



Meditari Accountancy Research

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Article information:

To cite this document:

Edward Nartey, (2018) "Determinants of carbon management accounting adoption in Ghanaian firms", *Meditari Accountancy Research*, Vol. 26 Issue: 1, pp.88-121, <https://doi.org/10.1108/MEDAR-03-2017-0133>

Permanent link to this document:

<https://doi.org/10.1108/MEDAR-03-2017-0133>

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Determinants of carbon management accounting adoption in Ghanaian firms

Abstract

Purpose – Carbon management accounting (CMA) is one part of sustainability accounting designed to provide information for the management of carbon dioxide (CO₂) releases. Adopting the contingency framework, this paper aims to examine the contextual antecedents that influence CMA adoption in Ghanaian firms.

Design/methodology/approach – The paper tests seven contextual dimensions, namely, strategy, structure, size, environmental management system (EMS), decentralization, technology and perceived environmental uncertainty, on CMA adoption from a survey of 125 accountants.

Findings – Consistent with prior literature, organizational strategy, structure, environmental management accounting (EMA), firm size, technology and perceived environmental uncertainty were found to be positively associated with CMA adoption and hence support contingency theory. However, a relationship between decentralization and EMA adoption was not supported by the sample data. Also, the existence of CMA systems was found to be low in the sample firms, although more than half of the respondents have EMS.

Research limitations/implications – The study is limited to Ghana hence possible generalization of the results is limited. Further exploration of contingency-based research in other emerging economies would provide valuable insights on CMA adoption and practices to contribute to the CMA literature.

Practical implications – The findings suggest that although CMA adoption and practices is low in the sampled firms, both contextual and environmental factors play a vital role in the adoption of CMA in developing economies, as it pertains to the generic management accounting systems. Policies governing CMA practice should incorporate organizational contextual factors.

Originality/value – The paper presents preliminary empirical evidence on the state of adoption and practice of CMA from an emerging economy perspective, an area which lacks empirical investigation both in the EMA and the carbon accounting domain. It draws considerable novelty on the basis that despite the growing interest in climate change-based research empirical works on CO₂ emissions conducted exclusively from management accounting perspective, and in developing economies in particular, have been scant. The paper extends the contingency theory framework from conventional practices to the EMA field.

Keywords Greenhouse gas emissions, Climate change, Contingency theory, Contextual factors, Carbon management accounting

Paper type Research paper

1. Introduction

One of the world's most threatening environmental issues has been the effects of climate change [Intergovernmental Panel on Climate Change \(IPCC\), 2007, 2014](#). Following the conclusions drawn by the IPCC that human activity is the cause of global warming, strategies to address greenhouse gas (GHG) emissions particularly carbon dioxide (CO₂) have increasingly attracted worldwide recognition as a high-priority issue ([Saka and Oshika, 2014](#)). Climate change has negative repercussions on the environment and human health and constitutes one of the relatively new and sophisticated forms of risk that is being tackled by governments and their citizens across the globe ([Woods et al., 2017](#)). Population



growth, urbanization and land use changes are highly associated with changes in environmental parameters (Duran-Encalada *et al.*, 2017). Although GHG emissions is less prevalent in developing countries, there has been calls for a new and more holistic approaches to the prevention and possible minimization of the adverse effects of climate change given its global nature (Bennett *et al.*, 2011, 2013). This is because the risks associated with GHG emissions and other climatic changes are a global phenomenon, and developing countries are no exclusion. In addition, the scientific evidence given by the serious risks posed by climate change to mankind has been overwhelming to the extent that the avoidance of its catastrophic effect demands global responses (Clarkson *et al.*, 2015). Moreover, only a minimal reduction in the total amount of GHG emissions at the corporate level has taken place in some advanced countries and that further increases in the global GHG emissions continues (Zvezdov and Schaltegger, 2015).

Although the definition of GHG emissions as given by the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) constitutes six different gases, both scholarly and anecdotal evidence suggest that CO_2 has a degrading impact on the environment (Cadez and Guilding, 2017). It has been estimated that a significant and rapid reduction of total CO_2 emissions will be required if the growing environmental, social and economic threats associated with climate change is to be halted (Meinshausen *et al.*, 2009; Cadez and Guilding, 2017). The level required to avert catastrophic climate change is to limit global warming to 2 degrees Celsius (IPCC, 2013). An even more ambitious target of 1.5 degree Celsius has been recommended by a number of non-governmental organizations (NGOs) and scientists to stay within safe planetary boundaries (Rockstrom *et al.*, 2009). The achievement of this carbon budget which has been estimated to support a world population of 9.2 billion by 2050, however, requires an annual average per capita emission levels to fall between 2.1 and 2.6 billion tonnes of CO_2 by mid-century. Although emission levels in sub-Saharan Africa (SSA) constitute the lowest in the world, the current per capita emission levels ranges between 2.7 and 3.9 billion tonnes of CO_2 when land-use change and forestry are respectively excluded and is higher than the stipulated 2.1 and 2.6 billion tonnes.

In this regard, the incorporation of CO_2 information into the strategic decisions of corporate organizations has received increasing pressures from all sectors including regulators, financial institutions, consumers and the general public (Yunus *et al.*, 2016). Being an extremely broad issue, carbon-reduction initiatives and corporate emission reporting which accountants and auditors are expected to play substantial role have expanded considerably (Tang and Luo, 2014). This has certainly defined a new role for managers and management accountants (Cadez and Guilding, 2017). In climate change policies, management accountants are expected to position themselves as managers in respect of not only carbon control but also climate-change strategy implementers (Lovell and MacKenzie, 2011). They are being increasingly called upon to allocate resources by using algorithms involving complex climate change issues in addition to their traditional cost and revenue management analytical domains (Howard-Grenville *et al.*, 2014). This is accomplished by incorporating the assets, liabilities and risks related to GHG emission management into conventional management accounting practices, governance and control mechanisms Chartered Institute of Management Accountants (CIMA), 2010; Deloitte, 2014; Hartmann *et al.*, 2013; Ernst and Young, 2015.

However, whereas organizational internal management issues of carbon accounting are mandatory in corporate decision-making, performance management and reporting, empirical works on CO_2 emissions conducted from management accounting perspective have been scant and largely remain a nascent field (Bebbington and Thompson, 2013; Cadez and Guilding, 2017). Yet, a pre-requisite to the disclosure of carbon information to external

stakeholders is the institution of carbon management systems of which management accounting systems (MASs) play significant role. Fundamentally, the functionality of MAS information [and for that matter carbon management accounting (CMA) systems] as designed and used by organizations are largely affected by both internal and external contextual factors (Otley, 1980). More precisely, the effectiveness of MAS information in organizations is affected by the extent to which the MAS information characteristics “fit” (or align with) contextual variables (Chenhall, 2003). The “fit” concept is the underlying principle of contingency theory (Burkert *et al.*, 2014) which suggests that “fit” between MAS information and context variables is important for achieving high organizational performance (Otley, 2016). In this regard, a state of “misfit” between the MAS information characteristics and context variables generally results in inferior outcomes which are typical of some aspects of performance (Hartmann and Moers, 1999; Meilick, 2006).

Despite these fundamental requirements of the MAS adoption and practice in corporate organizations, empirical support for works that translate the contingency framework from conventional practice to the environmental management accounting (EMA) domain, and the carbon management field in particular hardly exist (Hartmann *et al.*, 2013). Specifically, theoretically informed studies relating to the current state of CMA development remain relatively scarce (Christ and Burritt, 2013). Based on these voids, the current paper contributes to the CMA literature by filling a gap that translates contingency theory’s application from conventional practices to the environmental management domain. Specifically, it provides knowledge and understanding of the situational factors that influence MAS adoption in the carbon emission management field. Such theorizations are important as the “fit” relationships between variables remain fundamental to the adoption and implementation of CMA (Otley, 1980; Chenhall, 2003; Gerdin and Greve, 2004; Burkert *et al.*, 2014). The importance of a true and fair representation of an organization’s carbon footprint and efforts in emission reductions presented to external stakeholders is based largely on comparable and accurate measurement and estimation of carbon emissions which is provided by CMA systems. To the best of the author’s knowledge, this is the first study that has in exclusive sense examined the linkages between organizational contextual factors and CMA adoption. It presents preliminary empirical evidence on the state of adoption and practice of CMA from an emerging economy context.

The rest of the paper is organized as follows. Section 2 presents background to Ghana’s carbon management initiative and its justification for being the research site. Section 3 reviews the literature on prior studies on CMA, theoretical framework and hypotheses development. The research methodology is captured in Section 4, while Section 5 presents the results followed by a discussion of the results in Section 6. The summary and concluding comments together with future research directions is captured in Section 7.

2. Background to Ghana’s greenhouse gas emission mitigation efforts

A number of initiatives such as the National Clean Development Mechanism Guidelines (NCDMG) have been developed in Ghana to facilitate the evaluation of sustainable development contributions of the Clean Development Mechanism (CDM) projects (CDP, 2008; Carbon Trust, 2009; EPA, 2011). The CDM constitutes one of the flexible mechanisms defined in the Kyoto Protocol and makes available projects that focus on emission reduction and provide certified emission reduction units which may be traded in emission trading schemes. Actions that are expected to facilitate the attainment of low carbon climate resilience through effective adaptation and GHG emission reduction in several priority areas are currently being implemented within Ghana’s Intended Nationally Determined Contribution (INDC) framework (GH INDC, 2015). The mitigation and adaptation actions

resonate with the medium-term development agenda including Ghana Shared Growth Development Agenda II, the anticipated 40-year socio-economic transformational plan and the universal sustainable development goals. To realize this, a 10-year unconditional and conditional emission reduction trajectory spanning the period 2020-2030 has been drawn. Whereas the unconditional emission reduction goal targets the implementation of two transformational mitigation actions, the conditional emission reduction goal assumes the implementation of 18 transformational mitigation actions over the 10-year period.

