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ACCOUNTING FOR CLIMATE CHANGE – WHAT AND HOW TO MEASURE

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CARBON ACCOUNTING: A SYSTEMATIC LITERATURE REVIEW

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Abstract: ***The term Carbon Accounting is widely used by scientists in various disciplines and occurs especially within discussions of the integration of climate aspects into accounting, but no consistent definition of Carbon Accounting exists so far. The objective of this paper is a systematic literature review on the topic of Carbon Accounting in order to derive an appropriate definition of Carbon Accounting for different disciplines.***

Therefore, a systematic literature review according to Fink was conducted: selection of research questions, bibliographic article databases and websites as well as the appropriate search terms; application of practical screening criteria for the inclusion of relevant literature and the exclusion of irrelevant literature; application of methodological screening criteria and synthesizing the findings.

The literature research showed that there is no appropriate definition regarding Carbon Accounting. In general the literature can be divided into four sections: physical carbon accounting with focus on global and national area, physical carbon accounting in terms of Carbon Footprint(ing), monetary carbon accounting with focus on management accounting and monetary carbon accounting with focus on financial accounting. Based on these findings a definition for Carbon Accounting is proposed.

Keywords: Carbon Accounting, literature review, financial accounting, management accounting

I. INTRODUCTION

To consider Greenhouse Gases (GHG) in entrepreneurial decisions experiences a growing attention much initiated by the introduction of emissions trading in the European Union (EU), but also by the recent work of the Intergovernmental Panel on Climate Change (IPCC), the Stern Report and the Carbon Disclosure Project (CDP). Due to emissions trading Carbon Dioxide (CO_2) allowances have to be entered in the annual financial statements. Therefore they are considered in management accounting, too. But the question arises whether and how all other climate-relevant aspects are taken into account in management accounting. These comprehend other "inside-out" effects, i.e. GHG of the company, which are not yet included in emissions trading schemes [1].

Lately the GHG Emission Allowance Trading Scheme (ETS) in the EU just includes CO_2 emissions from power generation plants and very energy-intensive facilities such as they exist in the (ferrous) metal industry and mineral industry. CO_2 emissions from other processes are not included yet [1]. This also applies to all other GHG, which are listed in the Kyoto Protocol such as methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) [1], [2]. Besides legislation customers and investors might motivate companies to mitigate GHG emissions.

On the other hand changing climatic conditions lead to direct effects on companies, the so-called "outside-in" effects. Level effects (e.g. rising temperatures, decreasing precipitation amounts) or stability changes (e.g. extreme weather) can require adaptation strategies.

The discussion how to integrate climate aspects in accounting is often labeled Carbon Accounting. But natural scientists use this term as much as financial analysts. Do they have the same understanding and what are the differences?

These questions were the starting point for a literature review in order to elaborate on the understanding of the term Carbon Accounting in the different research areas and to offer a definition where a multitude of research strands is included.

II. METHODOLOGY

The objective of this paper is a systematic literature review on the topic Carbon Accounting in order to derive an appropriate definition of Carbon Accounting for different disciplines. According to Littell (2008) [3] a systematic review is "The application of strategies that limit bias in the assembly, critical appraisal, and synthesis of all relevant studies on a specific topic." Fink (2005) [4] proposes four steps for a systematic review, which we have taken as a basis. In the first step we selected our research questions, the bibliographic article databases and websites as well as the appropriate search terms. Then we applied practical review criteria for the inclusion of relevant literature and the exclusion of irrelevant literature. In the third step we applied methodological review criteria. Finally we synthesized our findings.

For the first step we decided to use on the one hand Google.Scholar[1] for a first overview and on the other hand the databases Academic Search Complete, Business Source Complete and EconLit with Full Text, which are hosted by EBSCO, for a deeper observation. We did not focus only on peer reviewed journals and books, we also searched for "grey" literature.

