., *CARSAV* and *INTENS*), *PROACT* (carbon strategy) and *CAS*PROACT* (interaction term between carbon accounting system and carbon strategy).

Model 1 analyses the interplay between carbon strategy and the *CAS* (H_1), while model 2 examines the relationship between the quality of the *CAS* and

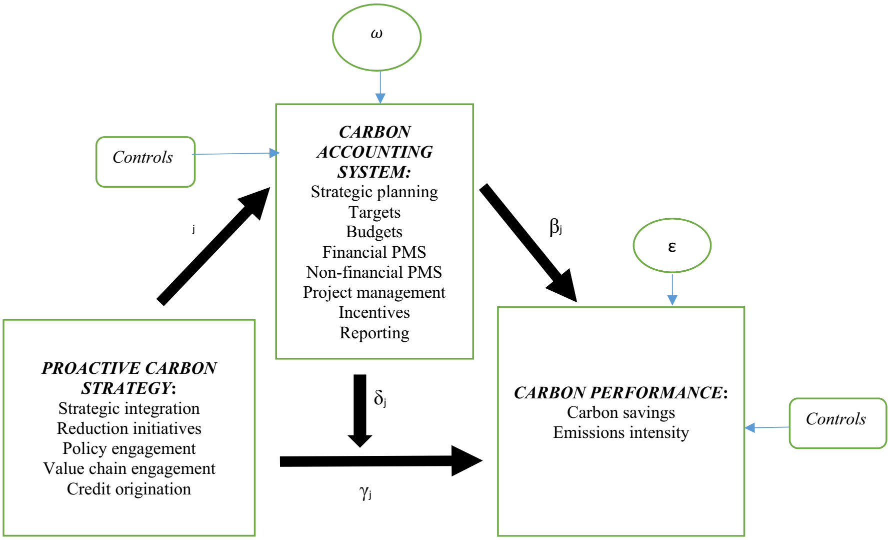

Fig. 1 The key relationships in the study

carbon performance (H_2). Model 3 tests for the direct influence of carbon strategy on carbon performance (H_{3a}), while Model 4 checks the moderating effect of the *CAS* on the carbon strategy-performance relationship (H_{3b}) by including *CAS*, carbon strategy and the interaction term between the two.

These examined relationships are portrayed in Fig. 1.

4.3 Measurement of constructs

4.3.1 The measurement of CAS

This study adopts the scoring methodology recommended by CDP, with minor modifications to assess the quality of the *CAS* (detailed scoring methodology is in Appendix 1). As this is a voluntary reporting scheme of carbon activities and performance, we are constrained by what is available in the CDP questionnaire, and what is disclosed by the responding organisations.

We follow prior literature in developing eight categories of the formal carbon accounting system.[4] Based on Gondet al.[5] (2012) eight components of the *CAS* are formulated: Strategic planning, Targets, Budgeting, Financial measurement system, Non-financial measurement system, Project management methods, Incentive,

[4] Due to data limitations and the structures of CDP questionnaires, we are unable to discern the use of informal controls in carbon management.

[5] Gond et al. (2012) also suggest a hybrid measurement system (such as the balanced scorecard). However, we are not able to construct the measure for this MCS, as firms do not disclose their sustainability balanced scorecard in their CDP responses.

and Reporting. Accordingly, we use strategic planning to ascertain whether carbon issues are integrated into the strategic planning process. As absolute targets are often seen as potential inhibitors of future economic performance and, hence, more difficult to achieve (Ellerman & Wing, 2003; Sue Wing et al., 2006), absolute targets are awarded higher points than intensity targets. Budgets are captured to denote the existence of a carbon budget or fund. The financial measurement system captures the use of financial measures in carbon management, specifically, to determine (i) whether there is an internal price of carbon, and (ii) whether monetary savings are calculated from carbon reduction initiatives. Next, the non-financial measurement system represents the use of non-financial indicators of carbon management. Project management methods check for the adoption of a formal financial-related method (e.g., IRR or NPV) used to drive investments in carbon projects. Incentive captures the existence of some form of evaluation and reward system for carbon mitigation, either financial, non-financial, or both. Finally, based on Burritt et al. (2011) and Simons (1995), we develop the measure: Reporting; to represent the interactive control, i.e., whether carbon information is reported and monitored by the board.

Accordingly, we are able to collect information about eight specific components of the CAS from the CDP questionnaire. This approach is also driven by, and is consistent with, the literature on EMCS and sustainability control systems. These components comprise, arguably, one of the most comprehensive indices in the literature focusing on carbon controls. The *CAS* is a composite index measure ranging in value from 0 to 13, computed by adding up the scores of the eight components.

4.3.2 The measurement of carbon performance

This paper employs two direct measures of carbon performance. Luo and Tang (2016) and Tang and Luo (2014) adopt a relative measure of carbon performance, an index based on four criteria: carbon intensity decline compared to the previous year, carbon intensity lower than the sector's median, at least one of the firm's targets being achieved, and carbon savings realised from at least one of the firm's emissions reduction initiatives. While this captures the likelihood of an improvement in carbon performance, a relative measurement does not capture the extent of improvement. Therefore, we capture the actual carbon performance via two direct measures: (i) *CARSAV*, the amount of estimated annual carbon savings achieved, computed by the natural logarithm of estimated annual CO_2 savings (metric tonnes CO_2) achieved from various initiatives implemented during the reporting year,[6]and (ii) *INTENS*, emissions intensity as computed by totalling scopes 1 and 2 and scaling by revenues. *CARSAV* captures both past carbon savings and on-going savings, hence, providing some perspective on the future carbon performance, while *INTENS* captures the current reporting year's emission level. Both measures are derived from the CDP

[6] To reduce the heteroscedasticity, we transform the actual variable into logs, consistent with Bose et al., (2021).

Table 2 Key constructs and expected signs of the coefficients

	CAS	Carbon performance constructs	
		CARSAV	INTENS
CAS		+ (H_2)	- (H_2)
PROACT	+ (H_1)	+ (H_{3a})	- (H_{3a})
PROACT*CAS		+ (H_{3b})	- (H_{3b})

questionnaire databases, consistent with the approach used prior studies (Chapple et al., 2013; Jung et al., 2018; Luo and Tang, 2014; Safiullah et al., 2021).[7]

4.3.3 The measurement of carbon strategy

Consistent with prior literature and the CDP questionnaire, proactive strategies represent a more proactive stance designed to reduce and offset emissions, or influence the policy-making process (Weinhofer & Hoffman, 2010). Hence, we measure proactive strategy as comprising strategic integration (Lee, 2012), innovation, and cooperation within or beyond the supply chain (Weinhofer & Hoffman, 2010), and political action to influence policy makers on climate change issues (Kolk & Pinkse, 2005; 2007; Jones & Levy, 2007). Strategic integration is represented by the integration of carbon issues into strategic processes (*STRINT*), and its score ranges from 0 to 3. Innovation is proxied by reduction initiatives (*REDINI*), political action by policy engagement (*POLENG*) and credit origination (*CREORI*), which are dummy variables taking the value of 1 should firms participate in any reduction initiatives, have a clear and consistent engagement process with policy matters, and originate their own carbon credits externally, respectively. Cooperation with supply chain partners is proxied by value chain integration (*VALCHA*) and it score ranges from 0 to 2. Proactive strategy (*PROACT*) (ranging from 0 to 8) is measured as the sum of strategy integration, reduction initiatives, policy engagement, value chain integration, and credit origination.

In additional analysis, we check to which extent reactive strategies are associated with performance benefits, as prior research suggests that proactive strategies are more likely to result in performance benefits than reactive strategies (Hart, 1995). Reactive strategies (*REACT*) are those that focus on compensation strategies, and comprise ETS participation and credit purchasing.

