CONSUMPTION-BASED AND LIFE-CYCLE EMISSIONS ACCOUNTING: STRENGTHS AND WEAKNESSES IN SUPPORTING CLIMATE POLICY

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EXTENDED ABSTRACT

The purpose of this paper is to explore emerging applications of consumption-based/life cycle assessment (LCA) accounting methodologies nationally, internationally and in the private sector. Slow progress at the international level in halting the growth of GHG emissions, coupled with the limitations of the territorial methodology for accounting for greenhouse gas (GHG) emissions used under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, has triggered an interest in these alternative approaches for accounting for emissions and attributing responsibility. Methods and standards for accounting for the life cycle emissions associated with goods and services, and for estimating the global carbon footprint associated with all consumption within an economy, are now under active development and are beginning to find practical application. The paper identifies the strengths and weaknesses of the two approaches for accounting emissions in relation to accuracy, timeliness, data robustness, assesses current applications of the consumption approach and suggests wider potential applications which could influence national climate policies and the international structure.

Key words: climate policies, consumption-based emissions, life-cycle assessment

1. INTRODUCTION

Under the United Nations Framework Convention on Climate Change (UNFCCC), countries measure and report emissions arising within their territories following Intergovernmental Panel for Climate Change (IPCC) guidelines. Under the Kyoto Protocol, emissions targets are set on a territorial basis, since countries have the ability to influence how goods and services are produced within their territories. However, there is a growing body of literature that points to the limitations of the “territorial” emissions accounting approach (Helm, 2012). This starts from the premise that the focus should be on the GHG emissions associated with goods and services consumed in a country and that this represents a more appropriate means of measuring responsibility for emissions. This paper highlights consumption accounting approaches for greenhouse gas (GHG) emissions, presents examples of current climate policy applications and suggests potential new applications. The paper includes the following sections: section two describes the two main techniques used to count consumption emissions, i.e. life-cycle assessment (LCA) and input-output analysis. Section three presents current and the potential future applications and section four assesses these applications focusing on policy making at local, national and international level. Section five discusses the future of consumption based approaches.

2. TECHNIQUES FOR ESTIMATING AND ACCOUNTING FOR GHG EMISSIONS

2.1 Territorial emissions

Under IPCC guidelines (IPCC, 2011), territorial emissions are generally estimated rather than measured directly. Most emissions, notably CO₂ and energy sector emissions which
dominate most emissions inventories, are estimated by multiplying data describing anthropogenic activity (e.g. kilometres travelled annually by vehicles of a given type, volume of natural gas burned in power stations) by an emissions factor referring to a unit level of activity. Uncertainties in territorial emissions can be due to: the omission of sources or double counting; accuracy of emissions factors; the measurement of emissions; and the natural variability of the activities that generate emissions CO\(_2\) emissions estimates are more accurate than those for non-CO\(_2\) GHGs. Emission estimates for agriculture and land use change are less accurate than those for energy-related activities. In general, GHG emissions inventories are considered sufficiently accurate for most countries (DECC, 2011).

2.2 Life-cycle emissions
While the territorial approach accounts for only direct emissions, life cycle assessment (LCA) also accounts for indirect emissions associated with the production of goods and services. It covers upstream emissions associated with intermediate goods and services and downstream emissions associated with disposal. LCA can be applied to a range of environmental impacts. However, “carbon footprinting”, which focuses on the estimation of GHG emissions associated with goods and services, has emerged as a particularly active area. Considerable efforts have been made to standardise approaches, notably through the international Greenhouse Gas Protocol (Bhatia et al., 2011). Even if standards are followed, it is still possible to calculate different carbon footprints for similar or even the same products. The “goal and scoping” phase of LCA allows discretion in defining system boundaries and functional units. To make LCA tractable, some processes in the supply chain are necessarily omitted. In an attempt to establish greater consistency, the European Union has been developing a Product Environmental Footprint methodology under the Resource Efficient Europe Initiative (EC Joint Research Centre, 2012).

2.3 Consumption-based accounting
Consumption-based takes account of carbon embodied in transactions between different sectors of the economy and that embodied in trade flows between countries. It allows the global carbon footprint of an economy to be estimated as well as the carbon footprint of specific categories of consumption. Input-output analysis forms the methodological basis for estimating consumption-based emissions. The number of countries undertaking research into consumption-based emissions has been increasing. The Netherlands, Italy, Japan, Sweden, Norway, Germany, the US, and the UK are examples (Wiedmann, 2009).

