Economic perspectives

The impact of the Scottish economy on the local environment: an alternative to the ecological footprint?*

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1 Introduction

In the last month, work partly sponsored by the Scottish Executive produced the first Ecological Footprint for Scotland (Best Foot Forward Ltd, 2004).[1] The Ecological Footprint begins by identifying the resource use and pollution generation that can be attributed, either directly or indirectly, to Scottish private and public consumption. The revealed burden on the environment is then converted to a sustainability score. This is the notional area of land that is required to supply the resources and neutralise the pollutants attributable to this consumption. If this Ecological Footprint value exceeds a critical level, the consumption pattern is identified as "unsustainable". This means that the average citizen is using more than their globally sustainable share of natural resources.

The Ecological Footprint is a powerful pedagogic tool for raising interest in, and awareness of, ecological and sustainability issues. Further, it has certain characteristics that we would be keen to support and retain. The notion that consumption is the ultimate driving force behind resource use and pollution generation is a key ecological and economic perspective. Further, it is of value to emphasise the fact that the production of goods and services requires a complex interaction between economic sectors, often scattered around the world. In the Ecological Footprint calculation, a large proportion of the resource use and pollutant generation indirectly embedded in Scottish consumption will occur outwith the Scottish boundaries.

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However, whilst calculating the Scottish Ecological Footprint is a good start – an effective consciousness raising exercise - it has limitations as a useful environmental accounting measure for the Scottish Executive. In a number of inter-related projects, financed through scotecon and the ESRC, we have attempted to develop an alternative environmental accounting framework based around Input-Output analysis and the more extensive use of Scottish-specific data (Allan et al, 2004; McGregor et al, 2001, Turner, 2003).

2 Limitations of the ecological footprint

There are three main limitations to the Ecological Footprint approach.[2] The first is conceptual. When calculating the Ecological Footprint, consumption in one legal jurisdiction is held responsible for environmental damage that occurs in some other jurisdiction. For example, the energy use embedded in imports that directly or indirectly enter Scottish consumption is attributed to the Scottish consumer. On the other hand, the responsibility for the resource use and pollutant generation associated with the production of Scottish exports is attributed outwith Scotland.

For example, Scotland's Footprint reports, "... rearing 1,000 tonnes of salmon can produce the sewage waste equivalent of a town of 20,000 people" (Best Foot Forward, 2004, p. 11). Given that the annual Scottish farmed salmon output is almost 140,000 tonnes, this implies that this sector generates equivalent to the domestic sewage waste of half the Scottish population. However, in so far as much of the farmed-salmon output is exported, the Ecological Footprint would not identify this as Scotland's responsibility. But no matter what one believes the moral position to be, in practice this is a problem for, and the responsibility of, the Scottish Executive.

Further, even where the environmental implications are global, rather than local, a country's responsibilities usually apply to its own pollutant generation or resource use. Typically countries sign up to treaties to limit their own emissions – not the emissions that are directly and indirectly generated in producing their consumption. For example, Scotland has targets to limit its production of CO_2 as part of the UK's commitment to the Kyoto agreement.

The second problem for the Ecological Footprint is information. To trace through the actual resource and pollutant generation embodied in a region's or country's imports is extremely difficult, and short-cut methods have to be employed (Office of National Statistics, 2002). We shall see that even for Scotland, environmental data are not as good as they should be. Many of the calculations in Scotland's Footprint apply average UK coefficients to Scottish data. We would argue that the Scottish Executive should spend more resources collecting Scottish specific data that relate to pollutant and resource use in Scotland. However, independent of this, it would be desirable to derive environmental accounting measures that do not depend on the accuracy of extensive foreign data.

A third issue is that a key element to the Ecological Footprint is the common measurement scale – the standardised global hectares - against which the pollutant generation and resource use is converted to one index. This index is a brilliant rhetorical device but is less useful for environmental management, which has to deal with individual problems. There are arguments for and against composite environmental and sustainability indices (Turner, 2002) but it seems unwise to give excessive weight to just one.

3 Environmental accounting using Input-Output methods

Input-Output analysis is based around a set of sectorally disaggregated economic accounts. In these accounts, the inputs to each industrial sector, and the subsequent uses of the output for those sectors, are separately identified. The primary function of Input-Output 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. Input-Output 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.

As can be appreciated, Input-Output therefore provides an ideal framework for environmental accounting. If the economic information in the Input-Output accounts can be augmented with environmental information relating pollution generation and resource use to direct production and consumption activity, the formidable analytical tools associated with Input-Output can be used for environmental analysis (Miller and Blair, 1985). This was first recognised by Leontief (1970). Moreover, the tracking of resource use and pollutant generation required for the Ecological Footprint can only be rigorously done through the use of inter-linked consistent Input-Output systems for trading nations (Bicknell et al, 1998).