Table 2 summarises the expected signs of the coefficients based on the hypotheses.

[7] We are also indebted to one the reviewers for suggesting non-industry-adjusted measurements of carbon performance.

Table 3 Panel A: sample by Country

Country	N	% of N	Country	N	% of N
Australia	60	3.59	Netherlands	33	1.97
Austria	12	0.72	New Zealand	15	0.89
Belgium	7	0.42	Norway	34	2.03
Brazil	27	1.61	Portugal	11	0.66
Canada	89	5.32	Singapore	9	0.54
China	4	0.24	South Africa	88	5.26
Denmark	12	0.72	South Korea	59	3.53
Finland	29	1.73	Spain	47	2.81
France	81	4.84	Sweden	17	1.02
Germany	57	3.41	Switzerland	31	1.85
Hong Kong	11	0.66	Taiwan	32	1.91
Ireland	13	0.78	Thailand	3	0.18
Italy	24	1.43	Turkey	27	1.61
Japan	182	10.88	UK	214	12.79
Mexico	4	0.24	USA	440	26.31
			Total	1672	100

4.3.4 Control variables

SIZE is measured by the natural logarithm of total revenues, which has been found to influence carbon strategy, disclosure/control, and performance significantly (Alrazi et al., 2016; Chapple et al., 2013; Gallego-Álvareza et al., 2015; Journeault, 2016). *ROA* is measured by net income to total assets, as poor profitability may be one factor that limits firms' ability to embrace higher quality carbon accounting systems (Uchida & Ferraro, 2007), and *TOBINSQ* is calculated to control for corporate management capability, as more innovative firms tend to invest in greener products and low-carbon technologies (Clarkson et al., 2015; Daske et al., 2008). Finally, *NEW* is measured by age of the assets of the company.

At the country level, several factors may drive corporate carbon-related strategy and accounting systems. First, developing countries may prioritise economic development (*LNGDP*) over environmental protection (Galeotti, 2007). Second, firms operating in code law (*LAW*) jurisdictions may adopt high quality carbon accounting systems, because such adoption can enable stronger firm-level corporate governance, to offset the weakness in the investor protection mechanism (Tang & Luo, 2014). Third, firms in countries with an *ETS* are subject to more regulatory pressures and, hence, are likely to adopt high quality carbon accounting systems (Tang & Luo, 2014). Hence, three variables, *LNGDP, LAW* and *ETS* are measured and controlled for. The details regarding the measurement of variables are defined in detail in Appendix 1.

Table 4 Panel B: sample by industry

Industry	N	% of N
Consumer discretionary	224	13.40
Consumer staples	168	10.05
Energy	125	7.48
Financials	103	6.16
Health care	88	5.26
Industrials	382	22.85
Information technology	192	11.48
Materials	224	13.40
Telecommunication services	58	3.47
Utilities	108	6.46
Total	1672	100

Table 5 Panel A: descriptive statistics

Variable(s)	Mean	Median	SD	Min	P25	P75	Max
CARSAV	9.90	9.86	1.09	7.90	9.12	10.70	12.00
INTENS	0.03	0.00	0.10	0.00	0.00	0.00	0.45
CAS	6.95	7.00	2.58	0.00	5.00	9.00	13.00
PROACT	5.13	6.00	2.06	0.00	4.00	7.00	8.00
REACT	0.39	0.00	0.59	0.00	0.00	1.00	2.00
SIZE	23.09	22.95	1.56	20.44	21.95	24.14	26.28
ROA	0.04	0.03	0.04	− 0.04	0.01	0.07	0.14
TOBINSQ	0.94	0.72	0.77	0.08	0.37	1.28	2.97
NEW	0.51	0.48	0.16	0.26	0.37	0.62	0.88
LNGDP	28.52	28.53	1.31	26.42	27.56	29.20	30.52
LAW	0.51	1.00	0.50	0.00	0.00	1.00	1.00
ETS	0.84	1.00	0.36	0.00	1.00	1.00	1.00

All variable definitions are in Appendix 1

5 Discussion of empirical results

5.1 Descriptive statistics

Table 3 panel A reports observations across our sample countries. We find that Japan, the United Kingdom, and the U.S.A. have the largest number of firm-year observations (i.e., over 180 each), and they make up around 50% of the total sample. Canada, France, and South Africa have observations over 80.[8] Further, our sample is made up of observations from 30 countries across the globe.

[8] In additional analysis, we removed from our sample countries that have less than 5 observations. Our untabulated results are qualitatively similar to those reported in this paper.

Table 6 Panel B: correlation matrix

	1	2	3	4	5	6	7	8	9	10	11
CARSAV (1)	1										
INTENS (2)	− 0.06	1									
	− 0.01										
CAS (3)	0.23	− 0.05	1								
	(< 0.01)	− 0.06									
PROACT (4)	0.25	− 0.1	0.57	1							
	(< 0.01)	(< 0.01)	(< 0.01)								
REACT(5)	0.32	0.02	0.22	0.24	1						
	(< 0.01)	− 0.43	(< 0.01)	(< 0.01)							
SIZE (6)	0.31	− 0.03	0.31	0.31	0.29	1					
	(< 0.01)	− 0.25	(< 0.01)	(< 0.01)	(< 0.01)						
ROA (7)	− 0.06	− 0.06	− 0.01	− 0.01	− 0.09	− 0.19	1				
	(< 0.01)	− 0.01	− 0.78	− 0.47	(< 0.01)	(< 0.01)					
TOBINSQ (8)	− 0.06	− 0.07	− 0.04	− 0.06	− 0.11	− 0.31	0.72	1			
	(< 0.01)	(< 0.01)	− 0.11	(< 0.01)	(< 0.01)	(< 0.01)	(< 0.01)				
NEW (9)	0.05	− 0.05	− 0.05	0.01	− 0.05	0.03	− 0.03	− 0.13	1		
	− 0.03	− 0.06	− 0.08	(< 0.01)	− 0.02	− 0.16	− 0.11	(< 0.01)			
LNGDP (10)	0.1	− 0.02	0.06	0.02	0.04	0.25	0.13	0.19	− 0.13	1	
	(< 0.01)	− 0.47	− 0.03	− 0.41	− 0.03	(< 0.01)	(< 0.01)	(< 0.01)	(< 0.01)		
LAW (11)	0.02	0.11	0.07	0.06	0.07	− 0.05	− 0.16	− 0.23	− 0.13	− 0.55	1
	− 0.26	(< 0.01)	− 0.01	(< 0.01)	(< 0.01)	− 0.01	(< 0.01)	(< 0.01)	(< 0.01)	(< 0.01)	
ETS (12)	− 0.01	0	0.01	0.07	0.12	0.18	− 0.04	0	− 0.16	0.39	0.22
	− 0.47	− 0.86	− 0.68	(< 0.01)	(< 0.01)	(< 0.01)	− 0.03	− 0.94	(< 0.01)	(< 0.01)	(< 0.01)

All variable definitions are in Appendix 1. Robust *t*-statistics are inbrackets. Variables are defined in Appendix A. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. Variance Inflation Factor (VIF) 2.71

Table 7 Carbon strategy (PROACT), carbon accounting system (CAS) and carbon performance (CP): Baseline results