For the search itself we have chosen the following search terms: "carbon*accounting", "greenhouse gas accounting", "GHG*accounting", " CO_2 accounting", "GHG inventory" and "carbon*footprint". With these exact phrases we searched in the title, abstract or in the full text of the documents. Google Scholar only offers search "in the title" or "anywhere in the article". After a first review of the literature two dimensions occurred: literature with a physical focus and literature with a monetary focus. For a further research we used the combined search terms "environmental accounting" AND "climate change", "greenhouse gas", GHG, carbon, " CO_2", "global warming", "GHG inventory" in order to cover the non-financial area. For a deeper literature review in the second dimension we decided for the search terms: "full cost accounting" AND environment, "climate change", "climatic change", CO_2, "carbon dioxide", GHG, "greenhouse gas".

For the detailed review we excluded literature with a biologic, microbiologic, chemical and biochemical focus.

TABLE 1: REVIEW PROTOCOL

Author
Year
Name of the document
Type of the document
Definition or description of "Carbon Accounting"

[1] According to Google Scholar (2009) is the literature research with Google.Scholar "[…] a simple way to broadly search for scholarly literature." It is possible to search across many disciplines and sources like articles, theses, books, abstracts and court opinions.

Definition or description of similar phrases like “Carbon Footprint (CF)
Disclosure of CO_2, Kyoto-Gases or all GHG
System boundary (nation, company, person, project. etc.)
Physical carbon accounting
Monetary carbon accounting (Following the International Federation of Accountants (IFAC) we differentiate between financial accounting and management accounting that are applied within an organization typically. Financial accounting primarily focuses on standardized information about the financial performance of the organization to external stakeholders such as investors, tax authorities, consumers et cetera. Management accounting offers information to management for internal decision making.) ▪ Management accounting ▪ Financial accounting

III. RESULTS

To start with the literature research with the phrase “Carbon * accounting” was very useful because of the variety of this term: Among “Carbon emission accounting”, “Carbon credit accounting”, “Carbon budget accounting”, “Carbon storage accounting”, “Carbon stock accounting”, “Carbon offset accounting “, “Carbon temporally accounting”, “Carbon monitoring accounting“, “Carbon amounts accounting”, “Carbon balance accounting”, “Carbon activities accounting”, “Carbon equivalent accounting”, “Carbon fuels accounting” and “Carbon baseline accounting” are used. We got a similar result by searching for the term “GHG * accounting”: “GHG emissions accounting”, “GHG abatement accounting”, “GHG project accounting” and “GHG Inventory accounting”.

After the systematic literature review by using the presented coding schedules we divided the literature into four sections which are titled as followed:

- Physical carbon accounting with focus on global and national area
- Physical carbon accounting in terms of Carbon Footprint(ing)
- Monetary carbon accounting with focus on management accounting
- Monetary carbon accounting with focus on financial accounting

After presenting the main findings of every section we summarize our findings in one definition of Carbon Accounting.

A. Physical carbon accounting with focus on global and national area

The literature of this section focuses on physical accounting of carbon dioxide on a global or national scale. In these articles no explicit definition of carbon accounting was made, but phrases like “Full Carbon Accounting”, “Partial Carbon Accounting” or “Greenhouse Gas Accounting” were explained. Cairns and Lasserre (2006) [5] explain that “Carbon accounting is widely used by scientists in various disciplines, and is a standard

tool for the IPCC." [5]. Jonas et al. (1999) uses four different phrases: Besides the mentioned "Full Carbon Accounting" (FCA) and "Partial Carbon Accounting" (PCA) he also differs between "Global-scale Carbon Accounting" and "National-scale Carbon Accounting" [6]. In the first case, all (carbon-related) components of a terrestrial ecosystem are integrated and are applied continuously over time (past, present, future). If Jonas et. al. [6] uses this term in the context of the Kyoto Protocol, he refers to 'terrestrial full carbon accounting' – "the atmosphere–fossil fuel– terrestrial biosphere system where the atmosphere is adjusted for the oceanic system." According to Jonas et. al. [6] the "PCA is applied, e.g., under the Kyoto Protocol, which makes specific allowances for the inclusion of biological sources and sinks resulting from direct human-induced land-use change and forestry activities." FCA as well as PCA can be used in order to account on the national scale whereby the latter one is the most practiced form.

