The current issue and full text archive of this journal is available at
www.emeraldinsight.com/0951-3574.htm

Received 2 March 2010
Revised 29 October 2010
Accepted 21 July 2011

Carbon accounting

Negotiating accuracy, consistency and certainty across organisational fields

Frances Bowen
School of Business and Management, Queen Mary, University of London, London, UK, and
Bettina Wittneben
Smith School of Enterprise and the Environment, University of Oxford, Oxford, UK

Abstract

Purpose – A fully functioning carbon accounting system must be based on measurement that is materially accurate, consistent over space and time, and incorporates data uncertainty. However, achieving these goals is difficult because current carbon accounting efforts are spread across three distinct organisational fields, each prioritising different goals. This paper aims to address these issues.

Design/methodology/approach – The authors identified three fields drawn together by the science of how carbon emissions can be measured, the social practices of carbon accounting, and accountability within the global carbon governance system. The authors hosted a workshop, and invited representatives participating in each of the organisational fields to highlight the contentious conversations within their field. The authors facilitated an across-field exploration of whether and how to achieve accuracy, consistency and certainty in carbon accounting.

Findings – It was found that there are tensions between accuracy, consistency and certainty in carbon accounting both within and across organisational fields. Framing the evolution of carbon accounting as negotiation between these goals across fields yields powerful implications for addressing current challenges in carbon accounting.

Practical implications – The authors provide guidance to policymakers on how to recognise legitimate uncertainty in carbon management science, manage the cost-benefits of policy and reporting mechanisms, and ensure actual greenhouse gas emissions reductions.

Originality/value – This paper exploits the unusual approach of integrating carbon accounting across levels of analysis, from the molecular level through processes, organisations, industries and nations. This approach should help scientific, corporate and policy decision-makers move towards a more fully functioning carbon accounting system.

Keywords Carbon accounting, Accuracy, Consistency, Measurement, Organizational fields

Paper type Research paper

This paper is based on discussions at a workshop on Accounting for Carbon hosted by the Smith School of Enterprise and the Environment at the University of Oxford in November 2009. The authors would like to acknowledge financial and administrative support received from the Smith School, both for the workshop and through the academic visitors program. The workshop was partly funded by IRIS (International Resource Industries and Sustainability Centre) at the University of Calgary (SSHRC Grant No. 603-2007-0010). Particular thanks go to the co-organiser of the workshop, Dr Chuks Okereke, for his assistance in developing the conceptual framework for the workshop, to Owen Owens and Dr Adam Bumpus for research assistance, and to workshop participants who shared their insights during the day.

Accounting, Auditing & Accountability Journal
Vol. 24 No. 8, 2011
pp. 1022-1036

0951-3574
DOI 10.1108/09513571111184742

1. Introduction

Climate change, with its increase in the frequency and intensity of extreme weather events, is threatening and already impacting communities around the globe (Kalkstein and Smoyer, 1993; Vörösmarty *et al.*, 2000; Berkes and Jolly, 2001; McMichael *et al.*, 2006). In order to avert catastrophic climate change, the Intergovernmental Panel on Climate Change (IPCC) stipulates in its 2007 report that we need to obtain massive cuts in greenhouse gases (GHGs) of 50 to 85 per cent by 2015 based on 2000 emissions (IPCC, 2007). Businesses can take on some of these cuts voluntarily, but it is clear that there has to be a regulatory drive to encourage investment flows into climate friendly technologies and curtail the consumption of fossil fuels (Randjelovic *et al.*, 2003). Governments can provide incentives for investment in green technologies or regulate the use of best practice industry examples (Orsato and Clegg, 2005). They could also implement carbon emission reductions by establishing a carbon tax or a cap-and-trade system for carbon. Each of these policy options differs not only in how they function but also on who bears the cost of the reduction and reaps the benefits of financial flows (Wittneben, 2009). All of these accountability systems, as well as voluntary emission reduction systems, require the measurement, collection and comparison of carbon dioxide (CO_2) emissions data.

Evolving climate change governance mechanisms such as the Regional Greenhouse Gas Initiative (RGGI) carbon auctions, the European Union Emission Trading System (EU ETS) and the potential federal cap-and-trade system in the USA also place pressure on companies to track and disclose their CO_2 emissions. Investors are increasingly taking note of carbon profiles in their evaluation of asset prices and potential investments. In response, companies are learning to report their carbon management initiatives, some going so far as to track CO_2 emissions through the value chain at the product level and disclose this information on consumer product labels. Firms face the challenge of developing carbon accounting systems (Vine and Sathaye, 1999), within the "ongoing experiment" of developing carbon markets (Callon, 2009, p. 537).

Economists analyse carbon markets as a set of technical questions on solving market failures through including externalities, focusing on the costs and benefits of various instruments to incorporate environmental costs (Hepburn, 2006). Yet there is increasing recognition that these markets are developed through "a laborious and ongoing process of construction of spaces for calculation and transaction, of accounting systems that determine both who is accountable and how and what to count and not to count" (Lohmann, 2009b, p. 500). These constructions, and the design of carbon measurement and accounting arrangements, are themselves a strategic activity (Callon, 2009). The evolution of carbon accounting provides us an opportunity to observe how the interests, expectations and goals of multiple actors influence the design of a new market.

