Efficient Operations of Industrial Symbiosis: An Enterprise Input-Output Model Integrated by Agent-Based Simulation

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Industrial symbiosis (IS) is a key for the implementation of circular economy. Through IS, wastes produced by one company can be used as primary inputs by other companies. Although identification of IS opportunities is usually enhanced, planning and operational phases still suffer from high uncertainty barriers as wastes are not produced upon demand but emerge as secondary outputs, depending on the demand for main outputs produced. The amount of a generic waste that two companies can exchange depends on: i) technical waste production coefficient of waste-producer; ii) primary input requirement coefficient of waste-receiver; and iii) final demands for main outputs produced by companies. However, these factors can change over time, causing uncertainty on potential physical flows. Such an uncertainty triggers fluctuations in waste treatment and transportation costs and makes difficult assessing the future economic benefits, thereby hampering companies to establish symbiotic collaborations. Companies need to deal with this operational uncertainty. In particular, they need dynamic models providing sensitivity analysis on factors affecting potential economic benefits.
This paper adopts an enterprise input-output model and integrates it into an agent-based model to measure the impacts of above-mentioned factors on economic benefits of IS. Empirical context covers a circular economy business case based on agriculture, animal farming, and biogas production.
Findings show that the quantitative ratios between final demands and waste and primary input coefficients are critical to optimize the cooperation. Some cases demonstrate that less technical efficiency or more waste production may increase the economic benefits, while others show that dematerialization or final demand change may reduce IS costs. Accordingly, information-sharing about adopted technologies and market demand help efficiently operationalize IS and highly encouraged by authors. Results lead us to innovative ideas to facilitate cooperation between separate sectors and implement future production zones nearby the waste streams rather than primary input locations

Keywords: industrial symbiosis, enterprise input-output, cooperation, operations, agent-based simulation