Cowie et al. 2007 [7] use the term GHG-Accounting and focus in their paper on accounting for biospheric carbon exchange. Based on the term "Accounting" which is defined as "comparing emissions and removals […] with commitments assumed by Annex I Parties under the Kyoto Protocol" [8] they enlarged this term to calculating 'debits' and 'credits' concerning an agreed target. Furthermore, emissions with anthropogenic origin should be accounted separately so that countries can decide for beneficial actions. If accounting isolates the anthropogenic component of estimated emissions or removals in order to provide appropriate incentives or sanctions for beneficial resp. detrimental actions, and to assess the effectiveness of policy measures.

Groen et al. 2006 [9] also don't define the term carbon accounting, but apply two approaches for carbon accounting: stock change and merchantable certified emission reductions.

Some authors such as Cowie et al. (2007) [7] and Jonas et al. (1999) [6] focus on GHG and other authors like Cairns et al. (2006) [5], Groen et al. (2006) [9] and Marland 2008 [10] concentrate on CO_2-emissions only. Additionally, the system boundaries differ between global [6], [10] and national [5], [7]; Jonas et al. (1999) [6], Marland (2008) [10] and Groen al. (2006) [9] chose projects as system boundary.

The investigated papers mainly focus on non-monetary aspects. Moreover, Cairns et al. (2006) [5] and Groen et al. (2006) [9] consider monetary aspects. For example Groen et al. (2006) [9] mention monetary terms like costs for site preparation, planting, thinning and harvesting that either recurring every year or as a fixed value for a year. Furthermore discounted costs and income as well as the Net Present Value are calculated.

B. Physical carbon accounting in terms of Carbon Footprint(ing)

In this research strand the term Carbon Accounting is not used, but the term carbon footprint (CF) is common. The CF can be traced back to the ecological footprint which is defined as "a resource management tool that measures how much land and water area a human population requires to produce the resources it consumes and to absorb its wastes under prevailing technology. The Footprint calculates the biologically productive land and water an entity (an individual, a city, a firm, a country) needs to obtain resources and dispose of waste. In this, it provides information to help manage ecological assets more carefully and to enable personal and collective actions that can move us towards truly sustainable development […]." [11] Kitzes and Wackernagel (2009) [12] explain that the CF is one part of a full Ecological Footprint and this global hectare-based CF can in addition to other components of the Ecological Footprint, for example cropland Footprint or fishing grounds Footprint, consolidate to the total Ecological Footprint of a population

or activity. According to Wackernagel (2008) [11] the CF “measures how much land would be required to absorb our emissions of carbon dioxide from fossil fuel (minus what is absorbed by the oceans)”. In contrast to Wackernagel (2008) [11] Baldo et al. (2009) [13] describes the CF as “the overall amount of carbon dioxide (CO_2) and other GHG emissions (such as methane) associated with a product along its supply chain, which includes its use phase as well as product end-of-life management.” This means that Wackernagel (2008) [11] measures the CF in hectares and Baldo et al. (2009) [13] in CO_2-equivalent. The latter unit is ascertaining by converting all GHG emissions into CO_2-equivalent. Kitzes and Wackernagel (2009) [12] accomplish that in the scope of a full Ecological Footprint the quantities of carbon dioxide emissions, measured in tones of carbon dioxide equivalents, are translated into the area, in global hectares. Wiedmann and Minx (2007) [14] prefer the measuring unit “tonnes of carbon dioxid", but don’t include other GHG. Moreover, they investigated the usage of the term CF in all scientific journals of the SCOPUS and ScienceDirect databases between 1960 and 2007. Their findings evince that the term CF is used as a synonym for the CO_2 emissions or GHG emissions in CO_2 equivalents of specific products, companies or organizations. They recommend the term “Climate Footprint” unless all GHG should be included. Wackernagel (2008) [11] as well as Kitzes and Wackernagel (2009) [12] also only include CO_2-Emissions into the definition of CF, but Baldo et al. 2009 [13], Finkbeiner (2009) [15] and Sinden (2009) [16] involve further GHG although it is not clear if all GHG or only the Kyoto-Gases have to be accounted.

