Decision Support Through Carbon Management Accounting—A Framework-Based Literature Review

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Abstract Purpose: Managing corporate carbon performance has seen a rapid development as a topic for the past decade. To effectively reduce corporate climate change impacts requires decisions on tracking and tracing of carbon emissions in a systematic manner. Yet, methods to manage information on corporate carbon performance have hardly been discussed in the extant literature. Whilst the global greenhouse gas emissions are further increasing, the total amount of corporate emissions has only decreased in some advanced companies. This raises the question of what decision situations a performance oriented carbon management accounting could support and in which areas research could be further developed to support carbon management efficiently and effectively. **Method**: A literature review was conducted to identify the current state of development of CMA. Relevant publications were analysed by means of taxonomic analysis. **Findings**: The analysis of academic CMA publications shows that the existing contributions on CMA methods only support few decision situations, still leaving many areas open for future research and practice. **Implications**: This chapter highlights the need for decision oriented research that enables CMA to fulfil its objective, i.e. to contribute to the efficient and effective reduction of carbon emissions.

1 Highly Topical, Yet Under-Researched

For the last couple of years, carbon management has seen a notable uptake as a topic in corporate practice (Bennett et al. 2013). To effectively manage carbon performance, accurate carbon information and thus its management with carbon

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accounting methods play an important role (Burritt et al. 2011). This necessitates a review of the current corporate carbon management accounting (CMA) literature and its contributions to supporting management decisions.

Many environmental accounting publications mention carbon management accounting as an exemplary (Ascui 2014; Ascui and Lovell 2012; Lohmann 2009; Schaltegger et al. 2013). In a review of over 800 publications on environmental management accounting, carbon accounting has even been identified as one of the most discussed themes (Schaltegger et al. 2013). Two reviews on the wider area of carbon accounting (Ascui 2014; Stechemesser and Günther 2012) provide a broad overview of the literature, including macro-economic accounting approaches. Extant literature is dominated by case studies and shows that various companies have discovered (at least some of) the potential benefits of carbon accounting (Ascui and Lovell 2012). Whereas these two existing reviews shed light on the extent to which the topic is of relevance to society in general and businesses in particular, they both reveal that carbon management accounting has remained largely under-researched. Ascui (2014) classifies most carbon accounting publications (56 out of 89 in total) as part of "carbon management accounting". Yet, only four publications are seen to belong to carbon management accounting at the organisational level with the remaining 52 approaches focusing on economies or the global level.

Despite the considerable attention climate change has gained for the past decade, no overview exists of what management decision situations are particularly supported with academic and professional literature on carbon accounting.

This chapter approaches the gap by reviewing the carbon management accounting literature in view of a decision-oriented framework (Burritt et al. 2002, 2011) and by bringing together diverging perspectives discussed in the extant literature. The chapter thus investigates what decision situations have been documented in carbon management accounting practice and research. The result is an overview that allows identifying areas of carbon accounting application that have not been scrutinised yet. Comparing the corporate carbon accounting literature and documentation on company cases (e.g. Lee 2011) with the range of possible carbon accounting applications unveils 'blind spots'. Neglected, yet important decision situations are uncovered and discussed with regard to future research. This review thus supports developing these research areas and enables companies to manage their carbon performance more efficiently and effectively. This chapter also develops several propositions that can serve as the basis for building hypotheses to further advance research on the application of CMA.

This chapter proceeds as follows. Section 2 frames the issue in the context of the extant CMA literature. Section 3 describes the methodology adopted in conducting the empirical part of the research. Section 4 presents the results of the literature review and discusses key findings. Section 5 discusses CMA in the context of efficiency and provides several implications for further research. The concluding section sketches a path to enabling CMA to contribute to its original purpose.

2 What We Know About CMA—A Literature Review

2.1 The Role of Accounting in Managing Carbon Performance

Despite its relatively short history, carbon management has been of concern to various domains in organisations. No matter whether production (Bunse et al. 2011), procurement (Vickers et al. 2009), logistics (McKinnon 2010; Lee 2011) or risk management, all departments and business units can benefit from information on the existing amount of carbon emissions, their sources and drivers, and the assessment of options to reduce carbon impacts (Burritt et al. 2011). Managing carbon issues and performance is thus strongly linked to accounting for carbon information.