The programme of actions which involve 20 mitigations and 11 adaptations in seven priority economic sectors are being proposed for implementation within the 10-year period. The basket of gases being mitigated includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). As part of the mitigation strategy, the abatement of fluorinated-gases (HFC-22 and HFC-410) from stationery air-conditioners is included. Relative to a business-as-usual (BAU) scenario, the mitigation goal targets a 15 per cent unconditionally GHG emission reduction totalling 73.95 $MtCO_2e^2$ emissions by 2030. Emissions are expected to increase from 19.53 $MtCO_2e^2$ in 2010 to 37.81 $MtCO_2e^2$ in 2020, and to 53.5 $MtCO_2e^2$ in 2025 and finally 73.95 $MtCO_2e^2$ in 2030 under the BAU conditions. With regards to the unconditional emission reduction goal, a 12 and 15 per cent decrease in emissions relative to the BAU emission levels in 2025 and 2030, respectively, is expected. The CO_2 equivalent is calculated using the 100-year global warming potentials ($CO_2 = 1$; $CH_4 = 21$; $N_2O = 310$; $HFC - 22 = 1,780$; $HFC - 410 = 2,060$) in accordance with the IPCC Assessment Report. The Global Warming Potential (GWP) indicators are being used on the national GHG inventory to establish historical emissions from 2010 to 2030.

Taking note of this action as part of Ghana's contribution to GHG emission reduction, a US\$7.2bn commercial facility to develop transformational gas project dubbed "Sankofa Gye-Nyame" is being mobilized. Under Ghana's INDC, the long-term goal of adaptation which aims to increase climate resilience and decrease vulnerability for enhanced sustainable development is informed by a number of factors including strict adherence to accountability and reporting of carbon emissions. This goal certainly falls within the purview of management accountants to provide accurate GHG cost information for managerial decisions.

3. Literature review, theoretical framework and hypotheses development

3.1 Carbon management accounting system adoption

Although the Global Reporting Initiative Standard (GRI 305, 2016) identifies types of emissions that are discharge of substances from a source into the atmosphere to include GHG, ozone-depleting substances (ODS), nitrogen oxides (NO_x) and sulphur oxides (SO_x), the current paper is limited to GHG emissions. Compared to the other forms of emissions, GHG emissions, especially CO_2 forms a major contributor to climate change and has gained wide recognition in developing countries (GRI 305, 2016). For example, carbon dioxide emissions were by far the largest contributor to GHG emissions and GWP in SSA natural terrestrial systems (Kim *et al.*, 2016). CO_2 emissions ranged from 3.3 to 57.0 $MgCO_2$. GHG emissions are air pollutants such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃) that have significant adverse impacts on ecosystems, agriculture, air quality and human and animal health (GRI 305, 2016).

Carbon accounting methods otherwise referred to as CMA systems (Zvezdov and Schaltegger, 2015) play significant role in providing accurate carbon information and the overall management of carbon performance (Burritt *et al.*, 2011). It is the branch of sustainability accounting that generates both short-term and long-term carbon information

to aid management decisions on carbon emission issues (Mauders and Burritt, 1991; IPCC, 2014; Burritt *et al.*, 2011). Bowen and Wittneben (2011, p. 1025) define CMA as “the measurement of carbon emissions, the collation of this data and the communication thereof, both within and between firms. It is a quantitative record of a particular unit that is established according to the operations of a company and communicated within and beyond the firm”. Although a number of devices/tools that support environmental and sustainability measures captioned as EMA has been developed (Unerman *et al.*, 2007), there is little empirical evidence supporting their practical adoption and usage. Besides, the adoption and practice of carbon accounting in the corporate world has been characterized by divergent CMA approaches. Gibassier and Schaltegger (2015, p. 346) describe CMA as:

[...] the recognition, the non-monetary and monetary evaluation and the monitoring of greenhouse gas emissions on all levels of the value chain and the recognition, evaluation and monitoring of the effects of these emissions on the carbon cycle of ecosystems.

Associated with this definition are three major types of CMA corporate organizations implemented for different purposes: organizational carbon accounting, product carbon accounting and project carbon accounting (Gibassier and Schaltegger, 2015; Cadez and Guilding, 2017). As specified by Burritt *et al.* (2011), organizational carbon accounting was developed specifically for measuring and analyzing a company’s carbon emissions as well as setting targets for minimization of carbon emissions. Product carbon accounting measures carbon emissions based on the life cycle assessment approach for one product only and is internally used for product optimizations and design and externally for eco-labelling purposes and communication to consumers. Project carbon accounting aims at creating CO_2 compensation offsets with joint implementation or CDM project.

Contrary to the above is the issue of compliance. As noted by Burritt *et al.* (2011), regulations relating to CO_2 emissions in many countries have in recent years become stricter to the extent that companies have no other option than to address carbon emission issues by generating carbon-related information. However, whether the engagement in the disclosure of carbon information is done to avoid the imposition of fines arising from legal requirements, safeguard operating license, or to gain competitive advantage requires an effective and efficient design of CMA systems solely for providing carbon-related information and are largely influenced by contextual factors. As Hopwood (2009), Gond *et al.* (2012) and Bebbington and Thompson (2013) point out, the embedding of sustainability within the strategic objectives of organizations and the appropriate alignment of their strategies and structures with the MAS information is a pre-requisite for ecologically sustainable management. Aligning CMA objectives as efficient and effective carbon emission reduction decision-oriented tool with organizational contextual factors has however not been realized. Little empirical evidence on the reporting of corporate carbon information pertaining to the collection, measurement and communication of carbon related data exist in the literature (Lohmann, 2009; Hopwood, 2009; Burritt *et al.*, 2011). This is because corporate carbon accounting has been recognized as relatively new and nascent area of research which deals basically with the effects of environmental capital (Gibassier and Schaltegger, 2015), and continues to receive attention via the development of markets for trading carbon emissions.

3.2 Theoretical perspectives

The most theoretical lenses widely used in existing environmental accounting studies include stakeholder’s theory (Liesen *et al.*, 2015), legitimacy theory (Duff, 2014) and new institutional theory (de Villiers and Alexander, 2014). These theories have also been widely

recognized as most extensively used as theoretical framework in corporate EMA studies, carbon reporting and financial accounting in general (Hoozee and Ngo, 2017), and in some cases, management accounting research (Woods *et al.*, 2012). However, a review of these theoretical dimensions revealed that a study of contextual dimensions on CMA adoption can be appropriately explained through the lens of contingency theory. The contingency model is a long-standing and well-recognized theoretical framework for explaining the design and success of organizational structure (Meilick, 2006; Burkert *et al.*, 2014). Its central theme is the concept of “fit” (Franco-Santos *et al.*, 2012; Burkert *et al.*, 2014) and posits that organizational performance is enhanced when appropriate “match” or “fit” between MAS information and organizational contextual factors is reached (Chenhall, 2003). According to Otley (1980), a significant component of the organizational structure of a company is its accounting system which forms part of particular features of the company, and whose appropriateness depend on circumstances surrounding the organization. In line with this view, Otley (1980, p. 413) states that “a contingency theory must identify specific aspects of an accounting system which are associated with certain defined circumstances and demonstrate appropriate matching”.

Although quite a number of literature has been dedicated to studies in EMA, explicit research efforts that focus on the understanding of organizational context factors, and their linkages with CMA adoption is far from expected (Christ and Burritt, 2013). Consequently, a significant knowledge gap that relates to the adoption of CMA in organizational context exists. While contingency theory application in the EMA field is limited (Bouma and van der Veen, 2002; Qian *et al.*, 2011; Burritt *et al.*, 2011; Qian *et al.*, 2015), that of CMA is far underdeveloped. Given this backdrop, the single research question which this paper seeks to find answers to is:

RQ1. To what extent do organizational contextual factors influence CMA adoption among corporate organizations in a developing country like Ghana?

More specifically, what are the contextual determinants of CMA adoption in Ghanaian corporate firms?

3.3 Hypotheses development

The current paper examines the adoption of CMA with reference to the following contextual variables: organizational strategy, size, structure, decentralization, technology and perceived environmental uncertainty. In addition to the contingent variables, the existence of environmental management system (EMS) is included as a dichotomous variable. To determine CMA adoption from the perspective of these contingent variables, the following *a priori* hypotheses are tested. These are formulated based on prior literature.

3.3.1 Organizational strategy and carbon management accounting adoption. The implications of strategic orientation for managerial practice have over the years been documented by empirical research in both management and accounting literature (Porter, 1980; Chenhall and Langfield-Smith, 1998). Considerable emphasis has been placed on the incorporation of strategy as a contingent factor of the management accounting practice (Langfield-Smith, 1997; Chenhall, 2003; Hartmann and Moers, 2003; Gerdin and Greve, 2004). However, irrespective of which strategic direction adopted by an organization, contingency-based research predicts certain practices as more appropriate and fit for particular strategies. In this regard, a variety of generic taxonomies of strategy has been explored: the prospectors/analysts/defenders model (Miles and Snow, 1978), product differentiation/cost leadership classification model, the build/hold/harvest model (Gupta and Govindarajan, 1984), and on a continuum, collapsing these three taxonomies ranging from prospectors,

builders and product differentiation to defenders, harvesters and cost-leaders (Abdel-Kader and Luther, 2008). This is based on the argument that different internal structures and processes as well as appropriate management accounting information are required for different strategies, and that certain strategies are more consistent with certain management accounting practice compare to others (Chenhall, 2003; Otley, 2016). For example, Chenhall (2003) noted that organizations that pursue differentiation strategies depend on future-oriented external management accounting information. Similarly, Langfield-Smith (1997) and Chenhall (2003) found that sophisticated information systems are not required for the strategy of defend/harvest/cost-leadership but are required for prospects/build/product differentiation strategies. As pointed out by Bouma and Van der Veen (2002) and Ferreira *et al.* (2010); these typologies as have been argued, play significant role in environmental management accounting (EMA) and hence CMA systems since carbon accounting is a subfield of EMA. Parker (1997) states that, strategies for environmental management pose influential factors on EMA systems. In line with these discussions, the following hypothesis is formulated:

H1. A positive relationship exists between organizational strategy and CMA adoption among firms in Ghana.