However, the informational problems previously discussed for the Ecological Footprint emerge again. Often there are limited data on the precise composition of imports and the sectors or elements of final demand for which these are destined. Even if we have this information, we need additionally to know where the imports came from and how they were produced. Essentially we need environmentally augmented Input-Output accounts for all the countries from which the target economy imports and for all the economies that they, in turn, import from etc.[3]

In an attempt to get round these informational problems, we have developed a method that we call the Neo-Classical Linear Attribution System or NCLAS. This method retains local consumption as the driving force behind environmental attribution but allows us to focus on the pollution generation and resource use within the geographical bounds of the appropriate local jurisdiction. It also has the advantage of only needing data from the economy under consideration: we do not need to worry about either detailed economic or environmental information from other economies linked through trade.

This method is a variant of the standard Input-Output multiplier attribution procedure (McGregor et al, 2001; Miller and Blair, 1985). Whereas with the standard Type II Input-Output multiplier employment income and household expenditures are endogenised, in the NCLAS approach trade is endogenised.[4] We label this a neo-classical approach as the economy is assumed to export essentially in order to finance imports (Dixit and Norman, 1980).[5] In this variant, the pollution generation and resource use embodied in an economy's exports are essentially allocated pro rata to the sectors and final demand uses that import. From this viewpoint, the cost of imports, both in economic and environmental terms, is the cost and environmental damage associated with the exports that the local economy has to provide to pay for these imports. Therefore in the example discussed above, the waste generation produced by exported farmed-salmon would be attributed to those sectors and consumption demand in the Scottish economy that import.

4 Scottish environmental attribution: a pilot study

We illustrate these ideas by applying them to Scottish data. Scotland has an important advantage over the other nations and regions of the UK in that the Scottish Executive produces frequent and timely Input-Output accounts for the Scottish economy. We use as a pilot the attribution of one pollutant, the important greenhouse gas, CO_2 for the year 1999.[6]

Table 1 gives the conventional, single-region Type I, attribution results (McGregor et al, 2001). The total Scottish CO_2 generation in 1999 is calculated at 48.9 million tonnes. This can be fully attributed to the elements of final demand indicated in the table. This means that 21.3 million tonnes of CO_2 was generated in Scotland to directly or indirectly support Scottish household consumption, with the production of RUK and ROW exports also making heavy CO_2 demands (13.8 million tonnes and 8.8 million tonnes respectively).

From an environmental accounting perspective, this measure has clear weaknesses. Over half of the CO_2 generation is attributed to exports. Under the Ecological Footprint approach, this would be primarily attributed to public or private consumption outwith Scotland. However, the CO_2 embodied in the imports that enter, directly or indirectly, in Scottish consumption are not reported. We tackle these problems in the following way.

Table 1: The attribution of CO_2 generation (tonnes, millions) within Scotland to elements of final demand

Households	*Government*	*Investment*	*RUK Exports*	*ROW Exports*	*Total*
21.3	3.6	1.4	13.8	8.8	48.9

Table 2: The two-region attribution of UK CO_2 (tonnes, millions) using the Input-Output NCLAS approach

CO_2 generated in	*CO_2 production supported by*				
	Households	*Scottish Government*	*Households*	*RUK Government*	*Total*
Scotland	22.7	3.8	19.7	2.7	48.9
RUK	16.9	3.3	443.7	51.4	515.4
Total	39.6	7.2	463.4	54.1	564.3

First, in order to deal with the imports from the rest of the UK, we have augmented the Scottish Input-Output table with a constructed Input-Output table for the whole of the UK for the same year.[7] Combining the two tables produces a two-region UK Input-Output table, with economic activity within and between Scotland and the Rest of the UK (England, Northern Ireland and Wales) separately identified. In this arrangement we can fully track the inter-regional flow of imports and exports. It is therefore possible to make estimations similar to those in the Ecological Footprint within the UK economy. Such an approach is appropriate given that the two regions are part of the same, albeit devolved, legislative system.

For trade with the rest of the world (ROW), however, we impose the NCLAS assumptions. That is to say, the demand for imports from ROW is treated as a demand for the exports to ROW. As argued earlier, this reflects the view that the role of such exports is to finance these imports. This is also a sensible practical procedure, given that we have no compatible and easily assembled data for the UK's trading partners.[8]

The results are presented in Table 2. To begin, reading along the rows identifies the CO_2 generated within Scotland and the RUK and attributes it to elements of Scottish and RUK public and private consumption. The CO_2 generation in Scotland is less than 10% of the value for the RUK, which broadly reflects the relative sizes of the two economies.

