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FOOTPRINT CALCULATIONS FROM THE PERSPECTIVE OF NATIONAL STATISTICAL INSTITUTES

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Summary:

Multi-regional input-output (MRIO) data is increasingly being used in academia and policy circles to calculate carbon, water and other “footprints”. These calculations are valuable because they provide society with information about the environmental pressures caused by consumption. Furthermore, this type of work can also help to answer other environment-economic questions related to the shifts in environmental burdens between countries (sometimes referred to as “carbon leakage” or the “pollution haven hypothesis”).

Academia and research institutes are doing the bulk of the work in this field, but National Statistical Institutes (NSI) are also increasingly producing footprint indicators. For the most part, these calculations are experimental and the way in which they are calculated varies significantly. The use of MRIO data, or at least partial MRIO data, is common. The availability of new MRIO databases, which aim to be as close to official statistics as possible, creates an opportunity for NSIs, to further refine and improve these statistics.

This paper aims to narrow the gap between the academic literature and NSIs in order to explore the potential for future work on MRIO-based footprints at NSIs. This is done by providing an inventory of the work that is currently being done at NSIs. Furthermore, the MRIO databases that might be useful for NSIs are reviewed and the methodologies used for MRIO databases are contrasted to the production of NSI data. A number of problems (the new SNA guidelines and the new ISIC/CPC classification) are also discussed because these pose a challenge when it comes to establishing a link between the two worlds.

Keywords: multi-regional input-output analysis, carbon footprint, water footprint, ecological footprint, carbon leakage, pollution haven hypothesis, production perspective, consumption perspective, official statistics

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1. Introduction

The last decade has seen the development of many multi-regional input-output (MRIO) databases, many of which include environmental data (Wiedmann et al, 2011). These databases are invaluable tools to help shed light on some very important environmental-economic problems. In particular, these MRIO databases have helped to advance *footprint calculations* and support the discussion about *producer and consumer responsibility* as well as the analysis of *global shifts in environmental pressures*. Researchers that are familiar with these topics will know that they are methodologically very similar, if not identical in some situations. However, because these three applications answer very different research questions, they are first discussed separately.

Footprint calculations

The calculation of "footprints" started with the work on "ecological footprints" in the early 1990s (Rees, 1992, Wackernagel and Rees, 1996).[2] The ecological footprint calculates the amount of land and water (surface area) that is necessary in the production of a certain consumption bundle. For example, the amount of agricultural land that is required to produce food is a component. An important, but often criticised component, is the fictive amount of forest that would be required to sequester the human CO_2 emissions (van den Bergh en Verbruggen, 1999).

The ecological footprint is capable of directly linking human consumption to environmental pressures. It also shows the "overshoot" i.e. the difference between the ecological footprint and the actual area of productive land available to us. This communicative power has led influential institutes such as the World Wildlife Fund to adopt it in their Living Planet Report (WWF, 2010). On the other hand, the methodology of the ecological footprint has also been criticised (van den Bergh and Verbruggen, 1999; Grazi et al., 2007; Fiala, 2008).

The ecological footprint has also inspired researchers to develop other footprint indicators such as the carbon footprint and water footprint (and related indicators such as the raw material requirements). Although the methodologies are currently quite different, there are efforts to harmonize their calculation. For example, in the FP7-project OPEN-EU an effort was made to identify a "family of footprints" by defining the similarities and differences in methodologies and data (Galli et al, 2011). The overall conclusion was that footprints should converge towards the use of MRIO data and techniques for their calculation (Weinzettel et al., 2011).[3]

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[2] Note that the use of input-output techniques to attribute energy use and environmental pressure to consumption started in the late 60s and early 70s (Hoekstra, 2010).

[3] The increased use of input-output techniques is symbolized by the publication of a special issue on the carbon footprint in the *Economic Systems Research* (the journal of the international input-output association) in 2009 (ESR, 2009).

Production versus consumption perspective

Footprint indicators make explicit the environmental pressures that are caused by consumer behaviour. However, their calculation is often used to prove another point as well. It is a strand of the literature which is often referred to as the "production versus consumption perspective" (Peters, 2008; Peter and Hertwich, 2008).

Underlying the discussion is the question: Which environmental pressures is a country responsible for? In the polluter-pays-principle who is the polluter? On the one hand you could say that the industries, which are also responsible for most of the wealth creation in a country, are responsible. This is commonly referred to as the production perspective. Agreements such as the Kyoto Protocol, have a very similar basis because they are based on all greenhouse gas emissions within the geographical boundaries of the country. On the other hand, the consumption perspective is based on the premise that the proverbial "polluter" is the person that consumes the end product of industry. The consumer perspective is captured by calculating environmental footprints because they include all environmental pressures abroad and in the source country.