2.2 Purposes of CMA

On the one hand, carbon management comprises activities related to the coordination of activities to achieve a resource-efficient (i.e. under consideration of time and resources spent) and effective reduction of carbon emissions. On the other hand, carbon management can be defined as those activities that aim to secure the success of an organisation by managing carbon emissions (efficiently and effectively). CMA therefore aims to support managing carbon performance with regard to both perspectives, environmental effectiveness and economic efficiency (cf. Schaltegger and Csutora 2012; Stechemesser and Günther 2012).

Okereke (2007) identifies five groups of motivations to deal with carbon management. Legitimacy Credibility has been seen as an important motivation underpinning a given company's carbon management endeavours. Furthermore, cost reduction has been identified as another reason. More recent developments in the ethical discourse place ethical considerations as another relevant factor for managing carbon performance. Furthermore, chief executives have increasingly considered climate change as a matter of fiduciary concern (e.g. Hoffman 2006). Last but not least, a number of the FTSE companies have begun to emphasise the need to move away from seeing climate change only as a risk towards viewing it as also presenting business opportunities (e.g. Okereke 2007).

Creating carbon information by means of accounting techniques and systems enables managers to gain a relative advantage in performing their managerial tasks and attaining the corporate objectives. The purpose of CMA, in particular, should therefore be providing managers with information that assists corporate decision-making related to carbon emissions. In view of the above incentives for carbon management, Schaltegger and Csutora (2012) describe CMA as having the following objectives:

- Creating transparency and taking account of "un-sustainability" of the past and current operations.
- Forecasting future greenhouse gas emissions
- Identifying reduction potentials and evaluation of reduction measures:
- Providing support of the implementation of carbon management measures

2.3 The CMA Framework

To systematise the analysis of the carbon management literature and its contribution to support different management decision situations, this research is framed within the CMA framework (Table 1) proposed by Burritt et al. (2011). Based on the more general environmental management accounting framework proposed by Burritt et al. (2002), this framework breaks carbon management information down into four dimension: i) the nature of the information—physical or monetary; ii) the time frame of decision-making—past, present and future; iii) the length of time frame, that is, short-term or long-term; and vi) the routineness of the information supplied —regular or ad hoc.

Table 1 The CMA Framework (Burritt et al. 2011, 82)

		Carbon management accounting (CMA) Framework			
		Monetary carbon accounting		Physical carbon accounting	
		Short term	Long term	Short term	Long term
Past oriented	Routinely generated	1. Carbon cost accounting	2. Carbon capital expenditure accounting	3. Carbon flow accounting	4. Carbon capital impact accounting
	Ad hoc	5. Ex post assessment of short term/relevant carbon costing decisions	6. Ex post assessment of carbon reducing investments	7. Ex post assessment of short term carbon impacts	8. Ex post assessment of physical carbon investment appraisal
Future oriented	Routinely generated	9. Monetary carbon operational budgeting	10. Carbon long term financial planning	11. Physical carbon budgeting	12. Long term physical carbon planning
	Ad hoc	13. Relevant carbon costing	14. Monetary carbon project investment appraisal	15. Carbon impact budgeting	16. Physical environmental investment appraisal

2.4 Carbon Accounting for Eco-Efficiency

For an environmentally friendly change to be economically viable, it needs to be more efficient than the practice that it substitutes (Andrews 2006). This problem has been among the central research themes in environmental management accounting literature for the past two decades (e.g. Bennett et al. 2013; Schaltegger et al. 2013). Probably the most relevant term and concept in this context is eco-efficiency (Schaltegger and Sturm 1990; Schmidheiny 1992; WBCSD 2000).

The concept of eco-efficiency was introduced into (environmental) management to extend the basic concept of efficiency (Schaltegger and Sturm 1990; Schmidheiny and BCSD 1992; Schmidt-Bleek 1994; von Weizsäcker et al. 1997, 2009; Hawken et al. 1999). Although defining eco-efficiency and finding a way to measure it has been considered "difficult" (Britt et al. 2011) since its introduction, several different definitions and methods have been proposed (e.g. Schaltegger 1998). Generally, efficiency refers to producing the maximum number of output with the least input. Eco-efficiency, in the context of carbon management, has a slightly different meaning.

