Quantifying the environmental impact reduction potential of circular economy policies through environmentally extended multiregional input-output analysis

Topic: Input-Output Analysis: Sustainable Production and Consumption policies (10)
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Since its popularization, the concept of the circular economy has continued to evolve, and its boundaries have become less well-defined. It has expanded beyond its original focus on closing resource loops, improving waste management, and increasing resource efficiency, to incorporate actions before, during and after productsâ€™ use phase, commonly characterized as R-strategies. The expansion of the circular economy concept has introduced a level of ambiguity in which actions or interventions are a part of it, and which are not. Multiple definitions exist, and depending on which is adhered to, the circular economy has branched out into other policy areas (e.g., food and energy) and has come to entail interventions that would require significant behavioral change on the part of end consumers. As a result, estimations of the potential environmental benefits of circular economy interventions in the existing literature vary greatly. This study provides a holistic perspective on the potential of the circular economy (CE) to generate environmental benefits by (1) creating a list of CE interventions spanning several policy-relevant consumption domains and grouping them into core (bounded definition) and broad (expanded definition) CE interventions, and (2) modelling these interventions at EU-27 level in an environmentally extended multiregional input-output framework to assess their global environmental benefit potential in terms of climate change, air pollution, and biodiversity loss mitigation.

Based on a review of definitions of the circular economy and the modelling approaches of CE interventions in existing literature, we curated a list of 17 CE interventions to model in this study. Of these interventions, 13 are core interventions and four are broad interventions. These interventions act on four consumption domains (food, mobility, housing, and other goods and consumables), as well as the extraction and reuse of raw materials.

To model these interventions, we used the highly disaggregated FIGAROe3 input-output tables as a basis, complemented with EXIOBASE v3.8.2 and REX3 environmental extension data. Using the macroeconomic projections published as part of the 2023 edition of the Global Energy and Climate Outlook report, we created baseline data for a current version of the economic system (year 2020) as well as a potential future low-carbon version (year 2050) assuming compliance with the Nationally Determined Contributions and Long-Term Strategies.

For each intervention, its expected impact on associated economic sectors was quantified as a percentual change relative to the baseline data. The ambition level for this percentual change was determined based on existing policy documents and academic literature and modelled at high and medium values. Anticipated rebound effects were included in the modelling by increasing sectoral spending on service activities or by redistributing a portion of the savings to spending in other sectors. The interventions were implemented individually, as well as combined along several dimensions (including the core vs. broad dimension), at medium and high ambition level in both the current economic system and the potential future low-carbon variant.

When implemented at the high ambition level in the current economic system, the global impact reduction potential of all 17 CE interventions is 22% for GHG emissions, 25% for particulate matter impacts, and 19% for land-use based biodiversity loss. The combined core interventions contribute the largest share of the total impact reduction potential for climate change and air pollution (about two thirds), while for biodiversity loss, the combined broad CE interventions contribute just over

50%. Expressed as an average per intervention, the four broad CE interventions have a bigger impact reduction potential than the 13 core interventions. However, the broad CE interventions are ambitious interventions that would require substantial behavioral changes from end consumers and therefore may be more difficult to realize.

Implementing the combined 17 CE interventions at the high ambition level in the potential future low-carbon economic system shows that their relative impact reduction potential is close to that of the current economic system for each of the three impact indicators. Moreover, implementing the combined 17 CE interventions at the medium ambition level instead of the high ambition level in the current economic system still results in significant impact reductions for each of the three indicators (12.4% for GHG emissions, 13.9% for particulate matter impacts, and 10.1% for biodiversity loss).

In sum, our results show that implementing CE interventions at EU-27 level has significant potential to generate global environmental benefits and contribute to mitigating the triple planetary crisis, independent of the scope of CE definition being considered.