Global shifts in environmental pressures

In an autarkic country, the totals in environmental pressures according to the producer and consumer perspective would be the same. Differences occur because of trading relationship with other countries in the world. One can therefore observe that all countries have an "environmental trade balance" which is similar to the economic "balance of trade". This environmental trade balance, which is the difference between the environmental pressures embodied in imports and exports, will be changing over time. This may be caused by economic developments as well as institutional agreements such as the Kyoto Protocol on climate change or WTO agreements on trade liberalisation.

A lot of scientific research has been done to analyse these shifts in environmental pressures. Various hypotheses have been proposed. For example, the term "carbon leakage" is often used to label studies that investigate whether countries' emissions under the Kyoto protocol are being reduced by importing emission intensive products from countries that do not participate in the Protocol (Peters, 2008, Weber et al, 2008; Peters and Hertwich, 2006/2008; Babiker, 2005). A related field of research is the "pollution haven hypothesis" that investigates the same shifts from developed to developing countries resulting from differences in environmental regulation (Eskeland and Harisson, 2003;Cole, 2004).

MRIO databases such as WIOD and EORA (see section 3), which have time series, and which also link to socio-economic data (such as wages and productivity) are crucial to understand the shifts in environmental balance of trade and the underlying causal mechanisms.

Similarities

MRIO-based calculations can help to shed light on all three of these research fields. In fact, readers that are familiar with this literature will recognize that in the MRIO setting, the same set of calculations will yield results that are relevant for all three of the above research questions. In other words these calculations yield valuable information about the functioning of societies.

In the scientific literature on these topics the use of MRIO-based models is increasing. The improved availability of MRIO databases is likely to bolster this development.

The role of National Statistical Institutes (NSIs)

The above developments have taken place primarily in the academic realm. However, NSIs are also increasingly looking at these issues. As we will show, quite a few NSIs have developed and published (experimental) calculations, particularly on carbon footprints.

NSIs are governed by the principles of "official statistics", which regulate the quality standards, methodological soundness, institutional impartiality and consistency in the data production. The United Nations has laid down these guidelines in the "Fundamental principles of official statistics".

Given the valuable information which MRIO calculations provide about the environmental performance of a country, there is an argument to produce these indicators on a regular basis at NSIs.[4] This paper will explore whether footprints, based on MRIO data, will be a common and "official" output of NSIs in 5-10 years. What obstacles might there be? How does academic and statistical work differ? Are there ways to remedy these differences? In this paper we hope to bridge the gap between statistics and academia in four ways:

- Producing an inventory of the work on footprinting at NSIs (section 2).
- Reviewing the MRIO databases and methods that may be used by NSIs (section 3)
- Illustrating how MRIO data and NSI data are produced and exploring how these two approaches may be combined. The WIOD (World Input-Output Database) and Statistics Netherlands data are taken as a case study (section 4)
- Producing an overview of problems which both communities will have to face (the recording of goods for processing in the SNA 2008 and the ISIC and CPC revision) (section 5).

[4] Note that these types of calculations can also be applied to other developments in society. The "embodiment" of labor (hours worked), produced capital or knowledge (R&D or education content of labor) could lead to valuable indicators about the global shifts in trade patterns. The potential use of MRIO is therefore broader than environmental applications.

Note that in the remainder of paper we will only be referring to "footprint calculations" despite the fact that in the introduction we have stressed the point that there are other relevant research issues as well. For the sake of clarity we have chosen to only name one of the three research streams in the remainder of the text. We have chosen footprint because this is the most popular variety at NSIs. Nevertheless, it is important for NSIs to realise that the calculations yield valuable information beyond the footprint.

2. Overview of NSI work

Table 1 provides an overview of the NSI work on footprints that is known to the authors. In the second part of the table we have included studies by other government agencies, other than the NSIs, that are also engaged in the analysis and calculation of footprints.[5] In some cases this is done in close cooperation with the NSI.[6] This overview is not exhaustive, but it does provide a good overview of the NSIs and related government institutes that are active in this field.

Several statistical offices (Canada, Denmark, Netherlands) started experimenting with environmentally extended IO analysis in the late 1990s (see for example de Haan, 2004). This was often due to the availability of time series of IO tables in combination with emerging environmental accounting programs. These initial efforts were often based upon the "domestic technology assumption", which assumes that imports are produced with the same production technology as domestic products. In the table we refer to this as the Single Region Input-Output (SRIO) model.

The table shows that several other statistical offices have followed suit. Some use the SRIO approach (Sweden, Eurostat), but the table shows that many of them have started to use partial MRIO models. Partial MRIO models can exist in many forms, but what distinguishes them from comprehensive MRIO tables is that interregional trade flows (at the industry to industry level) are not accounted for. Some countries use country specific emissions but apply the domestic IO table (e.g. Netherlands, Germany) others use in addition country specific IO tables (e.g. Denmark). Differences are due to whether the domestic IO table or the full IO table including imports is put on the diagonal.