Note first that this attribution produces the same figure for CO_2 generated in Scotland as reported in Table 1. Whilst this method will give a more detailed account of the CO_2 attribution and will distribute this attribution differently across final demands, it is a robust accounting procedure that will always reproduce the control figures for CO_2 production in the two regions. Note also that there is now no longer any pollution attributed to ROW exports. The CO_2 attributed to ROW exports is now redistributed to elements of final demand that directly or indirectly import from the ROW.

Reading down the columns shows the amount of CO_2 generated, in both Scotland and the RUK, that is attributed to a particular element of final consumption. Therefore, the first column indicates that 39.6 million tonnes of CO_2 is generated directly or indirectly for Scottish private (household) consumption and that over 40% of this occurs in the RUK. Scottish public (government) consumption is much less CO_2 intensive, so that the total CO_2 production supported by Scottish government consumption is much lower at 7.2 million tonnes and over 45% of this occurs in the RUK. Combining Scottish private and public consumption shows that 46.8 million tonnes of CO_2 is embedded in Scottish consumption, as against the 48.9 million tonnes that is produced within Scotland. Put another way, the CO_2 generated in the RUK supporting Scottish consumption is less than the CO_2 generated in Scotland supporting RUK consumption.

One point is apparent from Table 2: there are major economic and environmental interdependencies between Scotland and the RUK and, by extension, much of the pollution generated in any UK region is likely to be supporting consumption outwith that region. Given this degree of spatial interdependence, a question must be asked concerning the desirability of having environmental policy delivered at the local level (Oates, 1999). It is not clear how far individual regions will be able to take a UK-wide perspective and some form of co-ordination seems necessary.

A second point is that Scotland runs a CO_2 trade surplus with the RUK. By a trade surplus we mean here that it generates more CO_2 in providing for the consumption requirements of the RUK than the RUK does meeting Scottish consumption needs. Overall, Scotland produces 4.5% more CO_2 than its consumption requires. This differential might be important for the devolution financial settlement (currently determined through the Barnett formula) if some parts of the country bear greater environmental costs than others in meeting national consumption. This issue is likely to be more important where these are local, rather than global, pollutants.

5 Extending the analysis: better data

In attempting to track pollutant attribution within the UK, we have had to estimate some key data and this severely affects the accuracy of the results. The central problem is that the last available appropriate Input-Output table for the UK is 1995. This information had to be "rolled forward" to make it compatible with the 1999 Scottish table.[9] This procedure generates errors. We therefore work here with a high - ten sector - level of industrial aggregation as a greater degree of sectoral resolution would have been misleading. However, this reduces the accuracy and sensitivity of the results.

Second, in these inter-regional calculations we have adopted average UK CO_2 intensity production and consumption coefficients. Although we have Scottish specific figures, these cannot generally be used as there is no corresponding consistently derived data set for the RUK. However, we do introduce region specific information for electricity generation. This is in recognition of the fact that not only is this an extremely important polluting process, but it is also one where Scottish technology, with a relative concentration on hydro-electric power, would be expected to differ strongly from the UK average.

In many respects Scotland is in better position than any other UK region to generate good environmental accounts. The information presented here gives an indication of what could be done. However, this will require the commitment of greater resources than at present to collect environmental information in a way that is compatible with economic data so that a proper economic/environmental accounting system can be put in place.

Further, the environmental position of Scotland is clearly closely inter-related with that of other regions in the UK. Again more information is required on both economic and environmental inter-action between the regions and countries of the UK. In Scotland's Footprint, the authors strongly recommend the collection of more detailed inter-regional trade data in the UK. However, this was rejected in the interim Allsopp Report (Allsopp, 2003) into the appropriate provision of UK regional statistics. We believe that the Allsopp decision is misguided. If the geographic delegation and devolution of economic and environmental policy is to be effective much more accurate and timely inter-regional trade information is needed.

It is important to say that the production of an accurate set of environmental accounts is only the first step. Such accounts give a snapshot of the position at one point in time. They can be used also, if sensitive enough, to monitor progress on environmental targets. However, ideally we need to be able to model and predict the implications of economic and environmental policies in Scotland and the inter-action with the RUK and ROW. But a sound accounting framework is a prerequisite of such modelling activity.

References

Allan, G., Hanley, N.D., McGregor, P.G., Swales, J.K, and Turner, K.R. (2004), "An Extension and Application of the Leontief Pollution Model for Waste Generation and Disposal in Scotland", Strathclyde Discussion Papers in Economics, 04-05.

