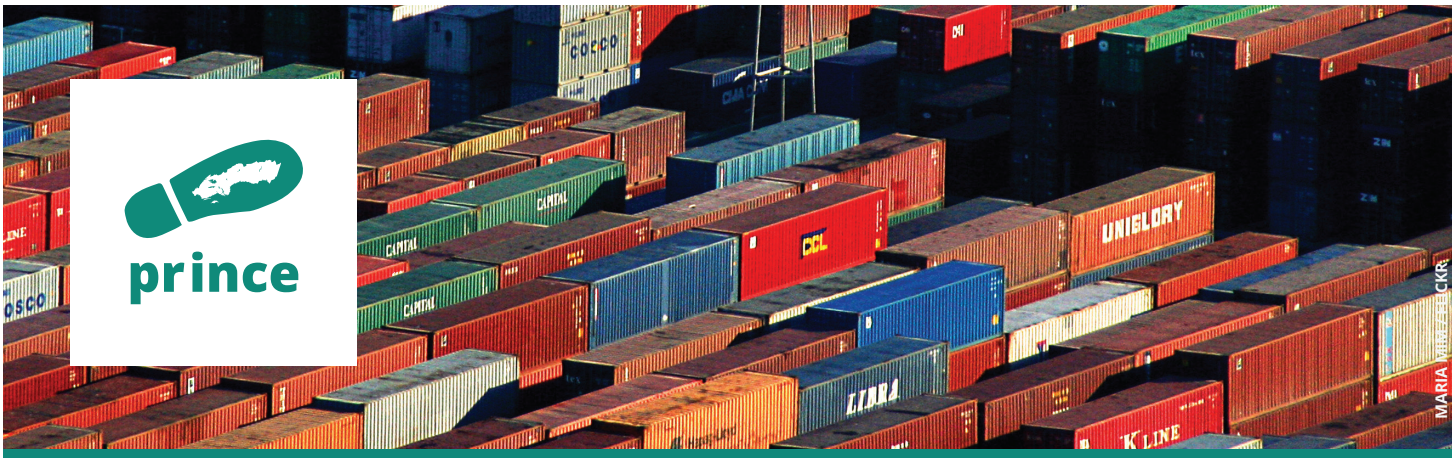

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Environmental Footprinting With Multiregional Input-output Models

The PRINCE project will generate indicators of the environmental pressures linked to Swedish consumption, both at home and in producer countries. This brief outlines how the project will combine Swedish national statistics with an environmentally extended multiregional input-output model to create a comprehensive system for consumption-based national accounting.

In today's globally connected economy the goods we consume are often imported from thousands of kilometres away, using goods and commodities that originate in yet other countries. At the same time material consumption has reached unprecedented levels, imposing high and growing costs in environmental degradation and resource depletion around the world.

These trends go to the heart of the calls in the 2030 Agenda to address global inequalities and move towards sustainable consumption and production patterns – one of the ways that richer, import-dependent countries can contribute to sustainable development.

Some governments and statistical offices are thus seeking better ways to track the total environmental pressures linked to consumption in a national economy – specifically to the impacts of production around the world, not only those associated with domestic production – in order to monitor longer-term change and guide policy.

The PRINCE project in Sweden (see box overleaf) is one such attempt. Sweden provides a good illustration of why such macro-level accounting is important, as recent studies have shown that while greenhouse gas emissions have been falling domestically, the global emissions linked to Sweden's consumption have actually increased markedly since 1990.

The indicator framework being developed by PRINCE builds on environmentally extended input-output modeling. This is the most practical and cost-effective way to create consumption-based environmental accounts at a national (or regional) scale.

This brief gives an overview of some of the main considerations and options in constructing environmentally extended input-output models. In particular it focuses on the use of multiregional input-output (MRIO) models to take account of complex supply chains.

WHY ENVIRONMENTALLY EXTENDED INPUT-OUTPUT MODELING?

An accurate consumption-based environmental accounting system requires three types of information: 1) how much of different goods and services are consumed in the national economy; 2) where goods and services were imported from (and as far as possible, a detailed model of supply chains going all the way back to the original

The PRINCE project

The PRINCE project is developing a system of macro-level consumption-based indicators for Sweden for a wide range of environmental pressures, including greenhouse gas emissions, chemical pollutants and use of resources such as land, water and fish. This system will help monitor progress towards Sweden's Generational Goal:

to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders.

PRINCE responds to a call from the Swedish Environmental Protection Agency (EPA) and Swedish Water and Marine Management Agency (SwAM). The framework developed by PRINCE should be able to produce policy-relevant indicators that can be updated regularly without substantial new research each time, and using the latest techniques. The system should also be compatible with Sweden's national statistics.

PRINCE is being implemented by a research consortium led by Statistics Sweden. It is generously funded by a research grant administered by Naturvårdsverket and SwAM.

production of raw materials and other primary inputs); and 3) the environmental pressures associated with production of the imported goods and services, including of the primary inputs.

Sweden, like many other countries, regularly compiles national supply, use and input-output tables as part of its national accounts. These tables provide detailed information for a given year on production activities, the supply of and demand for goods and services, intermediate consumption (consumption by businesses, aggregated to the industrial sector level), primary inputs and foreign trade.

These tables can be a good starting point for consumption-based accounting, addressing both points 1 and 2 above. When combined with environmental accounts they can also be used to work out what fuels and other resources were required emitted during the production of consumed goods and services, as well as what pollutants were emitted. When data is combined in this way, it is sometimes referred to as an environmental extension to the input-output accounts (see the box opposite).

National input-output tables only show the interactions within a domestic economy. This means that environmental extensions can yield a relatively detailed picture of impacts of domestic production, but they cannot trace impacts along international supply chains, which might include production processes in multiple countries, together with several imports, exports and re-exports along the way.