The German method is an example of a hybrid method where physical details from the German energy flow account is used to add greater detail to the monetary IO table to ensure consistency with the actual physical energy consumption of industries.

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[5] The OECD also has published on footprint-type calculations (Ahman and Wyckoff, 2003; Nakano et al, 2009).

[6] Note that the principles of official statistics do not state that only the statistics from NSI should be considered "official". Other institutes may also be considered suppliers of official statistics as long as they adhere to the fundamental principles of official statistics laid out by international bodies such as the United Nations and Eurostat.

Only Statistics Canada, DEFRA and PBL have used full-MRIO models. PBL has used GTAP (see section 3), DEFRA and Statistics Canada have constructed their own MRIO databases, often with less regions (4) than the MRIO databases. Overall conclusion is that there is wide range of methods that are used. The availability of MRIO databases could be very useful in the process of standardisation.

Table 1 also contains several columns with additional information. From the column "most recent year" we deduce that carbon footprint data often have a time lag of several years, with the most recent year currently available being 2009. We also observe that the number of regions analysed is often rather small compared to MRIO datasets such as WIOD and GTAP (see section 3).

The focus clearly is on carbon footprints although some NSIs also include a wider range of environmental pressures such as energy or materials. The level of detail used is often 60 industries due to the availability of IO tables in that format.[7]

There is also clear interest in additional breakdowns of household consumption into household characteristics such as income; household composition (family members etc.); location (rural / urban) (4 out of 9 institutes);

Finally, when we look at dissemination practices it is apparent that the results are not always presented as "official statistics". Data are often disseminated in the form of analysis, but not available as official data sets (with exception of Canada, United Kingdom and Eurostat). In Sweden and the Netherlands interactive tools have been developed that allow users to obtain data according to their research interest (calculate your own carbon footprint). This reflects the uneasiness that is often felt in the statistical community to present statistics that are based on input-output modelling assumptions and MRIO databases.

3. Overview of MRIO databases

The calculation of footprint indicators at NSIs stands to benefit from the new MRIO datasets that have been developed or are still under construction. Table 2 lists some of the MRIO datasets that are currently available (or will be published this year). For an overview see Wiedmann et al, 2011.

Table 2 illustrates that the existing datasets are very much different in terms of detail or country coverage; industry breakdown and time series. All data sets seem to suffer from a time lag.

Assume that an NSI wants to use one of the above MRIO databases for its future work on footprints. Which would they choose? This is not a simple question, and it does depend on the exact aims of the NSI.

The GTAP database (or adaptations thereof) is probably the most widely adopted in academic publications. However, in many cases the economic and environmental

[7] As there is no official IO time series for Sweden it was developed from the SUTs.

data differ quite significantly from official sources, making it less of a candidate for work on official statistics. Furthermore, the GTAP consortium warns the users of the data for the risks of using the data in IO modelling; the database is not a repository of IO tables, but a consistent representation of the world economy in a specific base year for use in CGE modelling (GTAP website).

The OECD database is based on official published input-output data but is only updated every 5 years. It also has very few environmental extensions. In practice, it would only be able to yield a carbon footprint once every 5 years.

The EORA database is still under development. It is a very intriguing project because it is supposed to produce a long time series with the largest country coverage of all MRIO databases. The details of the methodology are however still not fully disclosed. The project aims to stay close to official statistics but it not yet clear whether this goal has been achieved.

The WIOD database was released in April 2012 and also is based heavily on official data sources. The fact that the database includes time series in current and constant prices makes WIOD very useful to go beyond footprint calculations and analyse the changes in production and consumption perspectives and the global shifts in environmental pressures. However, our initial judgment is that WIOD looks suitable for carbon footprint, but that the sector structure seems too aggregated for land or water footprints.

EXIOPOL and its successor CREEA provide a more detailed sector structure and are therefore better suited to environmental applications. Nevertheless, the fact that it does not have a time series (or a very recent year) is a drawback.

In short, there is no “perfect” MRIO database available yet. WIOD seems to be a good candidate for a carbon footprint, although its performance needs to be tested. However, when it comes to land or water footprint, databases such as EXIOPOL/CREEA seem more robust. Perhaps when the EORA database is released, it will also prove to be valuable resource for footprint work.

