Summary paper on the 'carbon accounting' methodology applied to the assessment of the Scottish Government's 2010-11 budget

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The views expressed here are the authors' own, and are not necessarily the views of the Scottish Government. The full report detailing the results obtained from this assessment can be found at: http://www.scotland.gov.uk/Publications/2009/09/17102339/0.

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Abstract

Hailed by WWF Scotland as a "World First", the Scottish Government in late September 2009 published a Carbon Assessment of their draft 2010-11 budget. Undertaken a year in advance of this assessment becoming a statutory requirement under the Climate Change (Scotland) Act 2009, this exercise produced some interesting results and generated a lot of interest. This article is intended to provide an overview of the exercise that was undertaken, and to highlight and address some outstanding issues that surround the assessment.

Introduction

In an address to the Scottish Parliament on 23rd January 2008 announcing his draft budget for 2009-10, John Swinney MSP, Cabinet Secretary for Finance and Sustainable Growth, outlined his proposals to produce estimates of the green house gas (GHG) embodied in Scottish Government budget spending. "It is a carbon assessment tool that can be applied across all Government spending in Scotland. Taking account of carbon impacts is already part of the best-value duty and it is an auditable requirement in the public sector, but the new carbon assessment tool will be applied to all Government spending in Scotland.[1]" There was already by this time, and continued to be thereafter, a substantial amount of work undertaken to fulfil this commitment.

The consultants PricewaterhouseCoopers were commissioned by the Scottish Government to undertake the initial assessment to determine the best tools to employ in producing a reasonable estimate of the Carbon that is 'supported' through the spending contained in the draft budget. Following consultations and an expert workshop held in November 2008, it was decided that the best methodology to employ in the 2010-11 assessment would be to use an environmentally augmented Input-Output (EIO) analysis. In evidence to the Scottish Parliament's Transport, Infrastructure and Climate Change Committee on 29th September 2009, Dr Thomas Wiedmann- Director of the Centre for Sustainability Accounting, and research associate of the Stockholm Environment Institute at the University of York, commented that the methodology employed in the High Level Carbon Assessment was "exactly the right one".[2] however he cautioned that care needed to be taken in interpreting the results of the assessment. The reason for this qualification will become clearer as we proceed through this article.

The full details of the methodology employed can be found in a paper entitled "Outlining the methodology and issues involved in the Carbon Assessment of the Scottish Government budget for 2010/11" http://www.scotland.gov.uk/Publications/2009/09/17102339/10. The purpose of this article is to give a brief overview of the issues involved, and to highlight some of the criticisms and reactions to the assessment.

The models used

Two separate Input-Output models were utilized in the Carbon assessment of the budget. The first model was an open economy 123-sector Input-Output model for Scotland, augmented with UK emissions intensity data to create an EIO model. The UK pollution intensities that were applied were the GHG intensity of a unit of each sectors output in the UK economy. These GHG-Output coefficients that were calculated were then inflated to the base year of the proposed budget spend (2010-11) using HM Treasury inflators.[3] It is worth noting here, that UK GHG intensity data was utilized throughout this assessment due to the lack of comprehensive Scottish GHG data in a form that is compatible with the Input-Output system.

The second model used was a closed economy 123-sector UK Input-Output model. A UK rather than a Scottish closed-economy model was chosen because the UK economy (and

hence IO model) is broader and therefore more reflective of a world model. For example there are sectors that are not present in the Scottish IO model or economy, such as the tobacco sector, whereas the UK model is broader and encompasses many of the sectors and industries that the Scottish IO system, and hence economy, lacks. Without the utilization of this second closed economy IO model, the first (Scottish) open economy model would not have captured the imports and hence the emissions embodied in imports required to meet the Scottish Government final demand represented in the budget. As a result, the EIO would have underestimated the emissions embodied in the Scottish Government's proposed 2010-11 budget. The methodology applied here in respect of the closed economy model is similar to that adopted by Wiedmann et al (2006) and the interested reader is pointed to their paper for a fuller outline.

