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Carbon Trading: Accounting and Reporting Issues

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ABSTRACT The impetus for this special debating forum arises from the concern about the impact of anthropogenic induced global climate change (GCC) and the assumption that GCC raises issues of significance with respect to the accountability of firms to stakeholders for financial and non-financial performance. Governments and supra-national bodies have sought to respond to GCC in a variety of ways, with the creation of markets in which carbon may be traded being just one manifestation. Carbon markets have the effect of putting a price on what was until very recently free and this change is likely to have financial consequences for firms in the longer term. In order to place the accounting implications of carbon markets in context, the paper provides a scientific and policy introduction to GCC. As regards accounting issues, the paper reviews the problems that are associated with the valuation of pollution allowances and their identification as assets (and the liabilities that arise if companies pollute beyond allowed levels). A closer inspection of the risks and uncertainties that arise from GCC initiates a discussion of non-financial accounting and reporting about carbon. Non-financial reporting is necessary to allow conditions for democratic accountability in an uncertain setting.

1. Introduction

Implicit within the decision to publish a special debating forum of the *European Accounting Review* on carbon trading is the assumption that 'carbon'[1] refers to something of significance with respect to the accountability of firms to stakeholders for their financial and non-financial performance. Put more carefully, the area of concern for the special debating forum is not with carbon per se but arises from a concern about the extent to which anthropogenic induced

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global climate change (hereafter GCC)[2] is a possibility (which itself arises from increased concentrations of greenhouse gases (hereafter GHGs) in the atmosphere). Governments and supra-national bodies (such as the United Nations and the European Union) have sought to respond to the threat of GCC in a variety of ways including supporting the development of scientific knowledge in this area as well as developing policies to deal with mitigation and adaptation[3] responses to GCC. Policy responses to GCC have been varied and include: (i) developing awareness in the population of behaviour changes that are sought (such as modal shift in transport, washing clothes at lower temperatures and turning off appliances on standby), (ii) support for energy efficiency measures (in households and generally within business), (iii) providing information on relative carbon impacts of consumer choices (on goods as diverse as white goods, cars and potato crisps) and (iv) economic/fiscal responses to GCC agenda (including fuel taxes and renewable energy production targets with incentives for development of renewable capacity). Creating markets on which carbon may be traded is but one manifestation of the policy response to GCC, but one that has a direct and immediate impact on corporations (if they are included as part of that market). In particular, this is a process of translating ecological concerns into economic phenomena, which will then impact upon accounting practice. This paper provides an introduction to the special debating forum with the first section providing a high level scientific and policy introduction to carbon issues. The paper then moves to overview the impact of carbon trading on accounting and reporting activities. At its simplest, accounting for carbon requires the valuation of assets (such as granted pollution rights) and liabilities (if an organisation is obliged to buy additional rights to cover their emissions). But more generally, this paper addresses diverse ways in which accounting is involved in the broader process of change (Burchell *et al.*, 1980, 1985) associated with GCC. In this respect, the paper considers new avenues of research on how accounting may be involved in the communication of risks and uncertainties (these two terms will be distinguished later in the paper) associated with GCC and, probably more importantly, in the negotiation of the interplay between GCC risks and GCC uncertainties.

2. Global Climate Change: An Introduction to the Science

This section of the paper describes the greenhouse effect, identifies anthropogenic impacts on GHG concentrations and outlines the science of GCC. Scientific data in this area is produced (most pertinently) by the United Nations Intergovernmental Panel on Climate Change (hereafter the IPCC).[4] A lay person's introduction to the science of GCC can be found in Gore (2006), Monbiot (2006) and Lynas (2007) with Begg *et al.* (2005) documenting corporate responses to this agenda. Stern (2006) is also a valuable resource in this context.

The 'greenhouse effect' (discovered by Fourier in 1829) is an essential natural process for the maintenance of life on the planet. The earth receives energy from the sun, a proportion of which (approximately 70%) penetrates the atmosphere with the rest being reflected back into space (Le Treut *et al.*, 2007, p. 96). Of the energy that makes it into the atmosphere, a portion is absorbed by the earth's surface with the rest being reflected back into the atmosphere (called infrared radiation). As the atmosphere is more permeable to incoming solar radiation compared to outgoing infrared radiation, a proportion of the infrared radiation remains within the atmosphere and this creates the greenhouse effect. The result of this effect is that the average surface temperature of the planet is some 33 degrees Celsius higher than it would otherwise be (see Le Treut *et al.*, 2007, p. 97).

Several atmospheric gases are involved in creating the greenhouse effect with carbon dioxide, methane, nitrous oxide and hydrofluorocarbons playing a significant role. The warming effect of any one gas is determined by a combination of the amount of that gas released, its warming potential (determined by how sensitive it is to infrared radiation) and the length of time a gas exists in the atmosphere before it breaks down (light causes these gases to break down into their component parts). Table A1 in the Appendix provides a summary of the main GHGs, their life in the atmosphere and their warming potential.

Over the last 600,000 years the atmospheric concentration of carbon dioxide equivalents has fluctuated between 180 and 300 ppm.[5] Ice ages have been experienced at the bottom of the range and inter-glacial conditions at the higher end (we are currently in an inter-glacial period). Scientists have also been able to measure atmospheric temperature over this time and have identified a correlation between GHGs and temperature,[6] with anthropogenic emissions being responsible for changes being observed in the climate (IPCC, 2001; Stern, 2006).[7]

The industrial revolution was one of the most powerful forces that shaped our current social and economic arrangements as well as the pattern of human habitation, activity and impact on the planet. A key aspect of this revolution was the utilisation of fossil fuels in creating the energy to drive industrialisation. Fossil fuels (in the form of coal, gas, oil and peat) are stores of carbon that have been created in the distant geological past. Before utilising fossil fuels, society relied upon carbon that could be accessed from the biosphere (for example, in the form of wood)[8] as well as energy that could be derived from the environment such as water, wind and from the sun. The outcome of industrialisation has had both positive and negative results. While there is concern about the ecological costs of industrialisation, it has also led (for a relatively small percentage of human beings alive today) to a quality of life that has never before been experienced in human history. The concern, however, is that the ecological impacts that have been created by industrialisation will mean that '[o]urs are the most fortunate generations that have ever live ... [and] might also be the most fortunate generations that ever will' (Monbiot, 2006, p. xi). A key aspect of the ecological impact is that rising

GHG concentrations will trigger GCC which will itself have net adverse ecological, social and economic effects.

