EMERGING-E - The Construction of Global Multi-Regional Input-output Model with Green Electricity Disaggregation

Topic: Global MRIO Modelling and Applications for Emerging Economies
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Multi-Region Input-Output (MRIO) databases are essential for analyzing resource use and environmental impacts within global supply chains. Electricity production plays a major role in fossil fuel consumption and CO2 emissions. Enhancing efficiency in power generation could result in significant energy savings and emission reductions. Accurately representing the electricity sector in the MRIO model is crucial for understanding the impact of power generation structures on carbon reduction and green technology reforms, especially in emerging economies.

Among existing MRIO databases, only EXIOBASE and GTAP-Power disaggregate the electricity sector based on generation technologies, using different methods. EXIOBASE separates power generation from utilities and breaks it down into technologies such as coal, gas, hydro, wind, and solar. It relies on a combination of supply-use tables, life cycle inventory databases, and energy data from models like GEM-E3 to construct generic coefficients, which are then adjusted to generate country-specific input structures accounting for fuel substitution and co-production effects. On the other hand, GTAP-Power follows a cost-driven bottom-up approach within the GTAP-CGE modelling framework. It disaggregates electricity output into base-load and peak-load technologies, using micro-level data on fuel use, capital costs, and operation and maintenance (O&M) expenses to derive levelized input costs. Updates in GTAP-Power 11further incorporate transmission and distribution cost data and extend the scope to include heat generation for 80 countries. Both methods depend on assumptions and parameters derived from associated computable general equilibrium (CGE) models (e.g., GEM-E3 and GTAP), which are often unavailable in emerging economies, making it less suitable for disaggregating the electricity sector in the EMERGING MRIO model.

To accurately capture the evolution of the electricity sector and evaluate the potential of different technologies, we adopted the advanced disaggregation approach by integrating national statistics with point-source power plant data to disaggregate the electricity sector in the EMERGING MRIO model, creating the EMERGING-E MRIO model. This model divides the electricity sector into one transmission sector, one distribution sector, and 12 sub-sectors representing different power plant technologies (such as subcritical coal, hydro, etc.). We analyze the electricity generation mix across 9 specific economies using the EMERGING-E MRIO, EXIOBASE 3, and GTAP-Power 11 databases and validate the results by comparing them with each country's officially reported electricity mix. We also investigate differences in carbon accounting across the three databases by comparing COâ,, emission intensities of different electricity generation types and the associated production- and consumption-based carbon emission structures across these 9 economies. To evaluate the effects of electricity sector disaggregation, we compare national and sectoral consumption-based emissions between the EMERGING-E and the original EMERGING MRIO models in 2018. Furthermore, to further quantify uncertainty in the EMERGING-E model and in consumption-based environmental footprints derived from it, we conduct a two-stage uncertainty assessment. We first apply a Monte Carlo framework to assess uncertainty in key parameters underlying the EMERGING-E electricity disaggregation, reporting 95% confidence intervals for fossil-fuel generation shares and consumption-based value added across 245 economies. We then perform an analytical uncertainty propagation analysis for 2018 consumption-based carbon footprints to attribute total uncertainty to emission intensities, the Leontief inverse matrix, and final demand.