3.3.2 Organizational structure and carbon management accounting adoption. Organizational structure refers to the formal specifications of roles or tasks for individual members or groups of people that ensure the execution of organizational activities (Chenhall, 2007). Structure is generically conceived as the way in which an organization differentiates and integrates its activities. Decentralizing authority is the mechanism through which differentiation is achieved but integration connotes rules, operating procedures, committees, etc., although the definitions attributed to structure has been diverse, a fundamental issue in their requirements lies in the distinction between the outcomes of structure and structural mechanisms. It has been argued that structural arrangements not only impact on the efficiency of work and individual motivation but also assist in shaping the future of the organization through information flows and management control systems. Similar arguments hold for EMA and hence CMA adoption. The commitment of many different organizational functions is required for successful adoption and implementation of CMA activities (Lee, 2011). The implication is that the chances of successfully implementing a CMA design and adoption is not only influenced by the organizational structure of a business but also that which supports inter-functional processes, communication and sharing of ideas. The adoption of CMA to be consistent with the intent of organizational structure as either mechanistic or organic, differentiation or integration has been the focus of contingency-based research in management accounting. Based on these arguments, a formulation of a testable hypothesis follows:

H2. A positive relationship exists between organizational structure and CMA adoption among firms in Ghana.

3.3.3 Organizational size and carbon management accounting adoption. Organizations are able to operate more efficiently, create opportunities for specialization and division of labour partly due to their growth in sizes. In this vein, the possession of more power in controlling the environment in which organizations operate is vested in large organizations. Large organizations also have minimal task uncertainties in the event of large-scale mass production. Despite these advantages that characterize large organizations, they are faced with the challenge of handling greater quantities of information, instituting controls including documentation, rules, specialization of roles, and functions, and greater

decentralization down hierarchical structures, etc., as they grow and expand. In this regard, empirical evidence suggests a more sophisticated MASs is likely to be adopted by large organizations compared to small ones (Chenhall, 2003; Cadez and Guilding, 2008). This situation is not different from CMA adoption in that CMA adoption requires certain sophisticated resources. According to Abdel-Kader and Luther (2008) the resources and specialists required to transform from a simple to more sophisticated MASs can easily be afforded by large organizations. The assumption here is that CMA adoption varies across organizational sizes. Drawing on these statements, the following verbal hypothesis is formulated:

H3. There is a direct positive association between organizational size and CMA adoption among firms in Ghana.

3.3.4 Information technology and carbon management accounting adoption. Technology has been considered to include the contextual elements that are crucial for the efficient and effective functioning of an organization (Kim 1988) and has been identified as one of the main factors including two others (product volume and production capacity level) that determine the size of a company's carbon footprint (Hoffmann and Busch, 2008; Milne and Grubnic, 2011; Cadez and Guilding, 2017). In this regard, companies with high levels of technological advancement are expected to provide more CO₂ emission information compared to low technology-oriented firms. Tavoni *et al.* (2012) argue that achieving the dual objective of increasing positive output levels of CO₂ while at the same time minimizing negative outputs can only be realized concurrently through the adoption of improved technology. According to the IPPC (2014), economic growth and lack of radical technological innovation that facilitate transitions to low-carbon societies are the main reasons for continuing rise of CO₂ emissions across developed and developing countries. Extant literature suggest that managers' use of IT not only increases volume, speed and capacity of the data being handled but also enhances exchanges of information and communication across functions, parties, geographical locations and time zones (Forouzan, 2001). Mia and Winata (2008) hypothesize that managers' use of MASs information and IT are positively related as IT assists managers to use information effectively. The ability of IT to link one activity with another and make real data widely available through enterprise resource planning, electronic data interchange and the internet suggests its importance to the management of carbon emissions and hence influence on CMA adoption. These statements suggest that technology influences the adoption of carbon management systems and hence CMA. On the basis of these propositions, the following hypothesis is formulated:

H4. A direct positive relationship between IT use and CMA adoption exist in the Ghanaian context.

3.3.5 Perceived environmental uncertainty and carbon management accounting adoption. At the foundation of contingency-based research is the external environment which remains not only a powerful variable (Pondeville *et al.*, 2013) but also the most widely researched feature of the MAS-contingency framework (Otley, 2016). Uncertainty is associated with the variability of organizational environment (Pondeville *et al.*, 2013). Managers' perception of uncertainties that affect their decisions and perceived environmental uncertainty (PEU) is predicted to be associated with top managers' perceived inability to accurately predict an organization's external environment. Studies in contingency-based management accounting research (Chenhall, 2003) have found higher PEU to be associated with the essence for more open, externally focused non-financial styles of MASs. Based on these arguments, the following testable hypothesis is formulated:

H5. There is a positive association between manager's perceived environmental uncertainty and CMA adoption.

3.3.6 Decentralization and carbon management accounting adoption. Organizational structure refers to the formal specifications of roles or tasks for individual members or groups of people that ensure the execution of organizational activities (Chenhall, 2007). Structure is generically conceived as the way in which an organization differentiates and integrates its activities. Decentralizing authority is the mechanism through which differentiation is achieved but integration connotes rules, operating procedures, committees, etc. Although the definitions attributed to structure have been diverse, a fundamental issue in their requirements lies in the distinction between the outcomes of structure and structural mechanisms. It has been argued that structural arrangements not only impact on the efficiency of work and individual motivation but also assist in shaping the future of the organization through information flows and management control systems. In this regard, the implementation of CMA stands the chance of being successful if the organizational structure and/or decentralization of a business support inter-functional, communication and the exchange of ideas. The design of MAS to be consistent with the intent of organizational structure as either mechanistic or organic, differentiation or integration has been the focus of contingency-based research in management accounting. Decentralization is associated with the level of autonomy that has been delegated to managers (Chenhall, 2003). This contextual variable has been identified as important dimension of management accounting practice. Managers' greater responsibilities over planning and control activities as well as enhanced access to information not available to the corporate body is achieved through decentralization. According to Gerdin (2005), organizations resort to decentralization and focus on a more administratively oriented control strategy, as they expand and become more complex. CMA adoption in this case is found to "match" overall control strategy as a more highly developed and formal budgeting systems are used. The following hypothesis is formulated:

H6. There is a positive association between decentralization and CMA adoption.

3.3.7 Environmental management systems and carbon management accounting adoption. The creation of environmental management system (EMS) is a voluntary activity and initiative undertaken by corporate entities (Rankin *et al.*, 2011). Although it involves a voluntary initiative, the implementation of such a system provides a means for cost savings and profitability enhancement through improved corporate processes, products and services (Yunus *et al.*, 2016). It has been argued by Melayk *et al.* (2003) that the implementation of an EMS facilitates waste reduction if not eradicating it completely, minimize the level of energy use and reduces the negative impact of the firm's operations on the environment. Tan (2005) describes the implementation of EMS as a process that systematically prescribes, implement and audit environmental goals, policies and responsibilities. The existence and operation of EMS and its link with environmental performance has been examined by a number of studies (Melayk *et al.*, 2003). Firms with an EMS are likely to offer more detailed and credible GHG emission information compared to those without such a system (Rankin *et al.*, 2011). It is therefore hypothesized that the existence and implementation of an EMS helps organizations in facilitating the management of GHG emission reduction strategies, and that firms that pursue GHG emission reduction strategies are likely to adopt CMA (Burritt *et al.*, 2011). In line with these assertions, a formulation of the testable hypothesis follows:

H7. Firms that have and implement an EMS are likely to adopt CMA compared to firms that do not implement EMS

4. Methodology

4.1 Survey design, sample and data

The paper uses Ghana as the research site (Figure 1). The choice of Ghana stems from the fact that unlike the developed world where much of the emissions profile of individual countries is dominated by emissions from industrial activities and processes, oil and gas production and other energy sources, that of most developing countries especially SSA countries is dominated by environmentally degraded activities such as deforestation which arises from forestry and land-use changes (Kim *et al.*, 2016). As a result of limited industrialization in SSA, most emissions are not linked to fossil fuels; rather they are linked to agriculture and wider land-use change. Nonetheless, as a result of projected population and economic growth, GHG emissions in the region are expected to grow rapidly due primarily to increased fossil fuel use and extraction, expansions in cattle production and deforestation. For example, Ghana's emissions profile is dominated by emissions from land-use change and the forestry sector where more than half (53 per cent) of total emissions is driven by changes in forest land (WRI CAIT, 2015).

However, existing literature has focused predominantly on the industrialized countries. A report by Ghana's Third National Communications (TNC) to the UNFCCC noted that the increase in GHG emissions from $-3.0 \text{ MtCO}_2\text{e}$ to $1.3 \text{ MtCO}_2\text{e}$ as a result of land use during the period 1990 to 2011 was mainly due to deforestation (WRI CAIT, 2015). Also, between 2005 and 2010, Ghana's annual deforestation rate of 2.2 per cent was estimated to be the sixth highest in the world (TNC, 2015). Increased demand for wood and wood products for energy, agricultural expansion, increased animal grazing, population and development pressures and mining and mineral exploration are key drivers of increase deforestation. In this regard, one of the main policy directions of Ghana's climate change mitigation plan has been targeted at reforestation and afforestation of 10,000 hectares of degraded lands annually. For example, a significant decrease in emissions between 2010 and 2012 was as a result of reforestation plan for that period (WRI CAIT, 2015). Soil physical and chemical properties, rewetting, vegetation type, forest management and land-use changes are all found to be important factors affecting soil GHG emissions from natural terrestrial systems. This paper aims at examining the relationship between contextual factors and the adoption of MASs.