GHG concentrations in the atmosphere are currently higher than they have been at any time in the past 600,000 years. They have risen from a pre-industrial level of 280 ppm in 1750 to current levels of 430 ppm (rising at a minimum of 2 ppm each year – Stern, 2006, p. xvi). These increases have the effect of increasing average global temperatures[9] and it is these increases that create impacts of concern (Table A2 in the Appendix describes some of the impacts that may emerge if GCC accelerates). The potential (and actual) impacts of GCC have led to significant global concern and substantive policy action. Added to this is the realisation that the climate is not a linear system and that there may be discontinuities to come as a result of a 'runaway effect' (where physical responses to GCC further accelerate its effect) that will lead to what is termed 'dangerous' climate change.

The term dangerous climate change is used to describe the situation where changing concentrations of GHGs leads to effects that will be too quick for ecosystems to adapt to and will be significantly damaging to human populations. The desire of seeking to limit temperature increases to 2°C (currently the planet has warmed by approximately 0.6°C) has arisen from this concern, with 2°C of warming representing a suspected tipping point in the climate system.[10] The types of harm that some anticipate as potentially occurring beyond this point include: 'extinction of iconic species or loss of entire ecosystems, loss of human cultures, water resource threats and substantial increases in mortality levels, among others' (Schellnhuber, 2006, p. 12). There are also likely to be significantly adverse effects in all economic sectors. Indeed, a significant contribution of Stern (2006) was that he estimated the likely economic losses to the world should nothing be done to address GCC. For example, currently spending an estimated 1% of GDP would achieve stabilisation of emissions into a manageable zone (Stern, 2006, p. xvi). If nothing is done, however, he estimates that between 5 and 20% of GDP will be lost, 'now and forever' (Stern, 2006, p. xv) and these effects would be 'on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes' (Stern, 2006, p. xv).

Specifying the level of emissions that will trigger such events is thus a key requirement. If we continue on a business as usual trajectory, it is likely that by 2050 we will have 600 ppm GHG concentrations in the atmosphere. At this level triggering dangerous climate change is virtually guaranteed. The consensus is that something like 450–550 ppm should be aimed for (Stern, 2006, p. xvi). This type of figure is often used because it appears to be achievable in the timeframes that we are seeking to address GCC within (see Stern, 2006, p. xvii). It is, however, important to realise that the risks of dangerous effects still exist at these much lower concentration levels. For example, Stern (2006) suggests that even at 450 ppm there is a 26–78% probability of exceeding the 2°C warming target (Stern suggests that at this concentration temperatures may increase by an average of 5–6°C). In addition, even achieving concentrations of 500–550 ppm of GHGs will require a substantive change in activities. These changes have been translated into a set of policy imperatives that have been developed in supranational as well as national settings.

The framework for policy making in this area was agreed in the 1992 Rio Earth Summit. In particular, the United Nations Framework Convention on Climate Change set in motion a series of international conferences and processes that resulted in the Kyoto protocol being negotiated in December 1997. The protocol (United Nations, 1998) then required ratification by individual states and once a set of benchmark conditions were reached (in February 2005) it would come into force.[11] The most notable country that has not yet ratified the protocol is the USA although this does not make the protocol unworkable.[12]

The Kyoto protocol requires ratifying Annex I countries to reduce their emissions of a specified GHG basket by a collective average of 5% below their 1990 levels (under this agreement some developed countries[13] are 'allowed' to increase their emissions while others have to reduce them by much more than 5%). Developing countries are not required under Kyoto to reduce their emissions over this same timeframe, based on the concept of contraction and convergence. Contraction and convergence is a principle whereby those who emit at above average rates reduce their emissions while those who emit at a rate below average may increase their emissions. These two trajectories converge on an emissions level that is 'acceptable' (that is, at a level that will not trigger GCC). This is deemed equitable because of the close link between economic development and GHG emissions and thus satisfies the requirement for intergenerational equity as specified in the Bruntland Report's articulation of sustainable development (UNWCED, 1987).[14] At the same time, these figures do not take into account the fact that emissions may arise in one country but relate to another country's consumption. For example, given the amount of mineral extraction and processing that takes place in Australia (accounting in part for their high per capita emissions) the focus on emissions from a country can be seen as being unfair (this is why the Australian government was historically reluctant to ratify Kyoto). It is also the case that as China has become the world's manufacturing base, their emissions are affected by Western consumption of manufactured goods. These factors are not yet fully taken into account in per capita consumption figures (which are based on production of GHGs rather than consumption of GHGs in an economy).[15]

The Kyoto framework is a cap and trade system in which each country is allowed a certain level of emissions during the first commitment period (which runs from 2008 to 2012). If a country doesn't hit its targets during this period they have to provide a reduction of 1.3 tonnes in the future for each tonne of carbon they exceed their target. Mechanisms for GHG reductions are flexible and include the financing of projects in non-Annex I countries (developing countries) that will reduce GHG emissions in those countries (this is the clean development mechanism; hereafter CDM). Alternatively, Annex I countries (under the joint implementation process; hereafter JI) can reduce GHGs within transition economies. Projects accredited under Kyoto give rise to emission credits (Certified Emission Reductions, hereafter CERs) that must be additional (that is, they must create reductions that would not have otherwise taken place and these reductions must be permanent in nature). While there is currently no agreement on GHG emissions beyond Kyoto, it is virtually certain that some sort of framework will emerge (negotiations on the next framework started in 2007, with international aviation and shipping likely to be part of future agreements).