The entire analysis was carried out using the Type I and Type II Scottish open-economy and Type I UK closed-economy Leontief Inverses. The distinction between Type I and Type II Leontief analysis is important. Type I Leontief Inverses treat Households as a category of final demand and thus as an exogenous driver of the Input-Output system. Using Type II Leontief Inverses means that we treat Households as a production sector, using their consumption demands as their inputs and their labour services as their outputs. This type of analysis allows us to consider and calculate what is referred to in the literature as the 'induced emission effects'. That is, given that households receive remuneration for their labour services and then use that remuneration to purchase goods and services, and that this gives rise to the pollution being emitted to meet these consumption demands, we can calculate the emissions that are induced through the initial demand for labour services. In this case, these would be the emissions that result from households employment to meet Scottish Government consumption demands.

Running this model required asking the same question of both of these Input-Output systems: what would the direct, indirect (and in the case of the Scottish domestic model the induced) output/emissions generated by an additional spend of X on the output of a particular industry be? In order to do this within the EIO framework, each spending line in the draft budget (at the chosen level of disaggregation) had to be mapped to a single IOC industry category. (The IOC categories are based on the Standard Industry Classification (SIC) scheme which classifies all the industries in the economy by type, and covers all categories of industry in the economy).[4] This was done under the pragmatic principle of assigning each spending line to the IOC industry category of the recipient industry. This is not an exact process and there is necessarily an element of approximation in this aspect of the analysis.

Since the EIO employed was an extension of the UK and Scottish IO tables, and the standard 123 industry tables were available for the UK closed economy model and 126 sector tables were available for the Scottish domestic model, these were used in full for the initial analysis. However as with all IO analyses some aggregation was needed to reconcile the economic Input-Output models with the available environmental data, this reduced the resolution of the analysis. There are inescapable difficulties that occur in using this methodology, some of these were subsequently addressed through adjustments to the core methodology and these are discussed later in this article, others are simply unavoidable issues that always occur in the application of the EIO methodology and must be borne in mind by the reader.

The traditional criticism of the use of this type of demand driven framework for modelling analysis is that it assumes that there are no supply constraints. In other words, given that the Input-Output system embodies the interrelations and industrial linkages of the economy in a particular year to meet a particular level of final demand, it is likely to be the case that the composition of the economy would change if it were required to meet a different level of output. Examples of this would include the exploitation of economies of scale by a particular sector, if say, it were faced by an increase in demand for that sector's output. In this case though we are not asking these models to assess the impact of an entirely new increase in final demand, since the total managed expenditure in the Scottish Government budget (which is included in the existing Scottish IO framework) has been fairly consistent, rising from £27.7 billion in 2005-06 to £33.1 billion in 2008-09. So, while this criticism is still important, it applies more to dynamic modelling questions, and is of less of a concern when looking at the emissions impact of actual demand.

Transportation spending and emissions

On the day that the report itself was published, the immediate concern was that it omitted the environmental impact of people using the new roads that the government's budget was planning to build. To explain, assume that the government earmarked money in the budget to build a new road. The high level assessment that was carried out would include an estimate of the environmental impact of the materials purchased and used in the construction, other expenditure on the actual construction of the road and the impact deriving from the spending of the wages earned by the workers as a result of the construction of the road, but not the use of the road by motorists. This omission has been criticised. However these impacts are not, strictly speaking, totally omitted. The misunderstanding here derives from a lack of clarity over what Input-Output analyses does. The high level EIO analysis **does** include some of the emissions from the use of roads- as distinct from the construction of roads- through the induced emissions effect that operates through the impact on household income of Scottish Government spending.

Consider it like this. People don't just drive their cars (and hence emit pollution) because roads are built or exist – although it does seem likely that we would drive much less if there were no roads! People drive because they need to,

Figure 1: Domestic emissions (direct + indirect + induced) by industrial sector (with all local government spending treated as IOC 115)