Variable(s)	CAS	CP					
	Model 1	Model 2		Model 3		Model 4	
		CARSAV	INTENS	CARSAV	INTENS	CARSAV	INTENS
	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)
PROACT	0.6319*** (19.39)			0.0777*** (6.29)	− 0.0055*** (− 3.49)	− 0.0641 (− 1.62)	0.0039 (0.75)
CAS		0.0589*** (4.41)	− 0.0044** (− 2.30)			− 0.0327 (− 1.07)	0.0074 (1.58)
PROACT*CAS						0.0158*** (2.87)	− 0.0019** (− 2.46)
SIZE	0.2552*** (5.67)	0.3761*** (17.23)	− 0.0015 (− 0.55)	0.3578*** (18.56)	− 0.1017 (− 0.88)	0.3729*** (15.58)	0.0016 (0.58)
ROA	2.6549*** (3.88)	0.0762 (0.14)	− 0.0189 (− 0.18)	0.1359 (0.21)	− 0.0544 (− 0.72)	0.3343 (0.36)	− 0.0235 (− 0.22)
TOBINSQ	− 0.1377* (− 1.75)	− 0.0320 (− 0.94)	− 0.0111 (− 1.64)	0.0019 (0.04)	− 0.0100** (− 2.28)	− 0.0762 (− 1.31)	− 0.0106 (− 1.58)
NEW	− 0.0583 (− 0.14)	− 0.2103 (− 1.07)	0–0.0090 (− 0.30)	0.3294** (1.97)	0.0108 (0.54)	− 0.1048 (− 0.51)	− 0.0161 (− 0.55)
LNGDP	0.1602** (2.23)	− 0.0494 (− 1.46)	0.0230*** (4.11)	0.0244 (0.99)	0.0100*** (3.48)	− 0.0398 (− 1.12)	0.0209*** (3.83)
LAW	0.0006 (0.00)	− 0.0136 (− 0.22)	− 0.4829*** (− 5.36)	0.0470 (0.86)	0.0471*** (6.21)	− 0.0237 (− 0.38)	0.0433*** (5.44)
ETS	− 0.3282** (− 2.01)	− 0.2965*** (− 3.90)	0.0018 (0.19)	− 0.3659*** (− 5.20)	0.0063 (0.73)	− 0.3183*** (− 4.13)	0.0048 (0.49)
IND_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	− 7.0429*** (− 3.46)	2.6037*** (2.87)	− 0.5662** (− 3.64)	− 6.1934** (− 2.31)	− 0.2107** (− 2.59)	2.7513*** (2.79)	− 0.6064*** (− 3.87)
Adj R^2	0.5026	0.3864	0.0711	0.3770	0.0588	0.3968	0.0844
N	1672	1489	1672	1489	1672	1489	1672

This table Model 1 reports the Ordinal Logit regressions results of testing the relationship between proactive carbon strategy and carbon accounting system. Models 2 to 4 the dependent variable is carbon performance takes two alternative measures: *CARSAV* (natural logarithm of estimated annual CO_2e savings i.e., metric tonnes CO_2e); and *INTENS* (computed by totalling scope 1 and 2 scaled by revenues). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

The distribution of observations across industries is shown in Table 4 (Panel B). The biggest contributor is industrials (22.85%) followed by Materials (13.40%), and Consumer Discretionary (13.40%) respectively.

Table 5 (Panel A) presents descriptive statistics of all our dependent and explanatory variables. We find that *CARSAV* has mean (median) values of 9.90 (9.86). *INTENS* has mean (median) values of 0.03 (0.00) with a standard deviation 0.10. The mean (median) value of *CAS* is 6.95 (7.00), out of a maximum possible 13 points. This shows that most firms do not adopt extensive carbon accounting systems. Furthermore, *PROACT* has a mean (median) value of 5.1300 (6.000) out of the maximum possible value of 8, indicating most firms adopt a variety of proactive strategic responses. The summary statistics for the control variables are also shown in Table 5 (Panel A).

Table 5, 6, Panel B, presents the Pearson correlation coefficients. It demonstrates positive correlations between *CAS* and *PROACT*. *CAS* is also correlated with *CARSAV*, but not with *INTENS*. *PROACT* have positive correlations with *CARSAV* and *CAS*, and a negative correlation with *INTENS*. Further, we computed Variance Inflation Factors (VIFs 2.71) when estimating our regression models to test for signs of multi-collinearity between the explanatory variables. Thus, multi-collinearity is not a problem in our study (Hair et al., 2006).

5.2 Multivariate regression

5.2.1 The relationship between carbon strategy and carbon accounting systems (H_1)

Table 7 model 1 presents the baseline results regarding the interplay among the strategy-accounting-performance nexus.

PROACT is associated with *CAS* positively and significantly, indicating that more extensive carbon strategy requires a higher quality carbon accounting system (*Coff.* $= 0.6319$, $p < 0.01$).[9] Overall, H_1 is supported. Consistent with an RBV, a *CAS* provides the organizing capability that enables a proactive carbon strategy to be implemented effectively. A proactive strategy requires that an organisation adopts reduction targets, performance measures and regular carbon reporting, and integrates carbon measures into investment decisions in order to realise a proactive strategy aiming at carbon mitigation.

5.2.2 The relationship between the CAS and carbon performance (H_2)

Table 7 model 2 shows the results, with a significantly positive relationship between *CAS* and relative carbon performance (*CARSAV, Coff.* $= 0.0589$, $p < 0.01$), and with emissions intensity (*INTENS, Coff.* $= -0.0044$, $p < 0.05$). This confirms our H_2.

[9] We also ran a regression based on the components of *PROACT* and its relationship to *CAS*. Accordingly, all the strategies have a positive relationship with *CAS*. These results confirm prior studies (Adams & Frost, 2008; Bui & de Villiers, 2017; Pondeville et al., 2013), that the choice of carbon strategy is a significant driver of *CAS* quality.

Accordingly, a high quality CAS is linked to higher annual carbon savings and a reduction in firms' emissions intensity.

These findings are aligned with Journeault et al. (2016) and Luo and Tang (2016), who also found a positive association between environmental/carbon controls and carbon performance.[10]This is consistent with the RBV-focused literature that suggests better environmental (carbon) accounting brings about improved performance.

5.2.3 The relationship between carbon strategy and carbon performance, both direct and moderated by the CAS (H_{3a} and H_{3b})

Table 7 Model 3 shows the results of direct relationships between proactive carbon strategy and carbon performance. *PROACT* is associated positively with both *CARSAV* (*Coff.* $= 0.0777$, $p < 0.01$) and *INTENS* (*Coff.* $= -0.0055$, $p < 0.01$). Overall, this confirms H_{3a} that firms with more proactive carbon strategies achieve higher carbon savings and lower carbon emissions.

While aligning with a RBV perspective on the performance effects of a proactive strategy, our results are inconsistent with prior studies that question the usefulness of carbon management initiatives from a carbon reduction perspective (Damert et al., 2017; Doda et al., 2016). These studies, suggest that firms may do the talking before the walking, suggesting a gap between the talk (i.e., disclosure) and the impact of the actions (emissions reduction). Doda et al. (2016) suggest that firms might have already exploited the potential for emissions reduction before reporting. However, these studies use data prior to 2013 and do not capture proactive carbon strategy directly. Damert et al. (2017) include compensation strategies in the strategy index, while Doda et al. (2016) capture measurement and disclosure practices in the carbon management initiatives. Our study, by differentiating between proactive and reactive strategies, supports the notion that when firms pursue a proactive strategy in carbon management, their carbon performance is improved.