Given that different models of contingency "fit" (e.g. selection, matching and moderation) require different hypotheses formulation, statistical formats and interpretations (Hartmann and Moers, 1999; Burkert *et al.*, 2014), and following Chenhall and Morris (1986), the selection form of contingency "fit" model was found to appropriately test the variables which requires the statistical format of correlation analysis. The objective of the current

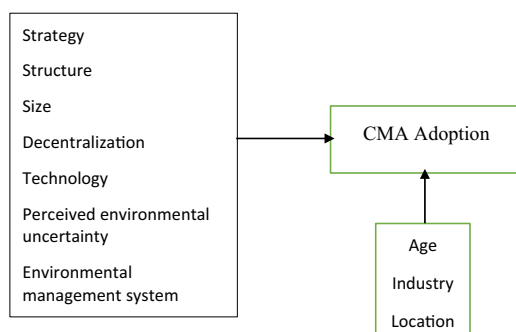


Figure 1.
Research model

paper is to investigate which context variables influence CMA adoption. More precisely, the paper tests the extent to which so-called *selection forces* align with the context variables and CMA adoption. To test these relationships as hypothesized in the preceding section, a survey questionnaire was self-administered to management accountants, practicing accountants as well as other top management personnel in 164 firms in Ghana between September and December 2016. These firms which were drawn from the mining, oil and gas and consumable fuels, chemicals and some manufacturing industries constitute top emitters of carbon per their activities.

The sample frame which consisted of all firms in Ghana was identified from the Registrar General's Department database. To pretest the questionnaire, a pilot survey to different accountants and managers was initially conducted. In addition to the survey questionnaire, data were sourced from publicly available documents including annual reports, stand-alone sustainability reports, and company websites covering the three-year period (2013 to 2015). Responses from 145 (88.4 per cent response rate) firms were initially received and subsequently removed questionnaires which were not fully answered after each of them has been carefully reviewed. In the end, 125 valid questionnaires were selected. The survey instrument that was used for this study consisted of a demographic section where respondents were asked to indicate their current status and number of years at this position as well as organizational size and industry type. The other sections comprised multi-item measures which were drawn from existing literature. A distribution of the firms' responses is summarized in Table I. As shown in Table I, Food/Beverage/water constitute the largest number of the firms sampled (36.0 per cent) followed by Paper Production/Printing Press (18.4 per cent). Also, majority of firms have existed between 5 and 10 years (34.4 per cent), and between 11 and 15 years (31.2 per cent), respectively. Total assets ranging from GH¢50m to GH¢100m is captured by 66.4 per cent of the firms representing the highest of the firms sampled, whereas 51.2 per cent represents the highest number of employees (100-200) a firm employs. This is followed by 50-100 representing 35.2 per cent. The turnover range has rather been very low as a whole 41.6 per cent was captured under GH¢10m-GH¢20m compared to 29.6 per cent representing GH¢21m-GH¢40m. In the next section, a discussion of the measures of each construct is presented.

4.2 Measurement of constructs.

The seven constructs of contingent variables that underpin MAS design and adoption were adapted from previously validated instruments. These include corporate organizational strategy, structure, decentralization, the existence of environmental management system, size, technology and perceived environmental uncertainty. Their significance in relation to CMA adoption has hardly been examined in the CMA literature.

4.2.1 Carbon management accounting adoption. The dependent variable, CMA adoption, is a binary variable which assumes the value of "1" if a firm engages in CMA practice and a value of "0" otherwise. Apart from asking respondents whether they engage in CMA implementation, the under listed questions in Appendix A which required only a "Yes" or a "No" response were asked from firms that responded in the affirmative to the main question. These questions provided further information on the nature of climate change integration process and outcome, engagement process with policymakers, number of projects under development, implementation stage purchase allowance/carbon credits and other related information.

Furthermore, and based on the three major types of CMA implemented by corporate organizations, a coding criterion was used to identify the adoption of CMA by the sample firms:

Nature of firm activity	N	(%)	Determinants of carbon management
Mining	12	9.6	
Oil drilling/refinery	5	4.0	
Cement production	2	1.6	
Steel/aluminum smelting	17	13.6	
Plastic manufacturing	8	6.4	
Food/beverages/water	45	36.0	
Paper production/printing press	23	18.4	
Wood/timber processing	7	5.6	
Textile manufacturing	6	4.8	
<i>Total</i>	<i>125</i>	<i>100.0</i>	
<i>Firm age</i>			
(5-10 years)	43	34.4	
(11-15 years)	39	31.2	
(16-20 years)	26	20.8	
Over 20 years	17	13.6	
<i>Total</i>	<i>125</i>	<i>100.0</i>	
<i>Total assets</i>			
(€50m - €99m)	83	66.4	
(€100m - €199m)	30	24.0	
€200m and over	12	9.6	
<i>Total</i>	<i>125</i>	<i>100.0</i>	
<i>Number of employees</i>			
(50-99)	44	35.2	
(100-199)	64	51.2	
(200 and over)	17	13.6	
<i>Total</i>	<i>125</i>	<i>100.0</i>	
<i>Turnover</i>			
(€10m-€20m)	52	41.6	
(€21m-€30m)	37	29.6	
(€31m-€40m)	26	20.8	
(over €40m)	10	8.0	
<i>Total</i>	<i>125</i>	<i>100.0</i>	

Note: \$1 = GH¢4.27

Table I.
Distribution of firms' responses

- *Energy efficiency initiative*: Following [Lee \(2012\)](#) promotes projects that are energy efficient as well as reduce direct emissions of GHG by substituting existing energy sources with a cleaner fuel.
- *Product innovation*: As pointed out by [Kolk and Pinkse \(2005\)](#), [Boiral \(2006\)](#) and [Weinhofer and Hoffmann \(2010\)](#) new products that emit less carbon can be designed or existing products can be improved upon to become carbon free during their production and/or use.
- *Participating in Emission Trading Schemes (ETS)*: According to [Jeswani Wehrmeyer and Mulugetta \(2008\)](#); [Weinhofer and Hoffmann \(2010\)](#), additional carbon emission capacity can be acquired by voluntarily participating in ETS.

- *Technology innovation*: This is noted by [Jeswani et al. \(2008\)](#) that GHG inventory can be improved upon by the change of process technology. Initiative to offset carbon: invest in projects that offset carbon emissions ([Weinhofer and Hoffmann, 2010](#); [Lee, 2012](#)). Process innovation: The development of new production processes that emit less carbon or the improvement of existing process to be carbon free ([Weinhofer and Hoffmann, 2010](#)).

4.2.2 Corporate environmental strategy. This variable was measured using an instrument adapted from [Banerjee et al. \(2003, p. 107\)](#). Each of the four-item scale incorporated by the instrument was measured using a seven-point Likert scale designed to gauge the extent to which generic *ex ante* environmental concerns were integrated with corporate strategic planning process. Respondents were asked to indicate the extent to which they agreed with each of the following statements (1 = strongly disagree; 7 = strongly agree):

- (1) Our firm incorporates carbon emission reduction strategy in its strategic process; and
- (2) In our firm, quality includes reducing the environmental impact of products and processes:
 - At our firm, we make every effort to link environmental objectives with our other corporate goals.
 - Environmental issues are always considered when we develop new products.

4.2.3 Environmental management strategy. Drawing on [Banerjee et al. \(2003, pp. 120-121\)](#), environmental management strategy was measured using an instrument which incorporates four items. The items that composed the instrument were slightly adjusted to reflect the current position. A seven-point Likert scale was used to measure each of the four items. The items measure the degree of the integration of GHG emission concerns into the overall corporate strategy of the sample firms. The instrument asked respondents to show by ranking on a seven-point Likert scale the extent to which they agreed with each of the four item statements (with 1 = strongly disagree to 7 = strongly agree):

- (1) The overall corporate strategic planning process of our firm incorporates carbon reduction and GHG emission-related issues.
- (2) As part of quality measures in our firm, the environmental effect of carbon emission from our operations and the products or services is reduced drastically.
- (3) Our corporate strategic plan ensures that carbon emission reduction objectives are linked with corporate goals.
- (4) Whenever new products/services are developed or launched, we ensure that they address GHG emission-related issues.

4.2.4 Organizational structure/decentralization. The survey instrument of [Gordon and Narayanan \(1984\)](#) which was drawn on the mechanistic/organic continuum of [Burns and Stalker \(1961\)](#) was adapted for the measurement of organizational structure. The instrument incorporates five items and uses a seven-point Likert scale to measure the extent to which the Chief Executive Officers (CEO) of individual firm delegate authority to decision-making concerning CMA adoption.

4.2.5 Size. Prior research suggests that larger organizations are abler to adopt sophisticated management accounting technique compared with smaller organizations ([Cadez and Guilding, 2008](#); [Chenhall, 2003](#)). As summarized by [Abdel-Kader and Luther](#)

(2008), this position suggests moving from naïve to more sophisticated management accounting practices requires resources and specialists only affordable by larger organizations. Given that numerous studies have identified perceived costs as a major factor inhibiting CMA adoption, it is reasonable to assume that CMA activities will vary in accordance with the size of an organization. Furthermore, larger organizations have generally been considered visible environmentally and subject to greater amounts of public and political scrutiny which may lead to increased involvement with CMA activities. Yet, to date, empirical investigation has largely ignored smaller organizations and the extent to which organizational size influences EMA adoption remains largely unexplored. Organizational size was measured based on each firm's total assets, number of employees, and turnover. Following [Chenhall \(2003\)](#) and [Abdel-Kader and Luther \(2008\)](#), the data on firm size was adjusted by conversion into natural logarithm. The natural log allowed for the extreme variability in sizes to be diluted and also enhance its distribution in terms of normality.

4.2.6 Information technology. Technology was measured by asking respondents to indicate on a seven-point Likert scale.

(with 1 = "never" to 7 = "all the time") using the scale of [Maiga et al. \(2013\)](#). The scale consists of five items[1]. The five items are:

- (1) our company depends largely on electronic mail for communication across the organization;
- (2) managers in my company assess information and data from other parts of the firm via the computer network;
- (3) managers in my company exchange information with manufacturing, engineering, and other functional areas electronically;
- (4) managers in my company obtain work information through the internet or similar external data networks; and
- (5) managers in my company communicate with customers, suppliers and other partners through the internet or other data interfaces.