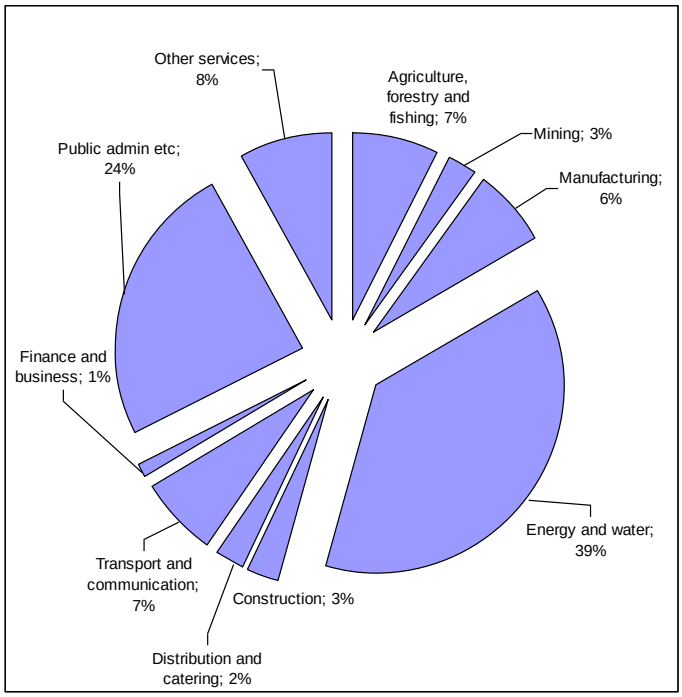


Figure 2: Domestic emissions (direct + indirect + induced) by industrial sector (with the 'General Revenue Grant' and 'Non-Domestic Rate' expenditure on local government disaggregated into 5 separate IOCs)

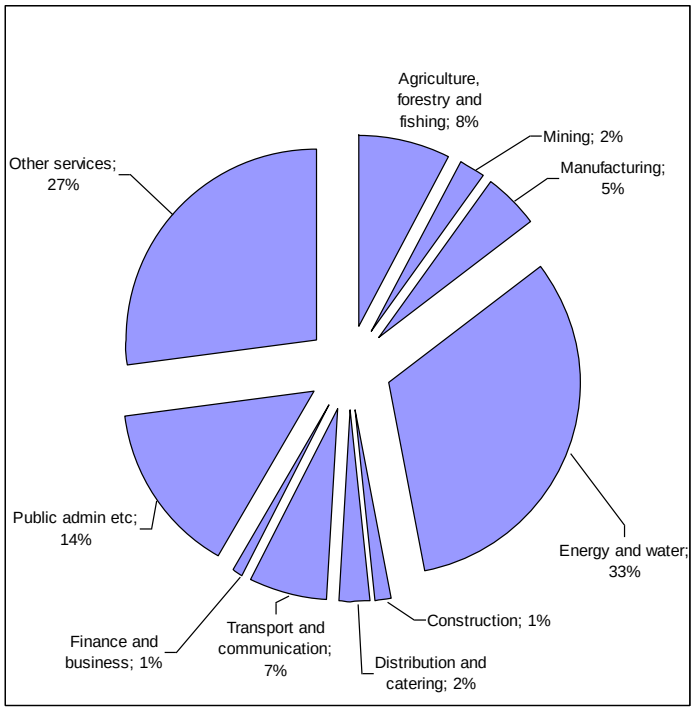
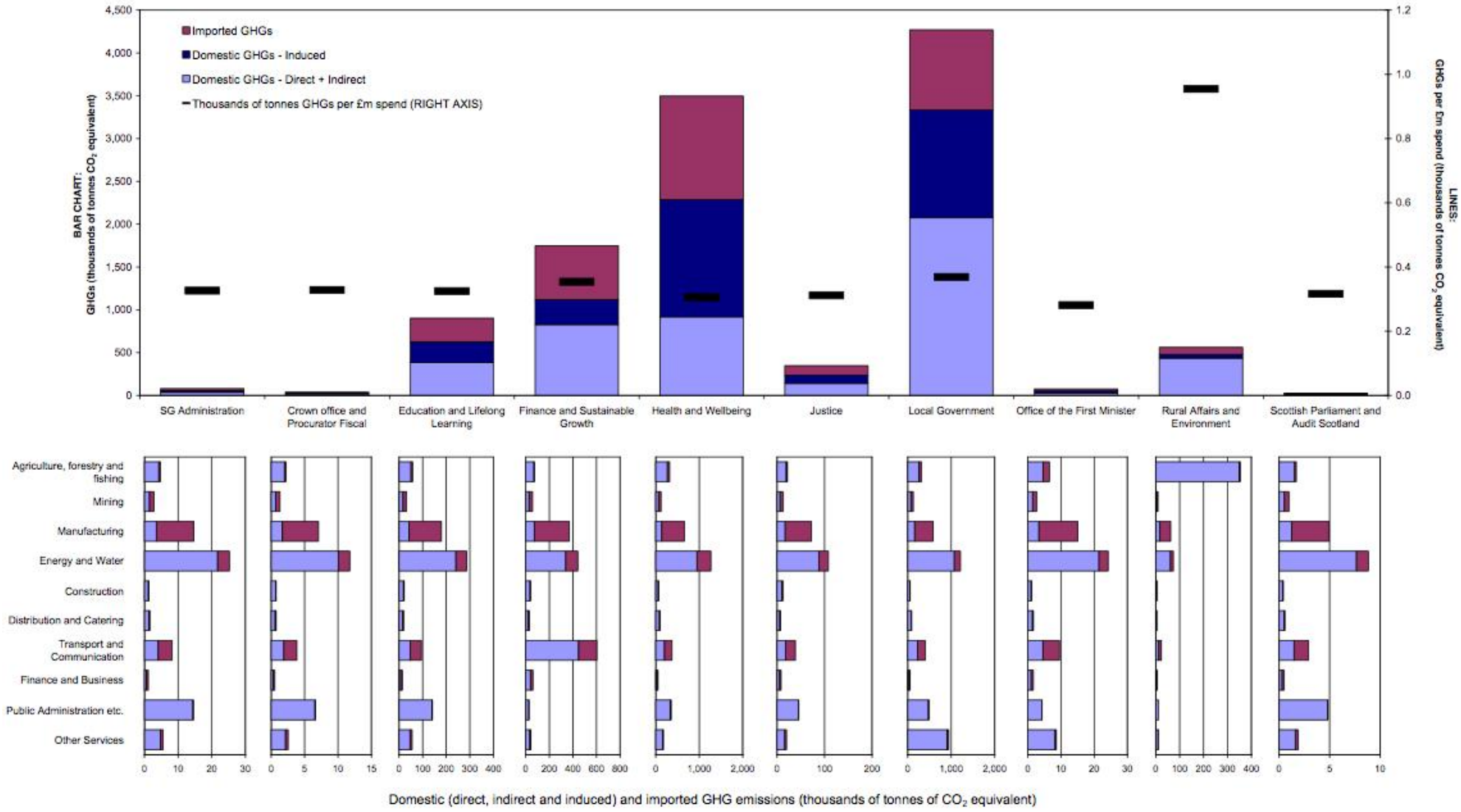