Moreover, Wiedmann and Minx (2007) [14] allude that all direct (on-site, internal) and all indirect (off-site, external, embodied, upstream, downstream) CO_2-emissions should be considered. By contrast Baldo et al. (2009) [13] divides the CF into direct/primary footprint and indirect/secondary footprint. Former involves the emission due to the combustion of fuels in the applicant plant and during the electricity generation; the indirect footprint encompasses these GHG that are generated from all the other sources.

However, in current discussions, CF is often used as abridgement of the product carbon footprint (PCF), which takes products and services as system boundary. Most of the literature discusses how to record CO_2-(equivalents)-emissions or GHG-emission and how to assess them in non-monetary terms (for example CO_2-emissions per product).

As described above CF measures and evaluates only CO_2 or GHG; other inputs and outputs are not considered. Thus, the examination is reduced to the environmental impact of "greenhouse effect". In contrast to that a Life Cycle Assessment (LCA) gathers and evaluates incoming (input) and outgoing (output) material and energy flows [18]. Therefore some “LCA purists” call the CF as a ‘castrated type’ of LCA. In their opinion all attributes or aspects of natural environment, human health and resources have to be considered [15]. In order to record GHG emissions companies can revert on different approaches such as the Greenhouse Gas Protocol (GHG Protocol) [19]. Another possibility is the international standard ISO 14064-1 which is also based on the GHG Protocol [20].

According to Wackernagel (2008) [11] the CF is nearly half of the total global Footprint and from 1961 to 2003 it was increasing more than 700% and hence it is the fastest growing component of the Ecological Footprint. So the CF might be an impetus to integrate life cycle approaches in organizations and decision making processes, a goal pure LCA did not reach yet [15].

C. *Monetary carbon accounting with focus on management accounting*

Similar to the already analyzed research strands the term Carbon Accounting is often used but not defined in the management accounting literature. Instead of Carbon Accounting terms like "Trade-based carbon sequestration accounting" [21], "Whole life carbon accounting" and "Operational carbon accounting" [22], "Carbon cost accounting"; "Carbon emission and sequestration (CES) accounting" [23], "Carbon management accounting" [24] and "Carbon business accounting" [25] are used, but only seldom described in detail. Prescott (2009) [22] distinguishes between "Whole life carbon accounting" that includes embodied and operational carbon for investment planning and "Operational carbon accounting" for annual reporting purposes. The basis for "Whole life carbon cost" is cumulative carbon emissions. Ratnatunga (2007) [23] applies on the one hand the term "Carbon emission and sequestration (CES) accounting" that has the objective to calculate the amount of CO_2 emitted by a source or sequestered in a biomass sink. On the other hand he uses "Carbon cost accounting" which is part of the "Environmental cost accounting". According to Ratnatunga and Balachandran (2009) [25] "Carbon business accounting", in short "Business accounting", encompasses strategic cost management (SCM) and strategic management accounting (SMA). It is discussed on the one side how the impacts of the (global) costs of CO_2 emissions can be captured by accounting systems and on the other side how they can be built into the cost and prices of different products and services. Furthermore, the impact on strategic decision making in organizations is discussed.

The researchers refer mostly to carbon dioxide although it is not always that clear. For example Prescott (2009) [22] uses among "carbon" also CO_2-equivalents what allows the conclusion that all GHG are included. ACCA (2009) [26] refers to GHG primarily. In contrast to the section above, a consistent system boundary is used: organization or entity. Prescott (2009) [22] focuses only on companies in the water sector.

The screened literature addresses the evaluation of returns on low-carbon investments, the development of carbon-related Key Performance Indicators (KPIs), and the identification of the financial consequences of climate change. [26] Kundu (2006) [27] analyzes the financial aspects of emissions trading. In his mind companies need to buy or generate Certified Emission Reductions in the scope of the Emission Trading or they have to pay penalties. Therefore accounting comprehends two facets: first, the value of the allowed amount of emissions and second, the costs that occur in order to meet emission-reduction commitments.

