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The International Journal of Accounting xx (2016) xxx – xxx
The International Journal of Accounting

Determinants of the Quality of Corporate Carbon Management Systems: An International Study☆

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Received 2 May 2014

Abstract

Firms' carbon management systems play a key role in controlling greenhouse gas emissions, but very little research has focused on determinants of carbon management systems quality. This study uses the holistic approach used by Tang and Luo (2014) and data from large companies that participated in the Carbon Disclosure Project to measure the quality of carbon management systems. Our results show that the overall quality of carbon management systems improved in 2012 relative to 2011, and the quality of carbon management systems is associated with the presence of an emission trading scheme, competitor pressure, the nature of the legal system, and carbon exposure. In addition, these country-level and firm-level factors also impact the types of carbon management systems adopted by the firms in our sample. Our findings suggest that institutional theory explains our results well. Other theoretical perspectives such as a shareholder/stakeholder orientation provide additional elucidation. Given that the quality of carbon management systems is not directly observable, our results are potentially useful to outside stakeholders who are concerned about risks associated with GHG emissions of a firm.

☆ We thank the participants of the research seminar at the Western Sydney University; University of Sydney; University of Technology, Sydney; *The International Journal of Accounting* (TIJA) symposium in São Paulo; the 2014 American Accounting Association annual conference in Atlanta; the two anonymous reviewers, and the discussant of our paper at the TIJA symposium; and the editors of TIJA for their useful feedback. Qingliang Tang gratefully acknowledges financial support from the School of Business, Western Sydney University. Le Luo also gratefully acknowledges financial support from Faculty of Business and Law, University of Newcastle.
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http://dx.doi.org/10.1016/j.intacc.2016.04.007
0020-7063 © 2016 University of Illinois.

JEL classification: Q54; Q56; L1; M14
Keywords: Climate change; Carbon accounting; Quality of carbon management systems

1. Introduction

Businesses are exposed to various risks related to climate change including direct physical risks, regulatory risks, and other risks.[1] National governments and nongovernmental organizations have adopted various carbon[2] initiatives, and companies worldwide are implementing carbon management systems as a response (Tang & Luo, 2014). A carbon management system is defined by Tang and Luo (2014) as "a way to implement a firm's carbon strategy or policy to enhance the efficiency of input-use, mitigate emissions and risks and avoid compliance costs or to gain a competitive advantage"[3] (p. 84). A large body of literature is devoted to environmental accounting (Anton, Deltas, & Khanna, 2004; Henri & Journeault, 2010; Jasch, 2003; Levy, 1997; Morrow & Rondinelli, 2002; Zhang et al., 2008; Zutshi & Sohal, 2004), and there has been a growing amount of research on carbon accounting in recent years (e.g., Liao, Luo, & Tang, 2015; Luo, Lan, & Tang, 2012; Luo, Tang, & Lan, 2013). However, few studies have been conducted on carbon management systems with the exception of Tang and Luo (2014). Tang and Luo (2014) made two important contributions: first, they presented a theoretical carbon management systems model that consists of ten key elements from four perspectives (see Appendix A); and second, they provided initial evidence that carbon mitigation performance is significantly related to the quality of carbon management systems. However, an essential question remains unanswered: why do some companies adopt high-quality carbon management systems but others do not? To investigate this important issue, we use a sample of 1805 observations from large firms in different countries in 2011 and 2012, and we quantify the quality of carbon management systems by scoring the ten elements of carbon management systems and standardizing the scores to create an index for each firm (Tang & Luo, 2014). We analyze the data using univariate and regression models; by doing so, we find that carbon management systems' quality varies noticeably across firms and is a function of external pressure and internal conditions. Specifically, companies tend to implement

[1] Direct physical risks affect a company's tangible assets and operation, including damage to production facilities or the availability of raw materials due to extreme weather, storms, floods, droughts, a rise in sea level, as well as increased risk to human health (e.g., the potential spreading of tropical disease). Regulatory risk arises when a government changes its climate policy, and other risks include risk to a business's reputation, changes in consumption patterns, and short-term adjustments to contract conditions. Examples include when consumers switch to products with a lower effect on climate change or when insurance carriers request higher risk premiums due to high exposure to climate change.

[2] The term *carbon* as used here is interchangeable with CO_2, *carbon equivalent* (CO_2-*e*), *emissions*, and *greenhouse gas*.

[3] Our definition of CMS excludes CMSs that exist purely for the purposes of greenwashing (*greenwashing* is the overstatement of carbon performance and understatement of climate change damages). However, in practice CMS may be designed for greenwashing and to avoid damage to a business's reputation. If this is the case, the company likely has no emission reduction target, takes no actions to reduce carbon emissions, has poor carbon governance, and so on; therefore, it will score low on our quality measure for CMS. Thus, our measurement mechanism should reflect to some degree opportunistic greenwashing behavior.

high-quality carbon management systems if they are located in countries that have an emissions trading scheme in place or in code law countries. Furthermore, carbon management systems' quality appears to converge within sectors as firms in the same sector face similar regulatory, economic, or institutional pressures. In addition, carbon exposure at firm level is found to significantly correlate with the quality of carbon management systems. Finally, external and internal conditions also affect firms' choice of type of carbon management systems. These conditions may change over time and thus have an impact on the perceived costs and benefits of carbon management systems, so the managers have to adapt or modify the carbon management systems from time to time to ensure that they can realize the maximum output from the system.

Our study contributes to a greater understanding of the determinants of observed variations in the quality of carbon management systems across firms, sectors, and countries. Although Tang and Luo (2014) proposed a carbon management systems model, it is not clear how the model is implemented in practice. Thus, our study extends prior studies and attempts to explain the factors that affect the quality of carbon management systems. Our international focus enhances researchers' knowledge of global carbon management system practices by showing that the availability of financial and technological resources, together with other national/industrial institutions, jointly motivates the development of carbon management systems at the firm level. This insight might not be obtained in a national setting (Annandale, Morrison-Saunders, & Bouma, 2004; Busch & Hoffmann, 2007; Khanna & Anton, 2002).

In addition, this paper provides descriptive data so corporate executives may learn implementation of carbon management systems from other firms beyond their own business sectors and nations. Moreover, information about the variety of carbon management system practices should be useful for stakeholders (particularly outsiders who are concerned with carbon risks) in forming expectations of the effectiveness of a carbon management system in different sectors and countries. Finally, an appreciation of the diversity in carbon management systems among countries and the factors that affect this diversity will help policymakers and regulators better target deficiencies in carbon management and identify areas where these deficiencies are most pronounced.

The remainder of this paper is organized as follows. Section 2 presents a literature review focusing on the distinction between environmental management systems and carbon management systems. Section 3 develops the hypotheses with regard to firm-level and national-level variables that are potentially correlated with the quality of carbon management systems. The research design is presented in Section 4 and the empirical results are reported in Section 5. Section 6 concludes the paper with a discussion of limitations of the paper and future research opportunity in this emerging area.

2. Literature review: environmental management systems versus carbon management systems

2.1. Environmental management systems

Klassen and McLaughlin (1996) state that "environmental management encompasses all efforts to minimize the negative environmental impact of the firm's products throughout their life cycle" (p. 1199). Environmental management system is defined as "a transparent, systematic process known corporate-wide, with the purpose of prescribing and implementing environmental goals, policies and responsibilities, as well as regular auditing of its elements"[4] (Steger, 2000, p. 24). Environmental management systems were initially utilized to ensure compliance with rapidly increasing legislation, but now it is perceived as a business opportunity and an instrument for risk management (Darnall & Edwards, 2006), which leads to a more comprehensive exploitation of the win–win potential of environmental and economic benefits. Empirical studies provide evidence that suggests a link between environmental management and improved ecological performance, reduced operational costs, and enhanced efficiency and market value (Darnall, Henriques, & Sadorsky, 2008; Ferreira, Moulang, & Hendro, 2010; Gupta, 1995; Klassen & McLaughlin, 1996; Klassen & Whybark, 1999; Melnyk, Sroufe, & Calantone, 2003; Pérez, Ruiz, & Fenech, 2007; Sroufe, 2003; Xie & Hayase, 2007).

The literature shows there are three main streams of research pertaining to environmental management systems. The first is primarily concerned with designing environmental management systems, and studies in this area often describe effective environmental management system models (Handfield, Sroufe, & Walton, 2005; Slocombe, 1998). The second is interested in the motivations behind voluntary adoption of environmental management initiatives by firms (Anton, Deltas, & Khanna, 2004; Henri & Journeault, 2010; Jasch, 2003; Levy, 1997; Morrow & Rondinelli, 2002; Zhang et al., 2008; Zutshi & Sohal, 2004). In this research, stakeholder concern is often cited as a driving force behind the adoption of environmental management systems (Annandale et al., 2004; Busch & Hoffmann, 2007; Khanna & Anton, 2002). The third stream concentrates on the role of environmental management systems to simultaneously improve environmental and business performance (Darnall et al., 2008; Ferreira et al., 2010; Gupta, 1995; Klassen & McLaughlin, 1996; Klassen & Whybark, 1999; Melnyk et al., 2003; Pérez et al., 2007; Sroufe, 2003; Xie & Hayase, 2007). Notwithstanding agreement on the importance of climate change, there is a lack of studies on corporate carbon management systems. Thus, there is an urgent call to fill this gap (Tang & Luo, 2014).