The two basic inputs to consumption-based accounting are input-output tables characterising transactions between different sectors of a national economy and data on sectoral trade flows between countries and regions. Building on territorial emissions data, matrices describing trade flows and input-output transactions between different sectors of the economy can be manipulated to attribute emissions to final consumption in consuming countries (Barrett and Scott, 2012). Two main modelling approaches have been employed for consumption-based accounting. “Single region input-output” (SRIO) modelling accounts for trade flows between a single country or region and the “rest of the world”. It is assumed that the technical characteristics of processes in the rest of the world are identical to those in the home country. In “multi-region input-output” (MRIO) models, different technology assumptions are made for each region and trade between different regions is accounted for. Consumption-based accounting is not a direct alternative to the territorial approach. Information from territorial analysis is a key input. Consumption-based emission estimates therefore inherit uncertainty from territorial emissions and embody additional uncertainty due to the economic data and modelling.

There are two types of uncertainty associated with input-output modelling. Parametric uncertainty is associated with coefficients in the input-output tables and other input data.
Structural uncertainty is associated with the choice of sectors and world regions used in the modelling. Factors affecting the accuracy of input parameters include the accuracy of the data used in the construction of the model, the compilation of the required data, the estimation of missing data and the ability to balance conflicting data. Also, the quality of data might not be the same for every region in the model. Wiedmann et al (2010) note that, in an MRIO analysis of UK consumption-based emissions using three world trading regions, non-UK data was available for only two years out of the period studied (1992-2004).

![Figure 1: Uncertainty Associated with UK consumption-based CO2 Emissions: Source Lenzen et al, 2010](image)

Figure 1 illustrates parametric uncertainty by comparing UK territorial emission estimates with consumption-based estimates, in both cases showing error bars. The level of sectoral aggregation plays an important role. Highly aggregated figures are relatively accurate and robust. However, the more detailed the approach and the more sectors are broken down to individual products, the more uncertain are the results (Baiocchi and Minx, 2009).

Figure 2 illustrates the implications of structural uncertainty. Different estimates of UK consumption-based emissions, based on different degrees of sectoral and regional disaggregation, are compared with territorial emissions. While the estimates are roughly aligned over a 17 year period, different aggregation strategies can lead to year-to-year emission changes moving in different directions. The timeliness of data provision to support consumption-based accounting is also an issue. The only internally consistent database on bilateral world trade has been established through the Global Trade Analysis Programme (GTAP) co-ordinated by Purdue University (Purdue University, ND). The GTAP database has been updated seven times since 1993 with each version referring to data that is about four years old. Thus GTAP data could be seven-eight years old at the time of use. National input-output data can be another gap.
2.4 Hybrid LCA approaches

“Hybrid” LCA approaches (Suh, 2003) are intended to address the problem of lack of “completeness” in standard LCA approaches by using consumption-based accounting methods to estimate emissions associated with intermediate goods and services that are not accounted for explicitly. Due to its inherent complexity, hybrid LCA has been applied mainly in the academic/research sphere. While addressing the completeness problem, hybrid LCA inherits some of the limitations of consumption-based accounting.

2.5 Greenhouse Gas Protocol

The GHG Protocol distinguishes three levels of accounting for emissions at the product or company level. Scope 1 emissions are direct, corresponding to territorial emissions at the country level. Scope 3 emissions are based on a full LCA. Scope 2 emissions are intermediate and capture what are often the most significant indirect emissions, those associated with the use of electricity and other purchased energy. The data to calculate Scope 2 emissions are readily available and this explains why Scope 2 emissions are found in a number of applications.

2.6 Characteristics of different accounting approaches

Table 1 summarises the characteristics of the different accounting approaches. The high level messages are that: a) territorial and GHG Protocol Scope 1 and 2 emissions are easiest to estimate and the most accurate; b) there are readily available methods for estimating LCA-based (and GHG Protocol Scope 3) emissions but the results will be systematic underestimates unless a hybrid approach is taken; and c) consumption-based emission estimates have theoretical merits but complex methods are required. Limitations on accuracy, availability and timeliness of data pose challenges in terms of application.