A fully functioning carbon accounting system needs to be based on measurement techniques that are: materially accurate, that is, they need to reflect actual atmospheric emissions; consistent over space and time through the use of calibrated equipment, agreed procedures and verification; and incorporate indicators of certainty to allow for valid interpretation of data. Callon (2009) questions the attainability of these theoretical goals through constructing markets as "problematic networks" crossing arbitrary divisions between economics, politics and science. Building on

	The counting carbon field	The carbon accounting field	The accountability for carbon field
Level of analysis	Molecular	Plant, corporate, product	Global social system
Origin of carbon problem	Physical, chemical, biological processes	Industrial production processes	Geopolitical entities
Purpose of carbon measurement	Calibration of atmospheric emissions; chemical equivalences	Assessment of organisational effort; ensuring a level playing field; carbon commoditisation	Allocation of emission reduction responsibilities across jurisdictions and generations; mitigation of emissions and reducing limits over time; enhance best practice in emission reductions
Illustrative organisations	International e.g. International Organisation for Standardization (ISO); Intergovernmental Panel on Climate Change (IPCC) National standards e.g. UK: National Physical Laboratories (NPL); USA: National Institute of Standards and Technology (NIST) National geo-science e.g. USA: American Geophysical Union (AGU); EU: European Geosciences Union (EGU); UK: British Geological Survey (BGS)	Specialised e.g. World Resources Institute (WRI); Climate Disclosure Standards Board (CDSB) General accounting e.g. International Accounting Standards Board (IASB) Accounting Firms e.g. Deloitte, PricewaterhouseCoopers Professional Associations e.g. Association for Manufacturing Excellence (AME); Institution of Chemical Engineers (IChemE)	Transnational e.g. UNFCCC Secretariat; European Commission for the EU ETS; International Carbon Auction Partnership National e.g. UK: Department of Energy and Climate Change; USA: Environmental Protection Agency Sectoral e.g. Corporate: International Emission Trading Association (IETA); Not-for-profit: Gold Standard by WWF

Table I.
Three carbon accounting organisational fields

Callon (2009), and taking an institutional theory approach, we argue that climate change mitigation is a "stem issue" that is problematised in different ways across overlapping carbon accounting organisational fields. We argue that achieving the goals of accuracy, consistency and certainty is difficult because current carbon accounting efforts are spread across three distinct organisational fields, each prioritising different goals.

We investigate how these challenges are being addressed by dividing the evolution of carbon accounting into three arenas where organisations vie for power devising carbon accounting methodologies and systems. The first organisational field consists of scientific organisations struggling with ways of identifying GHG emissions, capturing their existence at the molecular level, and modelling their atmospheric impacts. The second field includes traditional professional accounting actors that are attempting to find ways to set up carbon accounting systems within firms to record carbon decision-relevant data. The third field includes policy makers, industry associations, nongovernmental organisations (NGOs) and lobbyists that are devising

carbon accountability systems across firms and countries to collate GHG emission data and make firm data verifiable and comparable.

In order to analyse the evolution of carbon accounting, we hosted an Accounting for Carbon workshop at the University of Oxford in November 2009. We invited representatives participating in each of the organisational fields to highlight the contentious conversations within their field, and facilitated an across-field exploration of how to address current carbon accounting challenges. We found that there are tensions between the goals of accuracy, consistency and certainty in carbon accounting both within and across organisational fields. In this paper we will argue that framing the evolution of carbon accounting as negotiating accuracy, consistency and certainty across fields yields powerful implications for addressing current challenges in carbon accounting. Framing carbon accounting in this way can help policymakers negotiate the challenges of recognising legitimate uncertainty in carbon management science; managing the cost-benefits of policy and reporting mechanisms; and ensuring actual GHG emissions reductions.

Our analysis proceeds as follows: First, we discuss how the evolution of carbon accounting is divided across three distinct fields of organisations struggling to make sense of their role in climate change mitigation. Then, we outline how the three dimensions of accuracy, consistency and certainty take on different importance in these three organisational fields. We go on to draw implications for each of the challenges of recognising legitimate uncertainty, managing cost-benefit and ensuring actual GHG emissions reductions from understanding carbon accounting evolution as a process of negotiation across fields. We conclude with recommendations to policymakers on how a balance could be struck between accuracy, consistency and certainty to make carbon accounting systems more viable over time.

2. Carbon accounting as three distinct organisational fields

We define carbon accounting as the measurement of carbon emissions, the collation of this data and the communication thereof, both within and between firms. Carbon accounting has many similarities with other accounting systems: 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. However, accounting for carbon is also different from other accounting systems in that it is directly tied to regulatory or voluntary schemes, and in that the value of the unit recorded is not monetary unless translated through the price of carbon on a commodity market. The carbon accounting system is also unusual in that it is evolving within the context of innovations in developing consensus on scientific facts (for example, with the IPCC reports), and with the engagement of experts from a variety of unconventional sources (especially NGOs) (Callon, 2009).