2.2. Carbon management systems

Given the unique features and content of carbon management, studies on carbon management systems cannot be replaced by general studies on environmental management systems; thus, carbon accounting has recently emerged as a new area within the domain of environmental accounting (e.g., Liao, Luo, & Tang, 2015; Luo & Tang, 2015; Luo, Tang, & Lan, 2013; Reid & Toffel, 2009). The present research is directly related to that of Tang and Luo (2014), who proposed a theoretical model of carbon management systems with ten key elements. They evaluated carbon management systems' effect on carbon mitigation using a sample of 45 Australian firms and found that firms with higher-quality carbon management systems achieved better carbon mitigation. To the best of our knowledge, the

[4] Two of the most prominent examples of EMS are ISO14001 (a set of criteria for an EMS) and the Environmental Management and Auditing System (EMAS). Whereas ISO14001 was developed by the International Standardization Organization, EMAS is based on voluntary participation in a regulated system developed by the European Union and applies only to industry and used sites.

research of Tang and Luo (2014) is the first study to have identified what constitutes an efficient carbon management system and to have assessed its effectiveness. However, their study was limited by a small sample and a particular national setting, and they did not analyze why the quality of carbon management systems varies across firms or how companies integrate both external and internal factors in their decisions about the quality of carbon management systems. Our study explores these questions in an international setting.

Conceptually speaking, environmental management systems and carbon management systems are inherently interrelated in the sense that environmental management system is a broad, generic, and multidimensional concept, and carbon management system is one aspect of environmental management systems. Without a corporate philosophy for environmental protection, it is unlikely that the firm will have an ambitious carbon reduction target and high quality of carbon management systems. Normally, if a firm improves its carbon management systems, it also sees an improvement of environmental management systems, but the reverse direction is not necessarily true.

Thus, a general environmental management system or its other components, such as water management systems are not supposed to be a substitute for carbon management systems because the latter has its distinct focus (Tang & Luo, 2014) and should be discussed and investigated separately. First, carbon pollution differs from water pollution, hazardous waste, toxic chemical emissions, and other types of pollution in that the increasing level of GHG emissions causes global warming. Global warming is essentially an international and long-term issue, and its damage is probably irreversible (Lash & Wellington, 2007). Many international organizations have put carbon control as an urgent environmental issue and have given it the highest priority (IPCC, 2013). Second, corporate carbon strategy is guided by a different set of regulations with its own requirements and criteria (Luo et al., 2013), that were put in place in response to the increasingly stringent carbon reduction standards (Walls, Phan, & Berrone, 2011), which requires specific capabilities, knowledge and financial investment in energy efficiency, low-carbon technology, process innovation, and specific supply chain emission control. Third, since environmental management system is a multidimensional construct, different policies adopted by different firms merely reflect most serious environmental issues they face. However, carbon emissions are common for all firms, and this facilitates comparison and analysis between firms and sectors. In our context, an emissions trading scheme and carbon exposure may drive the quality of a carbon management system, but they may have nothing to do with water management. Similarly, the factors that affect water management differ strongly from those that influence carbon management.

3. Hypothesis development

3.1. External pressures

3.1.1. The presence of an emissions trading scheme

Prior evidence suggests that 1) the rising costs of compliance with carbon regulation, 2) threat of liability for emissions, 3) concerns about high-emission products among consumers, and 4) reputation with stakeholders are likely to motivate firms to adopt a carbon management system. One of the most prominent carbon regulations is an emissions trading scheme (also known as a *cap-and-trade scheme*), which is a flexible market mechanism designed to provide incentives to organizations to achieve carbon reduction goals and creates a price for carbon emissions. Hence, firms are expected to incur a fee to purchase permits if their emissions exceed the assigned cap; thus, cutting emissions can lead to reduced costs or increased income. In addition, the introduction of emissions trading schemes may affect the cost–benefit structure of firms, as it is also likely to trigger some intangible costs such as reputation and political costs.

While the adoption of carbon management systems is expected to reduce (increase) these direct costs (benefits), it also requires a substantial initial investment and ongoing operating costs (designing, processing, maintaining, monitoring, and administrative costs, etc.). If a firm perceives that the cost of reducing carbon is less than the cost imposed by the emissions trading scheme, it may implement an effective carbon management system to internalize this cost. In other words, to the extent that the cost of carbon reduction is less than the emission charge, a profit-maximizing company tends to invest in carbon reduction initiatives, which may be facilitated by a carbon management system. Firms that are subject to an emissions trading scheme may incur direct compliance costs, and noncompliance may result in heavy financial penalties (Blacconiere & Northcut, 1997; Chapple, Clarkson, & Gold, 2013; Luo & Tang, 2014a). These domestic firms may also face more competition from foreign firms located in areas without such an emissions trading scheme (Ernst & Young, 2009; Sato et al., 2007). So these firms are likely to have a strong desire to establish a high-quality carbon management system. Firms that have a higher cost of carbon reduction may choose to purchase emission permits rather than reduce carbon themselves. In addition, financial institutions in countries with an emissions trading scheme tend to impose more stringent requirements and extra fees with respect to accessing debt facilities to reduce their lending risks (Graham, Maher, & Northcut, 2001; Schneider, 2011). In sum, ceteris paribus, a firm in an area with an emissions trading scheme is likely to have a higher incentive to implement a carbon management system than its counterpart in an area without an emissions trading scheme.[5] Therefore, on average, carbon management systems quality should be higher in nations with an emissions trading scheme than in nations without such a system. Based on this discussion, we propose our first hypothesis:

H_1. All else being equal, firms in a country with an emissions trading scheme are more likely to adopt higher quality carbon management systems.

3.1.2. Competitor pressure

Bebbington, Higgins, and Frame (2009) use institutional theory to explain how various factors combine in the initiation of sustainable development reporting. Institutional theory (as opposed to agency theory) offers an alternative explanation for corporate environmental activity (e.g., Adams & Larrinaga-González, 2007). It focuses on the shaping effects of

[5] However, not all firms are covered by the emissions trading scheme, and an emissions trading scheme does not affect all firms equally. Instead, the impact of the emissions trading scheme varies across firms, and the net effect of the emissions trading scheme is jointly determined by external circumstances and institutions as well as internal conditions of each firm. Also note that not all countries have an emissions trading scheme in place in our sample.

social pressure and demonstrates that organizations mimic one another when practices become widely accepted and diffused. From this perspective, an organization's activities are not wholly at the discretion of managers who purposely initiate these activities to achieve carefully defined outcomes. Instead, they are selected from among "a narrowly defined set of legitimate options determined by the group of actors composing the firm's organizational field (i.e. industry)" (Hoffman, 1999, p. 351). Some authors (e.g., Cormier, Magnan, & Van Velthoven, 2005) point out that when firms observe that other firms have adopted exhaustive and elaborate disclosure strategies, they might also adopt such strategies out of peer pressure. Thus, it can be argued that firms in the same industry are probably competitors, and they are competing for the same market, raw materials, skilled labor, and other resources. They also face similar risks and are regulated by the same or similar laws with regard to climate change. Inasmuch as firms in the same industry are likely to influence or mimic one another, at equilibrium, practice should tend to converge in the industry.

In our context, this imitation mechanism can impact the quality of carbon management systems in that firms tend to adopt a carbon management system in line with norms set by other firms in their sector, because they do not want to be singled out as laggards or environmentally unfriendly organizations (Anton et al., 2004, p. 636). Thus, pressure from peer group competitors may motivate companies to devote efforts to minimizing the negative effects of carbon through high-quality carbon management systems so they may be poised to expand their market share or displace their competitors and gain a competitive advantage. This predicts a positive association between competitor pressure and the quality of carbon management systems. Thus, our second hypothesis is as follows:

H_2. All else being equal, firms with higher competitor pressure are more likely than firms with lower competitor pressure to implement higher quality carbon management systems.

3.1.3. The nature of legal systems

Prior literature has found evidence that legal systems may influence the accounting, financial reporting practice, and business behavior in different countries (Gray, 1988; Meek & Saudagaran, 1990; Salter & Doupnik, 1992). The disclosure of emissions data in response to the demands of outside users may be considered part of an accounting system, and thus the legal system may influence how processes develop and how disclosure decisions evolve. In addition, the legal system impacts the nature of regulation, which in turn affects carbon policy and activities among firms.

