INDUSTRIAL SYMBIOSIS AS AN EMERGING PROCESS DRIVEN BY AN ENTERPRISE INPUT-OUTPUT MODEL

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Industrial symbiosis concerns the cooperative exchange of resources through business networks. In the literature the mechanisms of inter-firm resource exchanges have been largely investigated (Chertow, 2000; Ehrenfeld and Gertler, 1996), whereas less attention has been devoted to study their creation and development (Chertow and Ehrenfeld, 2012). At this regard, the economic convenience is generally considered the most important driver (Chertow, 2007); however it is also recognized that trust plays an important role in sustaining cooperative relationships (Hewes and Lyons, 2008).
A critical debate in the literature concerns the extent to which such industrial symbiosis networks should be designed by adopting a top-down approach, such as the eco-industrial park model, or, conversely, should be let emerge from the bottom, as the result of a spontaneous, self-organized process undertaken by the involved firms. In the last years, literature seems to converge in considering the latter the most promising model (Chertow, 2007; Chertow and Ehrenfeld, 2012). Then, we are spurred to investigate on the self-organizing process which leads to the creation of stable industrial symbiosis relationships among business firms.
To pursue this aim, we frame industrial symbiosis networks as complex adaptive systems (Chertow and Ehrenfeld, 2012) and use agent-based simulation as research methodology (Axelrod, 1997).
We develop an agent-based simulation model consisting of N agents (firms), each of them available to create a symbiotic relationship with another agent, and characterized as an input-output process. The resulting process network is modeled as an enterprise input-output system (Albino and Yazan, 2013) having stochastic final demands, raw material purchasing costs, and waste disposal costs.
A fitness function is defined which measures the extent to which is beneficial for the agent i to build a symbiotic relationship with j. This function is defined by taking into account the economic benefits associated with the symbiosis, the benefits associated with trust, essentially in terms of reduction of transaction costs, as well as the path dependence characterizing the system evolution.
At the first step of simulation, each agent establishes a symbiotic relation with another one. In the next steps, the relationship is maintained, only if the fitness value overcomes a given threshold; otherwise, the relationship is interrupted. When the agent stops a relationship, will search another agent to connect with, and so on. Stable relations among firms may arise or not depending on the value of the fitness over time.
Using this model we carry out a simulation analysis to evaluate in which scenarios industrial symbiosis relationships arise and become stable. Alternative scenarios are designed changing the number of agents (N) and the uncertainty of final firm demand which impacts on waste production and raw material requirements. Some cases are discussed in order to provide a contribution for policy-makers.

References

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