As public pressure mounts to tackle climate change and therefore reduce emissions, companies find themselves under regulatory and public relations pressure to record, communicate and reduce carbon from their production of goods and services across the value chain (Lash and Wellington, 2007; Okereke, 2007). Scientists, accountants and policy makers are now devising strategies to deal with these new corporate demands. Some of the measurements are not straightforward because carbon can be found as an invisible and odourless gas across the production chain.

In order to capture the essence of this effort, carbon accounting systems have to evolve on three levels: the scientific knowledge of how to recognise and count carbon emissions; the accounting effort to collect and record this information; and the policy arena of devising accountability systems that use and compare this data. Each one of these arenas constitutes an organisational field. Organisational fields are groups of organisations that interact with each other surrounding one particular issue (Hoffman, 1999). Although carbon accounting is a large area in itself, organisations do not interact frequently across the three organisational fields of "counting carbon", "carbon accounting" and "accountability for carbon" (see Table I). Furthermore, we found in our conversations with actors from each field that each field emphasises differing priorities across key dimensions of carbon accounting. The balance of accuracy, consistency and certainty must be negotiated between and across organisational fields over time. Negotiating these different priorities can help us address several key challenges in carbon accounting.

2.1 The organisational field of "counting carbon"

The central issue connecting organisations in our first field is the science of counting carbon in a physical or chemical sense. When we are using "carbon" in our accounting systems, we are in effect only using a proxy for actual GHG emissions. The trade in the proxy of carbon might not always match up with the tons of CO_2-equivalent emitted. It is therefore essential for the development of a robust carbon accounting system that we pay close attention to the underlying science of counting carbon in a physical sense. As MacKensie (2009) put it, in order to design a functioning carbon market system, we need to develop a science of "making things the same".

Organisations participating in the counting carbon field include international bodies such as the IPCC, or the International Organisation for Standardization. These organisations develop recognised standards on, for example, calibration (e.g. ISO/IEC 17025) or greenhouse gas equivalences (IPCC, 2001). These international bodies are supplemented by national organisations responsible for ensuring accurate measurements and standards (e.g. the National Physical Laboratory in the UK), and geo-science organisations that promote scientific understanding of atmospheric emissions (e.g. the American Geophysical Union). All of these organisations have in common a focus on the physical, chemical and biological origin of the greenhouse gas emissions problem, including CO_2.

The carbon counting challenge in this organisational field is to calibrate atmospheric emissions and to develop our understanding of molecular-level issues such as the chemical equivalences of different greenhouse gases (MacKensie, 2009). Scientific knowledge in this domain, and the organisational structures such as the IPCC designed to validate and publicise it, is continuously evolving (Callon, 2009). Workshop participants from this organisational field identified controversies on which chemical substances should be counted towards greenhouse gas inventories, and how to measure emissions from sources that are difficult to measure (e.g. land use). Scientists in the measurement community need feedback from the other two organisational fields on which measurement technologies to prioritise when developing new carbon accounting and accountability systems. Most of the necessary technologies are already available, but guidance is needed on which (costly) technologies to develop for deployment on a wide scale.

2.2 The organisational field of "carbon accounting"

Organisations in our second organisational field are connected through efforts to develop or adapt carbon accounting systems within firms to record carbon management data. Firms, investors and securities regulators are becoming interested in assessing organisational efforts to manage GHG emissions risk (Lash and Wellington, 2007), and are demanding new quantitative and qualitative reporting standards within accounting systems (Cook, 2009).

Key actors within this field include specialised carbon accounting organisations such as the World Resources Institute that has developed the standardised GHG Protocol, or the Climate Disclosure Standards Board, which brings together businesses, environmental organisations and leading professionals to enhance best practices in carbon accounting and reporting. Accounting firms such as Deloitte LLP or PricewaterhouseCoopers are active players in this domain as they seek to shape, develop and build competitively valuable capabilities on helping firms learn about new carbon accounting requirements (Engels, 2009). Standards organisations such as the International Accounting Standards Board (IASB) seek to integrate carbon concerns into current accounting practices (Cook, 2009). Some professional associations such as the Association for Manufacturing Excellence in the USA are participating in this field by educating their corporate members about emerging carbon accounting requirements and collating best practices. The key audience in this field consists of large, visible and usually publicly listed firms that are now expected to report their carbon performance.

The key concerns of actors in this field are to develop consistent assessments of organisational effort on climate-related issues so as to ensure a level playing field between firms, industries, trading systems and over time. The focus is on accounting for carbon emissions as they arise through industrial production processes, whether at the plant, corporate or even product level. Within this field, carbon is commoditised so as to facilitate trade and to better understand trade-offs in firm-level GHG emission risk decision-making (Lohmann, 2009b). Controversial frontiers within this field include extending the scope of carbon accounting beyond direct emissions (scope 1) and indirect electricity use emissions (scope 2), to the optional reporting of other indirect GHG emissions across supply chains (scope 3) (WRI/WBCSB, 2001; Ranganathan *et al.*, 2004). There are active conversations in this field on the pros and cons of different carbon accounting methods, the extent to which carbon accounting should be voluntary or mandatory for different types of firms, and integrating both qualitative and quantitative GHG emissions data within existing managerial and financial accounting systems (Cook, 2009). All of these issues are contested within the carbon accounting field, and are interconnected with both the carbon counting and accountability fields.