The need to hit Kyoto targets also creates the impetus for national level policies aimed at reducing GHG emissions. There are a number of policy mechanisms being used including: emissions trading (such as that tried in the UK and currently operating in the European Union and in part of the USA); obligations to meet targets for renewable energy production (both in terms of electricity and transport fuel); mandated energy efficiency standards in products (such as buildings, light bulbs and white goods along with product labelling to support consumer choice around these products); and requirements for renewable energy to be incorporated into construction projects. In addition, governments are also active in attempting to influence individuals as well as organisations to reduce emissions.[16] One way in which influence can be effected is by creating mechanisms which impose financial costs on emissions (that is the cost of GHG externalities will be internalised). Stern (2006) suggests that a combination of carbon pricing, support for low carbon innovation and action on behaviour change will **all** be required to meet the agreed targets.

Carbon pricing implies the development of a market to provide flexibility for achieving GHG reductions. In a carbon market, participants are allocated allowances for emissions (most usually at a level lower than what they currently emit, with allowances reducing over time). In order to meet the allowable emissions target an organisation (or individual if the market is for person carbon allowances) can either take action on their own account or buy emission rights from someone else. The principle behind the use of a market mechanism to achieve reductions is the assumption that those who are most able to reduce emissions will do so first (at a lower cost) followed by those for whom emissions reductions are more expensive. Despite the conceptual simplicity of the idea, the design and operation of carbon markets is complex. For a review of the UK emissions trading system see National Audit Office (2004), NERA Economic Consulting (2004) and Department for Environment and Rural Affairs (2006).

Since 2005 the European Union Emissions Trading Scheme (Directive 2003/87/EC and hereafter EU ETS) has been in operation with the aim of supporting the EU-wide goal of reducing GHG emissions to a level which is 8% below 1990 levels (this is the Kyoto protocol target for the EU).[17] Under this scheme member states set a cap on the emissions from the installations covered by the scheme (these include energy-intensive installations such as electricity generation; iron and steel smelting; mineral processing industries such as cement manufacture; and pulp and paper processing industries), with installations being able to trade their allowances should they wish or need to. The World Bank (2008) reports that the EU ETS secondary market and the market for flexible CDM and JI mechanisms reached, respectively, a trade volume of $50 billion and $13.6 billion in 2007. Like all cap and trade systems, there are financial implications for those organisations who are part of them and hence implications for accounting practice. The paper now moves to address these issues.

3. Implications for Accounting and Reporting of Carbon

A number of implications could be drawn from the preceding section. First, that a scientific consensus is emerging that GCC is an issue that requires urgent attention. The way in which governments respond to GCC will affect all parts of society, including organisations which accountants have traditionally prepared accounts for. In fact, accounting is already involved in GCC in different ways, something that deserves the attention of researchers (Burchell *et al.*, 1980), given the intensity of social changes that GCC is likely to imply. Second, that the public policy domain is a fast moving one with legal and fiscal regimes developing that will require actions that will affect both those who buy goods and services as well as those who supply them. One element in the policy environment is the creation of markets where emission rights are traded and these create particular challenges for accountants. The different ways in which accounting and reporting is involved in GCC are explored using three layers of analysis: the financial accounting of carbon emission allowances, accounting and reporting for the risk associated with GCC and accounting and reporting for the uncertainty associated with GCC.

Financial Accounting of Carbon Emission Allowance Units

In the first instance, carbon trading creates short-term financial implications for companies (and potentially long-term implications as these schemes develop). Short-term implications arise from the cost of allocated or purchased allowances. For example, in the EU ETS companies receive free allowances annually to emit one tonne of carbon dioxide equivalents during a specified period (these are called European Union Allowances, hereafter EUAs).[18] These allowances are allocated on a calendar year basis. In addition to EUAs issued by cap and trade schemes (such as the EU ETS), emission CERs are also available from the CDM and JI mechanisms provided for by the Kyoto protocol.

At the end of each year, organisations must match their actual emissions with a sufficient amount of EUAs and CERs and then surrender these to the national registry (this matching has to be complete by 30 April of the year following the end of the calendar year). Organisations can trade their excess allowances and must acquire extra allowances if their emissions are higher than their allowances, including EUAs in the secondary market and CERs issued by entities carrying out CDM and JI projects. Allowances (both their spot and future prices) have been traded at more than €30/EUA, with an average for 2007 of €10 and a sharp decline by the end of 2007 (end of the first allocation period, 2005–2007), allegedly due to an initial allocation of allowances being above the actual emissions. The implication of being unable to buy allowances to cover any excess emissions, however, is more significant. Directive 2003/87/EC sets a penalty of €100/EUA for each unit uncovered by purchased allowances. In addition, entities still have to buy carbon emission rights to offset those uncovered emissions. This provides a double penalty for failure to either keeping within emissions levels or failing to buy emissions to cover excess emissions. This provides a substantive incentive to cover emissions and if allowances become less generous, and the market in carbon allowances more active, it could lead to substantive costs incurred by those who are unable to keep within their allowance inventory.