In King (2000) [21] a standardized accounting method is preferred which is applicable for the assessment and comparison of "early" carbon sequestration trades on the basis of the amount of CO_2 emission offset credits they will provide and their cost; Ratnatunga (2008) [24] discusses in his paper the impacts of carbon related issues on strategic management accounting. On the level of performance evaluation he suggests to extent the Weighted Average Cost of Capital (WACC) to Carbon-WACC, if financing of carbon related investments can be isolated. Also a Carbon-Economic Value Added (EVA) can be ascertained. The precondition is that carbon related net-income, investments and capital costs can be isolated. (Ratnatunga and Balachandran (2009) [25] reveals that there is a need for accurate carbon cost accounting using life-cycle costing techniques. In doing so not only costs for transport of a product or service to the point of sale, but also the carbon costs that occur ´presale` and ´postsale` have to be accounted. This includes the costs for time on rejects and recovery, meeting emission standards and production waste (presale) as well as landfill waste or litigation for environmental pollution (postsale).

The basis for an appropriate monetary management accounting forms an accurate capturing of the CO_2- or GHG emissions which means an organizations´ CF [26],[23]. As explained above Ratnatunga (2007) [23] mentioned the phrase "Carbon emission and sequestration (CES) accounting" which focus on the estimation of CO_2 emitted by a source or sequestered in a biomass sink.

Similar to the section "Physical carbon accounting in terms of Carbon Footprint(ing)" also some researchers in the area of management accounting (with focus on monetary terms) see some significant risks in the trend towards researching environmental KPIs in general and carbon accounting in particular. Parker (2008) [28] explains that a compliance measurement system for carbon impact will dominate the overall social and environmental responsibility program.

D. Monetary carbon accounting with focus on financial accounting

Especially accountancy firms address carbon-related financial accounting issues. That is one reason why we extended our literature sample beyond peer reviewed journals. The term carbon accounting focuses implicitly on the accounting for emission rights or emission permits (see [29],[30],[31],[32]). Currently within International Financial Reporting Standards (IFRS) or United States' Generally Accepted Accounting Principles (US GAAP) there is no accounting standard or interpretation that specify how to account for emission permits. Usually organizations conform to the general principles of IFRS [30] and in result there is a multiplicity of possible realizations in practice [31]. The consequences of a missing accounting standard is that financial performance is influenced concerning timing of recognition of assets, liabilities, profits and losses, measurement of balance sheet items at nominal value, cost or fair value, current and deferred tax and Value Added Tax (VAT) implications as well as presentation and disclosure [32]. Furthermore there are impacts on decision making regarding the participation in the EU ETS. Because of these two aspects a company needs to illustrate its accounting policy to the market [29]. Bakhshi (2007) shows in an example which changes could occur for balance sheets because of climate change. Thereby he concentrates on the most likely affected areas: product portfolios, property assets and long-term liabilities

Another problem accrues from the missing international carbon accounting and also reporting standard: it is very difficult to compare data sets [26].

According to Ratnatunga (2007) [23] "current financial accounting framework appears to be ill-equipped to provide the information required by companies to meet the challenge of global warming.", because accounting information systems are not created to cope with physical measures such as CO_2 sources and sinks. Even though these physical measures could express in monetary terms, the question if they should be categorized as assets or liabilities remains unanswered.

Mainly the explanations center on carbon (dioxide). Beyond that KPMG mentioned also the Kyoto-Gases which could be relevant in future times [32]. The system boundary is consistently the organization or entity.

