Spatiotemporal Environmental Consequences of the Transition to a Circular Economy

LIRIDE

Research team

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Context

The transition from a linear to a circular economic system implies a profound reorganization of resource exchanges within an industrial symbiosis. This may result in favourable environmental impact mitigation effects in one part of the network, but unfavourable ones in another. Thus, all market adjustments in response to such a transition must be examined to assess its performance. Existing tools have difficulty integrating these spatiotemporal interactions into the supply and demand of primary and secondary resources. This makes it difficult for local decision-makers to plan a transition to a circular economy with a comprehensive understanding of the environmental trade-offs that may ensue.

Goal

The main objective of this research project is to assess the direct and indirect environmental consequences of a transition to a circular economy with a high spatiotemporal resolution. As a case study, the effects of two technological transitions aimed at diversifying post-consumer glass recycling opportunities in the province of Quebec are examined. These are (i) technological upgrades to obtain a better quality of recovered cullet (CLOSED Scenario) and (ii) the micronization of glass residues for the marketing of glass powder in the cementitious materials market (OPEN Scenario).

Methods

This project focuses on coupling a multi-regional economic material-product chain model (MMPC) with consequential life cycle analysis (CLCA). This new integrated model is called the MMPC-CLCA. First, the MMPC optimizes the exchange of materials and products of an industrial symbiosis broken down into six regions in order to minimize the systemic material and non-material (e.g. transport) costs. Its formulation includes reverse logistics leading to market competition between natural resources and recovered materials for the manufacture of products. The consequences are the difference between the final equilibrium of the system with and without the circular transition. Then, the marginal flows are characterized in terms of environmental impacts using the ecoinvent v3.5 "consequential database" and the ReCiPe 2016 v1.1 characterization method. The final scores are grouped according to a territorial "producer pays" approach.

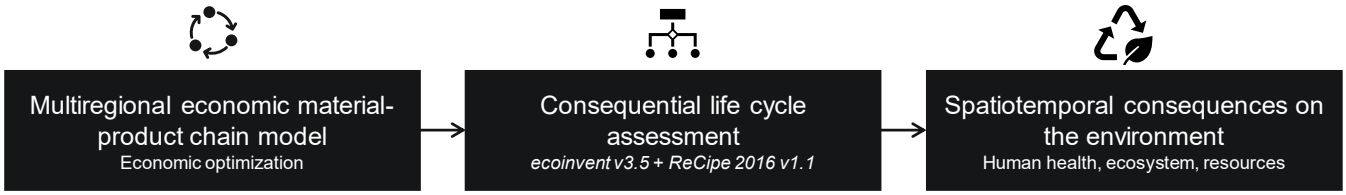

Fig.1— Simplified methodological framework of the CMPM-CVA model

Applications

This innovative approach allows to answer several key questions in a circular transition, as in the case of glass recycling scenarios: (1) What are the direct and indirect market adjustments brought about by this transition? (2) What are the marginal effects on human health, ecosystems and resources? (3) Which regions win and/or lose from the mitigation effects? In this way, it provides better support for planning a transition to a circular economy by exploring large-scale environmental trade-offs.

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