Carbon emission trading schemes raise the question of whether and how to recognise EUAs as assets and the obligation to deliver allowances as liabilities (with timing issues arising from the EU ETS process and year end dates for companies). Two aspects have centred the debate on the accounting for EUAs. First, considering that the majority of EUAs, in the initial allocation, are free for the companies affected and that only a small amount of the total emission rights contained within the EU ETS are purchased, the valuation of granted allowances is debatable and, given the volume of EUAs for some companies, has a potential significant impact in their accounts. Second, the recognition of assets and liabilities with different valuation bases could produce a volatility of results in some companies. These two aspects, together, lead to lobbying (for example, in the drafting of IFRIC 3) for the recognition and reporting of the net position with respect to emission allowances. According to this view, only purchased allowances would have an impact on the balance sheet. In the absence of regulation on this matter, IETA (2007) found that 60% of a sample of companies affected by EU ETS followed this net approach, recognising granted allowances at nil value, with the whole of the obligation recognised at the carrying value for the allowances already granted/purchased and the balance valued at market price.

Much of the research carried out on the accounting of pollution allowance markets has been inspired by the SO_2 emission trading scheme created by the US EPA in 1990. Commenting on it, Wambsganss and Sanford (1996) argued that it is inconsistent not to recognise granted allowances while purchased allowances are recognised on the balance sheet and as expense when they are used to compensate for pollution emissions. These authors recommended that granted allowances be treated as donated assets, valued at market at the date of their receipt, based on the rationale that this would provide a uniform accounting for all allowances, regardless of whether they are granted or purchased.

Additionally, Wambsganss and Sanford (1996) argued that charging the cost of all allowances to profit and loss for pollution emissions would alleviate the associated externalities.[19] IETA's survey (2007), however, found that only 5% of companies affected by EU ETS followed this 'full' approach.

With the issuance of IFRIC 3 in 2004,[20] the International Accounting Standards Board (IASB) followed Wambsganss and Sanford's view (1996). However, the European Financial Reporting Advisory Group (EFRAG) issued negative endorsement advice, whose rational stems from the measurement and reporting mismatches that are produced when assets are measured at cost and the corresponding liability at fair value and where allowance revaluation gains are recognised directly in equity while expenses relating to the liability are recognised in profit and loss. EFRAG considered that these mismatches would result in an artificial volatility of results in companies, especially when the company does not trade emission rights, with the effect of IFRIC 3 not reflecting the 'economic reality' of the organisations.

Given the negative endorsement advice from EFRAG and a request from the European Commission (IASB, 2008), IASB changed its mind and decided that accounting for emission allowances was not an urgent matter, resulting in the withdrawal of IFRIC 3 in June 2005. However, in December 2007, considering the development of emission trading schemes and the above-mentioned diversity in practice, the IASB changed its mind again and added this issue to the IFRS agenda (IASB, 2008).

Accounting and Reporting for the Risk Associated with GCC

The importance of GCC suggests that accounting and reporting should move beyond the conventional accounting toolbox to reflect risks associated with GCC to assist decision makers to understand the possible effects of GCC on corporate performance and prospects. In her commentary on Wambsganss and Sanford (1996), Gibson (1996) argues that accounting should transcend neoclassical economics and that the question of how to account for pollution allowances seems immaterial given the materiality of the pollution itself (as Gray, 2002, p. 693 put it 'these are amendments of existing accounting practices'). In its place, Gibson suggests that an ecological approach to emissions problems is likely to be more informative than an economic approach. In other words, in addition to financial information, non-financial information will be needed to provide relevant information about the risks associated with GCC. Indeed, in order to reflect a 'true and fair view' of corporate performance and the context of their operations, non-financial reporting will be needed to provide information about the impact of GCC and adaptation to GCC (via changing regulations or via changing corporate activities) on organisations.

GCC is characterised by risk and uncertainty, and Stern (2006, p. 1) suggests that the economic analysis of GCC 'must be global, deal with long time horizons, have the economics of risk and uncertainty as its core, and examine the possibility of major, non-marginal change'. The remaining analysis of the implications of GCC for accounting and reporting will focus on the notions of risks and uncertainty associated with GCC. In this respect, there is a need to distinguish risk from uncertainty because these terms are sometimes used interchangeably in the accounting literature. Risk involves the existence of a probability distribution of potential gains and losses. For example, different approaches to GCC mitigation will expose different industries and/or firms to different possible gains/losses. Uncertainty, in contrast, is characterised by the existence of different probability distributions of outcomes, where each distribution gives rise to different expected utilities (Stern, 2006). Uncertainty is by its very nature more difficult for an organisation to deal with.

According to the Stern Review (Stern, 2006), estimates of loss of global GDP due to GCC may be 10% by the end of the century (there is a wider range of possible estimates also suggested by Stern). Stern also suggests that carbon pricing may have a modest impact on the economy compared with the impact of increases in oil and gas prices. For example, the economic impact of the Brent spot price increase from \$26/bl (2003 average) to \$100/bl would be equivalent to an unchanged oil price with the imposition of a \$196/tCO_2 carbon price (for reference the EUA's price is approximately €30/tCO_2). Although the global cost of actions to tackle carbon emissions is relatively modest (less than 1% of GDP presently, as estimated in the Stern Review), it is likely to be unevenly distributed between countries, sectors and companies. Those countries, sectors and companies that are more reliant on energy-intensive goods and services may be hardest hit by GCC. Industries and companies are already actively exploring the risks derived from GCC (see, for example, Pinkse and Kolk, 2007). Indeed, Lund (2007) studied the impact of the EU ETS in the energy-intensive industries (assuming a 30% CO_2 reduction after the Kyoto time period) and found that its effect would be disproportionately larger for some electricity-intensive industries, exceeding 10% of production value in 2020.