Pioneers within this field realise that they are expending an enormous effort to account for the carbon in just a select few products. After two years of effort on their carbon labelling initiative, Tesco is still only labelling 130 of its 40,000 product lines with their full carbon footprints. Laggards fear that early carbon accounting efforts from the fringe of the traditional accounting field, such as the Carbon Disclosure Project's survey-based database, will lock in and shape future disclosure standards. The carbon accounting field is drawn together thorough dealing with how to provide

for social demands for increased GHG emission performance transparency at the firm level.

2.3 The organisational field of "accountability for carbon"

Finally, we position carbon accounting within a broader governance system of how accountability for carbon is allocated in the current system of governance. Carbon accounting is unique in the way that it goes beyond the need to communicate company performance to a limited set of shareholders and investors. It also needs to fulfil other stakeholder demands and/or government requirements to report emissions and enable the functioning of carbon markets. Our third organisational field consists of transnational and national, governmental and non-governmental organisations contesting the issue of allocation of CO_2 emissions reductions responsibilities across jurisdictions and generations.

Transnational examples include the United Nations' UNFCCC Secretariat, the European Commission that administers the EU ETS, and the International Carbon Action Partnership (ICAP). National organisations include the Department of Energy and Climate Change through initiatives such as the CRC Energy Efficiency Scheme in the UK, and the recent entry of the US Environmental Protection Agency into the mandatory greenhouse gas emissions reporting domain. Key actors in this field include the three bodies negotiating commensurability standards for carbon trading - the International Emission Trading Association (IETA), the International Swaps and Derivatives Association and the European Federation of Energy Traders (MacKensie, 2009). The field incorporates experts from NGOs such as the World Wide Fund for Nature (WWF), that have initiated the development of the Gold Standard for premium quality carbon credits (Lohmann, 2009b), and the Prince of Wales Accounting for Sustainability Forum, who are seeking to develop a Connected Reporting Framework (Hopwood, 2009). This field is also populated by a large number of market designers, carbon traders and brokers, lobbyists and members of advocacy NGOs seeking to influence the design of carbon trading schemes such as the EU ETS (Braun, 2009)

Key issues in this organisational field centre on how the accountability for carbon is allocated across nations, industries and time (Giddens, 2009). Actors in this field focus on the answerability of emitters for their activities, and enforceability where actors fail to deliver on their commitments (Newell, 2008). The accountability field is currently dominated by a desire to commoditise carbon so as to quantify national CO_2 emissions inventories and allocate mitigation responsibilities. In contrast with the carbon accounting field, however, the focus is not only on the ability to commoditise carbon to facilitate trade and the production of national inventories, but also to realise actual and decreasing caps on the amount of carbon traded over time. Within this field, the origin of the carbon problem is widely understood to reside in the historical industrial development trajectories of developed and developing countries (Giddens, 2009). The challenge is to devise a set of governance systems that can ensure real, scientifically measurable cuts in greenhouse gas emissions, and enforce consequences on those actors who do not take appropriate mitigation actions. While national carbon inventories are not based on collating carbon accounts from firms, there is also an important interaction between the carbon accountability and accounting fields on the extent to which governments have the information to be able to hold industry accountable for emissions.

3. Negotiating accuracy, consistency and certainty within fields

In the discussions across the organisational actors invited to our workshop it became apparent that there is a real incongruence among the three fields in the importance they ascribe to accuracy, consistency and certainty in the reporting of carbon emissions. We devised the following definitions for these three aspects (Bumpus, 2009):

(1) *Accuracy*. Measurement techniques need to be materially accurate, that is, they need to reflect actual atmospheric emissions;

(2) *Consistency*. Measurement needs to be consistent over space and time through the use of calibrated equipment, agreed procedures and verification;

(3) *Certainty*. Measurement needs to incorporate indicators of uncertainty as a key metric in carbon accounting to allow for valid interpretation of data.

Table II describes how each of the organisational fields weighs the importance of these three aspects of carbon accounting. The scientists in the counting carbon field insisted on the importance of measuring CO_2 and other GHGs accurately. Since some of these calculations are more easily attainable than others, an indicator of certainty is necessary to attach to the results of the emission calculations. GHG emission calculations vary highly in certainty: whereas the calculation of CO_2 emissions from the burning of a particular fossil fuel is fairly straightforward, methane emissions from cattle can vary by breed, feed and other contexts. This presents challenges for accurate and certain calculations. Within this field, the consistency across calculations is not seen as such a high priority because it is recognised that emissions cannot easily be compared across greenhouse gases even by using a common unit such as CO_2 equivalent (Smith and Wigley, 2004; Shine *et al.*, 2005; Bruce *et al.*, 1995; Vine *et al.*, 2003).

Accounting professionals in the field of carbon accounting want to establish credibility through an apparently high degree of certainty in their carbon reporting requirements. As with other types of corporate reporting, it is conventional to report point estimates of emissions, without indicators of uncertainty in the underlying measurement. Apparently certain measures provide reassurance to interested stakeholders that firms are managing their GHG exposure, increasing corporate legitimacy. Consistency is also important for external reporting so as to maintain a level playing field between firms within and across industries.

