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Scaling circular supply networks – balancing the trade-offs of (de)centralization

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In achieving a transition to more circular, waste-free supply networks, the issue of the scale at which to close the loops of different chains is relevant for a wide variety of sectors and applications. Food donation networks for example, face considerable operational challenges as the supply of donated food is unpredictable in terms of products and quantities, and perishable food products have limited shelf life. Effective redistribution is desirable however, as unsold food is ideally still made available for human consumption. Food donation is often organized locally by volunteers who redistribute unsold products from local outlets. Aggregating supply at a larger scale could circumvent problems that arise here by smoothing the strong variability in supply across individual locations and better matching demand and supply for different products across the larger network. However, aggregation and centralization is often less resilient, involves more transportation, and increases the lead time of food with limited remaining shelf life. In the timber industry – a markedly different sector – large sawmills have highly optimized waste streams, whereas smaller sawmills offer the benefit of less transportation and often more resilient chains. When aiming for circular use of timber products, also the return flow, processing, and repurposing of materials after their initial use should be organized cognizant of the tradeoffs involved in scaling these circular networks. These diverse examples show that the issue of centralization versus decentralization is a recurring question for circular supply networks, and presents mathematically similar problems across diverse sectors. Quantitative approaches that help to understand these impacts regarding scale size and the ability to implement circular economy principles are currently lacking. In identifying the key modelling characteristics of this problem for different concrete cases such as for the aforementioned food banks, for agriculture, forestry, processing or others, we identify the multiple objectives, constraints and interdependencies involved. The aim of this project is to make an inventory of these issues when (de)centralizing waste-optimal supply chains and modelling these trade-offs for selected cases. Based on these concrete cases we subsequently develop an abstract model template that can be implemented in other contexts as well. This generalizable model supports decision-making on (de)centralization of circularity in different sectors and provides general principles for organizing circularity across the economy.

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