

The Environmental Footprints Explorer - a database for global sustainable accounting

June 5, 2015

Environmentally extended Multi Regional Input Output tables and analysis (EE MRIOs) have emerged as one of the main tools to analyze resource use and environmental impacts across international supply chains. They provide insights into the life cycle impacts of the production and consumption of commodities world wide, taking into account the global supply chain of purchased commodities.

Currently half a dozen EE MRIO databases are available which differ in their environmental and economic focus as well as in the level of detail. As these databases become increasingly large, it has become increasingly difficult for the non-input-output expert to access the most important attributes and results of basic calculations.

Here we present an unifying web-platform, the Environmental Footprints Explorer, designed to access indicator results calculated based on these databases. The main functionality of the web-platform include (1) in detail exploration of a single database (2) comparison between databases using a common classification system and (3) exporting analysis results and API access to these.

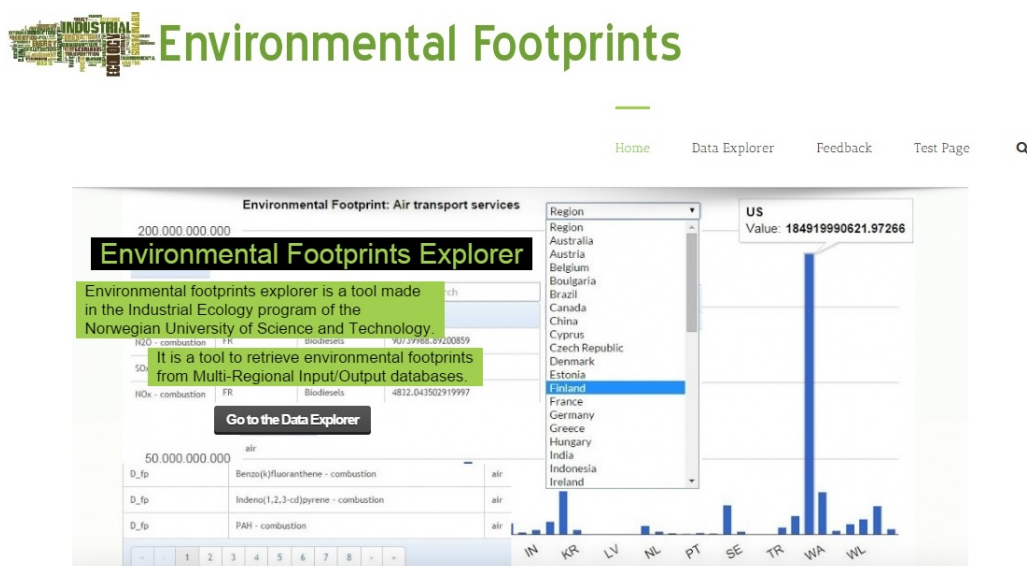
The presented web-platform removes the obstacle for policy-makers and the public alike to access EE MRIO results.

0.1 Introduction

Evidence guided policy making aiming for lessening the negative environmental and social impacts of our society require a comprehensive accounting principle. Such a principle must not only take into account direct domestic emissions and resource usage but also make the connection across global production networks - ultimately we are often interested in what forms of consumption have driven the impacts caused in production processes.

Global Environmentally Extended Multi Regional Input-Output (EE MRIO) tables provide such a system by taking into account the interrelations between production and consumption. EE MRIO tables link supply chains from the source of an impact, across countries, across processing stages, and to the final consumer. As such, estimates can be made about the amount of greenhouse gas emissions occurring in China to produce steel used in European televisions, or the amount of land used in Brazil required to feed British consumers. An important aspect of EE MRIO tables is that they are macro level economy-wide systems that provide a holistic picture of global production and consumption.

During the last years, several EE MRIO databases have been published ?. These databases differ in their environmental and regional focus and also due to the applied accounting principles and implementation details ??? . Analysing EE MRIO databases require a certain degree of training and the increasing size of the underlying matrices also set high requirements on used hardware. Thus, although most of the databases are free to use the detailed results of the analysis of these databases are often hidden in the supplements of scientific articles and reports. Here we present the Environmental Footprints Explorer (Figure 0.1), a web platform which provide access to the calculated results of various EE MRIO databases. The platform also allows to compare the results across databases in a consistent classification.



The Environmental Footprints Explorer

The rest of the article unfolds as follows. In the next section we give some background information on environmental accounting followed by an overview about recently published EE MRIO databases. The development section describes the architecture of the web platform and the routines used for calculating the results. We then present the platform and highlight some use cases. We conclude with a description of the future development.