3. ACTUAL AND POTENTIAL APPLICATIONS

There has been a number of life cycle/consumption-based applications in both the public and private sectors. Applications can be “soft” i.e. those that provide background information for decision-making, and “hard” e.g. sustainability criteria for biomass, that are embedded in regulation. There has been a far greater uptake of “soft” applications. Currently, LCA-based soft applications, already in place, include managing supply chains (e.g., GHG Protocol), and product design (EU Eco-Design Directive). LCA-based hard applications include life-cycle emissions of energy supply (e.g. EU Fuel Quality Directive, EU Renewable Energy Directive). I-O based soft applications, currently under development, include GHG emissions accounting on a city/community level (e.g. PAS 2070-UK, Greater London Authority) while I-O based hard applications are still proposals.
There has been a far greater uptake of “soft” applications. This reflects the lack of robustness of consumption-based methodologies which renders them less fit-for-purpose in more demanding regulatory environments.

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<th>Table 1. Characteristics of accounting approaches</th>
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<td><strong>Data availability</strong></td>
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<td><strong>Territorial emissions</strong></td>
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4. ASSESSMENT OF CURRENT AND POTENTIAL APPLICATIONS

4.1 Informing consumers and producers

LCA of goods and services can help companies manage the environmental footprint of their supply chains and, when accompanied by suitable information mechanisms, for example eco-labels, guide consumption decisions. Eco-labels are given to goods and services which are proven to meet high environmental standards with respect to raw materials extraction, manufacturing processes, use and disposal (European Commission 2012). LCA is the tool used by businesses to assess a product’s conformity with these criteria, by evaluating upstream and downstream emissions. LCA can be a costly process and the costs may be prohibitive for small businesses.

Product LCA has been encouraged through legislation. The EU Ecodesign Directive (EU Commission, 2009b) sets a Europe-wide framework for ensuring that the life cycle environmental impacts of products, including those that use energy, are taken into account. The UK has introduced a formal legal requirement for listed companies to report their corporate level Scope 1 and Scope 2 emissions as of April 2013. The Tokyo Metropolitan Government requires entities operating within the City to participate in a cap-and-trade scheme for Scope 1 and Scope 2 emissions (Tokyo Metropolitan Government, 2012).
4.2 Informing policymaking
Life cycle/consumption-based approaches have been used to guide policymaking at both the city/community and national levels. The Greater London Authority is developing tools for estimating the carbon footprint of London in order to guide a range of policies (Doust, 2012).
West Sussex County Council in England has broken the carbon footprint of individual residents down into sixteen segments such as flying for personal reasons, food and drink and fuel use in private vehicles. The Council’s aim was to improve consumption behaviour by getting them to understand the environmental impact of their lifestyle and connect their footprint to life-style choices (HC Energy and Climate Change Committee, 2012, p.14).
The UK’s Department of Energy and Climate Change (DECC) regularly publishes Scope 1 and 2 level data on GHG emissions at the local and regional authority level. DECC’s analysis breaks emissions into three segments (road transport, domestic and industrial and commercial). The UK’s Bioenergy Strategy (DECC, 2012) provides a specific example of life cycle thinking being used to inform public policy making. The Strategy was partly informed by energy system modelling that explicitly accounted for the life cycle emissions of different forms of bioenergy. The objective was to identify “best” uses of biomass that would optimise minimise global (lifecycle) GHG emissions.

4.3 Incentivising investment in technologies to optimise the global footprint
An increasing number of studies have applied LCA methods to sources of energy. This approach has found “hard” application in two EU Directives on Fuel Quality (European Commission, 2009a) and Renewable Energy (European Commission, ND). The Fuel Quality Directive requires fuel suppliers to reduce the GHG intensity of supplies over time. Specifically, “suppliers must reduce GHG life cycle emissions by up to 10% per unit of fuel and energy supplied” by 2020 (European Commission, 2009a). Greater use of biofuels would contribute to meeting this goal. The Fuel Quality Directive uses estimates of the life cycle emissions associated with biofuels to compute progress towards the targets. The Directive allows suppliers to replace default life cycle emission values with more accurate values when supported by evidence.
Under the Directive, the European Commission has estimated lifecycle GHG emissions from fossil fuels. The emission value assigned to oil produced from Canadian tar sands was initially 107 g/MJ compared to 87.5 g/MJ for conventional crude oil. This would have made it very difficult to meet the requirements of the Fuel Quality Directive while sourcing significant quantities of oil from Canadian tar sands. It has been proposed that a revised EU New Car Emissions Directive could be based on either “well-to-wheels” or life cycle emissions rather than tailpipe CO₂ emissions as at present (CE Delft/ICF/ EcoLogic, 2011). Indirect emissions associated with hybrid and battery electric cars are higher than for conventional vehicles.
One approach for incentivising investment in low carbon technologies for electricity generation could be the application of a carbon price based on life cycle emissions rather than direct emissions. In the UK, for example, the Climate Change Levy (CCL) has recently been extended to cover fuels used for electricity generation. Indirect emissions could be taxed, under the current levy regime, along with those associated with direct combustion. The EU Emissions Trading Scheme also establishes a price for carbon. An option would be for trading to reflect life cycle emissions rather than point source emissions.