Table 1: Overview of footprint calculations at NSI's and other government agencies

NSI/Other	Institute	Country	Type	Country specific IO	Most recent year	Environmental	Regions	Industries	Data online	Household characteristics	Interactive
National Statistical Institutes	Statistics Canada	Canada	MRIO	Y	2002 and 2006	GHG	4	?	Y	N	N
	Statistics Denmark	Denmark	Partial	Y	2005	CO_2	13	60	N	Y	N
	Eurostat	Eurostat	SRIO	N	2000-2007	8 pressures	2	64	Y	N	N
	INSEE	France	Partial	Y	2005	CO_2	±15	60	N	Y	N
	DESTATIS	Germany	Partial	Y	2007	CO_2	14	73	N	N	N
	Statistics Netherlands	Netherlands	Partial	N	2009	GHG (4	17	60	N	Y	Y
	Statistics Sweden	Sweden	SRIO	N	1993-2008	Energy; materials; air emissions	2	134	Y	Y	Y
Other government agencies	PBL Netherlands Environmental Assessment Agency	Netherlands	Partial and MRIO	Y	2001	GHG (3) and land	13	57	N	N	N
	DEFRA	United Kingdom	MRIO	Y	1990-2009	CO_2 and GHG	4	123	Y	N	N

References: Statistics Canada (Statistics Canada, 2012); Statistics Denmark (Rørmose et al, 2009); Eurostat (Eurostat, 2012); INSEE (Lenglart, 2010); DESTATIS (DESTATIS, 2010); Statistics Netherlands (Edens et al, 2011; Statistics Netherlands, 2010; 2011); Statistics Sweden (Statistics Sweden 2003); PBL Netherlands Environmental Assessment Agency (Nijdam et al., 2005; Wilting and Vringer, 2009; Wilting, forthcoming); DEFRA (DEFRA, 2012; Wiedmann et al, 2008).

Table 2. Overview of databases-Summary

	GTAP	EXIOPOL/ CREEA	WIOD	EORA	OECD
Acronym	Global Trade Analysis Project	EXIOPOL: Externality data and input-output tools for policy analysis CREEA: Compiling and refining environmental and economic accounts	World Input-Output Database	-	-
Institute	Purdue University	EXIOPOL: FP6 project lead by FEEM CREEA: FP7 project lead by TNO	FP7 project lead by the University of Groningen	University of Sydney	OECD
Website	www.gtap.agecon.purdue.edu	www.feem-project.net/exiopol/ www.creea.eu/	www.wiod.org	www.worldmrio.com	-
Years	1997, 2001, 2004, 2007 (years are not comparable)	2000 (EXIOPOL) 2007 (CREEA)	1995-2009	1990-2009	1995, 2000
Prices of previous year	-	-	1995-2006	-	-
Countries/ Regions	66-129 (depends on year)	43 (27 EU, 16 non-EU) (95% of the global GDP)	35 (27 EU and 12 non-EU) (80% of world GDP in 2006)	187	41 (90% of global GDP) (67% of global population in 2000)
Industries	57 sectors	130	37	100-500 sectors	17
Environmental data	Greenhouse gases (CO_2, NO_2, CH_4) Energy use Land use (split agro-ecological zone)	Emissions (56) Materials (96) Land use (15) Water use (14)	Energy use / several energy carriers Water consumption Land use Emissions of greenhouse gases Air pollutants Resource use/extraction Generation and treatment of various types of waste	Greenhouse gases Air pollution Water use Ecological Footprint	CO_2

4. Difference between MRIO data and official statistics

The previous section discussed the choice of an MRIO database that could be adopted at NSIs. Many of the MRIO projects claim to stay as close to official statistics as possible. Nevertheless, any NSI that analyses the data will find that these are different to the national accounts and trade data that they publish. In this section we will take a closer look at where these differences, which are often inevitable, arise in the MRIO production process.[8]

As a case study we have chosen to look at the data production process at Statistics Netherlands and how this relates to the production of the WIOD database. Figure 1 shows the most important relationships, although the details are of course much more complex.

We focus for the moment on the carbon footprint modelling in which input-output data is combined with the environmental accounts for greenhouse gases (see the dotted boxes on the left (CBS) and right side (WIOD) of the figure).

Statistics Netherlands/international databases

SUT/IOT: Statistics Netherlands produces detailed supply and use tables which distinguish approximately 600 different products and about 130 industries at its most detailed level. These SUTs are the basis for the production of the industry-by-industry input-output tables which are available at 133 industries for analytical purposes. The input-output tables are not produced using a simple mathematical procedure such as the "industry technology assumption", which is often used in MRIO work. A manual procedure is used in which the source and destination is specified for each product group.

The SUT/IOT tables are sent to Eurostat every year, in the format and frequency requested.[9] There is however a conceptual difference in the treatment of trade margins, as is explained in box 1.

Environmental accounts: Environmental accounting has a long history at Statistics Netherlands. A large range of different accounts are produced, including the

[8] Note that when the calculations are done using the domestic technology assumption, only official statistics are used. However, the scientific literature shows that this assumption does not provide a very good estimate of the actual emission abroad (Battjes et al., 1998; Lenzen et al., 2004; Andrew et al., 2009; Tukker et al, 2011).

