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How can we measure Scotland's footprint? (and, once we have, what do we do with it?)

by Karen Turner

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Introduction

Recent months have seen a great deal of interest and consultation in Scotland regarding environmental and carbon accounting in general, and the calculation and use of ecological and carbon footprints in particular. Ecological footprints are concerned with the global impacts of our consumption decisions in terms of resource use (most commonly focussing on land use), while carbon footprints are concerned with the pollution side of the equation, carbon emissions around the world engendered by our consumption activities. Footprint measures are powerful pedagogic tools for raising interest in, and awareness of, ecological and sustainability issues, and have some valuable characteristics. The notion that consumption is the ultimate driving force behind resource use and pollution generation is a key ecological and economic perspective. Even if our focus is on national targets (for example, meeting UK Kyoto agreements on reducing greenhouse gas emissions), it is important to emphasise the fact that domestic production of goods and services requires a complex interaction between economic sectors, often scattered around the world. In footprint calculations, a large proportion of the resource use and/or pollution generation indirectly embedded in Scottish consumption will occur outwith the boundaries of Scotland (and/or the UK). On the other hand, a large proportion of resource use and pollution generation in Scotland will be driven by consumption decisions in other regions and nations. Thus, in tackling global sustainability problems at the regional or national level, we need examine resource use and pollution generation under what are referred to as 'consumption accounting principles' as well the 'production accounting principles' reflected in standard resource use or emissions inventories.[1]

However, while footprint measures should, in principle, give us an indicator that captures resource use and/or pollution generation according to consumption accounting principles, this article argues that two important issues should be considered before further investment is made in constructing footprints for Scotland:

1. Can (ecological or carbon) footprints currently be calculated accurately for Scotland, and in a way that is comparable with measures for other regions/countries?

2. Even if we can make accurate and comparable footprint measures, would these be any more than contextual indicators that can be monitored, rather than measures of progress that can be influenced by policy and other human actions?

This article considers each of these questions in turn.

The need for transparency, analytical rigour, coverage and consistency in footprint measures, and the application of input-output accounting techniques

A crucial problem with past footprint measures (including, but not limited to, Best Foot Forward Ltd's 2004 ecological footprint analysis for Scotland) has been a lack of transparency, clarity and standardisation in the accounting methods used. Economic measures, such as GDP, are constructed using internationally agreed accounting techniques, and the methods recommended and used detailed in publicly available documents published by relevant statistical agencies. In contrast, accounting methods and data sources for footprint measures tend to have been somewhat opaque and incomplete in terms of coverage of consumption activities and supply chain activities, as well as being inconsistently calculated across different countries and regions. However, reflecting the growing policy, business and public interest in footprint calculations, there have recently been developments in the academic literature to develop standardised techniques using a basic accounting approach that is both transparent and analytically rigorous. This approach is standard input-output analysis applied in a multi-region or country context.

Input-output (hereafter IO) analysis is based around a set of sectorally disaggregated economic accounts (such as those published for Scotland by the Scottish Government on an annual basis). In these accounts, the inputs to each industrial sector, and the subsequent uses of the output for those sectors (by other local sectors and different types of internal and external consumers), are separately identified. The primary function of IO analysis is to quantify the interdependence of sectors within the economy: that is, the extent to which the output of one sector is used as intermediate inputs in the production of other sectors. For example, imagine that electricity is used in the production of plastics, which are then used as an intermediate input in the production of cars, which are subsequently sold to local consumers. IO provides useful mathematical routines to track this energy (and all other direct and indirect intermediate) use embodied within local consumption and other elements of final demand.

IO therefore provides an ideal framework for economic-environmental accounting. If the economic information in the standard economic IO accounts can be augmented with environmental information relating pollution generation and/or resource use to direct production and consumption activity, the formidable analytical tools associated with IO can be utilised. This was first recognised by Leontief (1970), but has been picked up more recently in numerous academic studies that have attempted to develop on Wackernagel and Rees's (1996, 1997) initial ecological footprint concept using IO accounting techniques (see Wiedmann et al, 2007, for a comprehensive review). As explained by Turner et al. (2007a) this would seem a natural development, given that the focus of ecological and/or carbon footprints is to capture the total (direct plus indirect) resource use and/or carbon generation embodied in final consumption in an economy: this is exactly what standard IO 'multiplier' analysis does. Building on earlier work by Munksgaard and Pedersen (2001), Turner et al. (2007a) go on to derive a multi-region input-output method that is appropriate for accounting for emissions and/or resource use under the production and consumption accounting principles (and also determining environmental trade balances as the difference between the two, equating to the differences between resource use and/or emissions embodied in imports and exports to/from the target region).