4.4 Influencing patterns of trade unilaterally
The unilateral application of climate change policies in a given region can result in “carbon leakage” because the competitiveness of energy intensive industries is weakened. Unilateral measures that combat carbon leakage can also protect domestic industry. The ideal way of combating carbon leakage would be through a “border carbon
adjustment” (BCA) whereby tariffs would be applied to imports from countries with weaker climate change policy regimes. BCAs could be introduced unilaterally or as part of the wider climate change international framework. This type of policy would need to be underpinned by LCA analysis. The BCA approach has not been applied but has been the subject of advocacy (Helm, 2012). There have been proposals to introduce BCA type measures in legislation in the EU (French proposal for a “carbon inclusion” mechanism”) and in the US (Waxman-Markey Bill). The debate about BCAs is closely linked to trade policy. BCAs could lead to trade restrictions between countries with different climate policies. Matoo et al (2009) have concluded that BCAs would result in a significant loss of exports from developing countries. A BCA could also fall foul of World Trade Organisation (WTO) rules. However, GATT rules allow carbon taxes as long as they do not result in positive discrimination for domestic products and they are based on environmental and not economic criteria (WTO, 2012). Reaching an international agreement on BCAs would be challenging.

4.5 Informing the current international structure

In principle, consumption-based approaches could influence the UNFCCC climate change regime. The “light” version would be to continue to use territorial emissions to define targets, but to take into account consumption-based emission estimates when setting targets. For example, a country with a growing amount of carbon embodied in imports could be set a more ambitious target in terms of territorial emissions. The consumption-based approach could address issues of equity and shared responsibility. Developed nations have effectively reached their targets by relocating polluting industry overseas, resulting in environmental externalities which have not been priced. Adopting targets on a consumption-based approach could address this externality. Shared responsibility could also encourage the higher participation of developing nations and contribute to more effective climate policies.

The ultimate step would be to base the international architecture on consumption-based approaches. This would be an enormous undertaking given that: a) the process through which the UNFCCC adopts new methodologies is slow and politically challenging; and b) consumption-based emission have intrinsically greater levels of uncertainty and complexity.

5. DISCUSSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

This paper has identified a wide range of existing applications based on life-cycle/consumption-based thinking both in the public policy domain and in the corporate sector. We have distinguished between “soft” and “hard” applications and between LCA-based and input-output-based methods. “Soft” applications are generally of a voluntary nature and are used to inform decision-making; “hard” applications involve compulsion and quantitative criteria, e.g. emission targets or mechanisms for pricing carbon. Fitness for purpose, in terms of data availability, timeliness of data availability, accuracy and deeper uncertainties, are the key to application. “Soft” applications, which entail a lower quality threshold, are most developed. “Hard” applications used to create incentives through the design of regulatory or market-based instruments are still rare. The treatment of bioenergy under the EU Fuel Quality Directive is the most prominent example. In the arena of “hard” applications, the argument that BCAs represent a way forward for climate policy in a world where a comprehensive international agreement has not proved possible has theoretical attractions. A degree of “rough justice” may be possible in establishing the life cycle emission estimates needed to underpin them. Nevertheless, robust and defensible calculations would be needed to stay within WTO rules.

The prospect of taking a consumption-based approach under a comprehensive international climate agreement seems remote. The need to secure wide agreement on methods through IPCC with its 193 member governments, the lower accuracy of consumption-based emission estimates, structural uncertainties in the modelling that
underpins estimates, and the lack of timeliness in generating data all militate against this step.

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