Allsopp, C. (2003), Review of Statistics for Economic Policymaking: First report to the Chancellor of the Exchequer, the Governor of the Bank of England and the national Statistician, HMSO, London.

Best Foot Forward Ltd. (2004), Scotland's Footprint: A Resource Flow and Ecological Footprint Analysis of Scotland, Best Foot Forward Ltd, Oxford.

Bicknell, K.B., Ball, R.J., Cullen, R. and Bigsby, H.R. (1998), "New Methodology for the Ecological Footprint with an Application to the New Zealand Economy", Ecological Economics, vol. 27, pp. 149-160.

Dixit, A.K. and Norman, V. (1980), Theory of International Trade, Cambridge University Press, Cambridge.

Leontief, W. (1970), 'Environmental Repercussions and the Economic Structure: An Input-Output Approach', Review of Economic Statistics, vol.52, pp.262-277.

McGregor, P.G., McNicoll, I.H. Swales J.K. and Turner K.R. (2001), 'Who Pollutes in Scotland? A Prelude to an Analysis of Sustainability Policies in a Devolved Context', Fraser of Allander Institute, Quarterly Economic Commentary, vol.26, no.3, pp. 23-32.

McGregor, P.G., Swales, J.K. and Turner, K.R. (2004), "An Input-Output Based Alternative to "Ecological Footprints" for Tracking Pollution Generation in a Small Open Economy", Strathclyde Papers in Economics, 04/04.

Miller, R.E. and Blair P.D. (1985), Input-Output Analysis: Foundations and Extensions, Prentice-Hall.

Oates, W.E. (1999), "An Essay on Fiscal Federalism", Journal of Economic Literature, vol. 37, pp. 1120-1149,

Office of National Statistics (2002), "Methodologies for Estimating the Levels of Atmospheric Emissions arising from the Production of Goods Imported into the UK", Report of a project undertaken by the Office of National Statistics, London.

Turner K.R. (2002), "Modelling the Impact of Policy and Other Disturbances on Sustainability Policy Indicators in Jersey: an Economic-Environmental Regional Computable General Equilibrium Analysis", Ph.D. thesis, University of Strathclyde.

Turner, K.R. (2003), "A Pilot Study on Constructing a Scottish Sectoral CO_2 Emissions Account", Fraser of Allander Institute, Quarterly Economic Commentary, vol. 28, no. 3, pp. 43-51.

Van den Bergh, J.C.J.M. and Verbruggen, H. (1999), "Spatial Sustainability, Trade and Indicators: An Evaluation of the "Ecological Footprint"", Ecological Economics, vol. 29, pp. 61-72.

Wackernagel, M. and Rees W. (1996), Our Ecological Footprint: Reducing Human Impact on the Earth, New Society Publishers, Canada.

Wackernagel, M. and Rees, W. (1997), "Perceptual and Structural Barriers to Investing in Natural Capital: Economics from an Ecological Footprint Perspective", Ecological Economics, vol. 21, pp. 3-24.

Endnotes

1. The major sponsor was Biffaward, and other project partners were Best Foot Forward Ltd, EnviroCentre, The Institute of Civil Engineers and Viridis.

2. For a more detailed discussion see Van den Bergh and Verbruggen, (1999) and Wackernagel and Rees (1996, 1997).

3. In their work for New Zealand, Bicknell *et al* (1998) get round this problem by assuming that the economies from which New Zealand directly or indirectly imports have production, trade and environmental structures identical to New Zealand. A more realistic short-cut assumption could be made but clearly such procedures are not optimal.

4. Formally, we treat the export sector as though it were a production sector that transforms exports into imports.

5. This is in contrast to a crude Keynesian or standard Input-Output approach where exports are taken to be exogenous.

6. We concentrate on CO_2 here because it is relatively straightforward to get Scottish specific coefficients because these can be derived from energy use (though in fact we can only make limited use of the Scottish specific coefficients because of limitations in the UK data). The only other pollutant where we have attempted Scottish specific figures is waste (Allan *et al*, 2004).

7. This extends the analysis in McGregor *et al* (2004) which used Jersey data to perform an environmental attribution for a single region set of accounts using the NCLAS principle.

8. For convenience, the investment figures have also been endogenised. The investment demand associated with the output of a particular sector is taken to be a fixed proportion of that sector's "Other Value Added" entry in the Input-Output accounts.

9. 1999 was the most recent year for which Input-Output accounts were available for Scotland when this work was done. The 2000 Scottish figures are now available.