The indirect relationship between strategy and performance is tested via the moderating effect between strategy and *CAS* in Table 7 model 4, where both *CAS* (the moderating variable) and *PROACT* (the independent variable) and the interaction term are included. Accordingly, *CAS* and *PROACT* are no longer associated significantly with carbon performance, but the interaction term *PROACT*CAS* is significantly associated with both measurements of performance. Hence, the presence of high-quality *CAS* strengthens the effect of proactive strategy on carbon savings (*CARSAV, Coff.* $= 0.0158$, $p < 0.01$). However, the negative association of the interaction term and emission intensity (*INTENS, Coff.* $= -0.0019$, $p < 0.05$) indicates that the effect of the combined presence of strategy and *CAS* is less than the sum of the individual effects on performance. In other words, the association between carbon strategy and emission intensity is lessened when firms adopt a higher quality *CAS*. Overall, the signs of the interaction terms are consistent with $H3_b$, that the combination of proactive strategy and high quality *CAS* is associated with higher carbon savings and lower emission intensity.

[10] Tang and Luo (2016) use similar measures of carbon performance.

Accounting for both direct and indirect impacts, the results indicate that carbon strategy has an overall positive relationship with carbon performance, both directly and in the presence of *CAS*. In other words, *CAS* moderates the relationship between carbon strategy and carbon performance.

5.2.4 Control variables

Table 7 indicates that firms with higher quality CASs tend to be bigger in size, and to operate in countries with a code law system. Further, based on Table 7 model (4), which controls for both *CAS* and carbon strategy, firms with more annual carbon savings (*CARSAV*) tend to be bigger in size and operate in countries without an *ETS*, while firms with higher emissions intensity (*INTENS*) operate in countries with higher economic development and a common law system. This confirms the role played by a voluntary context (no *ETS* regulation) in encouraging firms to adopt carbon mitigation initiatives and achieve carbon savings, while a code law system is more conducive to lower emissions intensity.

5.3 Additional analysis

Prior research also indicates that carbon strategies can be reactive or proactive (Jones & Levy, 2007; Kolk & Pinkse, 2005; Weinhofer & Hoffmann, 2010). Proactive strategies are more likely to result in performance benefits than reactive strategies (Hart, 1995). Table 8 model 1 show that *REACT* is associated with *CAS* positively and significantly, indicating that more extensive carbon strategy requires a higher quality carbon accounting system (*Coff.* $= 0.3725$, $p < 0.01$).[11]

Table 8 model 1 indicates that a high-quality CAS is needed, whether firms follow a proactive or a reactive carbon strategy. Two explanations are possible here. First, it is established by existing research that strategy (regardless of being proactive or reactive) influences accounting systems (Arjaliès & Mundy, 2013; Langfield-Smith, 2005). Second, some form of CAS is needed to account for carbon-related activities, even though those activities involve credit purchase or emissions trading (reactive strategies).

Further, results in Table 8 model 3 show that reactive strategy is linked to carbon savings (*REACT, Coff.* $= 0.1722$, $p < 0.01$) but has no relationship with emission intensity (*REACT, Coff.* $= 0.0019$, $p > 0.1$). No significant interaction terms in model (4) also suggest an absence of a moderating effect of *CAS* on reactive strategy-performance relationship. Overall, this confirms the lack of a clear association between reactive strategy and performance, partially explaining why earlier studies have not found a relationship between a composite strategy and carbon performance (Damert et al., 2017; Doda et al., 2016).

[11] We also ran a regression based on the components of *PROACT* and its relationship to *CAS*. Accordingly, all the strategies have a positive relationship with *CAS*. These results confirm prior studies (Adams & Frost, 2008; Bui & de Villiers, 2017; Pondeville et al., 2013) that the choice of carbon strategy is a significant driver of *CAS* quality.

Table 8 Carbon strategy, carbon accounting system and carbon performance: reactive strategy

Variable(s)	CAS	Carbon performance (CP)			
	Model 1	Model 3		Model 4	
		CARSAV	*INTENS*	*CARSAV*	*INTENS*
	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)
REACT	0.3725*** (3.45)	0.1722*** (4.43)	0.0019 (0.34)	0.1322 (1.01)	− 0.0068 (− 0.35)
CAS				0.0791*** (5.74)	− 0.0039** (− 2.58)
REACT*CAS				0.0017 (0.09)	0.0015 (0.58)
SIZE	0.4894*** (9.14)	0.3676*** (18.96)	− 0.0054*** (− 2.66)	0.3373*** (17.14)	− 0.0036* (− 1.72)
ROA	1.8379 (0.91)	0.0627 (0.09)	− 0.0557 (− 0.75)	0.0552 (0.08)	− 0.0571 (− 0.77)
TOBINSQ	0.0049 (0.04)	0.0222 (0.51)	− 0.0112*** (− 2.59)	0.0058 (0.13)	− 0.0100** (− 2.31)
NEW	− 0.7278 (− 1.50)	0.3668** (2.17)	0.0128 (0.65)	0.3692** (2.21)	0.0149 (0.75)
LNGDP	1.8534 (1.07)	0.0193 (0.78)	0.0109*** (3.75)	0.0127 (0.52)	0.0113*** (3.89)
LAW	− 3.0571 (− 1.26)	0.0381 (0.69)	0.0452*** (5.93)	0.0308 (0.56)	0.0462*** (6.11)
ETS	− 5.0119* (− 1.69)	− 0.3771*** (− 5.33)	0.0052 (0.60)	− 0.3661*** (− 5.23)	0.0049 (0.57)
IND_FE	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes
COUNTRY_FE	Yes	Yes	Yes	Yes	Yes
Constant	− 52.5934 (− 1.14)	0.8320 (1.26)	− 0.1762* (− 2.13)	1.2557* (1.92)	− 0.2073*** (2.56)
Adj R^2	0.3496	0.3700	0.0506	0.3862	0.0546
N	1672	1489	1672	1489	1672

This table Model 1 reports the Ordinal Logit regressions results of testing the relationship between reactive carbon strategy and carbon accounting system. Models 3 and 4 the dependent variable is carbon performance takes two alternative measures: *CARSAV* (natural logarithm of estimated annual CO2e savings i.e., metric tonnes CO2e); and *INTENS* (computed by totalling scope 1 and 2 scaled by revenues). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

In Table 9 model 5,[12] when we include *REACT* and *PROACT* and their interaction terms with CAS in the same regression, the results hold that only proactive strategy has an indirect relationship with both measures of carbon performance via the moderating impact of CAS (*CARSAV Coff.* $=0.0630$, $P<0.01$; *INTENS, Coff.* $= -0.1898$, $p<0.05$). However, no such indirect relationship exists when firms adopt a reactive strategy.

For robustness tests, we also adopt alternative measurements for carbon performance, when scaled by total assets, consistent with Chapple et al. (2013), Jung et al. (2018), Luo and Tang (2014) and Safiullah et al. (2021), and common shares outstanding, consistent with He et al. (2021). The results reported in Table 10 model 4 are qualitatively similar to our main results, confirming the existence of the moderating effect of *CAS* on the strategy-performance relationship.

We further divide the sample into carbon intensive and carbon non-intensive firms based on the emitting nature of the industry in which a firm operates (Safiullah et al., 2021). According to CDP, we identify carbon intensive firms as high carbon emission or energy consuming industries (energy, utilities and materials sectors are defined as the most carbon-intensive firms). Results in Table 11 model 4 suggest the interaction term is associated with carbon savings among carbon intensive firms (*Coff.* $=0.0262$, $p<0.05$), while the association with emission intensity is observed only among carbon non-intensive firms (*Coff.* $= -0.0019$, $p<0.05$). Hence, *CAS* has the ability to strengthen the impact of strategy on carbon savings in polluting firms, whereas its presence in less polluting firms may reduce the effect of strategy. This is possibly due to the already low level of emission intensity, such that the adoption of more extensive *CAS* may not enable significantly more reduction in emission levels.