More specifically, prior studies have often dichotomized legal systems into common law and code law systems (La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1998). In common law countries, statutes are interpreted by the courts such that case law develops and supports the statutory law, whereas in code law countries there is a relatively more codified law that applies to a wider range of activities. One of the major differences between the two systems is that countries with code law systems are perceived as having weak legal environments for investor protection, which has a profound impact on corporate governance and policy (La Porta et al., 1998). Consequently firms in countries with a weak investor protection mechanism tend to engage in stronger firm-level corporate governance to counterbalance the weaknesses in their countries' laws and enforcement and to signal their intentions to offer greater rights to investors (Choi & Wong, 2007; Durnev & Kim, 2005; Klapper & Love, 2004). This argument can be extended to the implementation of high-quality carbon management systems. Carbon management systems can be considered part of firm-level governance for climate change issues in the interest of investors. Managers are inclined to strengthen carbon management systems to compensate for weaker national legal systems with regard to investor protection that is more pronounced in code law countries. Thus, we propose the third hypothesis:

H_3. All else being equal, firms in code law countries are more likely than firms in common law countries to implement higher quality carbon management systems.

3.2. Internal conditions

3.2.1. Carbon exposure

A firm's carbon exposure is likely to be the most important determinant of carbon management systems adoption. *Carbon exposure* refers to a firm's exposure to future carbon related costs and liability (Al-Tuwaijri, Christensen, & Hughes, 2004). Heavy emitters are likely to receive a great deal of attention in the climate change debate, to be subject to intense scrutiny from environmental groups (Banerjee, 2001; Brammer & Pavelin, 2006), and to be the target of climate regulations (Patten, 2002a). Previous studies have also shown that firms with higher carbon emissions are penalized by a lower stock price and market valuation (Chapple et al., 2013; Luo & Tang, 2014a; Matsumura, Prakash, & Vera-Muñoz, 2014). Thus, we expect that companies with higher carbon exposure tend to have a greater desire to pre-empt mandatory carbon regulations and manage carbon-related risks through effective carbon management systems (Delmas, 2002; Lyon & Maxwell, 2003). In addition, the higher the emissions, the more important the carbon management system; thus, the benefits of such a system increase with total GHG emissions (Anton et al., 2004). We use the amount of carbon emissions (scaled by sales) as a proxy for carbon risk exposure. The fourth hypothesis is as follows:

H_4. Firms with greater carbon exposure are more likely than firms with less carbon exposure to implement higher quality carbon management systems.

3.2.2. Shareholder/stakeholder orientation

Simnett, Vanstraelen, and Chua (2009) contended that "a stakeholder-orientated or communitarian culture is one in which a broad spectrum of stakeholders are seen by society as possessing a legitimate interest in corporate activities" (p. 944). This type of philosophy stands in contrast to a shareholder-oriented perspective, which is concerned exclusively with protecting shareholders' interests. Stakeholder groups often have a wide range of considerations and expectations beyond the financial implications of a firm's operation. Etzion (2007) claimed that having a stakeholder orientation enables firms to undertake sustainable development rather than adhere solely to short-term economics. In addition, Van der Laan Smith, Adhikari, and Tondkar (2005) argued that managers in stakeholder-oriented societies would be more likely than those in shareholder-oriented ones to engage in socially responsible activities as part of a strategy of managing stakeholder relationships. Climate change is regarded as an issue of corporate social responsibility, and carbon mitigation initiatives involve substantial investment, but often without immediate financial return (Tang & Luo, 2014). Hence, firms with a stakeholder orientation are more likely than those with a shareholder orientation to have high-quality carbon management systems. In sum, this discussion leads to our fifth hypothesis:

H_5. Stakeholder-oriented firms are more likely than shareholder-oriented firms to implement higher quality carbon management systems.

4. Research design

4.1. Measuring the quality of carbon management systems

Corporate decisions to establish high- or low-quality carbon management systems depend on the cost of implementation and the benefits of reduced GHG emissions. Because the costs and benefits of carbon management systems for a particular firm are not public knowledge, measurements of the quality of such systems are not readily observable by outsiders. We therefore follow Tang and Luo (2014) and measure the overall quality of carbon management systems by analyzing its ten key constituent elements. Data were from firms' Carbon Disclosure Project (CDP) reports. Appendix A presents a summary of the basic carbon management systems elements and their purposes (Tang & Luo, 2014), and Table 1 summarizes the empirical proxy variables for the elements, the methods used to measure these variables, and the corresponding questions from the CDP questionnaire. The variable *OQCMS* (overall quality of carbon management systems) is calculated as the average equal-weighted sum of the standardized values[6] of the ten proxies, and it increases with the strength of the elements. The formula is

$$OQCMS = \frac{1}{10}\sum_{i=1}^{10} S_{Element_i},$$

where $S\_Element_i$ represents the standardized value of the ith element proxy. We argue that *OQCMS* is a valid measure because it reflects major dimensions of carbon management systems, including carbon governance, risk management, incentives, actions, accounting, auditing, the supply chain, engagement, communication, and disclosure. In our system (Table 1), although some proxies are dichotomous, which considers only whether the element is present or not, other variables reflect more substance of the constituent element. For example, the value of *AUDIT* indicates variation among firms in the intensity with which the firms engage in external assurance. That is, the value shows not only whether the firm purchased external assurance but also the percentage of emissions that is covered by

[6] We use standardized variables because our original proxy variables are measured in different ways, which does not allow us to add them together directly to construct an overall index. A standardized variable (sometimes called a z score or a standard score) is a variable that has been rescaled to have a mean of 0 and a standard deviation of 1. First the mean is subtracted from the value for each case, resulting in a mean of 0. Then the difference between the individual's score and the mean is divided by the standard deviation, which results in a standard deviation of 1 (Tang and Luo 2014).

Please cite this article as: Luo, L., & Tang, Q., Determinants of the Quality of Corporate Carbon Management Systems..., *The International Journal of Accounting* (2016), http://dx.doi.org/10.1016/j.intacc.2016.04.007

Table 1
Measurement of the ten carbon management system element proxies.

CMS element	Proxy variable	Map to question(s) in the 2011 and 2012 CDP questionnaires	Measurement of variables	Range	
1. Board function	*BOARD*	Q1.1	Where is the highest level of responsibility for climate change within your company?	3 points = "Individual/Sub-set of the Board or other committee appointed by the Board," 2 points = "Senior Manager/Officer," 1 point = "Other Manager/Officer," and 0 otherwise.	0–3
2. Risk and opportunity assessment	*RISKMANAGE*	Q2.1	Please select the option that best describes your risk management procedures with regard to climate change risks and opportunities.	2 points = "A specific climate change risk management process," 1 point = "Integrated into multi-disciplinary companywide risk management processes," and 0 otherwise.	0–2
3. Staff involvement	*INCENTIVE*	Q1.2	Do you provide incentives for the management of climate change issues, including the attainment of targets?	1 point = "Yes," and 0 otherwise.	0–1
4. Emission target	*TARGET*	Q3.1	Do you have an emissions reduction target that was active (ongoing or reached completion) in reporting year?	3 points = "Absolute and intensity targets," 2 points = "Absolute target," 1 point = "Intensity target," and 0 otherwise.	0–3
5. Policy implementation	*PROJECT*	Q3.3	Q3.3 Did you have emissions reduction initiatives that were active within the reporting year (this could include those in the planning and/or implementation phases)?	The number of green actions taken by a firm to avoid emissions.	
		Q3.3a (CDP 2011)	Q3.3a (CDP 2011): If yes, please provide details in the table below.		
		Q3.3b (CDP 2012)	Q3.3b (CDP 2012): For those initiatives implemented in the reporting year, please provide details in the table below.		

6. Supply chain emission control	*SUPPLYCHAIN*	Q3.2	Does the use of goods and/or services directly enable [greenhouse gas] emissions to be avoided by a third party?	1 point = "Yes," and 0 otherwise.	0–1
7. Carbon accounting	*ACCOUNTING*	Q8.2	Please provide your gross Scope 1 emissions in metric tonnes of CO_2-e.	1 point is awarded for the report of each Scope 1, 2, and 3 greenhouse gas emissions up to 3 points.	0–3
		Q8.3	Please provide your gross Scope 2 emissions in metric tons of CO_2-e.		
		Q15.1	Please provide data on sources of Scope 3 emissions that are relevant to your organization.		
8. Carbon assurance	*AUDIT*	Q8.6	Please indicate the verification/assurance that applies to your Scope 1 emissions.	1 point is awarded for no more than 20% of Scope 1 emissions, 2 points for more than 20% but less than or equal to 60%, 3 points for more than 60% verified externally, and 0 points otherwise.	0–9
		Q8.7	Please indicate the verification/assurance that applies to your Scope 2 emissions.	These same scoring procedures are also used for Scope 2 and Scope 3 emissions.	
		Q15.2	Please indicate the verification/assurance that applies to your Scope 3 emissions.		
9. Engagement with stakeholders	*POLICYENGAGE*	Q2.3	Do you engage with policymakers to encourage further action on mitigation and/or adaption?	1 point = "Yes," and 0 otherwise	0–1
10. Disclosure and communication	*TRANSPARENCY*	All of the questions in the 2011 and 2012 CDP questionnaires		The methodology and criteria are the same as the CDP CDLI methodology (see CDP Scoring Methodology, 2011; CDP Scoring Methodology, 2012; also see Cotter & Najah, 2012; Griffin, Lont, & Sun, 2012; Prado-Lorenzo & Garcia-Sanchez, 2010 for the use of CDLI score).	0–100

Note: CMS = carbon management systems; CDP = Carbon Disclosure Project; CDLI = Carbon Disclosure Leadership Index.

the assurance and which types of GHG emissions (i.e., Scope 1, 2, or 3[7]) have been verified (Table 1). Similarly, we measure risk management by taking into account the content of the mechanism for climate risk control (Table 1).