This is an advantage of multiregional input-output models. MRIOs combine national input-output tables and trade data in order to model flows between the industrial sectors of different economies. Environmentally extended MRIOs can thus produce far more nuanced indicators that take into account the transformation of goods along complex supply chains internationally. This can reveal impact "hotspots" around the world associated with a country's consumption that would be invisible in system based only on national tables.

The extensions in an environmentally extended MRIO can be differentiated by producer country (so that a unit of output from a particular industry in Country A is associated with larger environmental pressures than the same output in Country B) to reflect differences in national environmental policies, practices and technologies.

To date, a handful of global MRIO models are available, and the PRINCE team includes researchers who have been involved in developing many of them.

CHOICE OF APPROACH

Developing an environmentally extended global MRIO takes a lot of time and resources. Therefore, to construct national consumption-based accounts it makes sense to use an existing MRIO. There

Environmental extensions

While the majority of consumption-based environmental accounting results for Sweden have focused on either CO_2 emissions or combined GHG emissions; most commonly the basket of GHGs defined in the Kyoto Protocol.

PRINCE is looking at a much larger range of environmental pressures, including pressures associated with emissions or use of hazardous chemicals, agriculture and other land-based production such as nitrogen and phosphorus pollution, emissions from land-use change, and pressures linked to the use of resources (such as land, water and fish).

In order to determine whether these could be turned into viable environmental extensions (and therefore indicators), the PRINCE team looked at what data was available and how suitable it was (for example level of detail, gaps). Some areas where data is too weak to produce indicators will be the subject of case studies.

are two important decisions to be taken: which MRIO to use, and whether and how to combine the MRIO with the existing domestic economic and environmental extension data.

One of the first activities carried out under PRINCE was to review numerous available assessments and consumption-based data publications regarding Sweden's enviromental footprint, based on the different international and Swedish models, in order to compare and constrast the results. This review focused on greenhouse gases, being the most frequently studied environmental pressures.

The simplest approach for PRINCE would be to use an existing MRIO as the model, including its data for Sweden (including any pre-existing environmental extensions). In addition, while the breakdown of economic activities into industrial sectors in each MRIO varies, they may provide more detail for specific types of policy analysis than the Swedish national accounts (e.g. they may have a larger number of agricultural sectors than the Swedish national accounts).

However, relying solely on an MRIO would sacrifice the high quality and detail of the Swedish national statistics, as the majority of MRIOs have to transform each of the national datasets to make them compatible. The data for Sweden in an MRIO may therefore be quite different to the national accounts (not least in terms of either economic structure or latest year available).

The alternative is to integrate an existing MRIO with the Swedish national data, keeping the Swedish data, as far as possible, largely intact. This option takes advantage of the accuracy and detail about domestic supply chains while retaining the detailed representation of international supply chains in an MRIO, making it more likely to meet more of PRINCE's original project aims and criteria. However, this integration is not without challenges, as discussed below.

INTEGRATING AN MRIO WITH NATIONAL STATISTICS

Some of the most important considerations in choosing an MRIO to integrate with the national accounts for consumption-based monitoring purposes are:

- How often it is likely to be updated
- How compatible it is with the national accounts in terms of economic structure (industrial and service sector breakdown)
- The country/regional breakdown (e.g. the GTAP MRIO divides the world into 129 regions, while the WIOD MRIO has only 40 more aggregated regional groups).

The PRINCE team looked at two main options for integrating Swedish national statistics with an MRIO.

The first is to fully accommodate the Swedish national accounts data in the MRIO, and rebalance the other country data in the MRIO to fit with the Swedish data. The main advantage is that the final model's data for Sweden are kept fully consistent with national accounts. New Swedish data can be added where available and possibly updated without having to update the rest of the model. At the same time, the model retains the detailed international industrial sector transactions and trade data from the MRIO. This approach was taken in an earlier project for the Netherlands (Hoekstra et al. 2013).

A disadvantage, however, is the need to balance and reconcile the MRIO data: this can be time-consuming and how it affects the data for other countries needs to be carefully checked. It may be unfeasible to do this regularly enough for annual monitoring.

The second alternative is to calculate the environmental pressures associated with imports to Sweden in the MRIO and then apply these to Swedish data on imports from each of those countries. This makes use of the MRIO for tracing interactions between international industries and trade, but keeps the Swedish national data intact at the greatest level of detail available, and does not require reconciliation and balancing.

This is relatively simple, but requires that any goods exported from Sweden, processed elsewhere and then re-imported would be dealt with by the MRIO component, rather than by the Swedish national statistics, even though the latter may represent the process more accurately than the MRIO. A study carried out within PRINCE suggests that in an economy like Sweden's, the environmental impacts embodied in these supply chains are small, so it should not have a significant impact on the results. Hence, this is the option chosen for PRINCE, although it may not be appropriate for other economies.

NEXT STEPS

Following the selection of the MRIO and integration approach for PRINCE, the next step is to construct compatible environmental extensions from data identified. All of this data is being examined to select the most appropriate and refine it. It will then be organized in the required framework for linking to the PRINCE database for all countries of the world, and test run. The preliminary results will then be reviewed, and a final indicator set – which can be regularly updated – will be identified based on these results. A set of case studies will also be carried out to further investigate particular environmental pressures of interest once initial results are available.

Further reading

Hoekstra, R., Edens, B., Zult, D., Wu, R., and Wilting, H. 2013. *Environmental Footprints: An Methodological and Empirical Overview from the Perspective of Official Statistics*. http://www.eframeproject.eu/fileadmin/Deliverables/Deliverable6.2.pdf.

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