With few exceptions, the production of goods and services (as well as their use and disposal) inevitably generates carbon emissions. These carbon emissions are undesired outputs. Therefore, eco-efficiency, or more specifically carbon efficiency, refers to the value created by a product or service measured against the amount of carbon emissions caused. Carbon efficiency thus serves as a score to enable companies track and make progress in being carbon efficient.

Several authors have discussed eco-efficiency and what it entails. Derwall et al. (2005) interpret it "as the economic value a company creates relative to the waste it generates". For Huppes and Ishikawa (2005) eco-efficiency pursues the "general goal of creating value while decreasing environmental impact". These definitions are very similar and revolve around the basic idea that being eco-efficient means benefitting the environment while being economically successful (Schaltegger 1997).

Based on the CMA framework this paper examines what decision situations the existing carbon management accounting literature covers and deals with.

3 Research Methodology

To develop a research synthesis of the existing CMA literature (e.g. Onwuegbuzie et al. 2012), we conducted a literature review of all publications that explicitly refer to *organisational* CMA activities. Analysed publications include articles in academic journals as well as related professional literature such as reports of accounting bodies and consulting companies.

The data collection consisted of two complementary search strategies. Firstly, searches were executed in the academic search engine "google scholar". In addition, searches were run in the academic publication databases *EBSCO*, *JSTOR* and *Thomson Reuters Web of Science*. The search terms used are shown in Table 1. The search was conducted for every possible combination of the left and the right side of the table (Table 2).

Subsequently, further publications were identified by means of snowball sampling (Biernacki and Waldorf 1981). We adopted both forward and backward snowball sampling. In the latter approach, the references of already identified publications were scanned manually to identify referenced further relevant publications. Forward sampling was used to identify papers that have cited the identified publications.

The list of identified publications was then manually screened to sort out those publications that fall outside the scope of this literature review. Given the focus on carbon management accounting at the organisation level, several decision with regard to the publication scope were made. Excluded were:

- publications not related to managerial or corporate activities, such as on carbon accounting for buildings (e.g. Shao et al. 2014)
- publications in the domain of natural sciences (e.g. Cacho et al. 2003)
- publications strictly related to carbon footprinting for communication purposes (e.g. Scipioni et al. 2012)
- assurance- and verification-related publications (e.g. Martinov-Bennie 2012)
- publications related to the larger field of sustainability and environmental accounting which do not specifically deal with CMA in depth (e.g. Burritt and Schaltegger 2012)
- publications focused on carbon management (rather than carbon management accounting; e.g. Bradley et al. 2013)
- pedagogical discussions of carbon accounting (e.g. De Aguiar and Fearfull 2010)

This approach to data collection resulted in 31 publications, presented in Table 3.

Subsequent data analysis was conducted by means of taxonomic analysis. The primary purpose of this method is creating a classification system that categorizes the domains in a discipline or a research field to help the literature reviewer understand the relationships among the domains (Onwuegbuzie et al. 2012). Thus, a

Table 2 Search terms

Carbon	Accounting
Climate	Management
Emission	Footprint
Greenhouse gas	Allowance
GHG	
CO_2	