Actors in this field dominated by economic market logic are often content with maintaining distance between "traders" conceptual, largely electronic universe of "abstract", simplified and fungible carbon credit numbers and the "concrete", diverse, particular, highly complex, often obscure local projects that produced them" (Lohmann, 2009b, p. 506). It is this distance that can help maintain consistency and an aura of certainty. The casualty, of course, is accuracy. Accuracy will only be

	Organisational field		
	Counting carbon	Carbon accounting	Accountability for carbon
Accuracy	High	Low	Medium
Consistency	Low	Medium	High
Certainty	Medium	High	Low

Table II.
Importance of the three dimensions across organisational fields

inspected in full detail when the price of carbon or the required CO_2 emission reductions is excessively high as this means that any false measurement could be quite costly.

Finally, organisations in the accountability for carbon field focus mainly on consistency across carbon calculations. Only consistency can make it possible for emissions by companies and economies to be compared over time, supporting answerability and enforceability for CO_2 emissions. That the recorded emissions are indeed accurate is important to grant legitimacy to the system and also to satisfy various stakeholders. To introduce an indicator of certainty, however, would make comparisons highly cumbersome and hence undesirable among policymakers in this field. The focus instead is on reducing nonlinearities, uncertainties, indeterminacies and unknowns to neat probabilistic scenarios compared to a constructed "business as usual" (Lohmann, 2009b). The conversation in the accountability field is driven more by managing probabilities than seeking certainties.

Thus there is an inherent discrepancy among the three dimensions of assuring accuracy, consistency and certainty. Although accuracy is scientifically valuable, it may come at a high cost to both the development of measurement techniques and the reporting efforts of companies. There is also a risk that accuracy that is too strongly enforced will make company reports difficult to analyse and interpret (Hopwood, 2009). In fact, a market system requires the comparison between emissions, both within and across companies, prioritising consistency (MacKensie, 2009). The problem is that ensuring consistency with existing accounting standards can lead to some "very strange results" when applied to the new carbon emission instruments (Cook, 2009), even within one organisational field. Understanding the differing importance placed on consistency across fields can help us understand the IASB's unsuccessful support of its International Financial Reporting Interpretations Committee's (IFRIC) interpretation of emissions rights. The very features desired by carbon market designers to improve carbon accountability (prioritising consistency) led to "public outcry" in the carbon accounting field (Cook, 2009, p. 457).

These factors need to be taken into consideration when developing carbon accounting and reporting standards. At this early stage of development, it is important to recognise the different perceptions in the three co-existing communities and survey the tolerance for compromise across the organisational fields.

4. Implications: carbon accounting as negotiating dimensions across fields

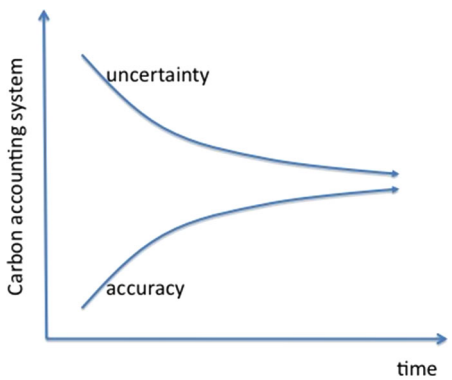
Understanding the tensions within and between organisational fields can help illuminate at least three key challenges within carbon accounting. First, the carbon system should be developed while recognising legitimate uncertainty in carbon measurement science. Members of the carbon accountability and accounting fields are asking the measurement community to develop new GHG measurement science to capture physical, chemical and biological processes in which they have not been interested before. Current carbon emissions policies are not well equipped to deal with legitimate uncertainty in the science, and yet policymakers require some reassurance that their political and economic efforts will pay off in actual emissions reductions and eventual climate change impact. We may be caught in an across-field impasse where we need good scientific measurement before we develop potent GHG mitigation policy,

but we need the carbon market to drive the development of the necessary measurements and standards.

One solution to this challenge is to move towards indicators of uncertainty or tolerances in carbon reporting, not just point indicators. Firms are already well equipped to embrace this uncertainty through established accountancy tools such as sensitivity analysis or hedging, but this is not yet fully developed in carbon emissions reporting. The accountability field is also familiar with a range of potential emissions scenarios when estimating probabilistic future emissions compared with "business as usual", but places less emphasis on the uncertainty surrounding current emissions inventories. In the short run, less emphasis should be placed on developing carbon accounting systems "accurate" to several decimal places, and more on understanding the tolerances around current best estimates of firm or national carbon accounting performance. We need to be explicit in recognising that in current organisational and national-level carbon accounting, accuracy is low and uncertainty is high (see Figure 1). Initial high tolerance levels allow companies to begin to report their carbon performance relatively easily (Bumpus, 2009), but this uncertainty should be recognised and reported, and uncertainty in carbon reporting should decrease over time.