0.1.1 Environmental Accounting

Principally, pressures arising from economic activity can either be tallied at the actual place of production or at the point of the consumption. Traditionally, the accounting at the actual place of production has been used for policy decisions. For example, the Kyoto Protocol was based on the production principle, which is now discussed to be one of the reasons for its limited success ?.

Consumption based accounting (CBA), on the other hand, has been gaining momentum for policy making ? as increasing globalisation of production networks occur. In CBA, all resource use and environmental pressures (for example emissions) occurring along the the supply chain of products are added up and allocated to the final consumer of the product. This allows to assess the environmental pressure caused by a domestic demand abroad ??.

Indicators based on consumption based accounting are also known as various types of 'footprints'. Nowadays, these are increasingly used for informing policy makers as well as the public about ongoing environmental ????? and social problems ?.

CBA requires a comprehensive description of the global socio-economic metabolism including among other the structure of domestic economies, their resource use and efficiency and the amount of trade between countries and regions. Environmentally Extended Multi Regional Input-Output databases (EEMRIO) provide all these data in a consistent framework.

0.1.2 EE MRIO database

Draftnote: The section provides a short overview about current EE MRIO projects. This will be extended in the final version.

EXIOBASE

EXIOBASE is a global EE MRIO aiming to support analysis of technologies, policies, and standards in relation to EU sustainability policies. The environmental focus of the database is reflected in a high level of detail in the agriculture, energy, mining, transport, and waste management sectors. EXIOBASE provides satellite accounts for over 300 environmental interventions.

The database was developed and analysed in three consecutive EU projects:

EXIOPOL ?, CREEA ? and the ongoing project DESIRE. The currently available version, EXIOBASE 2, implements the economic and environmental accounting principles proposed in the UN System of Economic and Environmental Accounts ?. The ongoing development of EXIOBASE 3 concentrates on providing a time series of EE MRIOs and now-casting this time series to the current year.

Currently, EXIOBASE consists of EE MRIOs for 27 (28 in the upcoming version 3) EU countries, 16 major economies and 5 rest of world regions in industry by industry (163 sectors) as well as product by product (200 sectors) classification.

WIOD

The objective of the compilation of the World Input Output Database (WIOD) was to provide a tool for analysing the effects of globalisation on trade patterns, environmental pressures and socio-economic development on a global level ?. WIOD consists of a time series (1995–2011) of IOT for 27 EU countries, 13 non-EU countries, and 1 RoW region. WIOD distinguishes 35 industries and 59 products. The WIOD has prioritized aggregate accounts as consistent as possible with official statistics. The database has been used extensively to analyse fragmentation of supply chains and trade in value added.

2.2.3 Eora

Eora is a time-series (1990-2011) of input-output tables with high country detail (187), utilising assymetric levels of detail and concepts of supply-use. There is further a smaller version of Eora at 26 sectors common for all countries. The total database has 15,909 sectors with the size of the system having just over 250 million variables. The database has 35 types of environmental indicators covering air pollution, energy use, greenhouse gas emissions, water use, Ecological Footprint, and Human Appropriation of Net Primary Productivity. A key point of the Eora database is its inhomogenous classification in the full detail version.

0.2 Development

Calculation of EE MRIO accounts (Multipliers, Footprints, impacts embodied in trade, etc) followed standard IO methodology.

All results are calculated through input-output analysis (IOA) following classic Leontief demand style modeling and are applicable for analysing historic data. IOA is essentially an allocation of production based impacts (here denoted \mathbf{F}) to the goods and services that flow to final demand (here denoted \mathbf{Y}). The allocation starts from the basic production balance, where gross output \mathbf{x} is the sum of total intermediate demand \mathbf{T} and final demand.

$$x = T + y \quad (1)$$

Normalising intermediate production (to produce one unit of output, we can calculate the required inputs, giving the coefficient matrix \mathbf{A})

$$A = Tx^{-1} \quad (2)$$

Then we can combine the above two equations, using what has been known as the Leontief inverse, to estimate the total output for a given demand

$$x* = (I - A)^{-1}y* \quad (3)$$

In MRIO modelling, for a certain demand, in a certain country, the production required to satisfy the demand is calculated. The point of departure from national accounting in gross domestic product terms is that imports are endogenised in the flows of goods to demands, and exports are excluded from a country's demand – in line with gross national expenditure calculations. A second point of departure from available input-output tables is that generalizing the input-output table for environmental inputs or emissions to the environment is required. Similar to the \mathbf{A} matrix of intermediate coefficients, a matrix of environmental interventions per unit output \mathbf{S} is used to calculate the overall environmental impact \mathbf{F}^* associated with a certain demand \mathbf{y}^*

$$F* = SLy* \quad (4)$$

In order to compare the different EE MRIOs included, we aggregated each into the Common Classification System ?. This system comprises the common denominator for all EE MRIOs available and leads to an aggregation to 41 regions (40 countries and 1 Rest of the World) and 17 sectors. Due

to the European focus of some EE MRIO projects, the Common Classification includes all European Union countries (except the new member state Croatia). The results of the calculation were then exported into csv files and imported in an sql database using phpMyAdmin tool. The development of the web-based user interface was done using wordpress developer's platform. The tool for the data exploration was developed using the shortcode methodology.