Organisations are likely to face differential risks from GCC in the form of regulatory risks and competitive risks. Regulatory risks stem from the different policy instruments developed at the national and supra-national levels, of which carbon trading is but one option. As we have seen, carbon trading schemes are increasing, both in number and in traded volume, but still most of the allowances are allocated free of charge and not all sectors are included. Significant regulatory risks for different companies arise from the possibility that the governments decide to auction allowances, to restrict their number or to include new sectors, if and when the objective to reduce carbon emission by more than 80% (on a 1990 baseline) is translated into policy. For example, in July 2008 the European Commission approved the inclusion of airlines in the EU ETS from 2012 (proposed in Directive 2003/87/EC), with an estimated impact in the cost of tickets that range from €2 to 9 in EU internal flights to €40 in flights between the EU and the USA (*El País*, 2008). In addition, the World Bank (2008) suggest that an additional source of regulatory risk stems from the delays in the registration of JI/CDM credits, which need accreditation to validate and verify each project, from the regulator.

In a carbon constrained future, competitive risks arise from the likelihood that carbon-intensive products and services become obsolete compared with low emission products and technologies (Kolk and Levy, 2001). Busch and Hoffmann (2007, p. 525) contend that a company's carbon

> risk profile is mainly determined by: (a) the company's asset mix, (b) the dependency on and intensity of carbon-based input factors and energy production, (c) the possibility for substitution and technological alternatives, (d) the technological trajectory and industry specific innovation patterns, (e) the company's position in the value chain, and (f) the location of its operational activities and sales.

In fact, this competitive risk is likely to be more important than the risk of a loss of competitiveness caused by the introduction of carbon markets or carbon taxes. Conversely to the often argued point that a loss of competitiveness would result from the introduction of schemes such as the EU ETS in some parts of the world, Stern (2006) finds that the bulk of the economy is not vulnerable to foreign competition as a result of energy price increases and that, if the carbon abatement measures are taken at a large scale level (for example, the level of the EU), only some sectors are marginally vulnerable to external competition.

Investors, policy makers and the public in general, therefore, could be expected to need information from which they can assess the carbon intensity of corporate products and services and estimate the regulatory and competitive risks that a corporation is likely to face. Moreover, there is also a need for information on how the organisation manages GHG emissions (and the risks associated with their approach). This is likely to require non-financial accounting and reporting of and about GHG emissions. Such a conclusion could explain the apparent success of initiatives such as the Carbon Disclosure Project (CDP thereafter).[21] In addition, the GHG Protocol[22] provides the starting point of a standard for the measurement of GHGs and hence potentially the benchmarking of corporate performance in this area.

Initiatives such as the CDP and the GHG Protocol indicate that risk management and corporate social responsibility (perhaps in the form of stand-alone reporting) are increasingly addressing GCC risk. Bebbington *et al.* (2008) show how in one sustainability report the management of financial risks takes precedence over the management of broader risks. It may be that in the case of GHG reporting financial and environmental risks are more closely aligned than usual due to the significant effect of GHG externalities. This opens new research avenues in two directions at least.

First, further research should examine the interplay between how organisations tackle carbon emissions and how their carbon position and carbon management is disclosed. As an exemplar of this fruitful line of research, Kolk *et al.* (2008) studied the development of carbon reporting mechanisms, with a particular view on how large companies responded to the CDP. They concluded that even though these reporting mechanisms are developing quickly, there are still many problems for the meaningfulness of this information, especially around the issues of commensurability and comprehensiveness.

Second, research will be needed to evaluate the value relevance of disclosures about carbon exposure and carbon management, and to empirically test hypotheses that corporations face risks from GCC and carbon trading schemes. For example, Johnston *et al.* (2008) explore how the financial market reacts to information about the position of companies in the context of the US SO_2 emissions trading scheme (suggesting that the conclusions drawn in this market will help to understand the valuation of the position of organisations relative to GHG emission allowances). Although we posit that GCC has a distinctive nature, as opposed to other forms of pollution (they also address this point), the use of this comparison is likely to be useful. In brief, Johnston *et al.* (2008) find that the market assigns a positive value to emission allowances that a corporation banks. This implies that emission allowances are viewed as assets by investors. In addition, they also find that the market reacts (but in a more ambiguous manner) when a firm buys emission rights. They suggest that this may be the case as the buying of emission rights provides investors with some information about how the firm is managing the risks associated with emissions. At the same time, they also note that the reporting regime in the USA for this market is not well developed. These finds imply that we may be some way off achieving ‘good’ financial reporting disclosure of carbon emissions data (including emissions banked and emissions purchased) but that investors are likely to need this information to accurately value the risks faced by corporations.

Accounting and Reporting for the Uncertainty Associated with GCC

Stern (2006) argues that the methods of standard economics, focusing on marginal analysis and abstract from dynamics and uncertainty, are not suited for the problems raised by GCC. As explained in the second section, GCC is unique in several respects: (a) it affects the whole planet regardless of where GHGs are emitted; (b) the effects of GHGs are persistent (CO_2, for example, lasts in the atmosphere for 100 years) and develop over time; (c) the chain of causality between emissions, GCC and the effects on humankind is characterised by uncertainty; and (d) these changes are likely to be non-marginal. Considering the last aspect, Stern (2006) finds that in all scenarios, the consequences of GCC will become disproportionately more severe with increased warming (that is, the climate system is not linear and the response to warming will likewise not be linear). This uncertainty, and the severity of potential impacts of GCC, raises ethical concerns over the applicability of utilitarian risk/cost benefit analyses and favours the adoption of precautionary approaches (Aslaksen and Myhr, 2007). In this section, we outline the implications of a precautionary approach to accounting and reporting for GCC.

A precautionary approach has been defined by UNESCO (2005, p. 14) thus:

> when human activities may lead to morally unacceptable harm [e.g. serious and effectively irreversible, or inequitable to present or future generations] that is scientifically plausible but uncertain [i.e. should apply to very low probabilities], actions shall be taken to avoid or diminish that harm.

Aslaksen and Myhr (2007) develop a precautionary perspective for decision making on environmental risk[23] based on two intertwined pillars: scepticism about scientific approaches and the need to recognise the social aspects of uncertainty and hence to engage different stakeholders to input their perspectives in the process of decision making.