We can expect the accuracy of the overall carbon accounting system to improve as the measurement community continues to place emphasis on improving the accuracy of counting carbon (see Figure 1). This should both reassure the firms and actors in the carbon accounting domain that there is a more level playing field, and provide more credibility in the broader accountability community that the measurement system is encouraging actual emissions reductions. Over time, more firms, sectors and industries should be included in the overall carbon accounting system yielding both higher accuracy and lower uncertainty in measuring the overall system emissions.

While some uncertainties and inaccuracies will be resolved through patience and developing both scientific and social technologies to measure GHG emissions, others will remain, even in the long run (MacKensie, 2009). For example, the behaviour and measurement technologies available to future generations will always be unknown, but this does not mean that they should be ignored in current emissions mitigation policies. The workshop drew two other implications on the legitimate uncertainty



Source: Adapted from Bumpus (2009)

Figure 1.
Carbon accounting accuracy and uncertainty over time

challenge. First, we should be wary of locking in standards too early. Standards can have significant inertia over time, and an initial period of lower accuracy and higher tolerance for the development of different carbon accounting models may lead to measurement and reporting innovations that pay-off in the long run. This is compounded given the tendency to pay close attention to market design in the early stages of market development, but to begin to take market design decisions as given once the market has begun (Callon, 2009). Second, lessons from early experiences in other accounting domains show us that we may not need accurate accounting, but rather controllable accounting that can evolve over time (Suzuki, 2003). Developing more certain and standardised global accounting standards is an inevitably political process, and it may be easier to maintain constructive conversations with "losers" in the carbon market if the standards are not locked in too soon (Biondi and Suzuki, 2007).

The second key challenge in carbon accounting is managing the cost-benefit of carbon accounting systems. Scientific, organisational and public policy technologies have already been theorised to be able to capture most of the emissions measurements needed to positively impact the GHG emissions problem. The question is really about the time needed to develop practical measurements with a consistency that is acceptable to policymakers, and at a cost that is socially and politically acceptable. We should be careful in mandating accurate and expensive carbon emissions performance measurement at the individual, firm or country level when emissions are actually low. For example, by 2020, the EU ETS will cover around 50 per cent of overall carbon emissions, although it will only apply to far less than 50 per cent of firms. Similar arguments at the national level have led the accountability field to focus on the top GHG emitting countries' mitigation potential (Giddens, 2009).

The central recommendation from our workshop to address the second challenge is to ensure that measures are "fit-for-purpose", and to match the measurement to the aim of that measure. For example, if we intend to develop carbon accounting in order to generate market solutions through trading commoditised carbon, then the most important measurement dimension would be consistency to ensure a level playing field. However, if the goal is to mitigate the actual GHG emissions generated by human activities, then accuracy and certainty should be much more important criteria. Actively monitoring the cost-benefit of carbon accounting systems can also provide guidance on a range of measurement prioritisation challenges such as system leakages. We should use the Pareto principle to determine which system leakages are important to narrow uncertainty about, and which can be broadly estimated.

The third, and most significant challenge is ensuring actual GHG emissions reductions. As one of our workshop attendees pointed out, it is important to appreciate that "account-ing" for carbon is socially constructed (Biondi and Suzuki, 2007). Carbon accounting is a way of telling a carbon performance story, and such stories do not necessarily correspond with emissions reductions. Ensuring a connection between the carbon accounting system and actual GHG emissions reductions is a particularly difficult challenge when much of firms' impact on climate change, and organisational attempts to mitigate this impact, can only be measured in a qualitative sense and is reported separately from core financial data.

Reporting carbon performance in a separate corporate environmental, sustainability or social report does signal some awareness that firms are expected to respond to the climate change challenge. However, evidence suggests that these reports constitute

symbolic responses by firms, rather than substantive mitigation impacts, particularly for the largest firms. Firms' ceremonial adoption of carbon accounting can appear highly consistent, but may not be particularly accurate or yield concrete mitigation impacts. We should also remember that while narratives on qualitative data may be as useful as quantitative data, they can also lead to very long and inconsistent carbon reporting. If disclosure becomes too complex, we can have increased disclosure, but decreased transparency and eventual accountability (Hopwood, 2009).

The lesson from this challenge is that policymakers should recall that corporate carbon accounting is designed to report corporate behaviour and decision-making, and not GHG emission reductions per se. We should be sure not to rely on corporate carbon accounting to generate national GHG inventories since these systems are designed for consistency and commoditisation, not accuracy and mitigation. A carbon accountability system would be better based on national emissions statistics collected directly through national statistical surveys similar for those used for employment statistics, and not through cumulating corporate reports. This begs the question of how important or useful is extensive standards, monitoring and assurance at the corporate level, given that national emissions inventories do not use them as a source. Members of the carbon accounting organisational field will develop answers based on the need for fair commoditisation and developing a level playing field for trade. Members of the carbon accountability field emphasise that carbon market integrity is only useful if this is firmly tied to lowering caps on emissions over time. There are attractive policy options that do not require an elaborate carbon accounting framework to reduce emissions, such as mandating technological standards, reducing fossil fuel extraction or targeting investment in renewable and energy efficiency measures.

