Uncertainty Propagation in EE-MRIO

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IX
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Uncertainty Propagation in EE-MRIO - Abstract

Despite the prominent role of Multi-Regional Input Output models (MRIO) in sustainability analysis and policy making, the role of uncertainty in MRIO modeling is not well understood. In the last years, there have been two main lines of research with regards to uncertainty in MRIO: The first analyzed the sensitivity of MRIO results regarding aggregation of sectors and regions, the second took a more general approach and analyzed uncertainty of results due to uncertainty in the raw data, often using Monte Carlo simulations. The effect of aggregation on consumption-based accounts of regions and sectors (aka footprints) has been well researched in MRIO literature, with the general conclusion being that increased sector and country resolution lead to more accurate footprint estimates. Within aggregation uncertainty literature, satellite accounts/ environmental extensions have been analyzed and include carbon, as well as material accounts. Monte Carlo simulations, as the second main line of research within MRIO uncertainty, has also been utilized. Among the findings of these studies is that MRIO uncertainty is generally maintained at acceptable levels. However, in contrast to uncertainty due to aggregation, the latter line of research is restricted to GHG (greenhouse gas) and does not analyze other environmental extensions. Linear error propagation in MRIO has not been as commonly used as aggregation-based methods or Monte Carlo in understanding uncertainty in MRIO. Thus, in this analysis, we use linear error propagation to understand the propagation of uncertainty from environmental stressors to the final footprint estimate, along with footprint sensitivity to stressor uncertainty. The research addresses two questions; 1) To what extent does error propagate from satellite extensions to regional footprint estimates? 2) Do footprints vary in their sensitivity to extension uncertainty? To answer these questions, we conduct an analysis assuming a constant relative standard deviation for several satellite accounts. We then calculate resulting consumption-based accounts (footprints) by coupling the standard MRIO calculations with a linear error propagation analysis. We used a set of satellite accounts which cover a wide variety of sector distribution: GHG and Employment, which are more or less evenly spread across sectors, contrasted by Water Consumption and Land Use which are restricted to certain (mostly agriculture) sectors. We confirm the analysis results with a "classical" Monte Carlo sensitivity analysis. EXIOBASE 3 (3.8.2) in the product-by-product classification for the base year 2019 was used for all analysis. The research utilizes HPC (high performance computing) clusters for the calculations. We find that the satellite extensions Land use and Water consumption propagate more uncertainty compared to Employment and GHG. We also find that regions with evenly distributed extensions, propagate less uncertainty to final footprint estimates. In general, footprints/CBA of extensions which are evenly distributed across sectors show less sensitivity to uncertainty of the underlying extension. Pymrio, the python package for MRIO calculations, was used for EE-MRIO calculations. On a more general scale, the research offers significant progress in the field of uncertainty in EE-MRIO which will aid researchers to better interpret footprint estimates of various products, and final demand vectors. Assuming a 0.1 relative standard deviation, we find the following mean relative standard deviation per footprint; Employment: 0.015, GHG: 0.018, Water consumption: 0.023, Land Use: 0.028. In other words, we find that accounts such as Water and Land are more sensitive to uncertainty given their sector-specific nature. The results were tested using an ANOVA

(analysis of variance) test, as well as Tukeyâ€™s HSD comparison of means, and in general, were found to be statistically significant.