Table 3 Identified CMA publications

Title	**Authors**	**Journal**
Carbon reporting: does it matter?	Haigh and Shapiro (2012)	AAAJ
CO_2 emission reduction for Japanese petrochemicals	Gielen et al. (2002)	JCP
Climate change performance measurement, control and accountability in English local authority areas	Cooper and Pearce (2011)	AAAJ
Commercial local area resource and emissions modelling—navigating towards new perspectives and applications	Bradley et al. (2013)	JCP
Carbon trading: accounting and reporting issues	Bebbington and Larrinaga-González (2008)	EAR
Carbon accounting Negotiating accuracy, consistency and certainty across organisational fields	Bowen and Wittneben (2011)	AAAJ
Carbon management accounting: explaining practice in leading German companies	Burritt et al. (2011)	AAR
The European emissions trading scheme: an exploratory study of how companies learn to account for carbon	Engels (2009)	AOS
Carbon Footprint as a Basis for a Cleaner Research Institute in Mexico	Güereca et al. (2013)	JCP
Carbon accounting for supply chain management in the automobile industry	Lee (2012)	JCP
Carbon accounting and carbon footprint—more than just diced results?	Schmidt (2009)	IJCCSM
Research on the carbon footprint of beer; beverage industry environmental roundtable	BIER (2013)	Report
Uncertainty and variability in carbon footprinting for electronics case study of an IBM rack-mount server	Weber (2011)	Report
A supply chain view of product carbon footprints: results from the banana supply chain	Craig et al. (2013)	Working Paper
Product carbon footprint developments and gaps	Jensen (2012)	IJPDLM
Carbon-optimal and carbon-neutral supply chains	Caro et al. (2011)	Working paper
Input-output analysis and carbon footprinting: an overview of applications	Minx et al. (2009)	Economic Systems Research
Setting targets for reducing carbon emissions from logistics: current practice and guiding principles	McKinnon and Piecyk (2012)	Carbon Management
Product-level carbon auditing of supply chains: environmental imperative or wasteful distraction?	McKinnon (2010)	IJPDLM

(continued)

Table 3 (continued)

Title	**Authors**	**Journal**
Connecting the environmental activities of firms with the return on carbon	Oshika et al. (2012)	JoMA
Use of internal carbon price by companies as incentive and strategic planning tool	CDP (2013)	Report
Integrating information about the cost of carbon through activity-based costing	Tsai et al. (2012)	JCP
Making advances in carbon management. Best practice from the carbon information leaders	CDP and IBM (2008)	Report
Measuring carbon efficiency	Britt et al. (2011)	UCLA working paper
Managing carbon footprints in inventory management	Hua et al. (2011)	Int. J. Production Economics
Monitoring the carbon footprint of products: a methodological proposal	Scipioni et al. (2012)	JCP
Are there effective accounting ways to determining accurate accounting tools and methods to reporting emissions reduction?	Almihoub et al. (2013)	JSD
Drivers of tight carbon control	Bui and Truong (2013)	PMA Australasia Conference 2013 Proceedings
The role of input–output analysis for the screening of corporate carbon footprints	Huang et al. (2009)	Economic Systems
Corporate carbon performance indicators	Hoffmann and Busch (2008)	JIE
Measuring a carbon footprint and environmental practice: the case of Hyundai Motors Co. (HMC)	Lee and Cheong (2011)	Industrial Management & Data Systems

AAR Australian accounting review, *AAAJ* Accounting, Auditing and Accountability Journal, *AOS* Accounting, Organizations and Society, *EAR* European accounting review, *IJPDLM* International Journal of Physical Distribution and Logistics Management, *JCP* Journal of Cleaner Production, *JIE* Journal of Industrial Ecology, *JoMA* Journal of Management; *JSD* Journal of Sustainable Development, *UCLA* University of California, Los Angeles

taxonomic analysis can be described as building a set of categories that are organized on the basis of a single semantic relationship (Spradley 1997).

The analysis sought to identify what CMA practices have been documented in view of decision situations in which CMA information is used to inform decisions. The collected publications were therefore analysed based on their focus to identify dominant and under-represented decision situations supported by carbon information. The framework for this analysis was the CMA developed by Burritt et al. (2011) and presented in Sect. 2.

About two thirds of the sample of 31 publications were journal articles (23), whereas other publications comprised the remaining 8 articles (Table 3). Particularly notable is the observation that although most publications were

Table 4 Distribution of CMA literature by medium

Medium	Number of publications
AAAJ	3
JCP	6
Other journals	14
Grey literature	4
Non-academic literature	4
Total	**31**

published in accounting journals, apart from Accounting, Auditing and Accountabilit Journal (AAAJ) with three and the Journal of Cleaner Production (JCP) with six papers, each journal only features a single publication on the issue (Table 4).