While we have attempted to make sense of conflicting priorities in the evolution of carbon accounting by dividing our conversation into three primary fields, we recognise that such reduction in itself might limit our understanding of all of the interests at play (Callon, 2009). Actors that are primarily associated with one field can play important roles in the others, too. Accountancy firms, consultancies and corporations primarily involved in the carbon accounting field, for example, also played active roles in developing accountability mechanisms such as the EU ETS (Braun, 2009). We would encourage further research into the overlapping interests of actors in these fields.

5. Conclusions

In this paper we extended Callon's (2009, pp. 540-541) reminder that "calculative equipment, whether it serves to establish equivalences between chemical entities (for example to measure their effects on global warming), to price goods, to organise encounters between supplies and demands (auctions or other mechanisms), or simply to measure emissions, is [...] the subject of stormy debates and lies at the heart of structuring carbon markets". We focused on how three distinct communities emphasise the concepts of accuracy, consistency and certainty in the development of carbon accounting standards. The three organisational fields can be distinguished by their approach to carbon from the molecular, the organisational and the societal levels respectively. We find that an effective standard will have to strike a balance between these three conceptualisations, lowering uncertainty and increasing accuracy over time

to find an acceptable way to make carbon accounting work without risking inaccurate measurements.

Our analysis of the overlapping and emerging carbon accounting fields shows the complex nature of measuring, reporting and effectively communicating GHG emissions. The science of how emissions are measured is still under development, the social practice of accounting for carbon within an organisation is still contested, and the effectiveness of a global carbon governance system has not been proven. Scholars have shown that current systems of carbon markets are overly costly and ineffective (Wittneben, 2009) and some argue that the sheer notion of setting up a carbon market is inherently flawed (Lohmann, 2009a). Although carbon will need to be measured in other regulatory regimes as well, there are ways around having to go through the arduous and in some instances even technologically impossible process of counting carbon for carbon markets.

In the international climate change policy debate, there has been a notable move away from a focus on limiting fossil fuel extraction, consumption and subsidisation to the political emphasis to regulate carbon emissions by setting up carbon markets (Giddens, 2009). This has brought about the need to develop a carbon accounting systems. There are many regulatory measures that can be taken to reduce emissions without relying on a system of carbon accounting (see Gilbertson and Reyes, 2009). Conventional regulatory regimes have often proven to be more efficient and effective than market-based systems. The sulphur dioxide trading market set up under the US Clean Air Act in 1990, for example, lowered these emissions by 43.1 pre cent by the end of 2007, whereas the European regulatory scheme called "Large Combustion Plants Directive" was able to reduce sulphur dioxide emissions by 71 pre cent over the same time frame through conventional regulation (Gilbertson and Reyes, 2009). The carbon market was largely designed following the structure of the former regime leaving organisations to struggle with the new reality of counting carbon (Callon, 2009; Engels, 2009). Another way to reduce emissions is by encouraging or enforcing the use of best practice technologies. That way, emission reductions only have to be measured in a test situation and low emission technologies can be rolled out across an industry much more quickly.

It seems likely that carbon accounting will continue to grow in importance as new emission reduction regimes are set up and existing ones linked. Various stakeholders will pay increasing attention to an organisation's carbon budget, which has to be measured, reported and conveyed. As we embark on this path of reporting GHG emissions, many technological and social hurdles still need to be addressed. Our workshop revealed the importance of negotiating demands for accuracy, consistency and certainty across organisational fields. Policy makers and progressive business leaders need to consider how much effort and attention is put into improving consistency within these complex carbon accounting regimes in relation to the GHG emissions that are actually reduced over the course of the regulatory process. Without sufficient accuracy, other avenues of regulation that do not require carbon accounting may be more effective and efficient in reducing GHG emissions.

References

Berkes, F. and Jolly, D. (2001), "Adapting to climate change: social-ecological resilience in a Canadian western Arctic community", *Conservation Ecology*, Vol. 5 No. 2, p. 18.

Biondi, Y. and Suzuki, T. (2007), "Socio-economic impacts of international accounting standards: an introduction", *Socio-economic Review*, Vol. 5, pp. 585-602.

Braun, M. (2009), "The evolution of emissions trading in the EU – the role of policy networks, knowledge and policy entrepreneurs", *Accounting, Organisations and Society*, Vol. 34, pp. 469-87.

Bruce, J.P., Yi, H.-S. and Haites, E.F. (1995), *Climate Change 1995: Economic and Social Dimensions of Climate Change*, Intergovernmental Panel on Climate Change (IPCC) Working Group III, Cambridge University Press, Cambridge.

Bumpus, A.G. (2009), "Making carbon accounting count", IRIS Executive Briefing No. 09-01, December 2009, University of Calgary, Calgary.

Callon, M. (2009), "Civilizing markets: carbon trading between *in vitro* and *in vivo* experiments", *Accounting, Organizations and Society*, Vol. 34, pp. 535-48.

Cook, A. (2009), "Emission rights: from costless activity to market operations", *Accounting, Organizations and Society*, Vol. 34, pp. 456-68.

Engels, A. (2009), "The European Emissions Trading Scheme: an exploratory study of how companies learn to account for carbon", *Accounting, Organizations and Society*, Vol. 34, pp. 488-98.