4.2.7 Perceived environmental uncertainty. Perceived environmental uncertainty was measured by adopting an instrument developed and modified by past studies ([Duncan, 1972](#); [Miles and Snow, 1978](#); [Chenhall and Morris, 1986](#); [Abdel-Kader and Luther, 2008](#); [Pondeville et al., 2013](#)). The instrument focuses on three dimensions to measure perceived uncertainty. These are inadequate/insufficient environmental-related information; inability to confidently assign probabilities to the likelihood of environmental effect on the organization's success or failure; and inability to predict the losses incurred by an organization arising from an incorrect decision. Using a seven-point Likert scale (with 1 = "never" to 7 = "always"), the instrument incorporates seven items and obtains the frequency of the occurrence of each item in the respondent's job.

4.2.8 Industry-specific factors. As pointed out by [Abdel-Kader and Luther \(2008\)](#) and based on empirical evidence from contingency studies across a wide range of industry sectors, factors that are specific confounded to industry are likely to affect the design of MASs. In this regard, it is anticipated that the adoption of CMA systems is susceptible to industry-specific factors within which firms operate. In the current study, industry was measured as a dichotomous variable with a value of 1 if a firm belongs to environmentally sensitive industry and 0 otherwise. An environmentally sensitive industry was operationalized as all firms in the mining, oil, manufacturing, and cement producing industries ([Clarkson et al., 2008](#); [Yunus et al., 2016](#)).

4.2.9 Firm age. Firm age was measured by the log of the number of years the company has been in operation since it was incorporated. The generation of environmental information involves older firms that are well experienced, have high quality and highly reliable. It is expected that older firms might have invested in considerably large amounts of money towards the training of personnel or hire specialist/expertise to run the newly installed system. In the case of embarking upon green initiatives, there is the need for production reformation through continuous R&D or the purchase of green equipment, all of which requires high costs and commitment on the part of management as well as employees. Thus, the ability to generate quality reports for managerial decisions, be it capital or human provided greater opportunity for older firms to adopt sophisticated management accounting techniques integrating financial and non-financial measures (Chenhall, 2003; Abdel-Kader and Luther, 2008). The foregoing suggests that firm age is expected to influence the adoption of CMA.

4.2.10 Location. Location was measured as a dichotomous variable by assigning the value of 1 if located within a carbon emission zone and 0 otherwise. It is expected that firms located within a carbon emitted zone are likely to adopt a measurement system than those located outside the carbon emitted zone. Thus, location is expected to influence CMA adoption by firms.

Table II summarizes the variable measures and their expected signs.

4.3 Empirical estimation

The primary intent of this analytic investigation is to identify the contextual factors that influence CMA system adoption in the context of a developing economy. The statistical approach used in this analysis is correlation analysis as the contingency model being theorized and tested is the selection “fit” model where a natural selection (selection forces) underpin the relationships among the variables (Burkert *et al.*, 2014). In addition, a binary logistic regression model is used as the dependent variable (CMA adoption) is a binary dummy variable coded “1” for companies with CMA adoption and “0” otherwise. As an alternative to discriminant analysis, logit regression represents a classification approach, when there is no justification for the multivariate normal model. According to Hair *et al.* (1998), it is used for any combination of continuous and categorical independent variables. The full model specification is stated as:

$$\begin{aligned}
 CMA_{it} = & \beta_0 + \beta_1 OSTR_{it} + \beta_2 OSTUC_{it} + \beta_3 FSIZE_{it} + \beta_4 TECH_{it} \\
 & + \beta_5 DECEN_{it} + \beta_6 PEU_{it} + \beta_7 EMS_{it} + \beta_8 FAGE_{it} \\
 & + \beta_9 INDUS_i + \beta_{10} LOC_i + \beta_{11-15} YEARDUMMIES_i + \varepsilon_{it} \quad (1)
 \end{aligned}$$

where for firm *i* at period *t*, *CMA* = carbon management accounting; *OSTRA* = organizational strategy; *OSTUC* = organizational structure; *FSIZE* = firm size; *TECH* = technology; *DECEN* = decentralization; *PEU* = perceived environmental uncertainty; *EMS* = environmental management system; *FAGE* = firm age; *INDUS* = industry; *LOC* = firm location.

SPSS statistical software package (IBM Version 21) was used to analyse the survey data collected.

5. Results

5.1 Preliminary analysis

An assessment of the multivariate item measures for reliability, validity and internal consistency was undertaken at the preliminary stage of the analysis. More precisely, the

Variable	Definition	Hypothesis	Expected sign	Determinants of carbon management 103
<i>CMA</i>	A dichotomous variable with value 1 if a firm adopts CMA and 0 otherwise			
<i>OSTRA</i>	A continuous variable measured using scale responses via a seven-point Likert scale	<i>H1</i>	+	
<i>EMS</i>	A dichotomous variable with value 1 if a firm has an environmental management system and 0 otherwise	<i>H2</i>	+	
<i>OSTUC</i>	A continuous variable measured using scale responses via a seven point Likert scale	<i>H3</i>	+	
<i>DECEN</i>	A continuous variable measured using scale responses via a seven point Likert scale	<i>H4</i>	+	
<i>TECH</i>	A continuous variable measured using scale responses via a seven point Likert scale	<i>H5</i>	+	
<i>FSIZE</i>	Natural logarithm of firm's total assets, number of employees and revenue	<i>H6</i>	+	
<i>FAGE</i>	The natural logarithm of the number of years since a firm's operation			
<i>PEU</i>	A continuous variable measured using scale responses via a seven point Likert scale	<i>H7</i>	+	
<i>LOC</i>	A dichotomous variable with value equal to 1 if a firm is located in a carbon emission zone and 0 otherwise			
<i>INDUS</i>	A binary variable with value equals 1 if a firm belong to environmentally sensitive industries and 0 otherwise			
<i>YEAR DUMMIES</i>	For the three-year period a firm is awarded 1 if selected for a particular			

Notes: CMA = carbon management accounting; OSTRA = organizational strategy; EMS = environmental management system; OSTUC = organizational structure; DECEN = decentralization; TECH = technology; FSIZE = firm size; FAGE = firm age; PEC = perceived environmental uncertainty; LOC = location; INDUS = industry

Table II.
Summary of variable
measurement year
and zero otherwise

reliability of each measure was ascertained by comparing the Cronbach's alpha (Cronbach, 1951) coefficient score for each scale against the minimum threshold value of 0.7 generally accepted (De Villiers, 2003). Reliability analysis indicates the degree to which the items which make up the scale "hung" together. That is the extent to which the items which form the scale measure the same underlying construct. To examine the measures for dimensional purposes, factor analysis was performed where principal component analysis (PCA) was subsequently applied to capture the less well-established sensitivity measures. The minimum reliability statistic for all the items has a Cronbach's alpha of ranging from 0.7221 > 0.7. Cronbach's alpha coefficient for each construct is summarized in Table III.

Satisfactory internal consistencies were recorded for all the scales used to measure the reliability of instrument used for data collection. As the *alpha* in all cases is around/more than 0.7, it suggested that the instrument used is acceptable, has high reliability and does not open up errors. In addition, a PCA was performed to refine and reduce the initial large number of individual scale items and questions to form a smaller number of coherent subscales. The correlation matrix coefficients were in the majority of 0.3 and above hence satisfying the underlying assumption of PCA. Also, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value indicated 0.772 > 0.60 which were in excess of the cut-off

threshold of 0.6 (Kaiser, 1970) and the Bartlett's test of sphericity (Bartlett, 1954) reached a statistically significant value hence the factorability of correlation matrix is supported. Bartlett's test of sphericity chi-square (125) = 618.92, p -value < 0.001, indicated that correlations between items were sufficiently large for PCA. In addition, and following the PCA on the 42 items, an orthogonal Varimax rotation was performed to determine the eigenvalues of the scale items. The value of 1 or more suggested that the data was adequate to run in a regression model.

5.2 Descriptive statistics

The descriptive statistics for the contingent variables used in the study are summarized in Table IV. The data from the questionnaire was run using IBM SPSS 21. The results for the nominal variables are summarized in Table IV while those of the continuous variables are shown in Table V. The adoption of CMA is represented by only 36 firms (28.1 per cent) out of the 128 firms sampled. Table IV also shows that 61 firms representing 47.7 per cent possess EMS. This suggests that an appreciable proportion of firms have EMS in place but are yet to adopt CMA. As carbon accounting is just one aspect of environmental accounting, it suggests that a proportion of the 61 firms are engaged in other forms of environmental accounting. Only 29 firms (22.7 per cent) adopt carbon reduction emission strategy. This figure is closed to the number that has adopted CMA. The result suggests that not all the firms that have adopted CMA engage in carbon reduction emission strategy. Finally, 37 firms (28.9 per cent) belong to environmentally sensitive industries, while 71 (55.5 per cent)

Table III.
Reliability measures
of constructs

Construct	Cronbach's alpha
Organizational strategy (<i>OSTRA</i>)	0.7721
Organizational structure (<i>OSTUC</i>)	0.8022
Information Technology (<i>TECH</i>)	0.9117
Decentralization (<i>DECEN</i>)	0.7621
Perceived environmental uncertainty (<i>PEU</i>)	0.7660

Table IV.
Descriptive statistics
– nominal variables

Variables	Frequency	(%)
<i>CMA adoption</i>		
Yes	36	28.1
No	92	71.9
<i>Existence of environmental management system</i>		
Yes	61	47.7
No	67	52.3
<i>Adoption of carbon emission strategy</i>		
Yes	29	22.7
No	99	77.3
<i>Belong to environmentally sensitive industry</i>		
Yes	37	28.9
No	88	71.1
<i>Located within a carbon emitted zone</i>		
Yes	71	55.5
No	57	44.5

find themselves carbon-emitted zones. With regards to questions on the number of years at present position, the results show that on average, respondents have occupied their present positions for 5.7 years. This suggests that the respondents are not only knowledgeable and experienced in their respective fields but also have access to information based on which reliable perceptions can be provided. Based on these findings, the respondents (who were mainly management accountants of the sample firms) are well qualified to provide the needed information.