4 Emission Management Merely a Means to an End

4.1 Diversity in Research and Practice

Despite the low number of identified publications, the analysis reveals a considerable diversity of CMA practices. Whereas only one of the reviewed publications explicitly considers the CMA framework presented earlier, a reference to its dimensions is made in virtually all of these publications. Nevertheless, only few publications discuss several of these dimensions (e.g. time frame of the information and generation routineness) at the same time (Table 4). Even fewer publications discuss a combination of the properties within one dimension (e.g. linking physical and monetary carbon information). The latter observation combined with the low overall number of publications does not allow a meaningful quantitative analysis of the collected data such as a correlation analysis (Neuman and Robson 2004). Hence, the following analysis draws on a qualitative analysis of the collected data, framed in the context of the EMA framework (Table 5).

The juxtaposition between monetary and physical carbon information was analysed in the researched publication sample. The number of publications focusing on physical carbon accounting was twice as high as the number of publications focusing on monetary aspects. Only four publications link the two dimensions and refer to the eco-efficiency concept (Sect. 5).

In these publications (e.g. Minx et al. 2009; Tsai et al. 2012), physical information is used to support the identification of relevant emission sources where potential for reduction is available. The advantages of physical information are emphasised particularly in situations where such information allows or requires acting regardless of the monetary implications of such actions (which may be negligible from a cost-benefit perspective, e.g. Bennett et al. 2013).

Table 5 Analysis of the publications in view of the CMA framework

Dimension	Property	Number of papers
Nature of the information	Physical	16
	Monetary	8
Time frame	Past	16
	Future	5
Length of time frame	Short-term	6
	Long-term	7
Routineness of information supply	Regular	7
	Ad hoc	15

The numbers in each dimension do not add up to 31 (number of publications) in each dimension since some publications do not identify an explicit decision situation

The literature that focuses on improving carbon performance has documented corporate interest on collecting and using physical information for purposes beyond the short-term (e.g. Engels 2009; Tsai et al. 2012; Lee 2012).

The low number of publications related to the monetary significance of carbon information could suggest that the benefit of using monetary carbon information is limited to a small number of decision situations and companies. Therefore, it can be expected that developments in this area are likely to be expected as monetary significance grows and (e.g. saving) potentials are explored more profoundly.

Last but not least, the observed lack of simultaneous attention to both the physical and the monetary dimensions of carbon information reveals a gap in the literature. Nevertheless, some co-occurrence of "monetary and short-term" and "physical and long-term" information was observed. This observation is further discussed in Sect. 5.

The time frame of carbon information—whether past or future-oriented—has been discussed from different views in the identified literature. A clear focus on past information was observed. This can be explained with the number of publications on carbon footprinting (e.g. Schmidt 2009; BIER 2011).

Six publications identify the advantages of using both past and future carbon information (e.g. Hua et al. 2011; Haigh and Shapiro 2012). For instance, building (future) emission scenarios are proposed as a subsequent action to estimating (past) emissions (Murthy and Parisi 2013).

Particularly prominent is the short-term/long-term dipole. Among the 31 publications, a focus on either type of information was not observed. Whereas about the same number of publications on short term (6, e.g. Green and Li 2012; Haigh and Shapiro 2012) and long term (7) carbon information was observed, 9 publications actually highlight the significance of both decision situations and the related information demand (e.g. Britt et al. 2011; Tsai et al. 2012). The focus on long-term information similarly assumes a high significance of carbon emissions on business operations, regardless of the ongoing political discussion.

Those publications that discuss carbon accounting in the context of long-term decisions (e.g. Haigh and Shapiro 2012) typically refer to the legitimising effects of

carbon management. Such effects can also be achieved for organisations which do not emit considerable carbon emissions. Therefore, carbon accounting does not necessarily contribute in every case to reducing carbon emissions to the atmosphere but sometimes also help documenting that the company is not affected substantially by climate change issues.

In view of the fourth dimension of the carbon management accounting framework—regularity of data collection—the project-driven information collection dominated the sample (15). This emphasis is achieved due to the attention to carbon footprinting, which is often carried out on a one-off basis and requires detailed information to be collected specifically for a single project purpose. Jawjit et al. (2010) for example show that the ad hoc data collection in the case of greenhouse gas emissions from the rubber industry in Thailand allows for flexibility related to the goal of the analysis, its system boundary, and its functional unit (e.g. by including certain gases). Gielen et al. (2002), on the other hand, demonstrate a carbon emission reduction approach for a Japanese petrochemical company by means of information collected on a regular basis.