Since the introduction of the European-ETS in 2005 capturing information about CO_2 emissions are obligatory for all companies, which have plants for energy conversion and transformation, plants to produce or to process ferrous metal, plants to produce pulp from wood, straw or similar fibrous materials or to manufacture paper or paperboard (production capacity exceeding 20 tones per day) and plants of the mineral industry. The captured emissions have to transmit to the Emission Trading Authority. [1]

The integration of the aviation sector will be proceeded into the European emissions trading scheme by the EU Directive 2008/101/EC [35], which provides the integration of aviation from 2012. This means that emission rights need to be purchased for all flights that start or land in a certain sovereign territory in a quantity which is linked to the ejected emissions. From 2013 further GHGs will be included within the emission trading scheme such as PFCs, that is ejected from the production of primary aluminum, or N2O from some chemical manufacturing processes [36]. Prospectively it will be expected that the range of sectors will expand continuously either directly through the inclusion of a sector, or indirectly through the inclusion of other GHG. The existing or potential regulatory requirements have a direct impact on the balance sheet as well as profit and loss account. Therefore, companies need and will need to identify CO_2-intensive processes to implement appropriate countermeasures. Consequently, a direct incentive exists to include CO_2 and GHG emissions in business decisions. But some companies record and evaluate their CO_2 emissions voluntarily, not due to regulations.

On the one hand government and EU and on the other hand other stakeholders such as investors or customers have got an interest to know about the firm's GHG emissions. Investors could inform on their own about firm's climate risks by using the CDP, which arose out of an initiative by financial investors in 2000. In times of global climate change such information is increasingly important regarding investment decisions [37]. The CDP as an independent non-profit organization has got the world's largest corporate climate database. Disclosure according to relevant business information will play a decisive role for interested parties regarding investment decisions. i.e. CDP gains in importance. But even other organizations ask for companies' climate impact according to their investment decisions like SAM Indexes GmbH, which stands for Dow Jones Sustainability Indices.

Even customers and the public are increasingly interested in Carbon Disclosure, i.e. to give an account of companies' GHGs. Firm's climate impacts are focused thereby in general and their CO_2 emissions and CO_2 mitigation and avoidance strategies are focused in particular. The Global Reporting Initiative (GRI), which was founded in 1997, aims to develop a global standard for Sustainability Reporting. Further it offers a guideline how firms ought to display social, ecological and economical aspects of their activities. Five environmental performance indicators (EN 16, EN 17, EN 18, EN 29 und EC 2) focus on companies' climate performance such as ecological indictor "total direct and indirect GHG emissions by weight" (EN 16) or economical indicator "Financial implications and other risks and opportunities for the organization's activities due to climate change" (EC 2) [38].

Independently of the research strand no definition of Carbon Accounting is used. In summary we propose that Carbon Accounting should encompass all GHG because present regulations will enlarge to others GHG such as CH_4 in future times. The majority of the screened literatures focus either on organizations solely or among product etc. also on organization level so that the system boundary should be "organization". The distinction between management accounting and financial accounting is carried over (according to IFAC) but we also consider non-monetary terms so that the CF can be incorporated into the definition.

Therefore Carbon Accounting encompasses the capturing and valuation of GHG emissions with the object of non-monetary and monetary valuation for internal purposes (management accounting) or non-monetary and monetary valuation for external purposes (financial accounting). Organization can use for capturing CO_2 or other GHG the guidelines of the GHG Protocol or the ISO 14064-1. On the financial accounting level is

an additional differentiation need to be considered: mandatory and non-mandatory accounting.

An extension of Carbon Accounting to Climate Accounting is a further step, in order to take into account "outside-in" effects, that means if impacts of climate change require business adaptations.

IV. SUMMARY

We did a systematic literature review regarding the term Carbon Accounting. The review showed that no definition exists but that there a different research strands. Within of any research strand there are different understanding regarding the disclosed gases (CO_2, Kyoto-Gases or all GHG), the system boundary (global, national, organization) and valuation of disclosed gases (non-monetary or monetary). Therefore we divided the literature into four sections: physical carbon accounting with focus on global and national area, physical carbon accounting in terms of Carbon Footprint(ing), monetary carbon accounting with focus on management accounting and monetary carbon accounting with focus on financial accounting. We deduced from these findings following definition: Carbon Accounting encompasses the capturing and valuation of GHG emissions with the object of non-monetary and monetary valuation for internal purposes (management accounting) or for external purposes (financial accounting).

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