In Table V, the mean values for organizational strategy (*OSTRA*) and organizational structure (*OSTUC*) are approximately the same – 4.126 and 4.037, respectively. This suggests that the respondents attach equal importance to strategy and structure on CMA adoption. Also, the minimum and maximum values recorded for the sample firms is between 1.00 and 7.00 which suggests that there is much variation across the sample in terms of their responses. That is the response to the scale was unbiased and fairly distributed (i.e. not positively or negatively skewed). As can be judged from Table V, the mean values for all the scale measures are around the scale central value of 3.50 which suggests that the sample is coming from a normally distributed population. The natural log of number of employees (*NOE*), total assets (*TA*) and total revenue (*T/O*) of firm (*FSIZE*) recorded mean values 3.178, 4.381 and 4.209, respectively, with standard deviations of 0.887, 0.536 to 0.817, respectively. Information technology (*TECH*) is a scale measure and had a mean of 3.911 with a standard deviation of 1.213. Decentralization (*DECEN*) had a minimum (maximum) value of 1.117 (6.633) with an average of 4.633 and standard deviation of 1.117. Finally, perceived environmental uncertainty (*PEU*) had a mean of 3.754 with a standard deviation of 2.562.

5.3 Correlation analysis

The results for the Pearson’s Product Moment Correlation and Spearman correlation are shown in Table VI. The robustness of the results as reflected in the significance levels are shown by the fact that the results of the Pearson’s Product Moment Correlation and the nonparametric Spearman’s rank coefficients coincide. The results not only show a bivariate relationship between the endogenous variables and exogenous variables but also show no indication of the existence of multicollinearity as the highest correlation coefficient between the independent variables is 0.587 and 0.592 for Pearson and Spearman, respectively. As expected, CMA adoption is significantly and positively associated with *OSTRA*, *FSIZE*. Also, by examining the variance inflation factor (*VIF*) scores between the latent variables as well as its reciprocal (*1/VIF*) respectively, the multicollinearity was investigated. In line with the suggestion of Hair *et al.* (2015, p. 200), they are all below the threshold value (with an upper bound 0.564), confirming that the issue of multicollinearity is not present.

Variables	Mean	SD	Maximum	Minimum
Organizational strategy (<i>OSTUC</i>)	4.126	1.182	7.00	1.03
Organizational structure (<i>OSTUC</i>)	4.037	0.789	7.00	1.23
Firm size (<i>FSIZE</i>) - <i>NOE</i>	3.178	0.887	2.812	0.649
Firm size (<i>TA</i>)	4.381	0.536	3.193	0.882
Firm size (<i>T/O</i>)	4.209	0.817	3.099	0.774
Firm age (<i>FAGE</i>)	3.335	1.025	7.00	1.00
Information technology (<i>TECH</i>)	3.911	1.213	7.00	2.37
Decentralization (<i>DECEN</i>)	4.633	1.117	7.00	1.45
Perceived environmental uncertainty (<i>PEU</i>)	3.754	2.562	7.00	2.09

Table V.
Descriptive statistics –
continuous variables

Table VI.
Pearson product
moment and
Spearman correlation
of variables

	CMA	OSTRA	OSTUC	FSIZE	TECH	DECEN	PEU	EMS	FAGE	INDUS	LOC
CMA	1	0.117***	0.277***	0.472***	0.081**	-0.292***	0.488***	0.501***	0.236***	0.279***	0.226***
OSTRA	0.117***	1	-0.113*	0.115***	-0.146***	-0.135***	0.088**	0.068**	0.507***	0.087**	0.099***
OSTUC	-0.048***	-0.301***	1	0.493***	0.093**	0.393***	0.077**	-0.191***	0.017*	-0.131*	0.377***
FSIZE	0.265***	0.115***	0.528***	1	-0.456***	-0.156**	0.263***	-0.221**	0.093*	0.413***	0.318***
TECH	-0.020*	-0.146***	0.341***	0.133***	1	0.111***	-0.024**	0.138***	-0.099*	0.178***	0.216***
DECEN	0.286***	0.377***	0.142***	-0.083**	-0.057***	1	0.111**	0.098*	0.592***	0.201***	-0.099*
PEU	0.587***	0.010	0.077**	-0.564***	0.493***	0.068**	1	0.438***	0.091**	0.210*	0.306***
EMS	-0.191***	-0.414***	0.138***	0.105***	-0.219***	0.397***	0.522***	1	-0.077***	-0.059**	0.194***
FAGE	0.192***	0.381***	0.409***	0.201***	-0.017	-0.356***	0.561***	-0.089**	1	0.171**	-0.311**
INDUS	0.475***	-0.331***	-0.168***	-0.299***	0.302***	-0.441***	0.512***	0.066**	0.012	1	0.296**
LOC	0.216***	0.067**	0.221***	-0.139***	0.387***	0.090***	0.109***	-0.171***	0.137***	0.296**	1

Notes: ***Significant at the 1% level, **significant at the 5% level, *significant at the 10% level; CMA = carbon management accounting; OSTRA = organizational strategy; OSTUC = organizational structure; FSIZE = firm size; TECH = technology; DECEN = decentralization; PEU = perceived environmental uncertainty; EMS = environmental management system; FAGE = firm age; INDUS = industry sensitive environment; LOC = location

Also, the Pseudo r^2 value of 0.462 indicates that 46.2 per cent of the variation in CMA adoption by the sampled firms can be explained by the model. At the 1 per cent significance level, the exogenous variables were found to be statistically significant. This implies that the exogenous variables influence CMA adoption and are consistent with the prediction in *H1*, *H2*, *H3*, *H4*, *H5* and *H6*. The results thus support contingency theory which is consistent with prior studies. Like the mainstream business types, the adoption of CMA is influenced by organizational strategy (OSTRA), organizational structure (OSTUC), firm size (FSIZE), information technology (TECH) and perceived environmental uncertainty (PEU). The results also suggest that firms that have environmental management system (EMS) have much incentive in adopting CMA. Results of the confounding variables show that while firm age (FAGE) was not statistically significant and hence not related to CMA adoption, firm location such as highly environmentally sensitive areas (LOC) and firms whose activities impact directly on the environment (INDUS) does influence CMA adoption.

5.4 Multivariate analysis

The multivariate analysis results are presented in Table VII (Model 1). A cross sectional data obtained from the survey responses was used to test *H1*, *H2*, *H3*, *H4*, *H5*, *H6* and *H7* that have been developed for this study. At the 1 per cent significant level, the Wald χ^2

Variable	Model 1		Model 2		Model 3	
	Coeff	<i>p</i> -value	Coeff	<i>p</i> -value	Coeff	<i>p</i> -value
Constant	-13.091	0.013**	-12.372	0.000***	-8.265	0.010**
OSTRA	0.068	0.001***	-1,432	0.000***	2.122	0.000***
OSTUC	0.312	0.001***	2.097	0.002	3.411	0.008
FSIZE	0.317	0.000***				
FSIZE			0.007	0.211		
FSIZE					0.018	0.312
TECH	0.288	0.001***	3.288	0.000***	3.121	0.002***
DECEN	-0.003	0.106	4.010	0.223	2.991	0.104
PEU	0.817	0.002***	-3.211	0.021**	1.181	0.004***
EMS	0.331	0.004***	0.912	0.002***	0.173	0.011**
FAGE	0.010	0.389	-2.315	0.243	0.177	0.418
INDUS	0.881	0.010**	1.092	0.090*	0.289	0.002***
LOC	0.723	0.001***	0.772	0.030**	1.092	0.003***
YERADUMMIES						
W - χ^2	78.287		142.336		109.723	
P - R^2	0.462		0.227		0.306	
Observation	625		625		625	
No. of clusters classified (%)	81.03		78.82		75.33	

Notes: ***Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level. Variable definitions: OSTRA = a continuous variable measured using scale responses on a seven-point Likert scale; OSTUC = a continuous variable measured using scale responses on a seven-point Likert scale; FSIZE = firm size measured by natural log of number of employees; TECH = a continuous variable measured using scale responses on a seven-point Likert scale; DECEN = a continuous variable measured using scale responses on a seven-point Likert scale; PEU = a continuous variable measured using scale responses on a seven-point Likert scale. CMA = categorical variable with value 1 if a firm adopts carbon management accounting and 0 otherwise; EMS = categorical variable with value 1 if a firm has environmental management system and 0 otherwise; INDUS = binary variable with value 1 if a firm belongs to environmentally sensitive industries and 0 otherwise; LOC = categorical variable with value 1 if a firm is located in a carbon emission zone and 0 otherwise

Table VII.
Multivariate analysis

value of 78.287 was found to be significant. This suggests that a clear distinction between firms that adopt CMA and those that do not can be made by the model. In Model 1, the results show that a statistically significant relationship exist between all the variables except decentralization ($\beta = -0.003$, p -value = 0.110 > 0.05), and firm age ($\beta = 0.010$, p -value = 0.389 > 0.05). Support for *H6* could not be confirmed. Organizational strategy ($\beta = 2.069$, p -value = 0.001 < 0.01) and structure ($\beta = 0.312$, p -value = 0.001 < 0.01) were found to be statistically significant and thus correlate with CMA adoption. Hence, *H1* and *H2* are supported. Similar results hold for firm size ($\beta = 0.418$, p -value = 0.000 < 0.01), information technology ($\beta = 0.288$, p -value = 0.001 < 0.01), and perceived environmental uncertainty ($\beta = 0.817$, p -value = 0.002 < 0.01) supporting *H3*, *H4* and *H5*, respectively. Finally, the industry in which a firm belongs as well as the location of a firm were both found to be statistically significant in Model 1 with industry recording ($\beta = 0.881$, p -value = 0.010 < 0.01) and location ($\beta = 0.723$, p -value = 0.001 < 0.01). These results suggest that the industry-specific and firm location influence CMA adoption. This suggests that, a firm is predicted to adopt and implement CMA if it belongs to carbon sensitive industry and located within carbon-emitted zone.

