Relevance of Global Multi Regional Input Output Databases for Global Environmental Policy

Experiences with EXIOBASE 3

Arnold Tukker,[1] *Richard Wood*,[2] *and Stefan Giljum*[3]

[1]*Institute of Environmental Sciences (CML), Universiteit Leiden, Leiden, the Netherlands*
[2]*Industrial Ecology Program, NTNU, Trondheim, Norway*
[3]*Department of Socioeconomics, Vienna University for Economics and Business, Vienna, Austria*

In the era of globalization, supply chains are increasingly organized at the international level, thus disconnecting the location of production from final consumption. Consumption therefore has become a major, geographically distant driver of various local environmental and social impacts in countries, where raw materials are extracted or products manufactured. The investigation of the various "tele-connections" between local consumption and global impacts has developed into an important field of research within industrial ecology, with special issues, including in this Journal (see Hubacek et al. 2016), being dedicated to this topic.

In a world that is ever more connected via trade, GMRIOs are crucial instruments to understand not only how value chains drive the creation of added value, but also emissions, resource extraction, and waste production.

The need to provide indicators that take these international connections into account and allow assessment of the global impact of consumption from a "footprint" perspective has triggered the development of a number of methodological approaches and databases. The approach most widely applied for consumption-based, that is, footprint-type, assessments at the country level is (global) multiregional input-output (GMRIO) analysis (Tukker and Dietzenbacher 2013). MRIO models link domestic economic structures of a large number of countries with bilateral trade data on the product level and thus provide a detailed representation of monetary flows in the global economy. Extending the core MRIO model with environmental data allows quantifying the amount or impacts of natural resources or different types of pollutions embodied in internationally traded products and in final consumption.

This special issue introduces a new MRIO database (i.e., EXIOBASE 3), which was developed in the European Union Seventh Framework Program project DESIRE (Development of a System of Indicators for a Resource efficient Europe). EXIOBASE 3 allows assessment of the global environmental consequences associated with consumption of European and other countries and features times-series data at a high level of product and industry detail as well as providing a physical representation of the world economy.

The special issue contains four clusters of papers. These range from presenting methodological details of the construction of the various modules of EXIOBASE 3 via empirical assessments generated with this new database to deriving general conclusions about pathways of developing MRIO databases in the future. This special issue is built up as follows.

For the first part, the editors invited some crucial international institutional players in the field to provide their views on the relevance of work on input-output analysis for policy making. Contributions were received by Nori Yamano and Colin Webb who work on the OECD's Inter-Country Input-Output tables, and José Rueda-Cantuche, Maaike Bouwmeester, and Isabelle Remond Tiedrez who reflect on the joint work of Eurostat and the European Union's Joint Research Centre on European input-output tables.

In the second part, the special issue discusses the state of the art of the most commonly used MRIO databases and evaluates their strengths and limitations (Tukker et al. 2018a). It also presents the construction of EXIOBASE 3 that aimed at overcoming such limitations. The paper by Stadler and colleagues (2018) provides a detailed description of the compilation process of EXIOBASE 3. It provides details about refinement methods for both the monetary MRIO part as well as the

DOI: 10.1111/jiec.12767

Volume 22, Number 3

environmental satellite accounts and compares the characteristics of EXIOBASE 3 with previous versions of the database. Furthermore, EXIOBASE 3 is the first GMRIO that contains a comprehensive accounting of physical flows in the economy (using principles of physical mass balance). The compilation of this part of EXIOBASE 3 is discussed in the paper of Merciai and Schmidt (2018).

The third part of the special issue focuses on various empirical applications. Wood and colleagues (2018b) apply the new EXIOBASE 3 database to investigate the growth in environmental pressures in various countries in a time series from 1995 to 2011, discussing the role of international trade in contributing to environmental leakage. The contribution by Steinmann and colleagues (2018) turns to the issue of policy relevance of indicator sets on resource use and resource efficiency. They find that carbon, land, water, and material footprints cover almost 60% of the variance in product rankings among environmental indicators and that extension by five impact-oriented indicators increases the coverage to 95%. Moran and colleagues (2018) analyze so-called feedback emissions—in considering how intertwined the global economy has become, they look at how much of the pollution embodied in exports of a country is embodied back in the imports of that country, after traveling through global value chains. Their conclusion is that apart from some big economies such as China, such feedbacks are very limited, and there are thus potentially simple ways to link GMRIO models to individual country data not adequately represented in GMRIO databases. The paper concludes with a discussion on the implications for optimizing indicator sets for environmental policy making. Next, Usubiaga and colleagues (2018) use EXIOBASE 3 to estimate reduction of environmental footprints by reductions of the amount of food waste. Finally, Wood and colleagues (2018a) propose a framework that demonstrates the usefulness of MRIO databases such as EXIOBASE 3 in assessing the impact of policy measures—both geospatially, and in terms of supply-chain impact. Such approaches can give quick estimates based on exploiting EXIOBASE V3 to give the potential savings and rebounds of a technical implementation of a policy measure.

In the fourth and final part of this special issue, Tukker and colleagues (2018b) look to the future. They discuss options to make GMRIO databases and derived consumption-based indicators more robust and authoritative. The paper proposes a multistep approach, suggesting that, in the short term, so-called Single country National Accounts Consistent (SNAC) approaches would suffice. In the medium term, harmonized satellite data for a range of environmental categories could be developed and the Organization for Economic Cooperation and Development (OECD) MRIO data set used in combination with detailing procedures to increase the sector detail. For the long term, the paper argues for an internationally harmonized effort to establish a common, global MRIO framework, ensuring consistency in sector and product classifications and resolving the asymmetries of bilateral trade.