[9] ESA95 Questionnaire 1500 - Supply table at basic prices; ESA95 Questionnaire 1600 - Use table at purchasers' prices; ESA95 Questionnaire 1700 - Symmetric input-output table at basic prices; ESA95 Questionnaire 1850 - Symmetric input-output table for domestic production; ESA95 Questionnaire 1950 - Symmetric input-output table for imports

emission of greenhouse gases from 1990 to the present. The industry breakdown is about 70 sectors.

These environmental accounts data are provided to Eurostat as part of the compulsory EU-transmission of environmental accounts data.

International trade statistics: Statistics Netherlands produces monthly data for trade of goods as part of the INTRASTAT deliveries. International trade in services data are also compiled by Statistics Netherlands (from 2003 onwards - before that it was collected by the Dutch Central Bank).

The data on trade in goods is transmitted to the Eurostat databases (COMEXT) and the United Nations database (COMTRADE).

Box 1. Treatment of margins in the Dutch input-output table

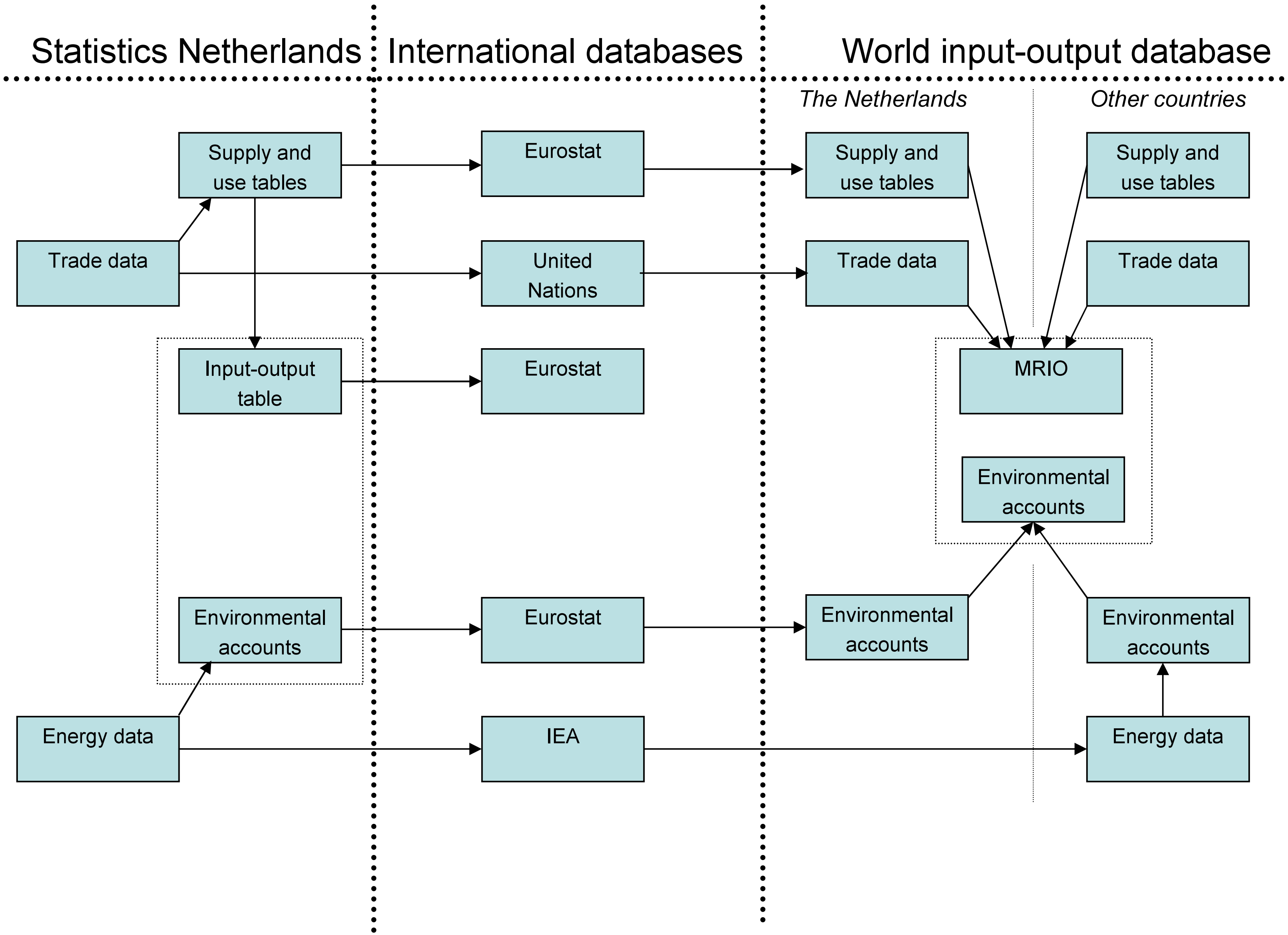
In the official IO tables, the trade and transport margins are kept outside the intermediate demand block; essentially they are an additional row and an additional final demand column. In the Eurostat tables, the trade and transport margins are consolidated with the wholesale and retail trade and transport industries. As we do not know the destination of the margins that are being produced, for our own environmental input-output analyses we have treated the production of margins as a pseudo-activity. This practice is however not compatible with an MRIO framework, since this is not the way which other countries classify margins.