Giddens, A. (2009), *The Politics of Climate Change*, Polity Press, Cambridge.

Gilbertson, T. and Reyes, O. (2009), *Carbon Trading – How It Works and Why It Fails*, Dag Hammarskjöld Foundation, Uppsala.

Hepburn, C. (2006), "Regulation by prices, quantities or both: a review of instrument choice", *Oxford Review of Economic Policy*, Vol. 22, pp. 226-47.

Hoffman, A.J. (1999), "Institutional evolution and change: environmentalism and the US chemical industry", *Academy of Management Journal*, Vol. 42 No. 4, pp. 351-71.

Hopwood, A. (2009), "Accounting and the environment", *Accounting, Organisations and Society*, Vol. 34, pp. 433-9.

Intergovernmental Panel on Climate Change (IPCC) (2001) in Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K. and Johnson, C.A. (Eds), *Climate Change 2001: The Scientific Basis*, Cambridge University Press, Cambridge.

Intergovernmental Panel on Climate Change (IPCC) (2007) in Pachauri, R.K. and Reisinger, A. (Eds), *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge.

Kalkstein, L.S. and Smoyer, K.E. (1993), "The impact of climate change on human health: some international implications", *Experientia*, Vol. 49, p. 969.

Lash, J. and Wellington, F. (2007), "Competitive advantage on a warming planet", *Harvard Business Review*, Vol. 85 No. 3, pp. 94-102.

Lohmann, L. (2009a), "Uncertainty markets and carbon markets: variations on Polanyian themes", *New Political Economy*, available at: www.thecornerhouse.org.uk/pdf/document/NPE2high.pdf (accessed February 2010).

Lohmann, L. (2009b), "Toward a different debate in environmental accounting: the cases of carbon and cost-benefit", *Accounting Organizations and Society*, Vol. 34, pp. 499-534.

McMichael, A.J., Woodruff, R.E. and Hales, S. (2006), "Climate change and human health: present and future risks", *Lancet*, Vol. 367, pp. 859-69.

MacKensie, D. (2009), "Making things the same: gases, emission rights and the politics of carbon markets", *Accounting, Organizations and Society*, Vol. 34, pp. 439-55.

Newell, P. (2008), "Civil society, corporate accountability and the politics of climate change", *Global Environmental Politics*, Vol. 8 No. 3, pp. 122-53.

Okereke, C. (2007), "An exploration of motivations, drivers and barriers to carbon management: the UK FTSE 100", *European Management Journal*, Vol. 25 No. 6, pp. 475-86.

Orsato, R.J. and Clegg, S.R. (2005), "Radical reformism: towards critical ecological modernization", *Sustainable Development*, Vol. 13, pp. 253-67.

Randjelovic, J., O'Rourke, A.R. and Orsato, R.J. (2003), "The emergence of green venture capital", *Business Strategy and the Environment*, Vol. 12 No. 4, pp. 240-53.

Ranganathan, J., Corbier, L., Bhatia, P., Schmitz, S., Gage, P. and Oren, K. (2004), *The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard*, rev. ed., World Business Council for Sustainable Development and World Resources Institute, Geneva.

Shine, K.P., Fuglestvedt, J.S., Hailemariam, K. and Stuber, N. (2005), "Alternatives to the global warming potential for comparing climate impacts of emissions of greenhouse gases", *Climatic Change*, Vol. 68 No. 3, pp. 281-302.

Smith, S.J. and Wigley, M.L. (2004), "Global warming potentials: 1. Climatic implications of emissions reductions", *Climatic Change*, Vol. 44 No. 4, pp. 1473-80.

Suzuki, T. (2003), "The accounting figuration of business statistics as a foundation for the spread of economic ideas", *Accounting, Organizations and Society*, Vol. 28 No. 1, pp. 65-95.

Vine, E. and Sathaye, J. (1999), *Guidelines for the Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-efficiency Projects for Climate Change Mitigation*, LBNL-41543, Lawrence Berkeley National Laboratory, Berkeley, CA.

Vine, E., Kats, G., Sathaye, J. and Joshi, H. (2003), "International greenhouse gas trading programs: a discussion of measurement and accounting issues", *Energy Policy*, Vol. 31 No. 3, pp. 211-24.

Vörösmarty, C.J., Green, P., Salisbury, J. and Lammers, R.B. (2000), "Global water resources: vulnerability from climate change and population growth", *Science*, Vol. 289, p. 284.

Wittneben, B.B.F. (2009), "Exxon is right: let's re-examine our choice for cap-and-trade over a carbon tax", *Energy Policy*, Vol. 37, pp. 2462-4.

World Business Council for Sustainable Development and the World Resources Institute (WBCSD and WRI) (2001), *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, WBCSD, Geneva.

Further reading

Bowen, F.E. and Dillabough, J.J. (2009), "Institutionalisation, intent and implementation: a meta-analysis of firm size and proactive environmental strategy", paper presented at the Strategic Management Society Conference, Washington, DC, October.

Corresponding author

Frances Bowen can be contacted at: f.bowen@qmul.ac.uk