Chart 1: Estimated domestic and imported GHG emission of tonnes of CO2 equivalent) by portfolio and generating industry. Scottish Government Draft Budget 2010/11



but also because they can afford to. If the government builds a new road people may drive more than before, if say it cuts journey times. However car ownership and distance travelled increase primarily with increases in income.[5] The 'household' environmental impacts, which in this case derive from the household spending the income they will receive from the proposed Scottish Government budget, are estimated and included in this assessment. This includes household expenditure, and hence emissions, associated with their transportation demands. So the economy wide 'induced' effect of Government spending, which supports emissions indirectly by paying households for their labour which households then spend on goods and services - the production of which causes pollution - **is** included here

It could be argued that the Scottish Government ought to take into account the effects of its actions (in improving infrastructure) on the behaviour of the entire country, or of every user of that infrastructure. That would require its own distinct analysis of the environmental impact of these improvements in infrastructure. However it is important to point out that in terms of responsibility, the high level assessment of the Scottish Budget does include the environmental impact of the Scottish Government spending on labour services (employees- both civil servants and those employed by businesses that provide goods and services to the Scottish Government) based as with this entire analysis on UK GHG economy wide average data.

The budget analysis should perhaps be augmented with this type of individual level assessments, and indeed this is a point for development that is acknowledged in the report itself, but it is incorrect to say that it does not include the environmental impact of the Scottish Government's budget in supporting road use - it does, but only that element of it that it directly supports through household income and employment. As Dr Wiedmann pointed out to the TICC Committee, in this entire exercise "there is a shared-responsibility perspective, in that the assessment shows the emissions that an activity generates, but the actors who produce those emissions are throughout the economy-they are industry and consumers." [6] This encapsulates an important point about the assessment - that it is an evaluation of the Scottish Government's impact on what is ultimately a shared responsibility across the Scottish economy.