In addition, for the sake of brevity, we rename and label the four perspectives used by Tang and Luo (2014) as *GOVERNANCE*, *OPERATION*, *ACCOUNTING*, and *COMMUNICATION*. We then measure the quality of these perspectives (each containing two or three elements) using the following formulas:

$$GOVERNANCE = \frac{(S\_BOARD + S\_RISKMANAGE + S\_INCENTIVE)}{3}$$

$$OPERATION = \frac{(S\_TARGET + S\_PROJECT + S\_SUPPLYCHAIN)}{3}$$

$$ACCOUNTING = \frac{(S\_ACCOUNTING + S\_AUDIT)}{2}$$

$$COMMUNICATION = \frac{(S\_POLICYENGAGE + S\_TRANSPARENCY)}{2}$$

4.2. Empirical model

To test H_1–H_5, we specify an ordinary least squares (OLS) regression model in Eq. (1) using two-year pooled data:

$$\begin{aligned} OQCMS = {} & \alpha_0 + \alpha_1 ETS + \alpha_2 COMPETITOR + \alpha_3 CODELAW + \alpha_4 lnINTENSITY \\ & + \alpha_5 SHAREHOLDER + \alpha_6 SIZE + \alpha_7 TOBINQ + \alpha_8 GDPPC + \alpha_9 ROA \\ & + \alpha_{10} CAPINT + \alpha_{11} BETA + \alpha_{12} INTENSIVE + \alpha_{13} YEAR2012 + \varepsilon \end{aligned} \tag{1}$$

The dependent variable *OQCMS* is defined in the previous section.

ETS is a dummy variable that equals 1 if a firm operates in a country with an ETS regardless of its scope (national/regional) or nature (mandatory/voluntary) and 0 otherwise.

Appendix B provides a summary of the status, scope, and nature of emissions trading schemes in the sample countries.

COMPETITOR is a proxy for pressure from firm *i*'s competitors. Consistent with previous research, it is measured as the average value of the *OQCMS* of all other firms with

[7] Scope 1 emissions are direct GHG emissions from sources that are owned or controlled by the entity. Scope 1 can include emissions from fossil fuels burned on site or emissions from entity-owned leased vehicles or other direct sources. Scope 2 emissions are indirect GHG emissions resulting from electricity, heating and cooling, or steam generated off site but purchased by the entity and the transmission and distributed losses associated with some purchased utilities (e.g., chilled water, steam, and high-temperature hot water). Scope 3 GHG emission sources include transmission and distribution losses associated with purchased electricity, employee travel and commuting, contracted solid waste disposal, and contracted wastewater treatment. Additional sources include GHG emissions from leased space, the vendor supply chain, outsourced activities, and site remediation activities and other emissions that are not Scope 1 or 2 emissions (www.epa.gov/aintrnt.gh.index).

the same two-digit Global Industry Classification Standard (GICS) code as the firm (Anton et al., 2004). The formula is as follows:

$$COMPETITOR_i = \frac{1}{N_k - 1} \sum_{j \neq i}^{N_k - 1} OQCMS_j$$

where N_k represents the number of firms in the two-digit GICS sector k.

CODELAW is a proxy for the type of legal system and equals 1 if a firm is headquartered in a country with a code law system and 0 otherwise (La Porta et al., 1998).

lnINTENSITY is a proxy for carbon exposure, calculated as the natural logarithm of the total amount of Scope 1 and Scope 2 emissions divided by total sales (Anton et al., 2004; Khanna, 2001; Khanna & Damon, 1999; Khanna, Koss, Jones, & Ervin, 2007). Log transformation is used because of the high skewness of the data (Al-Tuwaijri et al., 2004; Clarkson, Li, Richardson, & Vasvari, 2008). Following the prior literature (e.g., Chapple et al., 2013; Tang & Luo, 2014), we consider only Scope 1 and 2 for the carbon exposure measure, because current regulations (e.g., Australian National Greenhouse and Energy Reporting Act) target primarily Scope 1 and 2 emissions. Thus, carbon management systems are often designed for Scope 1 and 2 emissions. In addition, data on Scope 3 emissions are largely missing from many CDP reports.[8]

SHAREHOLDER is a proxy for a shareholder/stakeholder orientation. Following prior studies, we measure the variable as the percentage of shares held by institutional investors, including investment firms and pension funds (Reid & Toffel, 2009). A higher (lower) percentage of institutional shareholders means a stronger shareholder (stakeholder) orientation, because institutional shareholders with substantial shareholdings are likely to have a significant influence on managerial decisions.[9] As predicted by H_1–H_5, the coefficients of the first four variables (α_1–α_4) should be positive and α_5 negative.

4.2.1. Control variables

We also include a number of control variables that are frequently used in environmental accounting studies and that may be associated with carbon management systems quality. Large firms have higher pressure from the public and so have more incentives to design and adopt a high-quality carbon management system aimed at carbon reduction or stakeholder engagement (Anton et al., 2004). *SIZE* is therefore used as a proxy for firm size, and is calculated as the natural logarithm of total revenue. Prior research suggests that management capability is crucial for a firm's innovation and investment in new and low-carbon technology (Bansal, 2005). Thus, we use *TOBINQ* as a proxy for management's innovation capability (Clarkson, Li, Richardson, & Vasvari, 2011), calculated as the market value of common equity divided by the book value of total assets. The level of a country's economic development is also included, measured as the natural logarithm of the gross domestic

[8] Most companies do not report Scope 3 emissions because Scope 3 accounting requires an analysis of the upstream and downstream supply chains. Thus, methodological and practical difficulties inhibit consistent reporting and raise concerns over the double-counting of emissions.

[9] Please note a weakness of this measure is that there are increasing numbers of funds and investors that have a "green" orientation, and the measure used here does not differentiate between shareholders who might have different investing goals. We thank an anonymous reviewer for pointing this out.

product per capita (*GDPPC*),[10] because poor countries may prioritize economic growth over the prevention of carbon pollution due to lack of financial resources (Salter, 1998).

Return on assets (*ROA*) is a proxy for profitability and financial health, calculated as net income before extraordinary items/preferred dividends divided by total assets (Artiach, Lee, Nelson, & Walker, 2010; Clarkson et al., 2008; Melnyk et al., 2003). The empirical evidence on financial health is mixed. On the one hand, resource dependence theory suggests that profitable firms will have more resources and thus be able to afford expensive carbon management systems (Bansal, 2005; Delmas, 2000; Hart, 1995; Hillary, 2004). On the other hand, firms may develop carbon management systems regardless of their financial status if doing so is profitable (Henriques & Sadorsky, 1996).

Following Anton et al. (2004) and Khanna and Anton (2002), we use capital intensity (*CAPINT*) as a measure of reliance on capital markets and thus a proxy for pressures from general market participants. *CAPINT* is calculated as property, plant, and equipment divided by total assets (Anton et al., 2004; Khanna & Anton, 2002; Uchida & Ferraro, 2007). *BETA* is a proxy that controls for a firm's systematic risk or stock price volatility (Clarkson et al., 2008). A firm's systematic risk is potentially associated with climate risk so as to be related to carbon activity and CMS. *INTENSIVE* is a dummy variable that equals 1 if the firm is in a carbon-intensive sector (energy, materials, or utilities) and 0 otherwise. *YEAR2012* is included to control for the fixed effect of time. If *OQCMS* improved from 2011 to 2012, its coefficient (α_{13}) should be positive. Table 2 provides a summary of the variables and their measurement.

Information for measuring *OQCMS* and *lnINTENSITY* was obtained from the CDP database. Note that the CDP often requests carbon-related data on a 1-year lag. For example, the targeted firms generally disclosed their 2010 emissions in their 2011 CDP reports. Thus, we lagged financial data by 1 year relative to CDP data. Data for *SHAREHOLDER* were collected from the Thomson Reuters ESG ASSET4 database. Financial data were collected from the Thomson Reuters DataStream database. All variables were Winsorized at the 0.01 level (with the exception of *OQCMS* and the indicator variables) to reduce the impact of outliers. The results reported here are based on Winsorized data.

4.3. Sample firms and carbon data

The sample consisted of all firms that participated voluntarily in the CDP in 2011 and 2012. The 2 years of data reflected the most recent carbon management system practices at the time the research project was undertaken. Also, the CDP used a relatively consistent questionnaire and scoring methodology for these 2 years, which facilitated comparison and interpretation of the data.