However, while the multi-region input-output approach to accounting for emissions generation within countries and emissions embodied in trade flows seems to have become accepted in the academic community, it has not yet become common-place in the wider policy and consulting arena. This is most likely in part due to issues of data availability, as a full footprint calculation requires:

1. Domestic input-output accounts reported in an appropriate 'analytical' format (symmetric industry-by-industry or commodity-by-commodity matrices reported in basic, producer prices);

2. Physical pollution and/or resource use coefficients for each sector and consumer, to give a set of environmental IO accounts (with guidance in the form of the Eurostat NAMEA[2] format initiated by Haan, 2001, and applied to the UK by Vaze, 1999);

3. 1 and 2 for each direct or indirect trading partner Interregional and

4. international trade flow data in corresponding IO format.

Other issues that are likely to have so far constrained the application of IO methods for footprint calculations are a lack of policy case studies and the relatively recent nature of developments in the academic literature, as well as the need for non-technical translation and focussed dissemination of these developments.

However, in the case of Scotland, the policy, research, consulting and business communities have recently begun to put a great deal of effort into addressing these issues, particularly in the context of carbon accounting. In large part initiated by the work of the Scottish Government's Steering Group on Additional Measures of Progress[3] and by the recently formed Scottish Carbon Counting Group, a number of open seminars and workshops have been held in Scotland in 2008, with representation from all four broad communities list above, to discuss appropriate accounting techniques and their practical applicability. Particular focus was given to input-output techniques in a workshop sponsored by the Scottish Environment Protection Agency, SEPA) to inform the activities of the Scottish Government's Steering Group on Additional Measures of Progress.[4] This workshop was run by the author of this paper, and included a presentation by Professor Max Munday from the Welsh Economic Research Unit and ESRC-sponsored BRASS centre in Cardiff, who has been involved in similar consultation and developments with regard to economic-environmental accounting and footprint measures in Wales (see Jones et al, 2006, and Munday and Roberts, 2006). A report on this workshop (Turner, 2008) is available from the author on request[5], but a key outcome was a broad consensus on the following points:

- "While the development of the IO framework is resource-intensive, if we have faith in market-based solutions to the problem of climate change, we absolutely need to adopt an IO approach.

- Uses of an environmental IO approach are not limited to footprint calculations. It would facilitate the construction of a wide range of environmental indicators. Therefore, it is likely to represent 'good value for money' to policymakers.

- IO analysis would allow us to develop a better understanding of domestic and direct emissions generation as well as the indirect effects that can be measured through multiplier analysis".

  Turner (2008b, pp.5-6)

At the UK level in particular, there have also been developments in terms of more policy-orientated cases studies, with key proponents of the IO approach to footprint calculations in the consulting community being the Stockholm Environment Institute (SEI), and with crucial interaction on the academic side by the ESRC-sponsored RESOLVE unit at the University of Surrey (see, for example, Druckman et al, 2008). However, a crucial problem in the UK context, despite early developments in the practical application of environmental IO analysis originating with ONS (Vaze, 1997), is the fact that the last set of UK IO tables in the appropriate 'analytical' format for multiplier analyses such as footprint calculations were constructed for 1995.

Given that the economic and environmental positions of Scotland are clearly closely interrelated with those of other regions in the UK, and the UK national economy in general, the absence of appropriate UK IO data is a serious impediment to accurate carbon accounting for Scotland. However, Scotland has a very strong foundation of its own in terms of IO accounting. The Scottish IO team, based within the Office of the Chief Economic Adviser, produces economic IO accounts in analytical format on an annual basis, and consults regularly on potential developments of this basic framework through its Input-Output Expert User Group. Experimental interregional and international trade flow data (item 4 above), reporting Scotland's imports from both the rest of the UK and the rest of the world broken down by commodity have been produced (and used in limited pilot applications of the multi-region IO framework by Ferguson et al (2004) and McGregor et al (2004, 2008). Moreover, the Scottish Government has supported exploratory work into the extension of the Scottish IO framework to environmental applications for a number of years. For example, between 2001 and 2004, the (then) Scottish Executive ran a Scottish Environmental Accounts Working Group, a key output of which was a pilot sectoral CO2 account in IO/NAMEA format (see Turner, 2003). More recently, following the SEPA-sponsored workshop reported in Turner (2008), the Scottish Government's Steering Group on Additional Measures of Progress has made recommendations to consider the formal development of an environmental IO framework for Scotland. In addition, through its participation in Economic and Social Research Council's (ESRC) collaborative governmental studentship programme, the Scottish Government is co-funding a studentship titled 'The Use of Carbon Accounting in Scotland: Consumption and Production Based Measures of Carbon Emissions', due to begin in 2009, which will involve using IO analysis to produce a number of policy case studies applying the production and consumption accounting principles (where footprints fall under the latter). This brings us to our next question:

