DEVELOPMENT OF AN EMBEDDED CARBON EMISSIONS INDICATOR

A research report to the Department for Environment, Food and Rural Affairs by the Stockholm Environment Institute and the University of Sydney

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Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System

Final Report to the Department for Environment, Food and Rural Affairs

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Views expressed in this report are those of the authors and do not necessarily reflect those of Defra.

Executive Summary

1. This report describes work and results from the project 'Development of an Embedded Carbon Emissions Indicator', undertaken by the Stockholm Environment Institute and the University of Sydney on behalf of Defra (Project Ref.: EV02033). The work is a follow-up of a previous project where the most appropriate approach to constructing a robust account of impacts of trade and thus overall consumption in a headline indicator for Sustainable Development was identified. The present work describes the implementation of such a model.

2. The project aim was to develop and implement an initial data and model framework (called "UK-MRIO 1") for the flexible adaptation of national input-output and environmental databases for use in a multi-region environmental input-output model in the future, thus setting the basis for detailed multi-country analyses of environmental impacts associated with UK trade flows. This aim was not only achieved but actually exceeded in that a fully functional MRIO model with four regions (UK + three world regions) was assembled and a time series of balanced input-output data and embedded CO_2 emissions was produced on the full 123 sector level.

3. An updated review of recent literature on the estimation of emissions embedded in international trade confirms the trend towards accounting for 'consumer emissions' ('carbon consumption') in various countries. In 2007 alone, a respectable number of models has been developed worldwide in order to estimate emissions embedded in international trade of numerous countries and regions. Almost all of the studies present input-output based approaches and the use of multi-region input-output models is already well established.

4. As a tangible outcome of the current project we have constructed a time series of input-output tables for the UK from 1992 to 2004 by using the novel matrix balancing procedure CRAS, which is able to handle conflicting external data and inconsistent constraints. These tables are similar to the "Analytical IO Tables 1995" published by the Office for National Statistics (ONS) and include symmetric input-output tables (SIOT) for domestic transactions and imports for each year from 1992 to 2004. These tables represent an approximation of real economic activity close and robust enough for modelling purposes. The full time series of SIOTs also fills a gap in the public availability of symmetric tables which is due to an ongoing modernisation programme of the National Accounts. The ONS plays an important role in that it holds essential economic and environmental data that could help to improve the accuracy and policy relevance of the model.

5. We have also calculated a time series of direct and indirect carbon dioxide emissions associated with UK economic activities was produced, in particular emissions that are embedded in UK trade. Consumer emissions (CE) are significantly higher than producer emissions (PE) or the UNFCCC national total

(in 2004, CE are 132 Mt or 21% higher than PE and over 200 Mt or 37% higher than the national total reported to the UNFCCC, including overseas territories.

6. CO_2 emissions embedded in imports (EEI) are higher than emissions embedded in exports (EEE) for all years and there is a clear trend towards increasing EEI, which went up from 4.3% of producer emissions in 1997 to 21% in 2004.

7. From the three world regions investigated in this project, the Rest of the World region (which includes Asia) contributes most to EEI. This dominance has increased sharply in the last couple of years while EEI from non-European OECD countries have fallen significantly at the same time.

8. Another interesting result is that from all emissions embedded in UK exports (EEE), 27% came from imports to the UK in 1992; this figure increased steadily over the years ending up with 39% of EEE coming from import sources in 2004.

9. The results for embedded CO_2 emissions from the UK-MRIO 1 model are in line with findings from other researchers. Previous studies applying a range of different methodologies (SRIO, MRIO, MFA) also suggest that more embedded CO_2 emissions are imported to the UK than exported.

10. Most time and resources of the project were devoted to compiling initial data, estimating missing data and balancing conflicting data in the right way as this is the most crucial part of a MRIO framework. This ensures consistency, robustness and repeatability of the whole approach. A sensitivity analysis based on Monte-Carlo simulation will be undertaken as a follow-up project in order to quantify the uncertainty associated with the results.

11. The UK-MRIO system is based on a supply and use table (SUT) framework. This has several advantages, such as better data availability for initial estimates, flexibility of expansion, conservation of sector disaggregation and the option of adopting different technology assumptions for the creation of symmetric tables.

12. Availability of input-output data for both the UK and the Rest of the World (ROW) was reviewed and assessed. Although SUTs are annually published by ONS, these are not suitable for modelling purposes straight away and therefore had to be supplemented with information from Eurostat and balanced before they could be used. Crucial information such as imports and transition matrices are only available from the UK Analytical Tables from 1995 and thus it had to be assumed that the structure of these tables would not change over a period of twelve years. It is hoped that the modernisation of UK National Accounts will eventually provide more up-to-date information useful for (environmental) input-output modelling.

13. For ROW data, several data sources were evaluated towards their suitability for the UK-MRIO 1 model. Data for three major world regions from an earlier study could be obtained from the Netherlands Environmental Assessment Agency (MNP) for the years 1997 and 2001. These transaction matrices from the Global Trade Analysis Project (GTAP) are at a 30-sector level, comprise

OECD-Europe, other OECD and non-OECD countries and were deemed to be best suited for the initial UK-MRIO 1 model as they cover two years and are compatible with the scope of the project.

14. Trade data were taken from HM Revenue and Customs, but only the years from 1995 onwards could be covered with this data source. Great care was taken to obtain an accurate picture of imports to the UK from the three world regions. Total imports were brought in line with totals in the official SUTs provided by ONS.

15. A challenge is posed by detail and classification differences between the economic and environmental (CO_2) data for both the UK and the three world regions. CO_2 emission intensities can only be distinguished for 76 sectors in the UK and 18 sectors abroad, although the model is set up with 123 and 30 sectors, respectively. This is a significant limitation of the current model which needs to be addressed in future work.

16. The current model is a major step towards a fully fledged multi-region input-output model featuring multidirectional trade of a substantial number of UK trading partners. UK-MRIO 1 is already the most detailed and comprehensive modelling approach for the estimation of CO_2 emissions embedded in UK trade with high relevance for national and international environmental policy-making. The model can be used to produce a range of outputs, for example more detailed results for industry sectors, foreign economies, or other pollutants.

17. We suggest that the results from the current UK-MRIO 1 model be published in two ways. First, academic publications in peer-reviewed, scientific journals should be sanctioned and supported in order to get critical feedback on the methodology from the wider scientific community. Second, an 'embedded CO_2 indicator' showing a time series of CO_2 emissions from a consumption perspective ("carbon consumption") should be considered for publication with official UK statistics, alongside already existing greenhouse gas emission trends. This would give a more complete picture of emissions induced by UK economic activity. Even further revisions of method and data are not thought to generally refute the clear and robust trend that has emerged for consumer emissions.

18. Our recommendations for further research include general model expansions and enhancements ("UK-MRIO 2"), improvement of CO_2 and other environmental data, inclusion of individual countries and multi-directional trade, further sector disaggregation, and a comparison of currency conversion options.