The initial sample in the study included 3260 firm-year observations. We excluded two duplicate observations and deleted 686 observations that did not have a Carbon Disclosure Leadership Index score, which is necessary to construct the *OQCMS*. Then 640

[10] GDPPC values were obtained from the World Bank (http://data.worldbank.org/). Note that purchasing power parity estimates of GDPPC expressed in constant 2005 prices are used because these estimates reflect differences in the cost of living from one country to another.

observations were eliminated because of missing values for the independent variables. In addition, firms in the financial sector were excluded because of the different nature of their activities and regulatory restrictions and the sector's insignificant environmental impact. This does not mean the financial sector is not important. Instead, the financial sector plays a vital role in carbon reduction projects and energy efficiency initiatives. However, the carbon management systems adopted by firms in the financial sector to control the sector's own emissions appear to be a relatively trivial issue. Finally, only countries that had more than ten observations were considered for analysis. Thus, 28 observations were dropped. Our final sample comprised 1805 observations in nine GICS sectors (see Table 3 for more details on the sample selection process). Note that our sample firms were relatively large, and we selected them because large firms often have salient emission issues (Luo, Lan, & Tang, 2012; Luo & Tang, 2014b).

4.4. The CDP

Prior studies typically rely on Council on Economic Priorities rankings, industry classification, or toxic emissions as proxies for environmental results (Al-Tuwaijri et al., 2004; Bewley & Li, 2000; Clarkson et al., 2008; Clarkson et al., 2011; Hughes, Anderson, & Golden, 2001; Patten, 2002b; Shane & Spicer, 1983). Information is also typically collected from annual reports, sustainability reports, or company websites, and this generates heterogeneous environmental data[11] (Luo et al., 2012).

In contrast, our GHG data were mainly sourced from CDP reports (https://www.cdproject.net/en-US/Pages/HomePage.aspx). The CDP is a nongovernmental, not-for-profit organization that collects carbon information from large companies worldwide. The CDP sends a questionnaire to these firms, which can choose whether to participate in the project. If the firm decides to participate, it answers the questions and returns the questionnaire to the CDP, which then publishes the survey results on its website.

The use of CDP data is considered a strength in carbon research because CDP information is based on the formal responses of firms to a standard questionnaire, which minimizes biases arising from the self-selection of carbon data disclosed through other communication channels (Tang & Luo, 2014). In addition, the CDP reporting format and contents are accepted and used by more than 3000 large global firms. This information is thus relatively consistent (Luo et al., 2012; Luo & Tang, 2014b). CDP reports cover many relevant aspects of GHG disclosure, such as carbon governance mechanisms, carbon risks and opportunities, carbon strategy and targets, carbon actions and processes, carbon emissions and reporting, energy utilization, emissions trading and offsetting, and carbon communications and engagement.

We used the CDP questionnaire to enhance the internal validity of the study because this questionnaire is well developed and professionally administered, and it was used consistently by all participating firms. For example, the disclosure of climate information in annual reports or sustainability reports is not only voluntary but also purely

[11] For example, data for a single item may be obtained from the annual report for Company A but from a sustainability report or firm website for Company B. Thus, it is difficult to interpret and generalize the results (Luo et al., 2012).

Table 2
Variables and their measurement.

Variable	Measurement
OQCMS	The average equal-weighted sum of the standardized values of the ten element proxies (see Table 1 for the ten elements and their proxies)
ETS	A dummy variable that equals 1 if a firm operates in a country with an ETS regardless of its scope (national/regional) or nature (mandatory/voluntary) and 0 otherwise
COMPETITOR	The average value of the *OQCMS* of all other firms with the same two-digit Global Industry Classification Standard code as the firm
CODELAW	A dummy variable that equals 1 if a company has a board-level environmental committee and 0 otherwise
lnINTENSITY	The natural logarithm of the total amount of Scope 1 and Scope 2 emissions divided by total sales
SHAREHOLDER	The percentage of shares held by institutional investors, including investment firms and pension funds
SIZE	The natural logarithm of total revenue
TOBINQ	The market value of common equity divided by the book value of total assets
GDPPC	The natural logarithm of the gross domestic product per capita
ROA	Net income before extraordinary items/preferred dividends divided by total assets
CAPINT	Property, plant, and equipment divided by total assets
BETA	The firm's systematic risk or stock price volatility
INTENSIVE	A dummy variable that equals 1 if a firm is in a carbon-intensive sector (energy, materials, or utilities) and 0 otherwise
YEAR2012	A dummy variable that equals 1 for year 2012 and 0 otherwise

Note: ETS = emissions trading scheme.

discretionary. This means that not only can management exercise absolute discretion over what they wish to disclose, but reports may also omit information that the firm does not want to release. In contrast, CDP reporting is voluntary but not 100% discretionary, in the sense that all participating companies must answer the same questions, many of which are non-discretionary. Once a firm decides to participate in the CDP, it cannot manipulate the style or content of its data presentation (Luo & Tang, 2014b). The firm may skip a particular question in the CDP report, but it cannot delete a question at its discretion. The

Table 3
Sample selection process.

Initial sample	Number of observations
Firms that submitted 2011 and 2012 CDP questionnaires and made their responses publicly available and retrievable from the CDP database	3260
Minus	
Duplicate companies	2
No Carbon Disclosure Leadership Index score	686
Minus	
Observations with missing values	640
Firms in the financial sector	99
Firms in countries with fewer than 10 observations	28
Final sample	1805

Note: CDP = Carbon Disclosure Project.

omission itself may signal high sensitivity or non-availability of the data, or an unwillingness to disclose the information. Therefore, this non-discretionary (although voluntary) disclosure makes it more difficult for the firm to greenwash[12] (i.e., manipulate) carbon information. CDP reports have been used by many companies all around the world (e.g., Chapple et al., 2013; He, Tang, & Wang, 2013; Kim & Lyon, 2011; Luo & Tang, 2014a, 2014b; Stanny, 2013). Notwithstanding the voluntary nature of the disclosure, managers are potentially liable if the carbon information disclosed is subsequently found to be misleading. Although this voluntary disclosure is subject to manipulation, the threat of possible litigation may prevent or at least constrain attempts at greenwashing. In sum, although there are no internationally accepted standards for carbon reporting, CDP reports provide globally consistent and comparable data; this allows for more meaningful analysis and interpretation, thus increasing the power of our study.[13] However, with respect to external validity, because all the sample firms were relatively large and international in scope, caution should be exercised when generalizing the results to smaller firms or to local firms.

5. Empirical results

5.1. Descriptive statistics for dependent and independent variables

Table 4 reports descriptive statistics for the dependent and independent variables used in Eq. (1). Of the sample firms, 81.5% operate in a country with an emissions trading scheme, 44.7% are in code law countries, and 28.9% are in carbon-intensive sectors (energy, materials, or utilities; Table 4). The average natural logarithm of total revenue (*SIZE*) is 8.803, suggesting that our sample consists of relatively larger firms. On average, *ROA* is approximately 6% of total assets, and 6.7% of shares are held by institutional investors. Finally, the mean of *lnINTENSITY* is 4.29, implying that on average firms in our sample emit 72.96 tons of CO_2 equivalent for each million of sales (USD).

5.2. Univariate analysis of dependent and independent variables

Table 5 reports both parametric and nonparametric correlation coefficients for the variables in Eq. (1). The results are generally consistent with our expectations. For example, both parametric and nonparametric correlation coefficients for *OQCMS* and *ETS*

[12] Greenwashing involves attempts to overstate environmental performance with regard to climate change and/or understate environmental damage caused by a firm's operation. Greenwashing often shows a propensity for selective disclosure of positive aspects of carbon activity without full disclosure of negative information.

[13] Despite this, we acknowledge that caution should be exercised in using our measure of carbon management systems to detect greenwashing attempts. Greenwashing is inherently associated with voluntary disclosure. However, the format of the CDP questionnaire and operation of its survey would significantly reduce the freedom and opportunities of greenwashing, but it is not supposed or expected to eliminate all the possibility for voluntary carbon disclosure for image management purpose. Keeping this proviso in mind, we believe the CDP provided a relatively more reliable source for measurement of carbon management systems than other sources.

Please cite this article as: Luo, L., & Tang, Q., Determinants of the Quality of Corporate Carbon Management Systems..., *The International Journal of Accounting* (2016), http://dx.doi.org/10.1016/j.intacc.2016.04.007

are positive and significant ($p < 0.01$), suggesting that firms that operate in countries with an emissions trading scheme tend to adopt high-quality carbon management systems. In addition, *COMPETITOR* is significantly and positively related to *OQCMS*, implying that firms' carbon management systems are influenced by their sector peers. *CODELAW* is also significantly and positively related to *OQCMS*, suggesting that the type of legal system is correlated with the quality of carbon management systems.

In terms of internal conditions, both Pearson and Spearman correlation coefficients for *OQCMS* and *lnINTENSITY* are positive and significant, which indicates that firms with a higher carbon emission intensity and thus greater exposure to regulatory pressure and climate risks tend to voluntarily adopt proactive carbon management practices. Meanwhile, the parametric and nonparametric correlation coefficients for *OQCMS* and *SIZE* are positive and significant, and the coefficients for *OQCMS* and *SHAREHOLDER* are negative and significant, both consistent with our expectations. Overall, cross-correlations between these variables do not suggest serious problems with multicollinearity.