WIOD database

In essence the WIOD database is constructed using data from Statistics Netherlands, because it uses the Dutch data from international databases. The SUTs and environmental accounts are derived from Eurostat. Trade in goods is derived from COMTRADE. The energy data that is used to estimate CO_2 emissions are derived from the International Energy Agency (IEA) database. The IEA data is used to produce the air emissions data, including greenhouse gas emissions. In earlier stages, the WIOD consortium wanted to use environmental accounting data for some countries. It is not yet known to us, whether this is the case for the Netherlands. Note that the input-output data that is delivered to Eurostat is not used.

In the process of producing the WIOD database the SUTs are combined with the international trade data. The latter provide information about the bilateral trade flows, and are used to create trade shares which are used to split international in the SUTs. This yields asymmetries are resolved. After this reconciliation, the industry technology assumption is used to produce the full MRIO tables.

Figure 1. The production of the WIOD database from the perspective of Statistics Netherlands



Potential differences in data for the Netherlands - WIOD versus Statistics Netherlands

In the WIOD database the information for the Netherlands will be different to the information provided by Statistics Netherlands. This also means that the input-output analysis, based on the two databases, will differ. The main sources of differences are the following:

- Dutch SUT. Box 1 has discussed the conceptual differences between the SUT and IOT which is used for the Statistics Netherlands calculations. The Dutch input-output analysis would therefore take place using a different conceptual basis as well as a different aggregation level.
- Trade in goods data
    - Classification conversions. The source statistics for trade in goods are very detailed with over 10,000 products being distinguished. These are provided to the National accounts department which use a classification scheme of about 600 commodities. These are converted to the CPA classification for the delivery to Eurostat.
    - Conceptual differences. Trade in goods is defined differently in the COMEXT database when compared to SUTs because the latter excludes transit trade.
- Trade asymmetries. One of the largest problems in trade statistics is the existence of trade asymmetries i.e. the fact that the import statistics show a different value to export statistics. By definition, any solution will cause the national SUTs to be altered.
- Conversion of the SUT to IOT. In the WIOD procedure a simple mathematical procedure (the industry technology assumption) is used to produce input-output tables. In the case of producing an input-output table at the Statistics Netherlands, a manual method is used.

Strategies to use Statistics Netherlands data and MRIO data

The WIOD data for Netherlands will therefore not be equivalent to the official data published by Statistics Netherlands. The very nature of the source data (such as the trade asymmetries) makes it impossible to produce an MRIO database that is consistent to all underlying country statistics.

Nevertheless, it is conceivable that the WIOD database could still be made useful for official statistics purposes. Figure 1 makes it clear that there are several ways in which WIOD data can be combined with Dutch data:

1) MRIO level (outcome level): the Dutch official IO is inserted into the WIOD input-output table and subsequently the system (without adjusting the Dutch data) would need to be rebalanced. In that way, a custom-made WIOD-based database is created for the Netherlands.

2) (international) SUT level (intermediate level): WIOD uses international import flows from WITS (which is sourced with COMTRADE data (Erumbana et al 2010) to split up the country specific SUTs. This procedure could be modified by:

   a. Using a more detailed Dutch SUT with a larger number of products to compile the international Dutch SUT;

   b. Using Dutch trade data to split the Dutch imports and exports in the Dutch supply and use tables.

   It remains to be seen how easy the system could be made to balance after these adjustments are made to international SUTs.

3) WIOD as data source (basic level) for a new to construct MRIO[10] which would be built around official Dutch data (input-output and trade data). Most likely such a new MRIO would require fewer regions than WIOD in order to be useful for Dutch policy analysis.

5. Potential problems

There are two quite important changes that are currently having a large influence on the national accounts data that are published in the near future. They will therefore be of influence on the updates of MRIO databases.

5.1 Treatment of goods for processing in the SNA-2008

The System of National Accounts revision in 2008 has chosen to strictly follow the change of ownership criterion when recording transactions between units. This has major ramifications for input-output analysis as it drives a wedge between monetary supply and use tables and the physical supply and use tables. These 2008 SNA recommendations were felt necessary to ensure quality of economic statistics as it is much more aligned with business statistics.