With respect to scientific scepticism, Aslaksen and Myhr (2007) suggest that a precautionary perspective requires the consideration of long-term adverse consequences, awareness of ethical approaches implicit in scientific approaches and a more humble attitude towards technological improvements. Scientific scepticism does not imply ignoring the cumulative evidence of GCC, but to consider, for example, the plausibility of dangerous climate change. Adapting Aslaksen and Myhr's framework to GCC (2007, p. 495), the plausibility of morally unacceptable GCC would lead to a consideration of the second pillar of a precautionary approach, the social dimension of the uncertainty associated with GCC, that is, the 'recognition that the scientific, economic and social contexts are intertwined, and new institutions for participatory processes are needed to strengthen dialogue between stakeholders'. With respect to the assessment of GCC outcomes, Aslaksen and Myhr (2007) refer to the concept of 'risk window' to illustrate how each evaluator views environmental risks (for example, GCC) through a 'risk window' that makes visible only some of the likely adverse effects of GCC. These authors conclude that a precautionary approach would need the handling of technical facts as much as social issues (integrated assessment approach) in an interdisciplinary, participatory and transparent fashion.

Two consequences of such a precautionary/integrated assessment approach are important for accountants and accounting/reporting approaches. First, any account of the uncertainty associated with GCC should adopt a participatory approach by way of, for example, engaging stakeholders and mapping their different preferences according to their different 'risk windows'. One inspiration for such accounts of uncertainty could be Lehman's communitarian approach towards environmental accounting (1999, p. 238), which would 'be constructed as a vehicle that facilitates communication within the community and the development of possibilities for change, thereby creating democratic conditions'. Second, technical facts and social issues are incommensurable and this leads to call for attention to the potential problems involved in the standardisation of carbon accounting and carbon reporting without a sound understanding of the social and scientific causes and consequences involved in GCC. The accounting literature has often argued that some forms of environmental accounting in the contexts of environmental auditing (Power, 1991) and carbon markets (MacKenzie, forthcoming) could result in environmental issues being transformed into an economic and risk-based language and could result in the capture, limitation and distortion of the social and political issues involved in the environmentalist discourse.

From their analysis of the discourses on GCC and sustainable development, Cohen *et al.* (1998) concluded that GCC issues have been constructed in narrow and reductionist scientific terms and divorced from their social and political contexts. This has arisen because of the status accorded to the physical sciences and, thus, has resulted in GHG emissions being the focus of policy making. Cohen *et al.* (1998), however, remind us that the issues that can be known with scientific certainty are not necessarily the most important. In particular, Cohen *et al.* are concerned with the broader sustainable development agenda that includes issues, such as renewable resources, regional development, trade, North–South equity and responsibility to future generations. These issues, they contend, are difficult to address because, unlike the science of climate change, sustainable development has not developed in a reductionist manner and continues to question fundamental issues in a politicised debate leading, for example, to a lack of definition of what sustainable development involves. This paradoxical situation is leading to policy on the physical aspects of GHGs, at the cost of ignoring other, potentially more important, issues. These issues could include, questioning why GHG emissions continue to grow and how, if at all, they could be limited by moving a focus away from expansionist production and consumption models. In addition, focusing on emission reductions could displace debate on the equitable access to energy or the responsibility of high carbon consuming countries to support those affected by climate change (and this is without considering duties to future generations who will be affected by GCC).

Like Aslaksen and Myhr (2007), Cohen *et al.* (1998) propose the use of integrated assessment models to reach a convergence between more global, objective and science-driven approaches to GCC and more local, normative and problem-driven approaches of sustainable development. Cohen *et al.* (1998, p. 366) emphasise that studies using integrated assessment models would include broader social issues, be contextual and require the understandings of different people with the 'goal of facilitating consensus among a broad range of researchers and stakeholders'.

Considering the frameworks proposed by Cohen *et al.* (1998) and Aslaksen and Myhr (2007), research on the accounting and reporting of climate change, given the uncertainty involved, should develop approaches with a similar approach to that of integrated assessment models. In this respect, we anticipate that research should develop in two different ways to cope with the uncertainty surrounding GCC. First, it should investigate how carbon accounting and accountability unfolds using a research engagement approach (Parker, 2005; Adams and Larrinaga-González, 2007; Bebbington *et al.*, 2007). For example, research engagements intended to identify the potential of the different forms of accounting and reporting for GHG emissions to facilitate change toward less carbon-intensive organisations. This would need to scrutinise the point of view of local actors (in organisations but also stakeholders affected by GCC), who can bring alternative 'risk windows' and who are often excluded from risk evaluations (Belal and Owen, 2007).

Second, given the scientific and technical indeterminacy of GCC and the relative under-specification of protocols for reporting on GHG emissions, accounting research should proceed in line with Gray's proposal for normative-oriented research and for engagement in the process of designing carbon accounts (2002). For example, if we consider the case of reporting boundaries (see Archel *et al.*, 2008) drawing the boundaries of organisations for carbon reporting/accounting involves technical, economic but also political issues. In the World Resources Institute's GHG Protocol organisations can choose different scopes, ranging from only direct impacts (scope 1), to include the most obvious indirect GHG emissions of electricity (scope 2) to the undefined scope 3. Companies claim to use the GHG Protocol but more research is needed to scrutinise the way in which scope is defined, whether the scope chosen is appropriate given GCC,[24] whether the figures produced are commensurable (see Kolk *et al.*, 2008), whether there is any possibility of translating these boundary resolutions to more general issues of sustainable development or how GCC uncertainty is intertwined with the ill-defined scope 3 GHG emissions.