Other adjustments made

There were several tweaks to the standard methodology that were applied in the case of particular items of expenditure. This was done to increase the resolution of the analysis and to try to make the analysis as robust as possible. Here we simply summarise the main adjustments that were made to the standard methodology outlined above. The first item that was adjusted was the categorization of the block grant payments to local authorities contained within the budget. These two transfers, the General Revenue Grant (£8.4bn) and Non-Domestic Rates (£2bn), could simply have been classified in the analysis under IOC 115 (Public Administration), as the closest industry classification for these spending lines.

However using the Scottish input-output tables for Scotland, specifically the Local Authority final demand column, these spend lines were split proportionally over the categories of Local Authority final demand. This increased the resolution of the analysis by considering these spending lines as more than block transfers, but as actual spending by local authorities on goods and services. The effect of this disaggregation is shown below. Figure 1 shows the breakdown with all Scottish Government spending put through as IOC 115 "Public Administration", while Figure 2 shows the emissions breakdown with expenditure on Local Authorities disaggregated into the local authority final demand IOC's. It is clear that this disaggregation changes the composition of emissions supported by Scottish Government transfers to local authorities. The overall emissions levels supported by this expenditure changes as a result of this disaggregation from 4.3 MT of CO2 equivalent to 4.6 MT of CO2 equivalent, an increase of nearly 7%.

Other adjustments were made to the high-level assessment. For example, capital spending lines in the budget were 'top sliced' to account for the proportion of capital spending that were estimated to be spent outwith Scotland- this used gross fixed capital formation imports estimates that are calculated as part of the construction of the Scottish Supply and Use Tables. This was to make the assessment better reflect the emissions that the Scottish Government's consumption supports within Scotland. This top slicing occurred only in the vector applied to the Scottish EIO, not the UK Closed Economy EIO for obvious reasons.

The final adjustment that we will cover here was an adjustment made to all the capital spending lines of the budget. Whilst it is correct to assign revenue spending to the industry receiving the money in a final demand model, when dealing with capital spending (which is itself a final demand category within IO tables) it is not appropriate to do so. In a similar way to the Local Authority disaggregation outlined above, all the capital spending lines in the budget were disaggregated over a number of IOCs. Applying the methodology outlined at the start of this paper would have resulted in many of these spending lines being linked in the EIO with IOC 115 (Public Administration) which would have resulted in large amounts of the capital spend being considered (within the EIO) as being spent on items that were not sensible destinations for capital spending, like IOC 98 'Postal and courier services'.

Instead each capital spending line in the budget was disaggregated across the sectoral destination of Gross Fixed Capital Formation (GFCF) spending using *underlying* Gross Fixed Capital Formation estimates (used in the construction of the Scottish Supply and Use Tables to construct the GFCF columns of the Scottish combined use matrix). These underlying data estimate the types of capital purchases across 29 industry categories. For capital spending items the IOC assigned to the spending line is mapped to one of these 29 broad industry capital spending patterns and the amount allocated across all 126 IOCs accordingly. As would seem reasonable this tends to result in these capital amounts being run through the EIO (mostly) on the construction, computer services and motor vehicles industries.

The results

We do not replicate the full results here; these are available from the full report, which is available at: http://www.scotland.gov.uk/Publications/2009/09/17102339/10. Here we simply summarise and commentate on the main results contained in Chart 1. This chart shows the estimated emissions supported by each portfolio, and also shows the emissions intensity of each portfolio; this is the average level of emissions supported by each Million pounds of spending by that portfolio.

It is clear from Chart 1 that the portfolio whose spending embodies the largest emissions intensity (shown by the black bar on the chart) is the Rural Affairs & Environment portfolio. Similarly the portfolio with the largest total emissions is the portfolio with the largest share of the budget, i.e. Local Government, which in part motivated our earlier adjustment to increase the resolution of the environmental impact of this spending. Further, the lower part of Chart 1 shows the pattern of emissions by emitting industry for each of the corresponding portfolios; these indicate the sectors of the economy that are important in generating the emissions supported by the spending of each cabinet portfolio. So, for example, emissions from the Agriculture, Forestry and Fishing sector is the main source of emissions generated through the spending by the Rural Affairs and Environment portfolio. This may seem strange at first, but when you consider that the classification 'Agriculture, Forestry and Fishing' includes a broad swath of firms that supply and operate in the agricultural sector, it makes sense. A similar analysis can be carried out for each of the other portfolio level results, and the reader is referred to the principal budget document for more information on these.