Three different measures were used for firm size (FSIZE): firm's total assets (TA), turnover (T/O) and number of employees (NOE). The results of these tests are shown in Models 2 and 3 in [Table VII](#). In these two models, random effect regression was used for the empirical estimation. With the exception of the coefficient for FSIZE which is positive and significant in Model 1 ($\beta = 0.317$ and $p = 0.000 < 0.05$) but positive and insignificant in Model 2 ($\beta = 0.0071$ and $p = 0.211 > 0.05$), the results as shown in Model 2 (random effect regression) do not differ significantly from the pooled sample results shown in Model 1. In addition, two alternative measures of firm size (FSIZE) were employed as confounding variables. As shown in [Table VII](#), the natural logarithm of the number of employees was used as a proxy for firm size (FSIZE) in Model 2 which did not affect the results.

These results were not affected by alternative measures off firm size since the proxy for FSIZE is positive but insignificant for both Models 2 and 3. The existence of environmental management system (EMS) which is hypothesized by *H7* was found to be statistically significant for all the models: Model 1 ($\beta = 0.331$, p -value = 0.004 < 0.01), Model 2 ($\beta = 0.912$, p -value = 0.002 < 0.01) and Model 3 ($\beta = 0.173$, p -value = 0.011 < 0.05).

5.5 Further tests

To assess the model's robustness, a random sample was drawn from the originally 125 firms and logistically regressed the context variables on CMA adoption. The results as displayed in [Table VIII](#) for Models 1, 2 and 3 representing the firm size (FSIZE) variable for total assets (TA), number of employees (NOE) and turnover (T/O), respectively, did not change significantly from the original results obtained for the test variables. In addition, and following [Luo et al. \(2012\)](#) and [Haque \(2017\)](#), [equation \(1\)](#) was re-estimated to determine whether the estimation results are sensitive to a winzoration operation at 1 and 99 per cent levels. Again, the results did not depart from those obtained originally hence validating the findings.

6. Discussion of results

This paper provides empirical evidence on the factors that impact on CMA adoption in a developing country context. More precisely, it provides an integrative framework that highlights relationships among CMA adoption and the following six context variables: organizational strategy, structure, decentralization, size, technology and perceived environmental uncertainty. In addition, the existence of environmental management system

Variable	Model 1		Model 2		Model 3		Determinants of carbon management
	Coeff	<i>p</i> -value	Coeff	<i>p</i> -value	Coeff	<i>p</i> -value	
Constant	-11.401	0.010**	-7.854	0.004***	-10.444	0.012**	109
OSTRA	0.018	0.004***	0,118	0.000***	1.877	0.000***	
OSTUC							
FSIZE							
FSIZE (TA)					0.006	0.127	
FSIZE (NOE)					1.372	0.001***	
TECH (T/O)	0.222	0.000***	1.097	0.000***	0.002	0.209	
DECEN	-0.002	0.106	2.899	0.152	0.002	0.209	
PEU	1.002	0.000***	-2.001	0.001**	0.098	0.003***	
EMS	0.412	0.002***	2.017	0.001***	2.376	0.001**	
FAGE	0.003	0.207	-2.765	0.398	0.709	0.211	
INDUS	0.616	0.000**	-0.655	0.000***	0.107	0.001***	
LOC	0.881	0.021***	1.088	0.007***	1.008	0.002***	
<i>YERADUMMIES</i>							
$W - X^2$	75.821		98.076		110.527		
$P - R^2$	0.390		0.102		0.298		
Observation	586		708		682		
No. of clusters classified (%)	78.89		78.82		79.66		
	0.021	0.216	1.099	0.242	3.618	0.228	
	0.283	0.000***					
			0.014	0.181			

Notes: *Significant at 10%; **significant at 5%; ***significant at 1%

Table VIII.
Multivariate analysis

(EMS) among the sample firms was ascertained. Although the results show that some Ghanaian companies have adopted CMA practices, the overall level of adoption as reported by the sample firms have been very low. Despite the claim by some organizations to have EMS in place as the results indicated, they gave a “no” response to the practice of CMA systems. This suggests that while environmental management authorities may to some extent engage firms on environmental related issues, not much emphasis is being placed on GHG emission reduction strategies and the need to have CMA systems in place. CMA is though only a part of the broader spectrum of EMA practices; these findings are consistent with the findings of prior studies such as [Christ and Burritt \(2013\)](#) who found that the level of EMA is very low among publicly held Australian companies. The low adoption rate by Ghanaian firms suggests that much awareness about the risks posed by GHG emissions and climate change has not taken place within the sample firms. The failure by the Environmental Protection Agency (EPA) and other environmental management advocates to engage with individual organizations to incorporate environmental management and GHG emission reduction strategies into their business strategic plans becomes evident. Convergent with prior literature, regulatory uncertainty was found to be the major constraint to proactive strategy and CMA development in response to climate change in Australia ([Bui and de Villiers, 2017](#)).

On general grounds, the current paper contributes to the management accounting literature by providing knowledge and understanding of contingency theory’s application in the environmental management field, an area that has had mere investigation in prior contingency-based management accounting studies. To a larger extent, the limited empirical studies on CMA failed to take into consideration, the contextual dimensions that influence

CMA adoption and practice. In this regard, the current paper could serve as a foundation (or a reference frame) for the adoption of CMA systems in especially developing countries' concerns that would facilitate decisions on GHG emission reduction strategies. Given that CMA is a component of EMA, the findings show strong support for the contextual dimensions reported in prior EMA studies. It shows the importance of integrating contextual factors into the adoption of CMA, as different factors affect the design and practice of EMA systems. Such differing factors are in line with [Bouten and Hoozee \(2013\)](#) who document that the association between environmental factors such as reporting and various organizational disturbances and EMA systems' adoption exist.

In analyzing the findings from the individual test variables, the results show a significant impact of strategy on CMA adoption which suggests that strategy is critical to the design and implementation of CMA systems in Ghanaian corporate entities. This finding is in line with several CMA/EMA – strategy related studies. Complementing other studies such as [Ittner and Larcker \(1997\)](#), [Langfield-Smith \(1997\)](#), [Widener \(2004\)](#) and [Pondeville *et al.* \(2013\)](#), the findings of this study confirm that the “fit” concept which is the core of contingency theory translates into the CMA field, hence highlighting the importance of organizational contextual variables for the adoption of CMA systems. In the findings of [Pondeville *et al.* \(2013\)](#), a positive association between firms' corporate strategy and the development of EMA in Belgian manufacturing companies was documented. Their study involved the investigation of the role contextual and strategic factors (perceived environmental uncertainty, perceived stakeholder pressures and the degree of company proactivity) play in the development of management control systems (MCS) from a sample of 256 manufacturing concerns.

In addition, the findings on the strategic dimension complement the work of [Luo *et al.* \(2012\)](#). They examined how carbon disclosure strategies of the Global 500 companies respond to the challenges of climate change. More precisely, they investigated the motivational impacts of corporate organizations' voluntary participation in the 2009 Carbon Disclosure Project (SCD) by testing five variables comprising financial market, social, regulatory, economic and institutional factors. Their findings suggest that economic pressure and GHG-intensive environments influence carbon-related information disclosures. In other words, both social and economic pressures as well as the intense of GHG emissions are determinants of CMA adoption and use. It can be deduced from their findings that designing or developing CMA systems for carbon reduction strategies would be more pronounced in companies that face direct economic and social consequences as well as those sighted in carbon-intensive environments. These findings are again convergent with that of [Pondeville *et al.* \(2013\)](#) who in their study found that perceptions of pressures from various stakeholder groups positively influence the degree of corporate environmental proactivity. These findings suggest the importance of organizational stakeholders in the implementation of corporate environmental strategy and the adoption of CMA.

Still on corporate strategy, convergence on the strategic dimension with other works can further be reached. [Gond *et al.* \(2012\)](#) and [Bebbington and Thompson \(2013\)](#) noted that a quest for corporate environmental management involves an appropriate alignment of strategy, structure and management control systems. [Gond *et al.* \(2012\)](#) document that MASs offer deeper integration of sustainability within organizational strategy by theorizing the roles and uses MASs and sustainability control systems in the integration of sustainability within organizational strategy. [Cadez and Guilding \(2017\)](#) investigated the association between product output volume, carbon costs and CO_2 volume as well as the determinants of climate change abatement strategies pursued by Slovenian carbon-intensive firms. The objective of their research stem from the quest for minimizing

conventionally appraised costs, negative output and heightened eco-efficiency from a management accounting perspective. They concluded farther that when firms pursue growth strategy, it does not enhance corporate CO_2 emission reduction triggered by carbon improvement efficiency in the Slovenian context. This finding suggests that not all corporate strategies pursued by organizations lead to CO_2 emission reduction; hence, certain specific strategies are required when firms adopt CMA systems. Indeed, the importance of corporate strategy in MAS design or adoption has generally been shown to be positive to both environmental and non-environmental-related studies. For example, [Arjalies and Mundy \(2013\)](#) in their study of CAC 40 group of French listed companies which were analyzed from a levers control framework perspective showed a positive relation between the management of corporate social responsibility strategy and MASs design. Their finding provides insights into the achievement of strategic change as well as the attainment of strategic objectives by organizations by the use of MCS. They concluded that the transformation of organizational practices that contribute to sustainability is largely supported by the design of MCS. That is MASs play crucial role in organizational strategic processes that facilitate reporting, innovation, communication and the identification of opportunities and threats.

Taking the results for organizational structure, the findings show that this contextual variable and CMA are positively related. The findings suggest the positive impact organizational structure has on the implementation of CMA systems. These findings converge with that of [Cadez and Guilding \(2017\)](#) who found a positive relationship between cost structures and CMA systems of CO_2 polluting firms. They found that differing carbon cost structures are exhibited by CO_2 polluting firms. They provide useful insights into differential carbon cost structures across industries from a cost and management accounting perspective.

In terms of technology, the results of the sample show a positive association between technology and CMA adoption, suggesting that technological innovation enhances CMA development and carbon reduction strategies. Studies such as [Oliver \(2008\)](#), [Blanford \(2009\)](#) and [Tavoni et al. \(2012\)](#) have shown that technological innovation is consistent with the management and more efficient use of carbon-based resources. Hence, companies with technological innovation are likely to implement more efficient and effective CMA systems in the Ghanaian context. Consistent with [Cadez and Guilding \(2017\)](#), the current study highlights the importance of technology as a determinant factor in efficient carbon management from CMA perspective. [Cadez and Guilding \(2017\)](#) provided an understanding of how different technological processes identify different drivers of carbon-based resource conception (or carbon costs), CO_2 emissions and corporate strategies concerned with efficient carbon management across carbon-intensive sectors.