In conclusion, this section of the paper has outlined a number of areas where research on accounting and reporting for GCC is required. In the first instance, accounting for EAUs requires a relatively straightforward development and application of traditional accounting principles to ensure that accounts show a true and fair view of the financial implications of pollution allowances. In addition, there is likely to be a need for organisations to communicate with their stakeholders about the risks that arise from GCC and also to reflect the uncertainties of how GCC will unfold. This moves the debate into the area of non-financial reporting which, while not as well developed as financial accounting and reporting, has already started to exercise the accounting profession. This also suggests the need for more research on the ways in which accounting is implicated in the unveiling of, and the negotiation of the interplay between, GCC risks and GCC uncertainties.

4. Concluding Comments

In this paper we wished to outline (in a relatively non-technical manner) the science behind the concern about GCC as well as to outline the policy development that has been triggered by the scientific debate on climate change. Detail of the context in which the accounting and reporting for GCC debate is set is important because it will lead to particular accounting and reporting challenges. GCC raises risks for business, but it is fundamentally a global challenge for humankind, one that is uncertain, persistent, non-marginal, non-linear and raises a number of social and political issues. In this respect, different actions developed to tackle GCC, such as carbon markets, have accounting and reporting implications that deserve the research of accounting academics. However, by introducing the distinction between risk and uncertainty, we argue that GCC has implications beyond accounting for carbon emissions (Burchell *et al.*, 1980) and that research should imagine new social accounts to deal with uncertainty, along the lines of the suggestion already made in the social accounting literature (Lehman, 1999; Gray, 2002). This special debating forum is merely the start of the conversation over the implications of GCC.

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Appendix: Scientific Details for GCC

Table A1. Relative contributions of gases to global warming (note 1)

Gas	Lifetime	Global warming potential (100-year horizon)	Relative contribution over 100 years (%)
Carbon dioxide (CO_2)	50–200 years	1	61
Methane (CH_4)	10 years	21	15
Nitrous oxide (N_2O)	150 years	290	4
Chlorofluorocarbons (CFCs)	100 years	Various	11
HCFC-22 (note 2)	13 years	1,500	0.5
Others (note 3)	Various	Various	8.5

Notes: (1) These gases are also those that are subject to regulation via the Kyoto protocol. There are other gases (such as water vapour) that create radiative forcing but their overall effect is minor compared to this basket of gases and the concentrations. (2) Montzka *et al.* (1993). (3) See Jäger and Ferguson (1991).

Sources: Jäger and Ferguson (1991); IPCC (1996, 2001); Hadley Centre (1999).

Table A2. Selected GCC impacts[a]

- Seasons have been changing with spring arriving earlier. This has some positive impacts (for example, lengthening growing seasons) but also raises some problems for ecological integrity. For example, plants, insect and birdlife synchronicity (for example, the link between caterpillars being hatched at the time when there is plentiful food for them which in turn is synchronised with bird hatching) may be disrupted. Seasonal changes, therefore, may disrupt ecosystem functioning and individual species may suffer. These sorts of changes may also have an impact on the prevalence and impact of pest species on food production.
- Given there is more energy in the atmosphere the frequency and intensity of adverse weather events (for example, storms, storm surges, hurricanes, typhoons and tornados) may increase. This may cause loss of life, either directly (during the storm) or indirectly (following the weather event due to disruption of food production and/or disease following loss of functioning sanitation systems). Economic losses from disruption of activities (such as offshore oil and gas production) may also follow from such events. The incidence of heat waves may also have similar impacts, leading to deaths that would not have otherwise occurred.
- Changing precipitation levels will likely arise from the distribution of warming effects. Areas at the equator are expected to be drier (leading to more drought, crop failure and potentially more starvation) with those nearer the poles being wetter (leading possibly to crop failures and associated disruption such as flooding and landslides). Water shortages in drier zones may also lead to more conflict triggered by access to resources with associated displacement of civilian populations. Gore (2006) highlights that the current conflict in the Sudan can be linked to droughts made worse by GCC. Patterns of human habitation will also change as a result and large scale migration of environmental refugees may occur. Drought stress is likely to be experienced most severely in areas that are already under multiple environmental, social and economic pressures. Desertification and soil erosion may arise in these circumstances as well.
- Warming may impact on the size of glaciers and other ice cover with multiple effects. Where glaciers provide water resources to human populations (such as those in the Himalayas), then drinking water shortages may arise as will irrigation water shortages (with knock-on effects for food production and hunger). A sea level rise will also occur if there is a substantial melting of polar ice. While this has obvious impacts for human habitation around river deltas and coastlines, life in the sea will also be affected by changing salinity that may arise with large scale melting. Given the developing world depends heavily on fish for protein this will have further knock-on impacts on human populations. Warming at the poles also affects land that was previously permafrost. This has knock-on effects on forestry, transportation routes and housing (and other infrastructure such as oil and gas pipelines) in these parts of the world. In addition, methane that is currently frozen in the permafrost may be released (as carbon in other soils could do so as well) which would accelerate GHG concentrations and may create what is termed a 'runaway effect'.

[a]These examples are drawn from Gore (2006) and Stern (2006). They also demonstrate the systemic effect of changes to the climate system. That is, for any impact there are many potential environmental, social and economic ramifications. This is a characteristic of a 'wicked' problem – of which GCC is an example. See Rittel and Webber (1973) for the seminal work on such problems and the intellectual and practical challenges they present.

Notes

[1]The term 'carbon' is often used as a shorthand way to refer to greenhouse gases, of which carbon dioxide is the largest element. Greenhouse gases, however, are often measured in terms of carbon equivalent impacts and hence the shorthand of carbon is often used. Where the term carbon is used in this paper it is the shorthand sense. Where the gas carbon dioxide is meant, its full name or chemical compound will be used.