5.3. Multivariate regression

5.3.1. Determinants of OQCMS

The results of three OLS models, Eq. (1), using pooled data are presented in Table 6, Panel A. Model (1) includes only control variables, whereas Model (2) adds three more external pressure variables based on Model (1). Model (3) includes all external pressure, internal condition, and control variables. The adjusted R^2 increases significantly when internal condition variables are included into the model. This indicates that carbon emissions and shareholder orientation have incremental explanatory power over external pressures and control variables. Table 6, Panel B, presents the diagnostics for all independent variables. The table shows that the variance inflation factor of each independent variable is less than 3, suggesting no serious issues with multicollinearity.

The results from Model (3) show a significant and positive sign for emissions trading schemes ($\alpha_1 = 0.083$, $p < 0.01$), which strongly supports H_1. The coefficient of *COMPETITOR*, a proxy for competitor pressure, is positive and significant ($\alpha_2 = 0.446$, $p < 0.01$), supporting H_2. Consistent with H_3, *CODELAW* is positively and significantly correlated with *OQCMS* ($\alpha_3 = 0.143$, $p < 0.01$), implying that the type of legal system is correlated with the quality of carbon management systems.

In addition, the positive and significant coefficient for *lnINTENSITY* ($\alpha_4 = 0.034$, $p < 0.01$) supports the notion that firms with higher intensity emissions tend to implement better carbon management systems (H_4). The coefficient of *SHAREHOLDER* is not significant; thus, we fail to find evidence to support H_5.

In terms of the control variables, *TOBINQ*, *CAPINT*, and *BETA* are not significant, suggesting that they do not play a meaningful role in determining the quality of carbon management systems. Theoretically, we predict a positive association between *TOBINQ* and *OQCMS*, but empirically the coefficient of *TOBINQ* is not statistically significantly different from zero. A possible reason is that the significance of *TOBINQ* is diluted (or substituted) when we include other factors, such as firm size, external pressures, and carbon exposure in the model. Another possibility is that the variable is defined as the ratio of market value and book value of total assets, which captures market participants'

Table 4
Descriptive statistics (N = 1805).

Variable	Mean	Median	SD	Min	Max	P25	P75
OQCMS	0.07	0.16	0.5	−1.94	1.15	−0.24	0.44
ETS	0.81	1	0.39	0	1	1	1
COMPETITOR	0.07	0.08	0.09	−0.13	0.3	0.01	0.14
CODELAW	0.45	0	0.5	0	1	0	1
lnINTENSITY	4.29	3.99	1.8	−1.02	8.78	3.05	5.57
SIZE	8.8	8.85	1.46	5.51	12.09	7.8	9.82
SHAREHOLDER	6.7	5	9.04	0	91	0	11
TOBINQ	2.53	1.81	2.3	0.19	14.65	1.19	3
GDPPC	10.42	10.43	0.26	9.16	10.76	10.34	10.65
ROA	0.06	0.05	0.05	−0.09	0.24	0.02	0.08
CAPINT	0.64	0.59	0.41	0.01	1.96	0.29	0.92
BETA	1	0.96	0.54	−0.02	2.57	0.59	1.37
INTENSIVE	0.29	0	0.45	0	1	0	1

Note: N = number of firm-year observations. SD = standard deviation. All variables were Winsorized at the 1st and 99th percentiles with the exception of *OQCMS* and the indicator variables. Financial data are in millions of US dollars.

perception of management capability. However, this is not a perfect proxy because it does not directly measure the capability, which is affected by many internal conditions not directly observable by outsiders. We found that *SIZE* has a positive and significant coefficient ($\alpha_6 = 0.118$, $p < 0.01$), which is consistent with previous studies (González-Benito & González-Benito, 2006; Melnyk et al., 2003; Vidovic & Khanna, 2007). *GDPPC* is negatively associated with *OQCMS* ($t = -5.994$, $p < 0.01$), suggesting that firms in rich nations tend to devote their efforts and resources toward economic performance rather than carbon reduction. The result is not consistent with our expectation but comparable with the findings of Waldman et al. (2006) and McWilliams and Siegel (2001), who demonstrate that managers in wealthier countries are less inclined to consider the welfare of the greater community or society in their decision making. Similarly, contrary to our prediction, the coefficient of ROA is significantly negative, suggesting a highly profitable firm might be more susceptible to expansion or other changes such as restructuring or reengineering, but may not invest in low carbon projects whose costs are immediate but whose benefits are realized in the long term. The result corroborates Henriques and Sadorsky (1996) and Vidovic and Khanna (2007) (using sales to asset ratio as a proxy for profitability). We controlled emissions (*lnINTENSITY*) and find a negative sign of *INTENSIVE* suggesting that a firm in a non-carbon intensive sector may also have incentives to implement higher quality of carbon management systems.[14] Finally, the coefficient of *YEAR2012* is positive and significant, suggesting an improvement in carbon management systems quality over the research period when all other influences are controlled.

[14] These incentives for non-carbon intensive firms to adopt high quality carbon management systems include an attempt to improve its green image and/or a desire to reduce carbon for its business partners in a supply chain (Tang & Luo, 2014).

Table 5
Correlation matrix (N = 1805).

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
OQCMS (1)	1.00	0.09	0.08	0.16	0.12	0.28	−0.11	−0.10	−0.15	−0.08	0.10	−0.04	0.03
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.19)
ETS (2)	0.10	1.00	0.04	0.21	−0.19	0.12	−0.08	−0.02	−0.00	−0.05	−0.14	0.01	−0.20
	(0.00)		(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.51)	(0.86)	(0.05)	(0.00)	(0.71)	(0.00)
COMPETITOR (3)	0.14	0.03	1.00	0.08	0.12	−0.05	−0.04	−0.10	−0.01	−0.10	0.13	−0.25	0.01
	(0.00)	(0.18)		(0.00)	(0.00)	(0.03)	(0.11)	(0.00)	(0.59)	(0.00)	(0.00)	(0.00)	(0.82)
CODELAW (4)	0.16	0.21	0.08	1.00	−0.10	−0.14	−0.28	−0.34	−0.53	−0.30	0.10	−0.04	−0.06
	(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.11)	(0.01)
lnINTENSITY (5)	0.12	−0.19	0.19	−0.11	1.00	0.11	−0.04	−0.17	0.02	−0.17	0.65	0.01	0.64
	(0.00)	(0.00)	(0.00)	(0.00)		(0.00)	(0.10)	(0.00)	(0.37)	(0.00)	(0.00)	(0.57)	(0.00)
SIZE (6)	0.27	0.12	−0.04	−0.14	0.11	1.00	−0.16	0.30	0.26	0.30	0.05	−0.08	0.07
	(0.00)	(0.00)	(0.10)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.05)	(0.00)	(0.00)
SHAREHOLDER (7)	−0.09	−0.10	−0.04	−0.22	−0.04	−0.19	1.00	0.11	0.16	0.08	−0.12	0.07	−0.09
	(0.00)	(0.00)	(0.13)	(0.00)	(0.10)	(0.00)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TOBINQ (8)	−0.04	0.03	−0.09	−0.27	−0.14	0.22	0.06	1.00	0.30	0.61	−0.20	−0.17	−0.12
	(0.13)	(0.16)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
GDPPC (9)	−0.08	0.26	−0.01	−0.19	−0.05	0.21	−0.01	0.06	1.00	0.26	−0.08	0.08	0.00
	(0.00)	(0.00)	(0.82)	(0.00)	(0.03)	(0.00)	(0.58)	(0.01)		(0.00)	(0.00)	(0.00)	(0.90)
ROA (10)	−0.07	−0.04	−0.13	−0.26	−0.16	0.29	0.02	0.50	0.03	1.00	−0.17	−0.13	−0.12
	(0.00)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)	(0.42)	(0.00)	(0.22)		(0.00)	(0.00)	(0.00)
CAPINT (11)	0.09	−0.13	0.19	0.10	0.58	0.03	−0.09	−0.16	−0.05	−0.16	1.00	−0.06	0.47
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.00)	(0.02)	(0.00)		(0.01)	(0.00)
BETA (12)	−0.06	−0.02	−0.24	−0.07	−0.01	−0.08	0.06	−0.14	0.11	−0.13	−0.07	1.00	0.05
	(0.01)	(0.43)	(0.00)	(0.00)	(0.81)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)		(0.03)
INTENSIVE (13)	0.02	−0.20	0.09	−0.06	0.65	0.07	−0.07	−0.14	−0.04	−0.11	0.45	0.06	1.00
	(0.46)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)	(0.00)	(0.00)	(0.01)	

Note: N = number of firm-year observations. Pearson (Spearman) correlation coefficients are below (above) the diagonal. All variables were Winsorized at the 1st and 99th percentiles with the exception of *OQCMS* and the indicator variables. Financial data are in millions of US dollars. p values are reported in parentheses (two-tailed). See Table 2 for definitions of variables.

Table 6
Determinants of the quality of carbon management systems.