Our main analyses focus on the relationship from carbon strategy to *CAS*, and from carbon strategy and *CAS* to carbon performance. However, it is possible that two-way relationships may exist. Specifically, carbon accounting systems may also have an impact on carbon strategy. We run a lagged model for *CAS* and *PROACT* [13] and in Table 12 model 6 show that *CAS* is associated with *PROACT* positively (*Coff.* $=0.2991$, $p<0.01$), indicating that a higher quality CAS may support proactive carbon strategy in the following year. Thus, arguably, measuring carbon emissions might result in increased emissions awareness among employees and managers who, in turn, might change organisational operations and strategies over time. Hence, introducing a good CAS may lead to increased awareness, and support the move to a more proactive strategy.

[12] $\Sigma CP = \delta_0 + \delta_1 CAS + \delta_2 PROACT + \delta_3 REACT + \delta_4 CAS * PROACT + \delta_5 CAS * REACT + \sum \text{Control}_{it} + \text{FE}_{it} + \varepsilon_{it} (5)$

[13] $\text{PROACT}_{it\,(2015)} = \alpha_0 + \alpha_1\,\text{CAS}_{it\,(2014)} + \sum \text{Control}_{it} + \text{FE}_{it} + \varepsilon_{it.}$

Table 9 Carbon strategy, carbon accounting system and carbon performance: both proactive and reactive strategies

Variable(s)	Model 5	
	CARSAV	*INTENS*
	Coefficient (t-value)	Coefficient (t-value)
PROACT	– 0.3819** (– 2.10)	0.9721 (1.30)
REACT	0.2326*** (3.28)	– 0.1711 (– 0.87)
CAS	0.0896 (1.12)	0.0824 (1.30)
PROACT*CAS	0.0630*** (2.73)	– 0.1898** (– 2.36)
REACT*CAS	– 0.0585 (– 0.67)	0.2318 (1.06)
SIZE	0.3784*** (16.17)	– 0.0993 (– 1.31)
ROA	– 0.0637 (– 0.07)	4.6720* (1.75)
TOBINSQ	– 0.1156** (– 2.08)	– 0.1673 (– 0.92)
NEW	0.1499 (0.77)	– 0.0285 (– 0.04)
LNGDP	– 0.0733** (– 2.08)	0.4617** (4.52)
LAW	– 0.0676 (– 1.03)	– 0.3107 (– 1.58)
ETS	– 0.3811*** (– 4.76)	0.4647** (2.01)
IND_FE	Yes	Yes
YEAR_FE	Yes	Yes
Constant	3.7296*** (3.75)	– 8.1311*** (2.65)
Adj R^2	0.3635	0.0920
N	1489	1672

Table 9 reports the OLS regressions results of testing the relationship between carbon strategy, carbon accounting system and carbon performance. The dependent variable is carbon performance takes two alternative measures: *CARSAV* (natural logarithm of estimated annual CO2e savings i.e., metric tonnes CO2e); and *INTENS* (computed by totalling scope 1 and 2 scaled by revenues). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

We also run lagged models to test for the association between carbon performance (as independent variable) and carbon strategy and *CAS*.[14] Results show that firms with higher carbon savings may support proactive carbon strategies (*Coff. = 0.1686, p < 0.1, Model 7*) and a higher quality CASs (*Coff. = 0.3016, p < 0.01, Model 9*) in the following year. Similarly, firms with lower emission intensities adopt more proactive carbon strategies (*Coff. = – 0.2.0163, p < 0.05, Model 8*) and higher quality CASs (*Coff. = – 1.9934, p < 0.05, Model 10*). Hence, emissions reduction in the previous year provides the motivation for firms to move to proactive carbon management, in the form of more extensive strategies, or higher quality CASs.

[14] Lagged models are: $\text{PROACT}_{\text{it (2015)}} = \alpha_0 + \alpha_1\ \text{CARSAV}_{(2014)} + \sum \text{Control}_{\text{it}} + \text{FE}_{\text{it}} + \varepsilon_{\text{it}}$
$\text{PROACT}_{\text{it (2015)}} = \alpha_0 + \alpha_1\ \text{INTENS}_{(2014)} + \sum \text{Control}_{\text{it}} + \text{FE}_{\text{it}} + \varepsilon_{\text{it}}$
$\text{CAS}_{\text{it (2015)}} = \alpha_0 + \alpha_1\ \alpha_2\ \text{CARSAV}_{(2014)} + \sum \text{Control}_{\text{it}} + \text{FE}_{\text{it}} + \varepsilon_{\text{it}}$
$\text{CAS}_{\text{it (2015)}} = \alpha_0 + \alpha_1\ \alpha_2 \text{INTENS}_{\text{it (2014)}} + \sum \text{Control}_{\text{it}} + \text{FE}_{\text{it}} + \varepsilon_{\text{it}}$

Table 10 Carbon strategy, carbon accounting system and carbon performance: alternative measures of carbon performance

Variable(s)	Panel A: *CRASAV* and *INTENS* scaled by total assets		Panel B: *CRASAV* and *INTENS* scaled by common shares outstanding	
	Model 4		Model 4	
	CARSAV	*INTENS*	*CARSAV*	*INTENS*
	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)	Coeff. (*t*-value)
PROACT	– 0.0643 (– 1.61)	0.0041 (0.78)	– 0.0691* (– 1.69)	0.0037 (0.92)
CAS	– 0.0331 (– 1.31)	0.0077 (1.61)	– 0.0332 (– 1.42)	0.0083 (1.61)
PROACT*CAS	0.0159*** (2.93)	– 0.0018** (– 2.49)	0.0163*** (2.99)	– 0.0017** (– 246)
SIZE	0.3040*** (15.01)	– 0.0037** (– 1.73)	0.3936*** (16.12)	0.0021 (0.72)
ROA	0.0498 (0.09)	– 0.0561 (– 0.71)	0.3100 (0.30)	– 0.0241 (– 0.49)
TOBINSQ	0.0056 (0.19)	– 0.0111*** (– 2.62)	– 0.0861 (– 1.42)	– 0.0110 (– 1.63)
NEW	0.3941*** (2.98)	0.0151 (0.92)	– 0.1157 (– 1.11)	– 0.0169 (– 0.72)
LNGDP	0.0110 (0.78)	0.0127*** (4.12)	– 0.0381 (– 1.01)	0.0221*** (4.12)
LAW	0.0298 (0.89)	0.0434*** (5.12)	– 0.0211 (– 0.36)	0.0427*** (4.89)
ETS	– 0.3994*** (– 6.28)	0.0037 (0.27)	– 0.3113*** (– 4.01)	0.0037 (0.42)
IND_FE	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes
COUNTRY_FE	Yes	Yes	Yes	Yes
Constant	1.2871** (1.97)	– 0.3089*** (2.72)	2.6571*** (2.81)	– 0.7244*** (– 3.92)
Adj R^2	0.3911	0.0821	0.4011	0.1010
N	1672	1489	1489	1672

Table 10 reports the OLS regressions results of testing the relationship between carbon strategy, carbon accounting system and carbon performance. In Panel A the dependent variable is carbon performance takes two alternative measures: *CARSAV* (total estimated annual $CO2_e$ savings scaled by total assets); and *INTENS* (computed by totalling scope 1 and 2 scaled by total assets). In Panel B the dependent variable is carbon performance takes two alternative measures: *CARSAV* (total estimated annual $CO2_e$ savings scaled by common sharesoutstanding); and *INTENS* (computed by totalling scope 1 and 2 scaled by common shares outstanding). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