[2]Article 1 of United Nations Framework Convention on Climate Change (hereafter UNFCCC) defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between 'climate change' attributable to human activities altering the atmospheric composition, and 'climate variability' attributable to natural causes. 'Global warming' is a term sometimes also used in this context.

[3]Mitigation refers to taking actions to reduce GHG emissions. Adaptation refers to actions that seek to respond to changes created by GCC. These actions include ensuring that infrastructure is more resilient to climate change impacts, such as enhancing flooding defences. Both mitigation and adaptation are currently being pursued by governments and while adaptation helps deal with GCC impacts it does not prevent them arising (only mitigation can do this).

[4]The IPCC was formed in 1988 to respond to the risk of human-induced climate change. The United Nations Environment Programme and the World Metrological Organisation were the founding organisations of the IPCC, which is open to all members of the founding bodies. The IPCC was established in order to assess 'on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature' (see http://www.ipcc.ch/about/about.htm).

[5]These concentrations refer to radiative forcing (that is, the warming effect of greenhouse gases) in equivalent concentrations of carbon dioxide in parts per million of atmospheric volume.

[6]The link between these two factors is the inevitable outcome given basic physical laws and has been known since the early 1800s. Causality, however, is more difficult to establish and given the complexity of the underlying system there is also a reflexive relationship between these two variables.

[7]There are a number of natural factors that affect the climate system. For example, solar intensity (or 'sun spots') and volcanic eruptions. In addition, other human activities such as particulate emissions (sometimes also called global dimming) affect the greenhouse effect. Climate science adjusts estimates of global temperature for natural events and has established that the current warming effect can be directly traced to human activities (see Stern, 2006, Chapter 1).

[8]The deposit and release of carbon from wood, for example, occurs over relatively short periods of time (the growing cycle of forests) and hence does not have a material impact on GHG concentrations. Mass (de)forestation, however, does have an impact on GHG concentrations.

[9]Temperature increases are not evenly spread. Warming at the poles will be greater than the rate of warming at the equator.

[10]Stern (2006) suggests that if we wished to limit warming to 2–2.4°C we would need to reduce GHGs by 50% on 1990 levels by 2015. This would be a significant, if not impossible, challenge.

[11]The protocol required the signatures of 55 parties, including those that produced at least 55% of the CO_2 emissions in 1990 in what are called Annex I parties (these are the developed countries). When Russia ratified the protocol it came into force. A total of 172 countries and governmental entities have ratified the protocol to date.

[12]It is also important to recognise that within the USA a number of states are following a carbon reduction trajectory (for example, California) and that several mayors in cities around the country have also sought to develop policies that de facto result in Kyoto standards being

sought. This has resulted in some 46% of the US population living in states or cities where some variation of the Kyoto targets are being pursued (authors' own calculations).

[13]The EU is treated as a country under the Kyoto rules. This makes some variation between countries in the EU possible, but also emphasises why the EU is important in the context of emission reduction actions.

[14]Per capita annual tonnes of GHG emissions vary widely (all figures that follow are for the latest year in which there is data calculated in CO_2e t/person). High emitters include USA (2002, 24.09), Canada (2003, 23.45) and Australia (2000, 27.54). The UK (2003, 11.01), New Zealand (1999, 14.43) and the Netherlands (1999, 11.02) are examples of countries in the mid-range. Low emitters include India (2001, 1.34), China (1994, 3.05) and Samoa (1999, 2.53).

[15]If one moves to a consumption-based account of GHGs then techniques such as carbon footprinting (itself a sub-set of ecological footprinting) are required.

[16]The UK government (along with the Scottish Parliament) have gone further than most countries in establishing carbon regimes that will allow emission targets to start to be pursued. In the UK, legislation is currently being drafted to create a legal requirement for England and Wales to reduce its GHG emission by 60% by 2050 (the Scottish Parliament has signalled its intention to introduce legislation in the 2008–2009 year to require a 80% reduction by 2050 for Scotland).

[17]Other market-based schemes that have been experimented with include the UK Emissions Trading Scheme (this ran from 2002 until 2006 when it was rolled into the EU ETS), the New South Wales GHG abatement scheme and the Chicago Climate Exchange.

[18]EUAs are allocated by member states, according to their commitments and on a grandfathering basis (Markussen and Svendsen, 2005). Grandfathering refers to the fact that emission allowances are based on the history of emissions thereby reinforcing historical patterns of emissions.

[19]This point is subject to controversy (see Gibson, 1996; Lehman, 1996; Larrinaga-González *et al.*, 2002).

[20]For IFRIC 3 emission allowances are intangible assets (IAS 38) that when received free of charge need to be treated as a governmental grant: the emission allowances need to be recognised initially at fair value that gives rise to a deferred credit. As the installation emits carbon dioxide, the entity recognises an obligation to deliver allowances that is valued at the end of the reporting period at the market value of allowances. During the year, the entity amortises the deferred credit to profit and loss.

[21]The Carbon Disclosure Project (CDP, 2007) is a call from investors to the largest quoted companies to report on various aspects of their carbon profile and carbon management with the aim to scrutinise and enlighten about the 'risks and opportunities facing these companies due to GCC' (CDP, 2007, p. 14). This is essentially a piece of private disclosure regulation and participation in the CDP has increased each year.

[22]The Greenhouse Gas Protocol is an initiative of the World Resources Institute and the World Business Council for Sustainable Development intended to 'develop internationally accepted greenhouse gas (GHG) accounting and reporting standards for business and to promote their broad adoption' (WBCSD, 2004, p. 2).

[23]Risk is used by these authors in a broad sense that encompasses uncertainty.

[24]After considering the incidence of indirect GHG emissions, Rosenblum *et al.* (2000) estimated that the service and manufacturing sectors have similar global warming potential. Where boundaries are drawn has a significant impact on the conclusions that may be drawn in this instance about both risk and uncertainty.

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