In the shortcode script the server-side scripting was done in php while the user interface for the data exploration was developed in html. The queries for the retrieval of data were done using sql in combination with the wpdb class provided from wordpress. Interactive graphics were developed with google visualization api and javascripts.

0.3 Tool description

The interactive database provides three main functionalities:

1. Viewing detailed EE MRIO accounts of one database
2. Comparing EE MRIO accounts across databases using a Common Classification System
3. Visualizing and exporting EE MRIO accounts

We describe these three functions below together with a short example of an use case.

0.3.1 Viewing EE MRIO accounts based on a specific database

Users can specify one of the freely available EE MRIO databases. Within a database, several parameters can be selected (Figure ??). These include:

- Countries/regions available in the selected database
- Sector of the database (industry, product or final demand category)
- Environmental/social intervention

- Year
- Perspective (Footprint, production/territorial accounts, embodied pressures/impacts in imports and exports, Multipliers and Intensities)

The general idea behind the selection is that the user specifies four out of five parameters and gets an overview of remaining parameter.

For example, choosing the database EXIOBASE for 2007 and specifying export accounts for the perspective, CO₂ as the environmental intervention, and air transport service as sector result in a result list showing these parameters across regions (the undefined parameter, see Figure 0.3.3).

1. Select Database and Year

Database ▼

2. Select Stressor

Emissions ▼

3. Select 4 out of 5 fields

Parameter ▼ 2007 ▼ Region ▼ Sector ▼ Search

Parameter
Export accounts
Footprint accounts
Import accounts
Territorial accounts
Multipliers
Factor production coefficients

Stressor Region Sector Value Unit

Fig. 2 The Environmental Footprint Explorer aims to ease the data extraction from global EE MRIO databases. Users can select between different databases and specify the perspectives, region and sectors they are interested in.

0.3.2 Comparing accounts across databases in a common classification

The main problem in any EE MRIO comparison is the sector and accounting mismatch between the databases. To solve that issue, we aggregated every database into a Common Classification System (see Development) and selected environmental interventions common to all databases included. The Environmental Footprints Explorer provides a consistent way to access environmental accounts of different EE MRIO databases and also to compare these results across databases.

The implementation of the Environmental Footprints Explorer allows to easily extend the number of EE MRIO databases accessible. In the short term, all EXIOBASE versions, WIOD and the aggregated EORA system have been integrated. Some recent studies analyzed the differences between EE MRIO databases ????. These studies provided important background information on the reasons of the observed differences and some exemplified comparisons on the effect of the differences of indicators. In order to get the amount of difference for other indicators, any practitioner would need to redo the whole study, starting from parsing several EE MRIO databases, aggregating to a common system and re-analyze the indicator results.

The proposed web-platform provides an alternative approach. The comparison of the EE MRIO databases is readily available through the user interface as is the access to the detailed results. In the next couple of month, we plan to extend the number of EE MRIO included in the comparison. The upcoming update of EXIOBASE to version 3 (February 2016) will be included in the web-platform providing the first now-casted EE MRIO results. In addition, we will contact other EE - MRIO database providers to discuss a potential inclusion of their data into the unified web-platform.

0.3.3 Downloading results and API

The data extracted in the two use cases described above gets presented in a table (Figure 0.3.3) together with a visualization (Figure 0.3.3). Both items can be downloaded (as csv file and png graphics).

In addition, the web-interface also provides an full API access to the databases.

0.4 Conclusion and outlook

Here we described an unifying web-interface, the Environmental Footprints Explorer, developed to ease the access to EE MRIO results. The platform provides functionality for the in depth exploration of a single database as well as for the comparison across several EE MRIO databases. Although several EE MRIO have been developed and published in the past couple of years, the use of their results in informing the policy development process has been rather limited.

