Integrating stock-flow modelling and environmentally extended multiregional input-output analysis to assess the global environmental benefits of local circular economy policies: a case study of electrical and electronic equipment in Flanders, Belgium

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Circular economy (CE) policies are increasingly seen as important instruments to reduce greenhouse gas emissions, decrease resource dependency, and strengthen economic resilience. While many CE strategies target product lifetimes, reuse, repair, recycling, and demand reduction, their environmental impacts are rarely assessed in a framework that simultaneously captures physical material flows, global economic interdependencies and macro-economic projections. This gap is particularly relevant at the regional level, where policy makers require evidence on the local and global impact potential of circular interventions.

This paper develops and applies an integrated methodological framework to assess the environmental impacts of circular economy policies by linking stock-flow modelling and environmentally extended multiregional input-output (EEMRIO) modelling with prospective input-output tables. This approach was applied to the electrical and electronic equipment (EEE) sector in Flanders to assess the global environmental benefit potential of circular policy interventions. Specifically, this paper attempts to (1) quantify how CE policies affect the stocks and flows of EEE products in Flanders through service life extension, improved collection, increased reuse, and refuse strategies, and (2) quantify the environmental benefits (focusing on climate change and resource depletion impacts) of these CE interventions that occur in Flanders, in the EU, or in the rest of the world. The modelling approach consists of three layers.

The first layer is a stock-flow model used to quantify how EEE enters the economy, accumulates in use, and eventually becomes waste, and how this waste is treated. The modelâ€™s core data source is the Eurostat WEEE Calculation Tool, which provides a harmonised time series (1980â€“2022) of put-on-market (POM) data and Weibull lifetime parameters at the level of 54 UNU product categories. These data are aggregated to the EU-6 classification and combined with average unit weights to enable modelling in tonnes and product units. Future projections towards 2050 are based on demographic forecasts and bounded extrapolations of stock-per-household trends. Circular policy levers, such as extended active use, increased reuse, or demand reduction (â€œrefuseâ€•), are modelled as changes in product lifetime, collection and reuse shares, or put-on-market volumes. The stock-flow model forms the basis for the scenario analysis, ensuring physical consistency between inflows, stock accumulation and outflows over time.

The second layer extends the FIGAROe3 EEMRIO model with a Flemish environmentally extended input-output model for 2015. FIGAROe3 provides global coverage (EU27 and major trading partners plus a rest-of-world region) and is complemented with environmental extension data from EXIOBASE v3.8.2 and Eurostatâ€™s Air Emission Accounts. The Belgian region in FIGAROe3 is split into Flanders and rest-of-belgium, and Flemish supply and use tables (SUTs) (145 industries, 147 products) are converted to CPA 2.1 and NACE 2.1 classifications. This integration allows Flemish CE policy interventions to be analysed within a multiregional framework, capturing domestic and upstream emissions embodied in EEE consumption. A distinctive feature of the framework is the use of prospective SUTs to match the time horizon of the stock-flow model. To create these prospective tables, we projected the FIGAROe3 SUTs towards 2050 using macro-economic projections from the Global Energy and Climate Outlook 2024 published by the JRC.

The third layer translates the results from the stock-flow scenario analysis into economic adjustments to the SUTs. Reductions in put-on-market volumes are mapped onto changes in Flemish household demand for the corresponding product groups. Additional recycled material flows are substitute primary inputs in relevant industries. Changes in stock levels are reflected in adjustments to repair and maintenance demand. In this way, physically grounded scenario results are embedded into a macro-economic accounting framework.

Applied to the Flemish EEE case, the framework shows that interventions acting early in the value chain, such as extended active use and demand reduction, generate substantially larger environmental benefits than downstream efficiency measures. Because EEE consumed in Flanders is mostly produced in other regions, most avoided environmental impacts occur outside the EU-27, highlighting the importance of a consumption footprint perspective to assess impacts of local policy measures.

Overall, this paper presents a coherent and replicable modelling framework for assessing local circular economy policies. By integrating stock-flow modelling and EEMRIO analysis with prospective SUTs, it enables consistent scenario analysis across time horizons and geographical scales. The Flemish EEE case demonstrates how regional CE strategies can be embedded in a global systems perspective.