Combining this with our main results, we make two complementary arguments. On the one hand, CASs and carbon strategies appear to incentivise emissions mitigation and carbon savings. The presence of a high quality CAS moderates the relationship between carbon strategy and carbon performance, enabling a stronger effect of proactive strategy on achieving annual carbon savings, whilst lessening the impact of strategy with regards to lowering emission intensity. On the other hand, improved carbon performance incentivises firms to adopt more extensive carbon strategies and

Table 11 Carbon strategy, carbon accounting system and carbon performance: Carbon intensive vs non-intensive firms

Variable(s)	Panel A: Carbon intensive firms		Panel B:: Carbon non-intensive firms	
	Model 4		Model 4	
	CARSAV	*INTENS*	*CARSAV*	*INTENS*
	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)
PROACT	– 0.0981 (– 1.38)	0.0106 (1.18)	0.0083 (0.23)	0.0017 (0.28)
CAS	– 0.0948 (– 1.18)	0.0037 (0.51)	0.0230 (0.79)	0.0081 (1.47)
PROACT*CAS	0.0262** (2.12)	– 0.0018 (– 1.53)	0.0091 (1.63)	– 0.0019** (– 1.99)
SIZE	0.3057*** (7.21)	0.0014 (0.37)	0.3531*** (16.32)	0.0007 (0.18)
ROA	0.6230 (0.49)	– 0.0850 (– 0.61)	0.0170 (0.02)	– 0.0038 (– 0.02)
TOBINSQ	– 0.1484 (– 1.40)	– 0.0008 (– 0.08)	0.0161 (0.34)	– 0.0103 (– 1.22)
NEW	– 0.4065 (– 1.16)	– 0.0105 (– 0.17)	0.5206*** (2.76)	– 0.0313 (– 0.98)
LNGDP	0.0200 (0.44)	0.0049 (0.46)	– 0.0003 (– 0.01)	0.0285*** (4.53)
LAW	– 0.0400 (– 0.35)	0.0074 (0.47)	0.0400 (0.64)	0.0617*** (7.01)
ETS	– 0.6491*** (– 5.28)	0.0300** (2.07)	– 0.2235*** (– 2.57)	– 0.0132 (– 1.05)
IND_FE	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes
COUNTRY_FE	Yes	Yes	Yes	Yes
Constant	3.9872*** (2.71)	– 0.1725 (– 0.60)	1.1741 (1.48)	– 0.7937*** (– 4.26)
Adj R^2	0.0430	0.0430	0.3491	0.1194
N	627	881	1045	608

Table 11 reports the OLS regressions results of testing the relationship between carbon strategy, carbon accounting system and carbon performance. In Panel A and B the dependent variable is carbon performance takes two alternative measures: *CARSAV* (natural logarithm of estimated annual CO2e savings i.e., metric tonnes CO2e); and *INTENS*(computed by totalling scope 1 and 2 scaled by revenues). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

high-quality CASs. This can be driven by competitiveness and concern to differentiate in the marketplace via extensive carbon management.

Finally, in order to ensure that uneven country representation in our study does not drive the results, we re-estimate the models by i) excluding USA firm-year observations; ii) excluding the top 3 countries, being USA, UK and Japan. The results reported (Model 4) in Table 13 are similar to the results reported in Table 7, in terms of both the sign and statistical significance on the test variables of interest. We, thus, conclude that excluding the top countries does not drive/affect the results. Furthermore, Bose et al., (2021) suggest that investor protection (*INV_PRO*) can increase carbon regulatory oversight and hence this can effect firms' incentives to manage their carbon performance. Hence, we add an additional country variable, being investor protection

Table 12 Carbon strategy, carbon accounting system and carbon performance: lagged analysis

Variable(s)	Model 6	Model 7	Model 8	Model 9	Model 10
	$Dep = PROACT_{2015}$	$Dep = PROACT_{2015}$	$Dep = PROACT_{2015}$	$Dep = CAS_{2015}$	$DEP = CAS_{2015}$
	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)
CAS_{t-1}	0.2991*** (6.55)				
$CARSAV_{t-1}$		0.1686* (1.67)		0.3016*** (2.77)	
$INTENS_{t-1}$			− 2.0163** (− 2.36)		− 1.9934** (− 2.09)
SIZE	0.4143*** (5.83)	0.5041*** (6.32)	0.5701*** (7.19)	0.3682*** (4.29)	0.4954*** (5.60)
ROA	− 4.7041* (− 1.70)	− 7.0527** (− 2.34)	− 6.2294* (− 1.90)	− 3.4784 (− 1.07)	− 6.4609* (− 1.76)
TOBINSQ	0.2025 (1.05)	0.3401 (1.64)	0.5079** (2.19)	0.3762* (1.68)	0.5620** (2.17)
NEW	− 0.9033 (− 1.39)	− 1.6434** (− 2.38)	− 1.0354 (− 1.36)	− 0.9995 (− 1.34)	− 0.6539 (− 0.77)
LNGDP	0.2299 (0.09)	− 0.8560 (− 0.32)	1.8397 (0.64)	3.5742 (1.25)	5.0330 (1.57)
LAW	1.2005 (0.61)	0.1476 (0.07)	2.7856 (1.19)	2.3285 (1.03)	3.9403 (1.50)
ETS	0.1935 (0.17)	− 0.2477 (− 0.20)	0.3016 (0.22)	− 0.0031 (− 0.00)	0.9183 (0.60)
IND_FE	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes
COUNTRY_FE	Yes	Yes	Yes	Yes	Yes
Constant	− 14.0437 (− 0.20)	15.7064 (0.21)	− 60.5433 (− 0.75)	− 106.2872 (− 1.31)	− 147.0258 (− 1.62)
Adj R^2	0.2663	0.1946	0.2021	0.3125	0.2932
N	836	746	836	746	8.36

Table 12 reports the lagged regressions results of testing the relationship between Carbon strategy, carbon accounting system and carbon performance. Model 5 to 7 the dependent variable is $PROACT_{2015.}$ Models 8 to 9 the dependent variable is $CAS_{2015.}$ All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

INV_PRO in model 4.. The results in Table 13 also suggest that firms in countries with higher investor protection are more likely to achieve carbon savings and lower emissions intensity.

5.4 Endogeneity

In most business studies, endogeneity is a major issue owing to omitted variables, simultaneity, and the correlation between the explanatory variables and the error term in a regression model (Li, 2016). Endogeneity leads to inconsistent and biased estimates of the explanatory variables. Li (2016) demonstrates that the GMM has the greatest correction effect on the bias, followed by instrumental variables, fixed effect models, lagged dependent variables, and the addition of more control variables. Accordingly, we re-estimated our most comprehensive model (Model 4) using the dynamic GMM as developed by Blundell and Bond (1998) and applied by others (e.g., Al-Najjar & Belghitar 2011; El Ghoul et al., 2011; Eliwa et al., 2021). The results in Table 14 show that the variable *PROACT*CAS* is positive and significant for *CARSAV* (*Coff.* $=0.0069$, $p<0.05$) and negative and significant for *INTENS* (*Coff.* $= -0.0019$, $p<0.01$). In Table 14, the results for the control variables are broadly consistent with the main results. Overall, this suggests that the endogeneity issues are not likely to influence our main findings.

6 Conclusions

Carbon emissions bring risks and opportunities to organisations (Bebbington & Larrinaga-González, 2008; Cadez & Czerny, 2016; Bui and Villiers, 2017), and organisations adopt different strategies and environmental control systems, such as CASs. However, existing research has provided limited insights into the influence of carbon strategy and CASs in improving carbon performance (that is, reducing carbon emissions and increasing carbon savings). This paper analyses the three-way relationship between strategy-accounting-performance in the context of climate change issues, by drawing upon the CDP database for 2014 and 2015. In doing so, it provides three contributions to the literature.