The reason for that being are that on one hand that some expertise are

3 Select 4 out of 5 fields

Export accounts
CO2 - combustion
2007
Region
Sector
Search

Database

Time Series

Parameter

Stressor

Region

Sector

Value

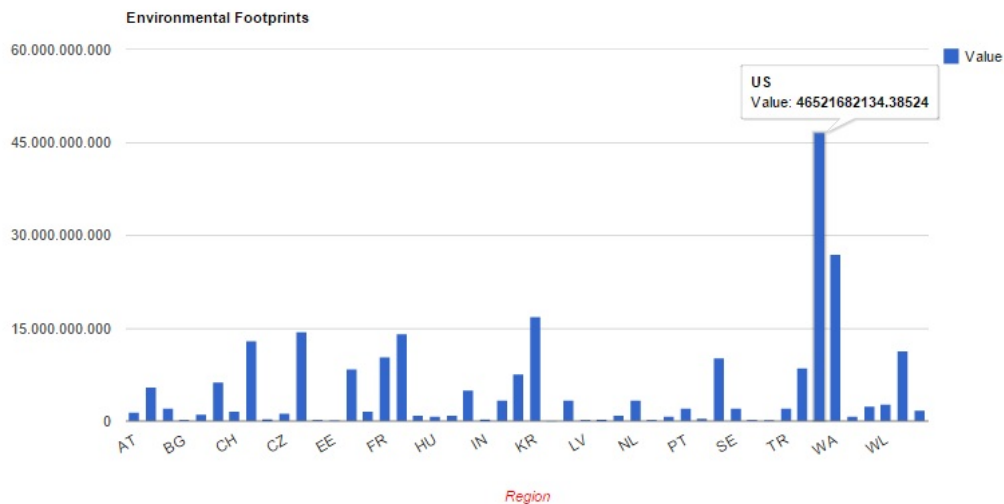
Unit

extobase	2007	Export accounts	CO2 - combustion	AT	Air transport services	1.44E+9	kg
extobase	2007	Export accounts	CO2 - combustion	AU	Air transport services	5.56E+9	kg
extobase	2007	Export accounts	CO2 - combustion	BE	Air transport services	2.04E+9	kg
extobase	2007	Export accounts	CO2 - combustion	BG	Air transport services	2.76E+8	kg
extobase	2007	Export accounts	CO2 - combustion	BR	Air transport services	1.16E+9	kg
extobase	2007	Export accounts	CO2 - combustion	CA	Air transport services	6.31E+9	kg
extobase	2007	Export accounts	CO2 - combustion	CH	Air transport services	1.62E+9	kg
extobase	2007	Export accounts	CO2 - combustion	CN	Air transport services	1.3E+10	kg
extobase	2007	Export accounts	CO2 - combustion	CY	Air transport services	3.81E+8	kg
extobase	2007	Export accounts	CO2 - combustion	CZ	Air transport services	1.29E+9	kg
extobase	2007	Export accounts	CO2 - combustion	DE	Air transport services	1.44E+10	kg
extobase	2007	Export accounts	CO2 - combustion	DK	Air transport services	2.58E+8	kg

1
2
3
4

Draw Column Chart

Results of a data query are presented as a table.



An automatic visualization procedure provides a quick overview about the extracted data.

needed to calculate indicators based on EE MRIO accounting, on the other hand the often overwhelming amount of data provided by current EE MRIO databases.

Some EE MRIO projects have tried to overcome that problem in the past by providing various kind of open access result reporting. For example, the OPEN:EU projects provides the policy tool EUREAPA to allow easy access to environmental and economic data for an EE MRIO model based on GTAP

?. The EE MRIO Eora ? includes a web-interface to access the main results (<http://worldmrio.com>) and the EXIOBASE project provide a booklet summarizing the main results for a policy audience ?. Similar initiatives exist also on the national level, for example the Open IO-Canada allows to retrieve environmental information based on the Canadian economic input-output tables (<http://ciraigdev.polymtl.ca>). However, all these initiatives fall short in enabling a comparison across databases.

The overall goal of the Environmental Footprints Explorer is to deliver the newest environmental accounting results to policy makers and the public. Previously, these data was filtered by the analyst of the databases and often restricted to the top level results considered novel enough for a scientific publication. Detailed data or the newest updates of previously published data may still be hidden in the databases, although they could be critical for informing targeting policy development.

Recently, the European Science Policy (<http://ec.europa.eu/programmes/horizon2020/en/h2020-section/open-science-open-access>) as well as various scientific journals ??? committed to a open science and data scheme. We feel, that, in an ideal situation, open science should not only provide open access to the raw data used for any analysis, but also provide a way to utilize the data for non-experts. The Environmental Footprints Explorer represents a first step in that direction.