

A systematic framework for extending MRIO databases: an application to energy-transition critical sectors in GTAP

Topic: Methodological advances in extending input-output databases: sectoral disaggregation, matrix augmentation, and hybrid approaches

Author: Camilla Citterio

Co-Authors: Lorenzo Rinaldi, NicolÃ² Golinucci, Maksym G. Chepeliev, Matteo Vincenzo Rocco

Multi-Regional Input-Output (MRIO) analysis is a powerful tool for evaluating the economic and environmental impacts of the energy transition. By capturing the intersectoral dependencies and trade flows, MRIO models offer a systemic perspective that is uniquely suited to analysing the cascading effects of large-scale transformations. However, the utility of this systemic vision is constrained by the high levels of sectorial aggregation in standard MRIO tables, which limit their capacity to capture the technology - specific supply chains that are critical to energy transition assessments. Sectors such as battery electric vehicles or green hydrogen production are regularly aggregated into broad industrial categories encompassing activities that can be distinctly different from one another, thereby obscuring the specific economic linkages, import dependencies, and emissions profiles that characterize each technology. The potential benefits of greater sectorial detail in MRIO tables have been demonstrated in prior studies.

While various methodologies exist for enhancing the sectorial resolution in MRIO tables, ranging from simple coefficient-based allocation procedures to complex optimization routines, a systematic framework for selecting and applying these approaches remains absent from the literature. A practitioner seeking to increase the sectorial detail of an Input-Output Table, without having deep expertise in the underlying theory, lacks clear guidance on which methodology is most appropriate for the case under analysis. This methodological gap motivates the present work.

This study classifies the available methodologies for MRIO table sectorial enhancement, synthesizing theoretical formulations and practical techniques developed in the Input-Output literature since the 1950s to incorporate new activities or disaggregate those embedded within broader aggregates. We develop a comprehensive framework that categorizes enhancement methodologies according to their underlying logic, including augmentation, disaggregation, and balancing techniques. These encompass coefficient-based allocation, RAS biproportional scaling, constrained optimization employing entropy-based or alternative distance measures, and combinations thereof. Crucially, the framework does not merely catalogue these methods but proposes a decision logic for their application. The scope of applicability for each methodology is determined by three principal factors: the structural characteristics of the source database, the properties of the target sector to be included or made explicit, and the nature and extent of auxiliary data availability.

The framework is applied to improve the sectorial detail for energy-transition-critical technologies within the Global Trade Analysis Project (GTAP) database, one of the most widely used multiregional environmentally-extended economic databases. The methodology identified as most fitting for this context employs coefficient-based allocation to distribute use values across disaggregated sectors while preserving GTAP's original bilateral trade structure, followed by constrained optimization using a cross-entropy objective function to ensure consistency with the original matrix and adherence to accounting identities. The resulting enhanced tables offer significantly improved resolution for key carbon-intensive or innovative low-carbon sectors without compromising the internal coherence of the broader economic system they represent.

Importantly, while the framework is demonstrated here in the context of sectors critical to the energy transition, it exhibits broader applicability across diverse sectorial contexts, offering a generalizable methodological contribution to the Input - Output literature and to its practical application a range of economic and environmental assessments.