Firstly, a CAS is useful in achieving carbon savings and reducing emissions intensity and, hence, plays a positive role in the fight against climate change, at least at the corporate level. Furthermore, a high quality CAS is associated with both proactive and reactive strategies and, hence, supports the significant role played by CASs in implementing different strategies and initiatives undertaken by corporations. Different from prior studies that are limited to one or several countries, or examine only a few components of carbon accounting (Tang and Luo, 2014; Wijethilake et al., 2016; Qian et al., 2018) we provide cross-country evidence of the association between CASs and carbon performance, using a comprehensive index of carbon accounting and an international dataset that spans 30 countries. We argue that in order to motivate high carbon performance, a high-quality comprehensive CAS needs to be properly designed and used. Our comprehensive CAS includes components such as

Table 13 Carbon strategy, carbon accounting system and carbon performance: Excluding USA, excluding USA, UK and Japan, additional country-level variable, investor protection

Variable(s)	Model 4					
	Excluding USA		Excluding USA, UK and Japan		Additional country level variable	
	CARSAV	INTENS	CARSAV	INTENS	CARSAV	INTENS
	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)	Coefficient (t-value)
PROACTIVE	− 0.0641 (− 1.62)	0.0025 (0.57)	− 0.2512 (− 1.31)	0.8518 (1.42)	− 0.2532 (− 1.30)	0.7954 (1.26)
CAS	− 0.032 (− 1.07)	0.0068 (1.45)	0.0351* (1.95)	0.0901 (1.46)	0.0422** (2.23)	0.0867 (1.30)
PROACT*CAS	0.0158*** (2.87)	− 0.0018*** (− 2.31)	0.0467* (1.87)	− 0.1707** (− 2.16)	0.0468* (1.81)	− 0.1569* (− 1.87)
SIZE	0.3729*** (15.58)	0.0013 (0.54)	0.4035*** (18.15)	− 0.0903 (− 1.33)	0.3971*** (17.68)	− 0.1055 (− 1.52)
ROA	0.3342 (0.36)	− 0.0238 (− 0.26)	− 0.0476 (− 0.05)	4.2889 (1.62)	− 0.3183 (− 0.34)	3.5489 (1.29)
TOBINSQ	− 0.0762 (− 1.31)	− 0.0094 (− 1.57)	− 0.1315** (− 2.33)	− 0.1740 (1.00)	− 0.1457** (− 2.59)	− 0.1862 (− 1.03)
NEW	− 0.1047 (− 0.51)	− 0.0066 (− 0.27)	0.1259 (0.64)	− 0.0356 (− 0.06)	0.1256 (0.61)	− 0.2116 (− 0.34)
LNGDP	− 0.0397 (− 1.12)	0.0221** (4.38)	− 0.0755** (− 2.14)	0.4486*** (4.54)	− 0.1087*** (− 2.75)	0.5142*** (4.68)
LAW	− 0.0237 (− 0.38)	0.0371*** (5.22)	− 0.0670 (− 1.01)	− 0.2793 (− 1.43)	− 0.0478 (− 0.68)	− 0.3495 (− 1.62)
ETS	− 0.3182*** (− 4.13)	− 0.0012 (− 0.14)	− 0.3489*** (− 4.33)	0.3939* (1.79)	− 0.2329* (− 2.01)	0.2879 (1.00)
INV_PRO					0.1289*** (4.47)	− 0.1019** (− 2.47)
IND_FE	Yes	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes	Yes
COUNTRY_FE	Yes	Yes	Yes	Yes	No	No
Constant	2.7512*** (2.79)	− 0.6234*** (4.31)	3.1351*** (3.14)	− 7.6210** (− 2.56)	4.0207*** (3.69)	− 8.7673*** (− 2.71)
Adj R2	0.3968	0.0751	0.3534	0.0717	0.3668	0.0729
N	1028	1232	698	836	1489	1672

Table 13 reports the OLS regressions results of testing the relationship between carbon strategy, carbon accounting system and carbon performance. The dependent variable is carbon performance takes two alternative measures: *CARSAV* (natural logarithm of estimated annual CO2e savings i.e., metric tonnes CO2e); and *INTENS* (computed by totalling scope 1 and 2 scaled by revenues). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

Table 14 Carbon strategy, carbon accounting system and carbon performance: the endogeneity tests (GMM)

Variable(s)	Model 4	
	CARSAV	*INTENS*
	Coefficient (t-value)	Coefficient (t-value)
PROACT	0.0189 (0.44)	0.0061 (1.43)
CAS	0.0015 (0.04)	0.0054 (1.15)
PROACT*CAS	0.0069** (1.98)	– 0.0019*** (– 2.77)
SIZE	0.1547 (5.18)	0.0007 (0.22)
ROA	0.6209 (0.74)	0.1451 (1.14)
TOBINSQ	– 0.0348 (– 0.65)	– 0.0227*** (– 3.31)
NEW	0.1976 (0.94)	0.0040 (0.12)
LNGDP	– 0.0276 (– 0.90)	0.0108** (2.44)
LAW	– 0.0311 (– 0.46)	0.0369*** (3.08)
ETS	– 0.1836** (– 1.99)	0.0161 (1.33)
Lag CARSAV	0.6185*** (17.06)	
Lag INTENS		0.8444*** (15.98)
Constant	0.9566 (1.33)	0.2625 (0.25)
IND_FE	Yes	Yes
YEAR_FE	Yes	Yes
COUNTRY_FE	Yes	Yes
N	898	808

Table 11 reports the GMM results of testing the relationship between carbon strategy, carbon accounting system and carbon performance. The dependent variable is carbon performance takes two alternative measures: *CARSAV* (natural logarithm of estimated annual CO2e savings i.e., metric tonnes CO2e); and *INTENS* (computed by totalling scope 1 and 2 scaled by revenues). All variable definitions are in Appendix 1

***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively (two-tailed tests)

strategic planning, financial and non-financial performance measures, targets, budgets, project management methods, incentive systems and reporting. Such a comprehensive CAS will provide a basis for best practices in carbon management to be developed and disseminated.

Secondly, the paper highlights the positive relationships between proactive carbon strategies and carbon performance, via enhancing carbon savings and lowering emission intensity. Whilst prior studies either imply (Clarkson et al., 2011) or examine a single country context (Moussa et al., 2020), we contribute empirical evidence in an international context of the role played by proactive carbon strategies. A carbon strategy helps develop and nurture the unique resources and capabilities that, in turn, improve carbon performance. This applies to proactive strategies that encompass strategic integration, reduction initiatives, policy engagement, value chain engagement and carbon credit origination. However, when firms adopt reactive strategies such as emissions trading and credit purchase, the association applies only to annual carbon savings and not to current year's emission intensity. Hence, we argue that proactive carbon strategy provides a better driver for both past and future carbon performance.

Thirdly this study is arguably the first to provide empirical evidence regarding the moderating impact of CASs on the strategy-performance relationship. Most prior empirical studies have found a positive association between CASs and performance, but have not considered strategy as a driver. We found that a higher quality CAS helps proactive strategy to have more pronounced impact on carbon savings among polluting firms. Hence, we tentatively argue that there is more value to be gained for polluting firms to improve the quality of their CAS, as this will allow proactive strategy to achieve more annual carbon savings.