Only three publications identify situations in which information needs to be collected both on a regular basis and ad hoc.

4.2 *Carbon Management Accounting—Emission Management or Emission Reduction?*

The dominant features of CMA as documented in the literature sample indicate that CMA gravitates around management accounting rather than around carbon reduction accounting. In other words, carbon is seen as another resource or constraint; therefore it needs to be managed in order to safeguard the success of organisations. Managing carbon emissions, however, was revealed to not be limited to reducing emissions (which is the overarching purpose of carbon efforts in a national and supranational context). In fact, reducing carbon emissions (mitigation) is the less common argument discussed in the extant CMA literature (Table 6).

As the analysis reveals, extant research focuses carbon accounting attention on information generation for adapting to the changing environment. This is done for example to secure the legitimacy of the company (e.g. Pellegrino and Lodhia 2012; Sullivan and Gouldson 2012) or to estimate the future price of operations (e.g.

Table 6 Adaptation as the dominating motivation for CMA

Motivation	Adaptation	Mitigation	Both
Number of papers	20	4	3

Four publications do not make a clear statement as to the motivation for CMA

Cooper and Pearce 2011). Furthermore, carbon information related to corporate activities increasingly influences investment decisions (e.g. CDP 2013).

The above observation is in line with the previous observations pertaining to the CMA framework dimensions. The previously identified focus of publications referring to past information supports this view, as such information does apparently not focus on improving climate-related impacts. The under-represented monetary information demand—albeit seemingly counterintuitive—may in fact support the view that carbon is not perceived to be of considerable monetary importance for many researchers and companies, therefore it is not tracked, analysed and reported.

As the literature review reveals, extant research in the area of CMA assume that companies have largely used carbon management accounting for adapting to a changing and more constrained business environment without necessarily contributing to reducing their emissions. This finding largely reflects the assumptions and prepositions of the authors dealing with the topic and is in most cases not supported well with a balanced empirical analysis. Sustainable development and corporate sustainability require improvements with regard to carbon impacts. Research thus needs to develop more useful approaches to CMA which are empirically tested and can support corporate practices effectively.

The following section discusses how CMA can be developed to efficiently contribute to effectively reducing the total amount of emissions stemming from business activities.

5 Discussion

Summarizing the observations made in the previous section renders an important observation visible. CMA has been documented to be used *either* for producing an account of the carbon performance of a company (e.g. product carbon footprinting; typically in physical units) or, less frequently, for identifying important strategic and operational business issues (typically in monetary units). A connection between the two dimensions was observed in only 4 of the 31 papers (Burritt et al. 2011; Lee 2011; Britt et al. 2011; Hoffmann and Busch 2008). Yes, linking the two dimensions may enable a win-win situation, i.e. improving corporate financial performance by means of improved carbon performance (i.e. reducing carbon emissions). The following sub-section discusses implications for improving carbon efficiency.

5.1 Eco-efficiency Beyond an Improved Carbon Footprint

One particular challenge for accounting for eco-efficiency is that it cannot always be represented by hard data since a number of difficulties arise when attempting to measure it (Britt et al. 2011). This literature review reveals that the views and

definitions of carbon efficiency may vary widely between companies. Furthermore, as discussed in Sect. 4, a benefit of carbon management may be gaining societal legitimacy or gaining power to influence future carbon legislation irrespective whether emissions are reduced or not. This assumption guides a number of publications that motivate carbon management with benefits other than improving product or process eco-efficiency. As a result, different representations of eco-efficiency have been discussed in the existing CMA literature.

Originally, eco-efficiency was defined as minimizing negative outputs while keeping or increasing economic success. In the case of carbon management, pricing of the environmental performance does not necessarily constitute a challenge. Typically all outputs can be in expressed monetary terms, and carbon emissions have market prices.

Eco-efficiency can also be applied in defining target outputs by the quantity produced from a given level of input. Carbon emissions, the undesirable output in this case, is mostly measured by the physical quantity that was generated, rather than attempting to monetize these factors (Färe et al. 1989). Examples of eco-efficiency indicators thus include value added (in monetary terms) per tonne of emitted CO_2 or the contribution margin of a product relative to its contribution to the greenhouse effect (in CO_2 equivalents).