Contrary to our expectation, the link between decentralization and CMA adoption was not statistically significant, and hence not supported by the results. The inconsistency in this finding could be due to However, the findings provide strong support for organizational size as having positive impact on CMA adoption. Previous management accounting studies document a positive relationship between organizational size and MASs design suggesting that the level of sophistication of the MAS information is associated with organizational size. The larger the organization the higher the demand for sophisticated accounting information. This finding on organizations' size is in perfect alignment with that of [Luo et al. \(2012\)](#) who found that big companies have a higher propensity for disclosing carbon information which suggests that larger companies are more likely to adopt and implement CMA systems for disclosure purposes.

Turning to perceived environmental uncertainty, the results confirm as having a direct positive impact on CMA adoption. This suggests that organizations whose activities are sensitive to environmental issues are more likely to adopt and practice CMA systems

compared to those whose activities are less environmentally oriented. More precisely, the adoption and practice of CMA systems is more likely to be implemented by companies that are more proactive in environmental related issues or perceived more environmental uncertainty. Again, this finding complements the findings of [Pondeville et al. \(2013\)](#) in their survey of 256 Belgian manufacturing firms to examine the association between environmental management control (EMC) systems and corporate environmental strategies. Their results suggest that the development of EMC systems is associated with companies that are more environmentally sensitive to their operations. They however found a negative association between the development of environmental information systems and perceived ecological environmental uncertainty which suggests that the development of an environmental proactive strategy or formal EMC systems is less likely to be supported by companies that perceive more environmental uncertainty. This second finding is however not in line with the current study which could result from situational factors. Notwithstanding, the findings suggest that corporate environmental objectives such as CMA reduction strategies would be better controlled if perceived environmental factors are integrated into CMA adoption and practices.

7. Conclusions

The aim of this paper was to investigate the determinants of CMA systems adoption by Ghanaian firms. The paper draws considerable novelty from the fact that despite the growing interest in environmental concerns related to climate change, empirical works on CO_2 emissions conducted from management accounting perspective especially in developing economy contexts have been very scant; hence, the motivation for this work. The paper draws on contingency theory as the underlying framework. The research framework incorporated organizational strategy, structure, decentralization, size, technology and perceived environmental uncertainty as contextual variables of which CMA adoption was logistically regressed on. In addition, the existence of environmental management system (EMS) was included and measured as dichotomous variables. The findings from the study show that contextual factors are related to CMA adoption although the findings suggest that CMA adoption is low by the sample of accountants. Overall, organizational strategy, structure, firm size, the availability of environmental management systems, technology and perceived environmental uncertainty were found to be positively associated with CMA adoption. Decentralization was however found not to be supported by the hypothesis and hence found not to be associated with CMA. Perhaps the respondents have very little knowledge about environmental management accounting and CMA in particular. Notwithstanding, the findings suggest that both contextual and environmental factors play a vital role in the adoption of CMA in developing economies, as it pertains to conventional MAS design. Policies governing CMA practice should incorporate organizational contextual factors.

The findings suggest that the accountants of the sampled firms perceived these contextual dimensions as relevant to CMA design and practice in their organizations. A number of theoretical and policy implications for CMA development in Ghana could be derived from the findings. In the first place, and from theoretical point of view, the contingent variables, namely, strategy, structure, technology, size and perceived environmental uncertainty, as the results indicated constitute significant elements that must be considered when determining the choice of CMA practices by firms. Contingency theory posits that there is no optimal structure for all organizations all the time hence the adoption of MAS practices by organizations is contingent upon the situation or circumstances in which they find themselves ([Chenhall, 2003](#)). The findings show that contingency theory is

supported by the results and that these context dimensions are attracted by the selection forces of CMA practices. To this end, policies by the Ghana Government exclusively directed at addressing GHG emission reduction strategies and other related environmental hazards by organizations should take into account the context in which such organizations operate. This is necessary as their responses to such directives stand the chance of being influenced by the circumstances faced by the individual organizations. It must be noted that the benefits of contingency theory research could be applied to the GHG emission field and the EMA field in general, but limited attention has so far been paid to this area by past studies probably due to its low level of awareness as a new field of research. This study contributes to the carbon management literature on the relevance of contingency theory in designing CMA systems in a typical emerging economy.

Like most studies, several limitations that may affect the results and subsequent interpretations and demand considerations are contained in this work. First, individual respondents from each of the 125 sample firms were relied on which clearly could result in potential bias in the responses. To avoid this related potential bias, a multi-informant design can be used in future studies. Closely related to this limitation is the fact that the analysis features managerial evaluations rather than actual corporate behaviours since the data reflect the extent to which accountants evaluate their CMA adoption and practices but not the true likeness of these perceptions. In this paper, it is assumed that the respondents are sufficiently knowledgeable and willing to provide an accurate depiction of their organization; hence, future studies can include objective indicators that relate to CMA adoption. Third, this study relied on only the selection fit model of contingency theory in examining the contextual dimensions of CMA adoption. Examination of the other contingency fit models (e.g. matching, mediation and moderation) in the CMA field and the EMA system in general remains unexplored. Fourth, the study did not address the reasons for the low-level adoption of CMA; hence, future studies can use a case study qualitative approach to investigate this phenomenon. This will offer a deeper insight into the reasons and barriers to the low engagement of CMA. Fifth, the study is limited to Ghana hence further exploration of contingency-based studies in other emerging economies would provide valuable insights on CMA adoption as possible generalization of these findings is limited.

Note

1. The original instrument of Andersen (2001) and Maiga *et al.* (2013) asked respondents to indicate on a sevenpoint Likert scale, the extent to which management use IT for managerial purposes such as communication. Since the current study concerns contextual variables and CMA adoption, the wording of the items was modified to reflect the current study.

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Appendix. Questionnaire items

1. Nature of Firm's Activity.....
2. Firm Age (from the date of incorporation)
 - (5 – 10 years.....
 - (11 – 15) years.....
 - (16 – 20) years.....
- Over 20 years.....
3. Firm Total Assets (€50 -€99) million.....
 - (100 – 199) million.....
 - Over 200 million
4. Turnover (10 – 20) million.....
 - (21 – 30) million..... (31 – 40)
 - million
 - Over 40 million
5. Name of Manager filling the questionnaire.....
6. Position.....

<i>Carbon Management Accounting (CMA) Adoption</i>		
	1	2
The accounting system in our firm performs the following functions: (1 = Yes; 2 = No) <input type="checkbox"/> Identification of environment-related costs. <input type="checkbox"/> Estimation of environmental-related contingent liabilities.		
<input type="checkbox"/> Classification of environment-related costs <input type="checkbox"/> Allocation of environment-related costs to production processes. <input type="checkbox"/> Allocation of environment-related costs to products. <input type="checkbox"/> Introduction or improvement to environment-related cost management.		
<input type="checkbox"/> Creation and use of environment-related cost accounts <input type="checkbox"/> Development and use of environment-related key performance indicators (KPIs).		
<input type="checkbox"/> Product life-cycle cost assessments <input type="checkbox"/> Product inventory analyses <input type="checkbox"/> Product impact analyses <input type="checkbox"/> Product improvement analysis		
<i>Environmental Management Systems (EMS)</i>		
<input type="checkbox"/> The overall corporate strategic planning process of our firm incorporates carbon reduction and GHG emission-related issues <input type="checkbox"/> Arrangements that enable third parties to avoid GHG emissions have been instituted by our firm		
<input type="checkbox"/> Our emission reduction been effective in the reporting years		
<input type="checkbox"/> Carbon dioxide emissions from burning biomass or biofuels or from the combustion of biologically sequestered carbons are relevant to our company		
<input type="checkbox"/> Our company is a member and participates in an emission trading scheme		
<input type="checkbox"/> Our company has initiated a project based on carbon credits and/or engaged in carbon trade within the financial reporting period		
<input type="checkbox"/> As part of quality measures in our firm, the environmental effect of carbon emission from our operations and the products or services is reduced drastically.		
<input type="checkbox"/> Our corporate strategic plan ensures that carbon emission reduction objectives are linked with corporate goals		
<input type="checkbox"/> Whenever new products/services are developed or launched, we ensure that they address GHG emission-related issue		

(continued)

<i>Organizational Strategy</i>		1	2	3	4	5	6	7
○○○○	Our firm incorporate carbon emission reduction strategy in its strategic planning process. In our firm, quality includes reducing the environmental impact of products and processes. At our firm we make every effort to link environmental objectives with our other corporate goals.							
	Environmental issues are always considered when we develop new products.							
<i>Structure/Decentralization</i>		1	2	3	4	5	6	7
○	Our firm provides a high level of autonomy to managers in taking decisions on carbon related issues.							
○○○○○	Managers are provided with greater responsibilities over planning and control activities.							
	Functional managers have the authority to make decisions on GHG emission reductions.							
	Middle managers have the authority to make decisions on GHG emission reductions.							
	In our organization carbon reduction decisions are made at the individual levels.							
	Pricing/costing of carbon emission reduction decisions are made at departmental levels.							
<i>Technology</i>		1	2	3	4	5	6	7
○ ○	Information exchanges in our firm are mostly internet or web based.							
	We have successfully integrated most of our software applications with environmental related issues.							
○ ○	Most of our software work seamlessly across environmental management fields.							
	Software application on multiple machines of multiple.							
<i>Perceived Environmental Uncertainty</i>		1	2	3	4	5	6	7
○○○○○○○	National/international environmental laws.							
	Environmental tax policies.							
	Environmental regulations affecting the sector.							
	Availability of substitute environmental products.							
	Environmental product demand.							
	Changes in the production process on the market.							
	Changes in the competitor's environmental strategies.							

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