PROCEEDINGS

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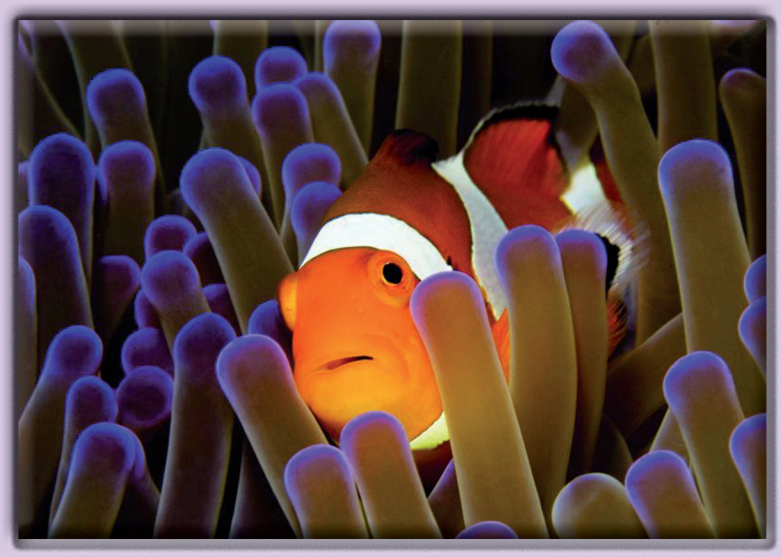
SYMBIOSIS USERS NETWORK



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Italian National Agency for New Technologies,
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ISBN: 978-88-8286-358-6

Editorial review: Giuliano Ghisu

Cover design: Cristina Lanari

RESOURCE INVENTORY FOR FOSTERING INDUSTRIAL SYMBIOSIS PRACTICES

Luca Fraccascia*, Guido van Capelleveen, Vahid Yazdanpanah, Devim Murat Yazan
Department of Industrial Engineering and Business Information Systems, University of Twente, The Netherlands
l.fraccascia@utwente.nl g.c.vancapelleveen@utwente.nl v.yazdanpanah@utwente.nl d.m.yazan@utwente.nl

Abstract

In this paper, we investigate the potential environmental benefits obtainable in Industrial Symbiotic Networks (ISNs) in case firms stock wastes when the demand is lower than supply. We design multiagent-based simulations to model the spontaneous emergence and operations of ISNs over time where firms are involved in substitution-based symbiotic relationships. In each simulation, we compute: 1) the amount of resources saved with respect to the amount of produced wastes; and 2) the amount of resources not saved because of the lack of inventory compared to the produced amounts. Results show that waste stocking could be a useful strategy to reduce the negative effects of the waste market dynamicity on the match between demand and supply.

Keywords: Industrial Symbiotic Networks, Inventories, Multiagent-Based Simulations.

Introduction

From the technical perspective, the most relevant condition for the development of Industrial Symbiotic Networks (ISNs) is the match between supply and demand of reusable resources, e.g., wastes [1]. However, ISNs' vulnerability to perturbations in the amount of both produced resources and required inputs negatively affects such a match [2]. When the produced amount (or required input) is reduced, the firm requiring the corresponding input (or producing the corresponding resource) is forced to buy additional amount of input from external suppliers (or to dispose additional amount of reusable resource in the landfill). Hence, since the economic benefit stemming from the industrial symbiotic relation (ISR) is reduced, the firm may decide to defect from the cooperative relation [3]. In order to deal with this problem, when demand is lower than supply, providers can stock the reusable resource rather than disposing. These stocked resources could be exchanged when the demand (potentially) becomes higher than supply. Whilst in some cases such a practice is hampered by the normative framework or because of technical issues [4], in other cases firms prefer not to stock because they are not willing to pay inventory costs. However, resource inventory can increase the amount of exchanged resources in the long period, hence providing firms with additional economic advantages, which could be higher than the inventory cost. To the best of our knowledge, this paper is the first attempt to investigate the strategy of resource stocking in ISNs. In particular, this paper is aimed at assessing the environmental benefits obtainable in case ISN firms adopt such a strategy.

