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Project Réunion — uniting MRIO initiatives

Unifying global approaches to multi-regional input-output analysis and environmental footprinting

A Project Réunion project

Executive Summary of a research proposal
funded by the Australian Research Council under its Discovery Project DP130101293.

1. Background

1.1 Geopolitical background

At present, the United Nations Framework Convention on Climate Change (UNFCCC) requires nations to report emissions from their territory. However, recently, there have been high-profile news items highlighting the inadequacy of the territorial responsibility principle that is applied in the UNFCCC's Kyoto Protocol. In 2008, the CI of this proposal was involved in a study commissioned by the UK Government, which resulted in a widely publicised report dismissing the official stance that the UK's emissions had been decreasing over time. Instead, including imports into the UK (notably from China), overall emissions caused by UK residents' consumption had increased [1, 2]. As a response, a public enquiry was launched by the UK Government Select Committee on Climate Change in October 2010, posing six specific questions related to the variation between territorial emissions, and consumption-based emissions of the UK, the uncertainty of the estimates, their policy relevance and the specific issues of carbon leakage [3]. More importantly, in a speech in Washington on 6 March 2009, China's top climate policy negotiator, bolstered the consumer responsibility viewpoint by calling on importers to shoulder the responsibility of emissions caused by China's exports [4]. Under a consumer responsibility principle, nations would additionally report emissions embodied in their imports, but exclude emissions caused by producing their exports [5]. A change from the current territorial responsibility principle to a consumer responsibility principle would benefit net exporters of emissions [6, 7].

Whilst the UNFCCC applies only to nations, more and more private- and public-sector organisations are moving to reporting their emissions responsibility from a consumer perspective [8], and this practice has become known as carbon footprint analysis [9]. Such carbon footprints are meant to include greenhouse gas emissions originating directly from the organisation's premises (scope 1), indirectly from power plants providing the organisation with electricity (scope 2), and indirectly from all supply chains connected to the organisation, that is, emissions across the entire life-cycle of operational inputs and outputs (scope 3) [10].

In response to these recent political trends, various accounting, product labelling, reporting, life-cycle assessment (LCA), and policy frameworks for consumer responsibility have been created or revived [11], and many of these deal with international trade, such as the European EIPOT project [12]. Environmental footprints are now not only used in terms of carbon, but also in terms of water, energy, biodiversity, land, primary productivity, and other environmental indicators [13]. By far the main challenge in quantifying these footprints is the incorporation of footprints resulting from imports across a multitude of complex international supply chains. It is widely recognised that this challenge can only be met by a comprehensive and reliable database on multi-region input-output (MRIO) tables, including international trade transactions, and so-called satellite accounts on environmental pressures [12, 14, 15].

1.2 National and international progress in the field of research

At present there are a number of initiatives aimed at compiling large-scale global MRIO databases [16-25]. The MRIO databases generated by these initiatives have different purposes, and this is reflected in their choice of sector and country detail. Further differences relate to whether a continuous time series is generated or not, and whether transactions are expressed in terms of basic prices as well as purchasers' prices.

Leaders of the various global MRIO initiatives first met at the 18th International Input-Output Conference at the University of Sydney (see http://www.isa.org.usyd.edu.au/io_2010/index.html). This meeting clearly revealed the benefits of a unified world MRIO framework for shaping environmental databases, sustainability reporting and environmental policy around the world. The University of Sydney subsequently provided seed support from its International Program Development Fund (IPDF), in order to enable these leaders in the field to meet twice more, and to initiate a global collaboration. During the first meeting at L'Hermitage-les-Bains on Réunion Island in March 2011, participants founded the Réunion Project (http://www.isa.org.usyd.edu.au/mrio/mrio.shtml), with the goal of coordinating worldwide activities on environmentally-extended MRIO database compilation and environmental footprinting. Following this meeting, the Japan External Trade Organisation (JETRO) made available funds for a second meeting, which was held in Tokyo in February 2012. A third meeting will be held at Kurokawa on Kyushu Island, Japan, on 13 and 14 July 2013, where the concrete tasks outlined in this ARC Discovery Project will be planned.

There is consensus between the leading MRIO developers that widespread application of MRIO data, for example for calculating environmental footprints, has been prevented by a number of factors. First, constructing an MRIO database is labour-intensive. Second, most available MRIO tables either do not cover the entire world, and/or group a large number of individual countries into regions, and/or aggregate detailed industries into broad sectors. Third, MRIO tables are often not available as a long, continuous time series, and at the time of their release, the most recent tables are already many years outdated. Finally, most MRIO databases currently provide only results without accompanying estimates of reliability and uncertainty [15]. These shortcomings are mainly due to problems in handling of incomplete, conflicting and mis-aligned data, but also due to limitations in computational capacity and lack of agreed methodology. These issues are the main obstacles for the confidence in MRIO databases, and hence for the worldwide acceptance and use of MRIO techniques for environmental footprinting.

In order to deal with these shortcomings in the most effective way possible, the strengths of existing MRIO frameworks need to be integrated, in close collaboration with all current world MRIO compilers, and in consultation with key global governance bodies. Two crucial items on the MRIO research agenda, agreed during the Réunion and Tokyo meetings, are

- therefore the comparative evaluation and integration of currently disparate world MRIO frameworks and environmental footprinting approaches, and
- the provision of MRIO databases at less cost and improved timelines.

These research needs constitute the main aims of this project.

2. Research Project

2.1 Significance

The research undertaken here is significant in an international context. The responsibility for carbon emissions is an intensely debated topic at Conferences of the Parties (COPs) to the Kyoto Protocol, with countries such as China citing the emissions-intensiveness of their exports as grounds for differentiated responsibilities [4], and the UK Government attempting to come to terms with their increasing overseas outsourcing of emissions-intensive industries [2, 3]. A major obstacle to widespread acceptance of the consumer responsibility principle is the accuracy with which emissions in international trade can be quantified.