Let us consider the following realistic example for the Netherlands (Van Rossum et al 2010):

An oil refinery plant (the processor) –resident in the Dutch economic territory - converts 75 million € worth of crude oil into 100 million € worth of petrol. The crude oil is owned by a foreign parent company and shipped in from abroad. The foreign parent sells the petrol abroad. The oil refinery plant is receiving processing fees from the parent company to compensate for operational costs.

[10] Although it may partly be a semantic issue whether this would be a new MRIO fed by WIOD (or other databases) or a modified WIOD.

The differences between the 1993 SNA and 2008 SNA recording of this economic activity are illustrated in the table below. 1993 SNA demands the imputation of a transfer of ownership. In this way the output of petrol and intermediate consumption of crude oil is explicitly covered in the production account of the oil refinery plant. The new national accounting guidelines do no longer allow this imputation and as a result imports of crude oil and exports of petrol are no longer recorded. Instead exports consist only of industrial services delivered to the owner of all products (crude oil and petrol).

Although value added remains the same, the recording of imports and exports and production changes significantly (see Table 3).

Table 3. Global manufacturing: inward industrial processing

According to SNA 1993		
Output of petrol	100	
Intermediate use of crude oil		75
Value added		25
Import of crude oil	75	
Exports of petrol		100
According to SNA 2008		
Output of industrial services	25	
Value added		25
Export of industrial services		25

In short: the new recording requirements drive a wedge between a physical and monetary description of the economy. For instance, as the chimney of our refinery will continue to smoke, large changes in emission coefficients will occur that reflect not only technical efficiencies but also legal / economic circumstances. Processors will have high emission coefficients (same emissions, much lower production). Emission coefficients between countries can no longer be easily compared. Moreover, using trade statistics (which is based on the cross-border principle and does not follow the SNA ownership criterion) to compile international SUTs (as in WIOD) becomes problematic as estimated ratio's (across countries) calculated for gross trade (e.g product) will be a mismatch to actual trade flows which (partly) cover trade in services.

This issue was addressed during the revision process of System of Environmental and Economic Accounting (SEEA). Essentially, two options were discussed:

- 2008 SNA SUT/IO tables are modified by adding monetary imports and exports information regarding processors: in other words, we continue to compile 1993 SNA based IO tables.

- Processors and regular manufacturers are separately identified in the IO table which would therefore obtain additional row(s) and column(s); each with their own emission coefficients.

The SEEA Central Framework recommends:

"in situations of goods send to other countries for processing or repair, or in cases of merchanting, the SEEA Central Framework recommends recording the actual physical flows of goods in those cases where the ownership of those goods does not change but remains with a resident of the originating country. No change to the monetary recording of these flows is recommended. This variation is particularly applicable in recording physical flows associated with the processing of raw materials (e.g. oil refining) where the physical flows may be largely invariant to the nature of the contractual relationships which are the focus of the recording of monetary flows in the SNA and the Balance of Payments." (UN 2012 1.43)

When doing environmental input-output analysis, monetary SUTs (or IO tables) would need to be adjusted, preferably according to the first option. Statistics Netherlands is conducting a project this year were such adjustments will be made. To give a rough idea, during the SNA revision process the recording of about 80 (large) companies in the Netherlands is being changed (in case of inward processing). This implies changes of the order of billions of euros in International Trade Statistics. It is not inconceivable that this issue is more problematic in the Netherlands than in other countries, due to the large (international) trade sector. Nevertheless, this issue clearly warrants more research.

5.2 ISIC and CPC revision

In addition to the conceptual revision (from 1993 SNA towards 2008 SNA), two technical revisions are being implemented by National accounts programs: the transition from ISIC rev 3.1 towards ISIC rev 4, and CPC Ver. 1.1 towards CPC Ver. 2. The ISIC revision has already been implemented in the Dutch National accounts for 2010 (Statistics Netherlands 2011) but the CPC revision will only be implemented together with the conceptual revision (2014).

As Table 4 illustrates, the ISIC transition is a difficult one in the sense that it is often not 1-1 and requires splitting up many industries. Major changes are that more detail in introduced in the services sectors (e.g. financial; real estate and business services are now disaggregated); but for instance also repair services has become a separate activity; important for E-IO is that there have been changes regarding the treatment of waste, wastewater treatment and recycling. (see Statistics Netherlands 2011 for more detail).

In the Netherlands the transition matrix was compiled based on employment data available in our business register. Time series of IO and SUTs have been made until 1988. In 2012 a time series will be made available from 1969 onwards.