What could we do with a Scottish environmental IO framework?

As noted above, among the conclusions of the SEPA-sponsored workshop the potential uses of an environmental IO approach are not limited to footprint calculations, and would facilitate the construction of a wide range of

environmental indicators. Munksgaard and Pedersen (2001) demonstrate how emissions and/or resource use can be accounted for under the production and consumption accounting principles using the same IO framework, and corresponding environmental 'trade balances' between any one region/country and the rest of the world derived. Applying the multi-region IO method detailed in Turner et al (2007b), McGregor et al (2008) demonstrate the corresponding calculation of environmental trade balances between any two regions or countries (with an illustrative analysis for Scotland and the rest of the UK), and how a combination of accounting principles can also be applied. For example, they apply the consumption accounting principle to trade flows between Scotland and the rest of the UK, but the production accounting principle at the national, UK, level (to reflect concern with domestic emissions generation under the Kyoto Protocol). An objective of the aforementioned ESRC/Scottish Government collaborative studentship will be to develop this analysis, hopefully aided by the availability of more robust regional and interregional environmental IO data, and drawing on (and perhaps collaborating in) developments made by other teams in the UK, such as the RESOLVE team at Surrey, and internationally (for example, colleagues at the Institute for Sustainability Analysis in Sydney are currently engaged in developing an international multi-region environmental IO framework).

However, in order for Scotland to move forward, and even become one of the world leaders in environmental accounting, including calculation of footprints, it is crucial to lay a solid foundation in terms of developing an appropriate economic-environmental accounting framework. At present economic and environmental data for Scotland are largely reported separately. If we think economic activity is the root cause of most environmental problems, we need to link and integrate economic and environmental accounts. In presenting a pilot NAMEA framework for Scotland, Turner (2003) notes that there are two broad issues in terms of data requirements that must be considered before a sectorally disaggregated economic-environmental database can be reported, and "[T]hese are:

1. The availability of region-specific data for Scotland on sources and generation of emissions.

2. Even if region-specific emissions data of an acceptable quality are available, there is the question of whether these can be reported for a sectoral breakdown that is consistent the Standard Industrial Classification (SIC) used in the economic accounts. If policy is orientated towards influencing activity in economic sectors, clearly there are benefits to environmental data being presented in a format that is consistent with existing economic accounts."

Turner (2003, p.44)

Of course, IO accounting is resource intensive and, therefore, further consultation is required in order to identify how the greatest value-added can be achieved in terms of current policy concerns and objectives within the constraints of the availability and resource implications of appropriate input-output data. However, investment in an appropriate information infrastructure (for a range of economic-environmental accounting measures, not limited to footprints) would seem to be a more sensible priority than further expenditure footprint measures, the accuracy and consequent usefulness of which will be negatively affected by the absence of accurate data describing the economic-environmental relationships that drive our footprint.

If we do develop accurate footprint measures for Scotland, what can we do with them?

A second question was raised at the start of this article. This was, even if we can make accurate and comparable footprint measures, would these be any more than contextual indicators that can be monitored, rather than measures of progress that can be influenced by policy and other human actions? A related question is the regularity of reporting. Presumably, we do not want to measure our footprint (be it carbon or ecological) once, and leave it at that. As Professor Munday argued at the recent SEPA-sponsored workshop (see Turner, 2008), that if government chooses to develop a footprint measure (or measures if both ecological and carbon footprints are required), this will involve a commitment to estimate the selected indicator at regular intervals in order to monitor our progress in terms of (hopefully) reducing its value, and to do so using consistent methodology.