A discussion of value creation in view of eco-efficiency has been virtually non-existent. Among the most prominent issues has been the lack of clarity when it comes to defining the constituents of eco-efficiency improvements through carbon emission reduction on one hand, or of creating carbon emission and eco-efficiency information on the other hand. As discussed in Sect. 2, (i) profit has been assumed as one motivation underpinning a given company's carbon management endeavours. In addition, (ii) credibility and leverage in climate policy development (iii) ethical considerations, (iv) fiduciary concern and (v) business opportunities have been discussed as motivation for managing carbon.

A closer inspection of these five motivations reveals a picture that carbon management accounting can create value and competitive advantages irrespective of whether carbon efficiency is improved or not. Profit or legitimacy can in some cases be boosted by offering products whose carbon footprint is known. This may provide some competitive advantage, at least until competitors offer similar information. A notable illustration of generating such a competitive advantage through superior carbon management accounting is DHL, who was the only company to offer a product whose carbon footprint could be established. Since competitors were not prepared to offer such information, DHL won a contract with the UK Government's Department of Health worth 2.3 billion Euro revenue over 10 years.

5.2 Implications for Developing Eco-Efficiency Indicators

The implications for the above discussion may influence the design of carbon management indicators. Whereas carbon indicators discussed in the existing CMA

literature focus on physical benefits of reducing emissions (Wilson and Dowlatabadi 2007; Yang et al. 2009), the goal of improving corporate sustainability raises concern about developing more adequate carbon-efficiency indicators. Such indicators need to enable companies to create performance benchmarks in view of overarching objectives and to rethink carbon indicators from an eco-efficiency and corporate carbon management perspective.

Carbon performance from an eco-efficiency perspective can be measured by linking the economic (monetary) value created by carbon management activities with the (monetary) carbon management effort invested or the (physical) carbon emission reduction achieved. For example, the value created can be expressed as the ratio of market share increase due to carbon management to the resources invested in carbon management.

In summary, the future developments in measuring carbon efficiency should aim at providing a balanced set of environmental performance indicators that link overarching corporate objectives with carbon emission targets.

6 Conclusion and Outlook

Despite the multitude of publications emphasizing the sustainability relevance of carbon management and carbon accounting, the majority of the publications explicitly dealing with CMA discusses aspects not related to the management relevance of improved carbon performance. Most of the explicit CMA literature deals with past oriented and ad hoc information while focusing on decision support to secure legitimacy or profits. Sustainable development and corporate sustainability, however, would—in addition—require considering future-oriented decision situations and the generation of routinely generated carbon information to create continuous management attention and to support management decisions for improved carbon performance.

As the analysis conducted reveals, research in the area has mostly assumed and considered carbon accounting for the purpose of securing the success of the company rather than for emission reduction. While this assumption underlying a large part of the literature can also be observed in the general context of sustainability accounting (e.g. Bozzolan et al. 2013), our literature review may imply that pursuing one single perspective in an isolated manner could be too one-sided as neither the legitimacy based motivation of reducing carbon emissions nor the profit or cost oriented view may provide a sufficient incentive for carbon emission reduction, the broader introduction of CMA and the achievement of substantial carbon emission reductions.

The identified discrepancy between the motivations behind carbon accounting as assumed in many CMA publications—to increase profits and/or to secure legitimacy—and the sustainability objectives of carbon management—to reduce carbon emissions—supports the view that there is a considerable potential to develop CMA, particularly to better support future oriented management decisions and

continued management attention leading to reduced carbon emissions and improved carbon efficiency. From a pragmatic perspective accounting and sustainability management researchers are challenged to propose and test new CMA approaches which effectively contribute to sustainable development and corporate sustainability by improving both corporate carbon and economic performance through carbon management accounting support and innovative CMA methods for better informed decisions.

Subsequent research is challenged to look into possibilities to harness the potential of CMA to actually reduce carbon emissions in view of an eminent ecological crisis (IPCC 2007). Expanding the currently limited set of carbon accounting tools at a management's disposal thus constitutes a central challenge.

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