2.2 Novel and innovative methodologies and concepts

The integration and unification of MRIO frameworks is a novel concept that has not been attempted before. Currently, only a handful of separate MRIO teams and their databases exist. This idea was first raised during the 18th International Input-Output Conference in Sydney.

During the MRIO unification, a number of innovations are expected. First, none of the existing databases encompasses all existing supporting raw data. The novel idea in this proposal is to create a Virtual Laboratory environment holding pooled global data with input from major MRIO compilers in a designated repository, as well as a joint analytical toolbox.

Second, researchers working in this project will construct a large-scale "Mother of MRIOs", an overarching database from which all existing MRIO databases can be derived. Such an overarching data structure will surpass existing databases in its dimensions, country coverage, and sector detail. The build pipelines of the Mother table as implemented in the Virtual Laboratory will be structured in a way that each team can in principle replicate "their own" MRIO database, albeit using less resources than previously.

Third, none of the currently active MRIO teams has developed mathematical optimisers that are able to balance and reconcile raw data into a sufficiently large-scale harmonized MRIO account containing in excess of 1 billion entries, whilst at the same time able to deal with severely conflicting information. This research will implement novel large-scale, parallel balancing algorithms that will run on multi-core computer clusters in order to reconcile MRIO tables with raw data [26].

2.3 Virtual Laboratories and the "Mother" concept

A Virtual Laboratory (VL) is a novel concept aimed at improving digital connectivity by connecting researchers to existing and new research facilities, data repositories and computational tools, and thus streamlining research workflows and enabling new opportunities for research innovation, more collaborative research, and new research efficiencies on a national scale. In Australia, VLs are created and administered under the lead of the University of Melbourne's NeCTAR project (www.nectar.org.au), and financed by the Australian Government's Education Investment Fund. NeCTAR VLs seek to support and engage research communities in Australia by enabling research collaboration and research workflows across multiple research disciplines and problem-oriented research domains.

More specifically, VL infrastructures integrate existing and new investments in research infrastructure (data storage, data collections, high performance computing, and networks) with the aim to support the "connected researcher" who at the desk-top or the bench-top has access to digitally enabled data, analytic and modelling resources, specifically relevant to their research. VL infrastructures include high performance computing resources, domain-oriented computational analysis and simulation tools, remote access to research facilities and laboratories, online collaborative research environments, real-time communications technologies, and automated research workflow tools.

Because of the ability to link a large number of researchers, a VL provides a suitable environment for compiling MRIO systems according to the Mother approach. Indeed, each researcher submits to the VL a) the raw data to a repository, complete with b) matching information that identifies which part of the MRIO the raw data constrain, and also c) concordance matrices that map the sector classification of the raw data into that of the Mother MRIO tables. Raw data sources that are regularly updated in a standard format may be linked into the VL using automated data feeds. The raw data feeds created by different users are coordinated using Application Programming Interfaces, so that any changes in data standards, naming conventions, or MRIO structure never have to be changed separately by all users.

The three user-specific raw ingredients are then gathered in a reconciliation engine that uploads the resultant Mother MRIO tables into a designated repository. The reconciliation step can involve any of the procedures commonly applied, such as the construction of an initial estimate and a balancing algorithm [11, 24, 27-35]. The VL is equipped with an analytical toolbox that allows users to calculate derived quantities such as Leontief inverses, multipliers and environmental footprints, as well as with a facility to interrogate outputs and extract them in various formats. Finally, a user interface comprises a) a library of user-defined concordance matrices that can be used to transform the Mother MRIO tables into any user-defined daughter format, and b) libraries for storing user-defined inputs and outputs, enabling multiple users to work simultaneously on various individual MRIO projects that may differ by which input data and/or reconciliation method is used. The entire workflow is handled within a cloud computing setting.

The Mother approach to MRIO promises significant savings in terms of human and financial resources because of its collaborative nature, timely deployment because of automation, comprehensive and detailed tables because of the combined input form multiple teams, and flexibility in sector representation because of the inclusive mother-daughter relationship. In addition, it provides harmonisation of fragmented, dispersed and mis-aligned raw data, and consistency of outputs because users utilise common analytical tools.

3. Personnel

The CI of this project is Prof Manfred Lenzen from ISA at the University of Sydney. The project will be supported by a number of Project Réunion members: Norihiko Yamano (representing the OECD), Arnold Tukker (EXIOPOL), Erik Dietzenbacher and Bart Los (WIOD), Satoshi Inomata and Bo Meng (IDE-JETRO), Glen Peters (GTAP), and Tommy Wiedmann (NeCTAR Industrial Ecology Virtual Lab).

The technical work will be carried out by three PhD candidates, who will during their candidature undertake extended research work stays at the University of Sydney as well as at supporting members' institutions.

This Project Réunion project will build upon experiences made during the development of the Australian Industrial Ecology Virtual Laboratory ("IE Lab"). The IE Lab is one of NeCTAR's Virtual Laboratories that targets a well-described, significant research challenge: in this case the compilation and use of a time series of Australian sub-national MRIO tables, set up within the University of Melbourne's NeCTAR Research Cloud. The IE Lab was conceived by Prof Manfred Lenzen, who is also leading its development and technical implementation. From 2014 onwards, the IE Lab will be operated by Prof Tommy Wiedmann. For further details see http://www.isa.org.usyd.edu.au/ielab/ielab.shtml.

4. Duration

This research project will commence in October 2013 and run until October 2016.

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