Table 4. Transition matrix from ISIC rev 3.1 towards ISIC rev 4. (from Statistics Netherlands 2011b)

SBI 2008 / SBI '93	1 Landbouw, bosbouw en visserij	2 Delfstoffenwinning	3 Industrie	4 Energie- en waterleidingbedrijven	5 Bouwnijverheid	6 Handel, horeca en reparatie	7 Vervoer, opslag en communicatie	8 Financiële en zakelijke dienstverlening	9 Overheid	10 Zorg en overige dienstverlening	Totaal
1 Landbouw, bosbouw en visserij	25 368	–	–	–	–	–	–	–	–	–	25 368
2 Delfstoffenwinning	–	20 716	–	–	–	–	–	–	–	–	20 716
3 Industrie	–	28	268 624	–	–	–	–	14	–	–	268 666
4 Energiebedrijven	–	–	–	33 271	–	–	–	–	–	–	33 271
5 Waterbedrijven en afvalbeheer	–	–	1 151	1 604	–	–	–	–	–	8 187	10 942
6 Bouwnijverheid	–	–		–	78 211	–	–	2 243	–	–	80 454
7 Handel, vervoer en horeca	–	–		–	–	135 955	52 458	–	–	–	188 413
8 Informatie en communicatie	–	–	7 976	–	–	–	20 249	19 070	–	5 867	53 162
9 Financiële dienstverlening	–	–	–	–	–	–	–	61 648	–	–	61 648
10 Exploitatie van en handel in onroerend goed	–	–	–	–	–	–	–	57 249	–	–	57 249
11 Zakelijke dienstverlening	1 710	–	–	–	–	–	5 288	102 301	–	1 252	110 551
12 Overheid en zorg	–	–	–	–	–	–	–	–	89 559	61 550	151 109
13 Cultuur, recreatie, overige diensten	–	–	336	–	–	312	–	194	–	23 130	23 972
Totaal	27 078	20 744	278 087	34 875	78 211	136 267	77 995	242 719	89 559	99 986	1 085 521

Changes in ISIC classification will be important for the possibilities to do E-IO analysis based upon MRIO models for recent years, given that source data has been changed already. For example in the UK (DEFRA 2012), data according to the new classification has been re-allocated towards the old classification in order to do the 2009 calculations.

It needs to be assessed whether MRIO time series such as WIOD should be upgraded taking both technical and conceptual revisions into account all at once (but then there is a need to wait for 2014 at least) or whether ISIC revision should be dealt with as soon as possible.

Dealing with the ISIC revision itself seems to require input country specific allocation matrices as presented in Table 2.

6. Conclusions

This paper has tried to bridge the gap between academic MRIO-work and statistical work on footprints. Four areas have been explored:

NSI work on footprints.

In this paper we have provided an inventory of nine known publications (by NSIs and related institutes) that have produced footprints. Most work is focused on carbon footprints, but the methods adopted vary significantly. It is clear that many of the institutes see these calculations as highly relevant, but do not yet see them as "official statistics".

MRIO databases available to NSI

The WIOD database is very useful for analysis of the carbon footprint because it provides a time series (in current and constant prices). However, its sector structure is less suitable for the land and water footprints. For this the EXIOPOL/CREEA database seems more suitable, but has the drawback that it has no time series data.

The EORA database, which is not yet public, also promises to be an interesting addition to the MRIO collection. It has a number of potential advantages (sector structure, country coverage, time series) but the details of its construction are not yet fully disclosed.

Strategies to use MRIO data for official statistics

To start adopting MRIO-based footprint at NSIs, NSI data will have to be combined with MRIO data from one or more MRIO databases. More research is needed before definitive choices can be made.

Statistical problems that will complicate the use of MRIO data

In this paper, two problems have been described which will pose a problem for future instalments of the MRIO databases: the new guidelines in the SNA-2008 on goods for processing (SNA-2008) as well as the new ISIC and CPC revisions.

7. Future work

In 2012, Statistics Netherlands and the Netherlands Environmental Assessment Agency are poised to develop a monitoring system for footprints of Dutch consumption starting with the carbon footprint. Building on the experiences with the carbon footprint modelling, IO-based systems for monitoring land, water and natural resource footprints will be developed in following years. The project starts with the compilation of a time series of carbon footprints for a historic period (1990-2010) and will provide updating techniques for calculating footprints in the most recent years (up to the previous year).

A multi-regional input-output model in which Dutch data from Statistics Netherlands will be combined with country-specific data obtained from MRIO databases like WIOD, EXIOPOL/CREEA and EORA (if available) seems to be the most promising approach in advance. For all years, the domestic part of the carbon footprint will be based on data obtained from Dutch national accounts. Where a detailed annual calculation of the foreign part of the footprint is not feasible, these emissions will be calculated in full detail for a limited number of years, e.g. every five year, and an interpolation procedure will be developed for the intervening years. Similarly, an extrapolation procedure will be developed for the most recent years.

During the project several modelling issues will be explored, such as selecting from a partial and full MRIO model, the number of regions that have to be included and the role of a rest of the world region. Selection criteria will be formulated for the trading partners that are most important from the perspective of greenhouse gas emissions. All efforts have to lead to a monitoring system that is useful for analyses that are relevant for Dutch environmental policies.

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