An interesting result lies in the comparison of the Local Government and Health & Wellbeing emissions estimates above. The total spending in both these portfolios is very similar in size in the draft budget (Health and Wellbeing totals £11,438 Million, and Local Government totals £11,580 Million) however the emissions embodied in this spend is estimated to be quite different. Emissions supported by the spending of the Health & Wellbeing portfolio total 3495.8 thousand tonnes of CO2 equivalent, compared to 4270.5 thousand tonnes of CO2 equivalent for the spending on Local Government in the budget.

The explanation for this difference lies in the nature of the spending patterns across each portfolio. The emissions embodied in spending across the aggregated sectors of the economy shown in the lower part of Chart 1, show that for these two portfolios the emissions patterns are broadly similar. The main difference is that the Local Government portfolio supports far more emissions from the 'Other Services' category. This is indicative of the fact that in the Local Government portfolio, more money is spent on 'Other services' than in the Health & Wellbeing portfolio, and the 'Other Services' category here includes a number of emission intensive sectors like 'Sewage and Sanitary Services'. So while these two portfolios spend similar amounts in total, the differences in their spending patterns does inform, in a realistic way, the emissions estimates that were produced. (All figures used in this example come from table 2 on page 11 of the Carbon Assessment of the Scottish Governments Budget 2010-11 document, available online at: http://www.scotland.gov.uk/Publications/2009/09/17102339/10.)

Concluding remarks

The use of Input-Output analysis for environmental-economic assessments is an important and current area of economic research. The ESRC currently fund a number of researchers looking into the issue of climate change, emissions reductions and carbon assessments from a range of different backgrounds. The Fraser of Allander Institute at the University of Strathclyde currently holds, through Dr Karen Turner, an ESRC Climate Change Leadership Fellowship[7], to look at this issue from an economic perspective for the UK, including regional and interregional analysis within the UK. The regional analysis that the Scottish Government has done in this assessment is unique in the world at the moment, but it is only one part of the far wider array of applications of economic analysis to issues of emissions analysis and the analysis of the environmental impact of the economy.

The Scottish Government is continuing to work on improvements and extensions to the methodology described in this paper, and the scope and nature of future assessments (which are on a statutory footing from 2010) is still to be determined. To this end they have presented these findings and this methodology to a number of academic and policy forums receiving in the process valuable feedback on both the methodology and ideas for the future developments. Comments, suggestions and feedback on this analysis are still sought and we hope that people, having read this article, will feel encouraged to contribute to the debate.

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Endnotes

[1] http://www.scottish.parliament.uk/business/officialReports/meetingsParliament/or-08/sor0123-02.htm#Col5287

[2] Minutes of the Scottish Parliament's Transport, Infrastructure and Climate Change Committee, 29th September 2009, available from: http://www.scottish.parliament.uk/s3/committees/ticc/or-09/tr09-2102.htm

[3] HM Treasury Inflators latest figures available as at 30 June 2009 from: http://www.hm-treasury.gov.uk/data_gdp_fig.htm

[4] The standard industry classification (SIC) is the basis of classifications within these Input-Output and Environmental Input-Output models. Reference hereafter to IOC X is a reference to the input-output classification sector x, where the input-output classification follows the SIC. More details on the standard industry classification are available from: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=14012.

[5] See Dargay and Hanly (2004), Giuliano and Dargay (2005), Giuliano & Narayan (2003) and the UK Department for Transport 'National Transport Model – Working Paper 3' (available at http://www.dft.gov.uk/pgr/economics/ntm/nationaltransportmodelworkin3035) which estimates a GDP-Traffic elasticity of 0.53, that is, in their model, an increase in GDP of 32% results in an increase in traffic of 17%.

[6] Column 2121, Minutes of the Scottish Parliament's Transport, Infrastructure and Climate Change Committee, 29th September 2009, available from: http://www.scottish.parliament.uk/s3/committees/ticc/or-09/tr09-2102.htm

[1] The ESRC Award page for the fellowship, which includes copies of fellowship outputs, is: http://www.esrcsocietytoday.ac.uk/esrcinfocentre/viewawardpage.aspx?awardnumber=RES-066-27-0029