This study has four main implications for practice. First, it provides insights to managers and practitioners into the significance of a high quality CAS in pursuing a strategy. It is argued that no matter what strategy a firm pursues, a high-quality CAS is essential for its effective implementation as CAS is needed to account for and manage carbon related activities. Second, a high quality CAS also contributes to the improvement of carbon performance. This will encompass a suite of carbon measures, for example, targets, budgets, incentives, strategic planning and project management methods. In other words, the more formalised a CAS, the more likely it is that firms will achieve a stronger carbon performance. Third, proactive strategies should be pursued to achieve ongoing carbon savings and lower emission intensity. Policymakers wishing to promote carbon mitigation will need to focus on schemes or mechanisms that encourage firms to undertake proactive strategies, including strategic integration, reduction initiatives, and credit origination, rather than to participate in emissions trading or credit purchase activities, which may not have an impact on emission intensity levels. Fourth, the moderating role of CASs indicates that firms that wish to achieve performance enhancement should consider establishing an appropriate CAS, so that when used in combination with a proactive strategy, higher performance outcomes result, compared with those potentially achieved under a proactive strategy alone.

This study is subject to some limitations. Firstly, we focus on disclosure-derived carbon accounting mechanisms and, hence, we cannot make assertions regarding internally derived carbon accounting; for instance, those that are not reported in the CDP, or not reported accurately. Secondly, there might be reservations regarding the accuracy of the emissions data voluntarily disclosed by firms.[15]Thirdly, we examine only those firms that responded to CDP within a limited timeframe (from 2013 to 2015). Given that reducing carbon emissions may require investments (e.g., in renewable energy to replace fossil fuel burning), a lag over several years has to be considered. A longitudinal study would therefore be needed to analyse whether or not CASs help to improve performance. Fourthly, our use of a disclosure-based database limits the insights into internal strategies and operations of organisational

[15] However, 50% of firms responding to CDP in 2014 and 55% to CDP in 2015 have third-party assurance for their emissions inventory (another 8% and 7% respectively had assurance underway, but this was incomplete in the reporting year) (authors' analysis).

carbon management. We are also unable to discern the presence and use of informal controls, such as peer pressures or culture, towards carbon management objectives. Independent surveys or case studies into both responding and non-responding firms may provide interesting comparative and in-depth insights, especially regarding the process of carbon accounting and strategy. To provide more comprehensive understanding of the three-way interaction between strategy-accounting-performance in achieving the carbon management objectives of organisations, future research can address these limitations through a wider inclusion of time periods, firms, and variables.

Appendix 1 Variable definition

Name	Variable(s)	Descriptions	Data source	Measurements	Scores
Carbon Performance	CARSAV	Carbon savings	CDP 2014–2015	Computed by the natural logarithm of estimated annual CO2e savings (metric tonnes CO2e) available from CDP questionnaires 2014–2015 i.e., CC3.3b	
	INTENS	Emission intensity	CDP 2014–2015	Computed by totalling scope 1 and 2 scaled by revenues	
Carbon Accounting System	CAS	Index measure of quality of CAS	CDP 2014–2015	Computed by totalling the proxies of eight CAS's sub-categories below	0–13
		Strategic planning	CDP 2014–2015	C.C2.2 a Is there any process for strategic planning, Yes 1 point, 0 otherwise	0–1
		Emission reduction targets		CC3.1a and CC 3.1b	0–2

Name	Variable(s)	Descriptions	Data source	Measurements	Scores
				Are there any emission reduction targets? 2 points for absolute targets, 1 point for intensity targets, 0 point for no target adopted	
		Carbon budget	CDP 2014–2015	CC3.3c What methods are used to drive investment in emissions? 1 point for a budget-related methods, 0 otherwise	0–1
		Financial performance measures	CDP 2014–2015	CC3.3c What methods do you use to drive investment in emissions? 1 point if an internal price of carbon is used, 0 otherwise	0–2
				CC3.3b. Is there a non-zero monetary savings derived from carbon reduction initiatives? 1 point for yes, 0 otherwise	
		Non-financial performance measures	CDP 2014–2015	CC1.2a. Is there emissions/energy/efficiency related performance indicators? 1 point for yes, 0 otherwise	0–3
				Is there energy related performance indicators used? 1 point for yes, 0 otherwise	

Name	Variable(s)	Descriptions	Data source	Measurements	Scores
				Is there efficiency related performance indicators used? 1 point for yes, 0 otherwise	
		Project management methods	CDP 2014–2015	CC3.3c What are the methods used to drive investment in emissions? 1 point if financial related methods are used, 0 otherwise	0–1
		Incentive system	CDP 2014–2015	CC1.2a. Is there is some type of incentives or entitlements for carbon performance? 1 point for either a monetary, non-monetary or both type of incentives, 0 if none	0–1
		Reporting of carbon information	CDP 2014–2015	C.C2.1.a Are results reported to the board? 1 point for yes, 0 otherwise	0–2
				C.C.2.1.b. Are risks reported annually or more frequently? 1 point for yes, 0 otherwise	
Carbon strategy	PROACT	Proactive carbon strategy	CDP 2014–2015	Composite measure of the following five components	0–8
		Strategic integration	CDP 2014–2015	CC 2.2a Short term strategy example 1, long term strategy Example 1, substantial business decisions 1	0–3

Name	Variable(s)	Descriptions	Data source	Measurements	Scores
		Reduction initiatives	CDP 2014–2015	CC3.3 Did you have emissions reduction initiatives that were active within the year yes 1 otherwise 0	0–1
		Policy engagement	CDP 2014–2015	CC2.3 h. What processes do you have in place to ensure that all of your direct and indirect activities that influence policy are consistent with your overall climate change strategy? If there is a process 1 otherwise 0	0–1
		Value chain engagement	CDP2014–2015	CC14.4a. Please give details of methods of engagement, your strategy for prioritizing engagements and measures of success (if method of engagement described 1 otherwise 0, if strategy for prioritizing or measurement of success available 1 otherwise 0	0–2
		Credit origination	CDP 2014–2015	CC 13.2a. Please provide details on the project-based carbon credits: if credit origination (at least 1) 1 otherwise 0	0–1
	REACT	Reactive carbon strategy	CDP 2014–2015	Composite measure of the following two components	0–2

Name	Variable(s)	Descriptions	Data source	Measurements	Scores
		Emissions trading	CDP 2014–2015	CC13.1 Do you participate in any emissions trading schemes if yes 1 otherwise 0	0–1
		Credit purchase	CDP 2014–2015	CC 13.2a. Please provide details on the project-based carbon credits: if credit purchase (at least 1) 1 otherwise 0	0–1
Controls	SIZE	Firm size	DataStream	Natural logarithm of total revenue	
	ROA	Return on Assets	DataStream	Calculated as the ratio of net income to total assets	
	TOBINSQ	Innovation capability	DataStream	Computed by dividing book value of total assets by firm's market value	
	NEW	Newness of assets		Age of assets	
	LNGDP	A country's economic development	The World Bank (2015)	Natural logarithm of gross domestic product per capita	
	LAW	A country's legal tradition	The world Factbook	Dummy variable whose value is equal to 1 if firm is located in country having code-law jurisdiction	
	ETS	A country's presence of an Emissions Trading Scheme	Tang and Luo (2014)	1 if firm's headquarter is located in countries having emissions trading scheme (regardless of whether voluntary or compulsory), 0 otherwise	

Name	Variable(s)	Descriptions	Data source	Measurements	Scores
	INV_PRO	Investor protection	Bose et al. (2021)	A measure of the protection of the interest of minority shareholders' and ranges from 1 to 7, with 1 signifying not protected by law and 7 signifying protected by law and actively enforced. The World Economic Forum (2015)	
	IND_FE	Industry fixed effects	Data stream	A vector of dummy variables indicating industry	
	YEAR_FE	Year fixed effects	Data stream	A vector of dummy variables indicating year	
	COUNTRY_FE	Country fixed effects	Data stream	A vector of dummy variables indicating country	

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