However, a key problem with a footprint measure, even if it is calculated using the type of transparent, rigorous and consistent/comparable method facilitated by adopting an IO approach, is that is just an indicator. If the value of our indicator changes between one year and the next, why did it change? If its value is determined by economic decision-making (e.g. what we consume, the technology we use), can we take action to change it? That is, can we reduce our footprint? This seems to be the key objective underlying measurement of footprints. However, in order to understand why our footprint changes over time, we need to be able to identify policy leavers and causal relationships within the economic system, and between economic and environmental factors. That, is we need to have knowledge of the transmission mechanism between changes in behaviour (which may be induced by policy actions or other factors) and the value of different variables that contribute to our footprint.

The argument for adopting IO techniques to measure indicators such as footprints is that the associated multiplier analysis is a powerful accounting tool for examining the structure of economic activity and associated issues such as the pollution and/or resource use engendered or embodied, directly or indirectly, in production, consumption and trade

flows. However, in terms of modelling the impacts of actual or potential changes in policy or other conditions, IO is limited. Where concern lies in analysing the impacts of changes in policy, or other disturbances, on variables of interest, such as environmental trade balances, a more flexible modelling framework is required. We require a modelling framework that will allow consideration of changes in behaviour on both the supply- and demand-sides of the economy, for example in response to changes in prices. Such a modelling framework[6] would use the IO accounting framework as a database, and, thus, shares its strengths, but introduce more flexible, theory-consistent and realistic representations of economic behaviour and relationships.

However, again, developments are already underway in this respect for Scotland. In October 2008, the author's team at the Department of Economics and University of Strathclyde in Glasgow began work on a project under the ESRC Climate Change Leadership Fellowship programme. This involves building on the type of IO accounting framework outlined above to develop a modelling framework that will contribute to ability of policymakers to fully assess the impacts of alternative policy options on the fulfilment of regional and national targets for reductions in greenhouse gas emissions. It will also incorporate measurement of a range of consumption and production based indicators. This work will involve collaboration with other researchers in a range of fields (including engineers, environmental scientists, economists and other regional scientists) and from a number of different countries (including the UK, US and Australia) and focus on different target economies. However, a basic interregional UK model has already been constructed (see Gilmartin et al, 2008), and will be developed throughout the project, though the quality of this development will clearly depend on the extent to which investment is made by the Scottish Government and ONS in the IO accounting framework outlined and recommended above.

Conclusion

This article has raised questions regarding the accurate and useful calculation of ecological and/or carbon footprints for Scotland. However, it is clear that a number of developments are already underway in Scotland to enhance our analytical capacity in terms of accounting for the environmental impacts of our behaviour and how we may improve our performance. Nonetheless, it is crucial that we continue to direct our efforts, and our public resources, in ways that will ultimately yield the most benefits. The core argument put forward here is that we must continue to invest in the informational and analytical infrastructure, even if this means delaying actual measurement of indicators such as ecological or carbon footprints. Ultimately, these are only useful to us if they are based on good data and sound measurement techniques.

Author note: It is important that the ESRC Climate Change Leadership Fellowship project outlined above will also take account of stakeholder needs in terms of both accounting and modelling work. Formally, this will be done through a series of open seminars and workshops, the first of which will be held in March 2009, and through a project web-site to be set up by the end of the year. Please contact karen.turner@strath.ac.uk if you would like to participate in any seminars or workshops and/or be placed on the mailing list to receive project updates via newsletters and non-technical papers. Informal contact is also most welcome.

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Endnotes

[1] The terminology of consumption and production accounting principles originated with Munksgaard and Pedersen (2001).

[2] NAMEA is an acronym for National Accounting Matrix including Environmental Accounts, which adopts an IO structure, though not necessarily in the analytical format required for the type of multiplier analysis used in footprint calculations.
[3]The Scottish Government convened the Steering Group on Additional Measures of Progress in 2006; it reported to Scottish ministers in the summer of 2008.
[4]. The purpose of the SEPA-sponsored workshop was to investigate issues relating footprint calculations raised by in a collaborative paper (Turner et al, 2007b) produced by the Scottish Government and Fraser of Allander Institute to inform the Steering Group on Additional Measures of Progress regarding the issues associated with different composite measures of sustainability.
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[6]Referred to as a computable general equilibrium (CGE) modelling framework.