This special issue has also been augmented by two book reviews of recent publications on MRIO: *Environmental and economic impacts of decarbonization: Input-output studies on the consequences of the 2015 Paris Agreement* edited by Dejuán and colleagues (Tukker 2018a) and *Techniques for evaluating the differences in multiregional input-output databases: A comparative evaluation of CO_2 consumption-based accounts calculated using Eora, GTAP and WIOD* by Owen (Tukker 2018b).

As argued in the columns of Yamano (2018) and Rueda-Cantuche and colleagues (2018) in a world that is ever more connected via trade, GMRIOs are crucial instruments to understand not only how value chains drive the creation of added value, but also emissions, resource extraction, and waste production. Creating such GMRIOs is a complicated affair. In this, scientists from the field of industrial ecology, input-output analysis, and practitioners from national statistical offices and related international organizations increasingly collaborate. As reflected by this special issue, and a recent one on Global Virtual Laboratories in *Economic Systems Research* (Lenzen et al. 2017), this is a promising way of working toward a formalized operational global accounting system that can be a major support of monitoring progress toward the Sustainable Development Goals.

Funding Information

Most papers in this Special Issue were written in the context of the Development of a System of Indicators for a Resource Efficient Europe (DESIRE), a Collaborative project under the Seventh Framework Program of the European Union, Grant Agreement No.: 308552.

References

Hubacek, K., K. Feng, B. Chen, and S. Kagawa. 2016. Linking local consumption to global impacts. *Journal of Industrial Ecology* 20(3): 382–386.

Lenzen, M., A. Geschke, M. A. Rahman, M. Daaniyall, Y. Xiao, J. Fry, R. Reyes, E. Dietzenbacher, S. Inomata, and K. Kanemoto. 2017. The Global MRIO Lab—Charting the world economy. *Economic Systems Research* 29: 158–186.

Merciai, S. and J. Schmidt. 2018. Methodology for the construction of global multi-regional hybrid supply and use tables for the EXIOBASE v3 database. *Journal of Industrial Ecology* 22(3): 516–531.

Moran, D., R. Wood, and J. F. D. Rodrigues. 2018. A note on the magnitude of the feedback effect in environmentally extended multi-region input-output tables. *Journal of Industrial Ecology* 22(3): 532–539.

Rueda-Cantuche, J. M., I. Remond-Tiedrez, and M.C. Bouwmeester. 2018. Institutionalisation of inter-country input-output tables: Working towards harmonisation and standardisation. *Journal of Industrial Ecology* 22(3): 485–486.

Stadler, K., R. Wood, T. Bulavskaya, C.-J. Södersten, M. Simas, S. Schmidt, A. Usubiaga, et al. 2018. EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. *Journal of Industrial Ecology* 22(3): 502–515.

Steinmann, Z., A. Schipper, K. Stadler, R. Wood, A. De Koning, A. Tukker, and M. A. J. Huijbregts. 2018. Headline environmental indicators revisited with the global multi-regional input-output database EXIOBASE. *Journal of Industrial Ecology* 22(3): 565–573.

Tukker, A. and E. Dietzenbacher. 2013. Global multiregional input-output frameworks: An introduction and outlook. *Economic Systems Research* 25(1): 1–19.

Tukker, A. 2018a. *Book review of Environmental and economic impacts of decarbonization: Input-output studies on the consequences of the 2015 Paris Agreement*, edited by Ó. Dejuán, Manfred Lenzen, and María-Ángeles Cadarso. *Journal of Industrial Ecology* 22(3): 601–602.

Tukker, A. 2018b. Book review of *Techniques for evaluating the differences in multiregional input-output databases: A comparative evaluation of CO_2 consumption-based accounts calculated using Eora, GTAP and WIOD* by Anne Owen. *Journal of Industrial Ecology* 22(3): 599–600.

Tukker, A., S. Giljum, and R. Wood. 2018a. Recent progress in assessment of resource efficiency and environmental impacts embodied in trade: An introduction to this special issue. *Journal of Industrial Ecology* 22(3): 489–501.

Tukker, A., A. de Koning, A. Owen, S. Lutter, M. Bruckner, S. Giljum, K. Stadler, and R. Wood. 2018b. Towards robust, authoritative assessments of impacts embodied in trade. *Journal of Industrial Ecology* 22(3): 585–598.

Usubiaga, A., I. Butnar, and P. Schepelmann. 2018. Wasting food, wasting resources: Potential environmental savings through food waste reductions. *Journal of Industrial Ecology* 22(3): 574–584.

Wood, R., D. Moran, D. Ivanova, K. Steen-Olsen, A. Tisserand, and E. Hertwich. 2018a. Prioritizing consumption-based carbon policies based on the evaluation of mitigation potential using input-output methods. *Journal of Industrial Ecology* 22(3): 540–552.

Wood, R., K. Stadler, M. Simas, T. Bulavskaya, S. Giljum, S. Lutter, and A. Tukker. 2018b. Growth in environmental footprints and environmental impacts embodied in trade: Resource efficiency indicators from EXIOBASE 3. *Journal of Industrial Ecology* 22(3): 553–564.

Yamano, N. 2018. Future development of the OECD Inter-Country Input-Output (ICIO) Database for Global Value Chain (GVC) and environmental analyses. *Journal of Industrial Ecology* 22(3): 487–488.

Conflict of interest statement: The authors declare no conflict of interest.

Address correspondence to: Arnold Tukker, Institute of Environmental Sciences (CML), Universiteit Leiden, P.O. Box 9518, Leiden 2300RA, the Netherlands. *Email*: tukker@cml.leidenuniv.nl