The overwhelming disadvantages of Index Decomposition Analysis compared to Structural Decomposition Analysis in Environmental studies

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IX
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Decomposition analysis is a methodology that identifies the driving factors of changes in performance variables of an economic system. It has been broadly applied to environmental studies since the 1970s and is now a widely recognized tool for environmental planning and policy. There are two conventional decomposition approaches: Index (IDA) and Structural Decomposition Analysis (SDA), whose main differences rely on their theoretical foundations and input data. While IDA is based on the theory of index numbers and needs time series of sectoral data, SDA is based on input-output analysis and hence requires input-output data. As both SDA and IDA are theoretically sound, in practice, the selection between them has mainly relied on the â€œtypeâ€• of data at hand (e.g., IDA-fit historical data are broadly available), under the assumption that results should, in theory, be similar. This has led to a large dominance of IDA environmental studies despite it being recognized that SDA provides more detailed results. Some authors have evaluated both techniques in the same case study (e.g., Guevara, 2015, Stachura, 2018, Wang et al., 2017, and Wei et al., 2021) and found significant differences between IDA and SDA results that could lead to contradicting conclusions. However, they did not specify which of them is better; as previously explained, both techniques are correct in theory. Such a conclusion cannot be made based on theory alone. Instead, it should be recognized that the characteristics of the decomposition model of the analyzed variable and the quality and aggregation of input data are as important as the theoretical foundations. This work demonstrates that when these two later aspects are also taken into account in the selection of decomposition technique for a given study, the SDA should be preferred. To do so, we rely on two existing decomposition studies of environmental variables: an SDA study of energy decoupling in Portugal and an IDA study of decarbonization in the UK. We reproduce each study with the other decomposition technique. First, we developed an IDA study of energy decoupling, in which we varied the data aggregation level while respecting the foundations of the decomposition model of the analyzed variable of the original study. Second, we develop an SDA study with a novel decarbonization model that better mimics the energy processes that occur in the economy with the same data quality as the original study. The comparison of these four studies shows that the IDA presents significant problems with data aggregation and model inconsistencies which can lead to opposite conclusions in the interpretation of decomposition results. For example, IDA shows that energy efficiency policies could have had a negative performance in 2004-2006 despite structural changes in the production system being more likely to have caused that effect. Also, IDA could make paying lower attention to household consumption patterns on decarbonization than to industrial energy intensity. Even though data aggregation issues affect both techniques, the SDA is more resilient against different levels of data aggregation. Moreover, SDA is more consistent with the physical processes that environmental flows experience in the economy. In addition, the characteristic of SDA models allows for better accounting of the limitations of the study. These results confirm that SDA is superior to IDA and more resilient to common general decomposition drawbacks. Even the IDA can provide erroneous conclusions regarding factor effects. Hence, IDA should only be used when structuring data as an input-output system is impossible. However, recent developments in environmental input-output analysis (namely the physical supply and use tables and the multifactor energy input-output model) allow structuring almost any environmental data as an input-output system, reducing the instances when SDA cannot be used.