Panel A: Main OLS regression

Variable	Expected sign	(1)	(2)	(3)
		OQCMS	*OQCMS*	*OQCMS*
External pressure				
ETS	+		0.078**	0.083***
			(2.447)	(2.635)
COMPETITOR	+		0.517***	0.446***
			(3.922)	(3.338)
CODELAW	+		0.121***	0.143***
			(5.019)	(5.659)
Internal conditions				
lnINTENSITY	+			0.034***
				(3.458)
SHAREHOLDER	–			0.001
				(0.799)
Control variables				
SIZE	+	0.123***	0.121***	0.118***
		(16.346)	(15.957)	(15.072)
TOBINQ	+	−0.004	0.001	0.002
		(−0.677)	(0.215)	(0.284)
GDPPC	+	−0.294***	−0.282***	−0.271***
		(−6.609)	(−6.269)	(−5.994)
ROA	+	−1.513***	−1.137***	−1.016***
		(−5.794)	(−4.334)	(−3.834)
CAPINT	+	0.076**	0.050	0.000
		(2.472)	(1.602)	(0.014)
BETA	+	−0.027	0.007	0.006
		(−1.282)	(0.306)	(0.257)
INTENSIVE	-	−0.064**	−0.036	−0.096***
		(−2.264)	(−1.274)	(−2.971)
YEAR2012	+	0.101***	0.061***	0.070***
		(4.565)	(2.699)	(3.100)
Constant		2.093***	1.793***	1.574***
		(4.597)	(3.927)	(3.403)
Observations		1805	1805	1805
Adjusted R^2		0.132	0.157	0.164
F		39.34***	35.67***	31.57***

Note: The table reports ordinary least squares (OLS) coefficient estimates. *T* statistics based on heteroscedasticity-consistent standard errors are in parentheses. *, ** and *** represent significance at the 0.1, 0.05 and 0.01 levels, respectively (two-tailed). All variables were Winsorized at the 1st and 99th percentiles with the exception of *OQCMS* and the indicator variables. Financial data are in millions of US dollars. The expected signs for the independent variables are presented in the second column. See Table 2 for definitions of variables. CMS = carbon management systems; VIF = variance inflation factor.

Panel B: VIFs for independent variables

Variables	VIF			
	(1)	(2)	(3)	(4)
ETS		1.24	1.25	1.25
COMPETITOR		1.29	1.31	1.33
CODELAW		1.29	1.39	1.35
lnINTENSITY			2.28	
lnEMIS				2.94
SHAREHOLDER			1.12	1.12
SIZE	1.18	1.20	1.28	2.37
TOBINQ	1.38	1.43	1.43	1.46
GDPPC	1.09	1.23	1.23	1.25
ROA	1.43	1.49	1.52	1.59
CAPINT	1.31	1.36	1.62	1.61
BETA	1.07	1.16	1.16	1.17
INTENSIVE	1.29	1.34	1.81	1.54
YEAR2012	1.03	1.18	1.19	1.18
Mean VIF	1.2	1.29	1.43	1.55

5.3.2. Firm characteristics and preference for carbon management systems type

The theoretical model of carbon management systems proposed by Tang and Luo (2014) includes four major perspectives: (1) carbon governance (*GOVERNANCE*), (2) carbon operation (*OPERATION*), (3) emission tracking and reporting (*ACCOUNTING*), and (4) engagement and disclosure (*COMMUNICATION*). Each of these essential perspectives (and the related elements) makes a distinct contribution to the overall quality of carbon management systems. Also, how these perspectives and elements are structured and combined in a particular firm can affect emissions reductions. In practice, companies may not invest the same amount in each perspective/element. For example, Company A may emphasize governance, whereas Company B focuses on operation. If all else is equal and Companies A and B have the same overall score for carbon management systems quality, Company A should have a high score in governance and Company B a high score in operation. Thus, the score for each constituent perspective reflects the relative weight of that perspective. Our question is, given that different companies adopt different types of carbon management systems with differing focus on each perspective/element, what factors affect the types of carbon management systems adopted by firms?

We conjecture that the choice is associated with firm characteristics and contextual factors including external pressures and internal conditions. For example, Table 7 shows that the score for *GOVERNANCE* (governance perspective) is positively associated with *lnINTENSITY* and *CODELAW* ($p < 0.01$), suggesting that firms with high-intensity GHG emissions and firms located in code law countries are more likely to implement carbon management systems with high-quality carbon governance. Similarly, the carbon operation perspective is correlated with certain country and firm characteristics (e.g., the presence of an emissions trading scheme, peer pressure, the nature of legal system, carbon intensity emission, and firm size). This means that firms tend to choose a carbon management system type based on their own unique circumstances. Thus, a theoretical model of carbon management systems with equal weight given to each element/perspective may not be suitable for all organizations, and firms will need to adapt the model to achieve the best outcome (Tang & Luo, 2014).

Institutional theory suggests that coercive forces—primarily in the form of regulations and regulatory enforcement—are one of the main impetuses behind managerial decisions (Delmas & Toffel, 2004; Delmas, 2002; Jennings & Zandbergen, 1995). Table 7 shows that large firms, firms in countries with an emissions trading scheme, and heavy emitters demonstrate similar preferences for certain types of carbon management systems, suggesting that these firms probably face similar threats from carbon regulation and

Table 7
Determinants of the quality of four constituent perspectives of carbon management systems.

Variable	(1) *GOVERNANCE*	(2) *OPERATION*	(3) *ACCOUNTING*	(4) *COMMUNICATION*
ETS	0.091**	0.207***	0.012	−0.043
	(2.086)	(5.170)	(0.275)	(−0.909)
COMPETITOR	0.042	0.830***	0.339*	0.580***
	(0.254)	(4.553)	(1.795)	(2.941)
CODELAW	0.089***	0.139***	0.230***	0.141***
	(2.809)	(4.180)	(6.398)	(3.625)
lnINTENSITY	0.038***	0.015	0.028**	0.065***
	(3.132)	(1.192)	(2.053)	(4.175)
SHAREHOLDER	−0.001	0.001	0.004**	0.001
	(−0.861)	(0.673)	(2.419)	(0.447)
SIZE	0.080***	0.108***	0.133***	0.176***
	(7.535)	(10.782)	(11.730)	(14.289)
TOBINQ	−0.002	0.001	0.004	0.005
	(−0.290)	(0.165)	(0.606)	(0.556)
GDPPC	−0.235***	−0.255***	−0.268***	−0.349***
	(−4.411)	(−3.971)	(−4.009)	(−5.567)
ROA	−0.974***	−1.252***	−0.123	−1.615***
	(−2.591)	(−3.990)	(−0.347)	(−4.003)
CAPINT	0.095**	0.092**	−0.162***	−0.116**
	(2.327)	(2.027)	(−3.298)	(−2.154)
BETA	−0.018	0.013	0.009	0.026
	(−0.561)	(0.470)	(0.326)	(0.793)
INTENSIVE	−0.083*	−0.127***	−0.089*	−0.075
	(−1.912)	(−3.061)	(−1.902)	(−1.554)
YEAR2012	0.047	−0.005	0.138***	0.151***
	(1.592)	(−0.166)	(4.208)	(4.304)
Constant	1.563***	1.468**	1.448**	1.877***
	(2.884)	(2.230)	(2.119)	(2.933)
Observations	1805	1805	1805	1805
Adjusted R^2	0.070	0.118	0.104	0.135
F	12.36***	20.33***	21.27***	25.08***

Note: The table reports ordinary least squares coefficient estimates. *T* statistics based on heteroscedasticity-consistent standard errors are in parentheses. *, **, and *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively (two-tailed). All variables were Winsorized at the 1st and 99th percentiles with the exception of *OQCMS* and the indicator variables. Financial data are in millions of US dollars. See Table 2 for definitions of variables.

Please cite this article as: Luo, L., & Tang, Q., Determinants of the Quality of Corporate Carbon Management Systems..., *The International Journal of Accounting* (2016), http://dx.doi.org/10.1016/j.intacc.2016.04.007

legislation (e.g., carbon tax, carbon pricing mechanisms). As a result, homogeneous external pressure and internal conditions compel these firms to respond in a similar manner to global warming. Better recognition of the drivers of this action is important because it not only will provide insight into the internal dynamics of corporate climate strategy but also may be helpful in designing policy to realize the optimal net benefits of carbon management systems.

5.4. Robustness tests

A number of robustness tests are conducted. First, we use an alternative measure as a proxy for the quality of carbon management systems (*OQCMS2*). That is, quality is measured as the number of good carbon management practices adopted (Anton et al., 2004; Melnyk et al., 2003) (see Appendix C). Both OLS and Poisson regression[15] models are analyzed to test the determinants of *OQCMS2*. The results (not shown) are qualitatively the same as those presented in Table 6.

Second, another two proxies (*ETS2* and *ETS3*) are used to measure the presence of an emissions trading scheme. *ETS2* is a dummy variable that equals 1 if a firm operates in a country that has a mandatory emissions trading scheme and 0 otherwise. *ETS3* is also a dummy variable that equals 1 if a firm operates in a country that has implemented a national emissions trading scheme and 0 otherwise. We replace emissions trading schemes with these two proxies and rerun the OLS regressions. The results (not tabulated) do not alter our main inferences.

Third, because most carbon regulations may target firms with a higher level of absolute carbon emissions, we replace *lnINTENSITY* with *lnEMIS*, which is calculated as the natural logarithm of the total amount of Scope 1 and Scope 2 emissions. The results using *lnEMIS* as a proxy for carbon exposure are qualitatively consistent with those reported in Table 6, Panel A, Model (3).

Fourth, in our main test, we use the average of the *OQCMS* of other firms in the same sector as a proxy for a firm's competitor pressure. We also consider using the quality of a given firm's carbon management systems relative to that of other firms in the sector. Thus, firm *i*'s competitor pressure is measured as a dummy variable as follows:

$$COMPETITOR_i = \begin{cases} 1 & \text{if } OQCMS_i \leq \frac{1}{N_k-1}\sum_{j\neq i}^{N_k-1} OQCMS_j \\ 0 & \text{if } OQCMS_i > \frac{1}{N_k-1}\sum_{j\neq i}^{N_k-1} OQCMS_j \end{cases}$$

, where N_k represents the number of firms in GICS sector k. The empirical results (not reported) are not qualitatively different from those in Table 6.

[15] Because of the discrete, nonnegative, and count nature of the *OQCMS2* data, Poisson regression is more appropriate as an estimation model.

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6. Discussion and conclusion

Existing studies provide some evidence that firms' carbon emissions have a negative impact on financial performance, firm value, and cost of capital (Griffin et al., 2012; He et al., 2013; Luo & Tang, 2014a; Matsumura et al., 2014). However, companies may have different motivations for implementing a carbon management system. Some companies do this as part of a proactive strategy to minimize exposure to carbon risks and liabilities (Klassen & McLaughlin, 1996; Tang & Luo, 2014), whereas others attempt to make it appear that their decisions are rooted in concern for the environment without making a significant commitment to addressing these issues in fact. In other words, these carbon management systems are instruments of greenwashing designed to enhance the reputation. Thus, it is imperative to explore what incentives and hurdles firms face in implementing high-quality carbon management systems.

This paper has sought to identify determinants of the quality of corporate carbon management systems. Using CDP data and the Tang and Luo (2014) framework, we found that the overall quality of carbon management systems improved during the research period and that both external and internal forces shape the way in which firms respond to climate change to reduce compliance costs or manage stakeholder relationships. The implication of these findings is that governments should provide stronger public policy signals to encourage firms in the private sector to reduce excessive emissions and capitalize on opportunities from climate change.

We acknowledge some limitations that provide opportunities for future study. First, our measure of the quality of carbon management systems is, to a certain degree, related to voluntary carbon disclosure. In addition, some of our measures of the strength of certain elements may not have been as precise as possible. For instance, we measured the number of carbon projects but not the extent or scale of each action, which is crucial to controlling emissions. Similarly, we were unable to measure how reduction targets were set, how resources were allocated to achieve these targets, and how this was related to staff compensation. Furthermore, we did not consider firms that had not disclosed their carbon data, so the sample might have been subject to self-selection bias.

Future studies may investigate implementation and the effectiveness of carbon management systems in terms of controlling emissions or refine our methodology to more accurately measure the strength of the individual elements of carbon management systems. In addition, our overall measure of carbon management systems is based on measurements of the quality of individual elements. However, our measure does not consider the interaction and interplay of these elements, which are likely to affect the outcome. Moreover, we treated carbon management systems as a separate system, even though carbon management systems do not operate independently within the whole system of the firm. Thus, future research may examine how firms integrate carbon management systems into their larger operating systems. For instance, other managerial functions, such as corporate governance, may enable carbon management systems to perform more efficiently and effectively. For this purpose a case study approach may provide more insight. In addition, the paper shows that after control emissions, firms in the non-intensive sectors have higher quality of carbon management systems than carbon-intensive sectors, suggesting that firms in these sectors (i.e., consumer discretionary, consumer staples, healthcare, industrials, information technology and telecommunications, etc.) also have incentives to adopt or improve their carbon management systems. For instance, firms that have direct contact with end consumers might want to impress their customers by showing a high quality carbon management systems. Other firms that may not have excessive emissions themselves may wish to reduce their customers' carbon exposure, and this motivates them to invest in carbon management systems. Thus, our result opens a door for future study to examine other motivations for carbon management systems not yet hypothesized in this paper. Moreover, our research interest is the quality of carbon management systems, not the structure of carbon management systems, because we measure the quality of carbon management systems based on the strength of each element. "Structure" of a carbon management systems refers to how the composite elements of a carbon management systems are arranged in a certain way, whereas "quality" means how good or bad a carbon management system is. We distinguish the two concepts, and at the same time we recognize that how the carbon management system's elements are structured might be associated with the effectiveness of the carbon management system (i.e., interaction effects of individual elements). Thus, we suggest that future research might investigate this interesting issue. Finally, we did not consider the impact of carbon management systems on firm valuation, which is a potentially interesting avenue for future projects. The ever stringent carbon regulations, in particular carbon markets, raise a lot of accounting and auditing issues, such as how to account for carbon assets and liabilities, how to report carbon information and provide GHG statement assurance, and so on (Busch & Hoffmann, 2007). Thus, we expect there to be a growing demand for carbon-related accounting knowledge and research among accountants who practice in a low-carbon economy.

Appendix A. Carbon management systems (Tang & Luo, 2014)

Element		Purpose
Carbon governance perspective		
1	Board function	To develop an overall climate change strategy and policy
2	Risk and opportunity assessment	To identify and assess carbon risk and opportunity
3	Staff involvement	To motivate staff and enhance awareness of climate change issues
Carbon operation perspective		
4	Emission target	To create a mitigation target that is consistent with the carbon strategy
5	Policy implementation	To enforce the carbon policy by prioritizing reduction actions and allocating resources to achieve targets
6	Supply chain emission control	To reduce supply chain emissions
Emission tracking and reporting perspective		
7	Carbon accounting	To keep track of the carbon inventory and emission footprint
8	Carbon assurance	To increase the reliability of carbon data
Engagement and disclosure perspective		
9	Engagement with stakeholders	To strengthen the link with stakeholders
10	Disclosure and communication	To increase the transparency of mitigation activities and outcomes

Please cite this article as: Luo, L., & Tang, Q., Determinants of the Quality of Corporate Carbon Management Systems..., *The International Journal of Accounting* (2016), http://dx.doi.org/10.1016/j.intacc.2016.04.007

Appendix B. Emissions trading schemes in sample countries

Country	Name of scheme	Status	Launch Year	Scope	Mandatory/ Voluntary
Australia	Carbon Pricing Mechanism	Operating	2012	National	Mandatory
European Union	European Union Emissions Trading Scheme (EU ETS)	Operating	2005	National	Mandatory
Iceland, Liechtenstein, and Norway	EU ETS	Operating	2008	National	Mandatory
Croatia	EU ETS	Operating	2013	National	Mandatory
Japan	Japan Voluntary Emission Trading Scheme (JV ETS)	Operating	2005	Regional	Voluntary
	Tokyo Emissions Trading Scheme	Operating	2010	Regional	Mandatory
New Zealand	New Zealand Emissions Trading Scheme (NZ ETS)	Operating	2010	National	Mandatory
China	Pilot Emissions Trading Schemes	Under development	2014	Regional	Mandatory
Korea	Emissions Trading Scheme	Under development	2015	National	Mandatory
Switzerland	Swiss Emissions Trading Scheme, planned link to EU ETS	Operating	2008	National	Voluntary
United Kingdom	CRC Energy Efficiency Scheme	Operating	2010	National	Mandatory
United States	California Emissions Trading Scheme	Operating	2013	Regional	
	Regional Greenhouse Gas Initiative (RGGI)	Operating	2009	Regional	Mandatory
	Western Climate Initiative (WCI)	Operating	2013	Regional	Voluntary

Appendix C. An alternative measure for *OQCMS*

Proxy variable	Measure (1 = yes; 0 = no)	Range
BOARD	Whether an individual/subset of the board or other committee appointed by the board has the highest level of direct responsibility for climate change within a firm in the reporting year	0–1
RISKMANAGE	Whether a firm has a specific climate change risk management process in the reporting year	0–1
INCENTIVE	Whether a firm provides incentives for the management of climate change issues, including the attainment of targets, in the reporting year	0–1
TARGET	Whether a firm has an emissions reduction target that is active (ongoing or reached completion) in the reporting year	0–1
PROJECT	Whether the number of initiatives implemented by a firm is above the median of the sample in the reporting year	0–1
SUPPLYCHAIN	Whether the use of a firm's goods and/or services directly enables a third party to avoid greenhouse gas emissions in the reporting year	0–1
ACCOUNTING		0–1

(continued on next page)

(*continued*)

Proxy variable	Measure (1 = yes; 0 = no)	Range
	Whether a firm has all inventories of Scope 1, Scope 2, and Scope 3 emissions in the reporting year	
AUDIT	Whether a firm has any Scope 1, Scope 2, and Scope 3 emissions verified/assured by a third party in the reporting year	0–1
POLICYENGAGE	Whether a firm engages with policymakers to encourage further action on mitigation and/or adaption in the reporting year	0–1
TRANSPARENCY	Whether a firm's overall carbon disclosure is not less than 70 in the reporting year	0–1

OQCMS2 = the number of carbon management practices adopted.

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