Methods

ISNs are studied in the complex systems perspective, i.e., as emergent networks arising from the spontaneous decisions of independent but interconnected firms [3]. This study adopts a multiagent-based simulation approach: we design a model where agents are the firms within the ISN and links among agents are ISRs. The model simulates the spontaneous creation and operation of an ISN over time in different environmental scenarios, defined by two parameters: 1) waste market dynamicity (WMD), modeled as the standard deviation of demand and supply of wastes compared to the mean value (see [3] for details); 2) ISN topology, modeled as the average firms' degree of centrality (DOC) in the ISN normalized by the total number of firms in the ISN. Whilst the former parameter is considered to have a negative impact on the match between demand and supply, the latter is considered to have a positive effect [3,5].

All the physical and monetary flows among firms are modeled by adopting the Enterprise Input-Output (EIO) approach [1]. The model is applied to a case study involving marble producers and concrete producers [5]. Simulations are run for 40 time periods and replicated 200 times. At the end of each simulation, we compute: 1) the amount of resources exchanged in absence of stocking strategies in comparison to the amount of produced reusable resources; 2) the amount of not-exchanged (but disposed) resources as a result of lacking inventories in comparison to the amount of produced reusable resources.

Results

Table 1 shows the percentage of resources saved in absence of resource stocking strategies (in black) and the percentage of not-exchanged resources as a result of lacking inventory (in italic red) for each ISN simulation scenario. For instance, imagine an ISN with average DOC equal to 1 and WMD equal to 0.4. In absence of resource stocking strategies, 42.59% of produced wastes is saved while an additional 11.71% could be saved if firms would adopt waste stocking strategies.

Table 1. Percentage of resources saved in absence of resource stocking strategies (in black) and percentage of not-exchanged resources as a result of lacking inventories for each ISN simulation scenario (in italic red)

		WASTE MARKET DYNAMICITY							
		0.1		**0.2**		**0.3**		**0.4**	
AVERAGE FIRMS' DEGREE OF CENTRALITY	**0.02**	14.24 %	*0.80 %*	13.24 %	*1.60 %*	12.23 %	*2.33 %*	11.33 %	*2.99 %*
	0.04	22.43 %	*1.30 %*	20.49 %	*2.50 %*	18.82 %	*3.70 %*	17.59 %	*4.75 %*
	0.1	37.43 %	*2.20 %*	35.00 %	*4.29 %*	31.44 %	*6.24 %*	28.68 %	*7.82 %*
	0.2	48.00 %	*2.80 %*	44.66 %	*5.59 %*	40.85 %	*8.15 %*	35.55 %	*9.78 %*
	0.4	54.56 %	*3.21 %*	50.44 %	*6.29 %*	47.06 %	*9.33 %*	40.94 %	*11.23 %*
	1	58.71 %	*3.46 %*	54.69 %	*6.81 %*	49.98 %	*10.00 %*	42.59 %	*11.71 %*

Discussion and conclusion

The percentage of not-exchanged resources because of missing inventory strategies in ISNs ranges between 0.8% and 11.71% and it is much higher when the WMD and the DOC are high. This illustrates that the practice of stocking wastes in ISNs can significantly reduce the negative effects of the WMD, which is recognized as an important barrier to the development of new ISRs [3]. However, this practice appears to be barely useful when the ISN is characterized by low DOC. In such a case, firms should concentrate on building social relationships and trust among them instead of dealing with technical issues [6]. Further developments will address the economic implications of resource inventory for firms, in order to assess the extent to which such a practice could enhance the economic benefits for firms.

References

1. D.M. Yazan, V.A. Romano, V. Albino (2016). The design of industrial symbiosis: an input–output approach. Journal of Cleaner Production, 129, 537–547.
2. L. Fraccascia, I. Giannoccaro, V. Albino (2017). Rethinking Resilience in Industrial Symbiosis: Conceptualization and Measurements. Ecological Economics, 137, 148–162.
3. L. Fraccascia, I. Giannoccaro, V. Albino (2016). Exploring the role of contracts to support the emergence of self-organized industrial symbiosis networks: An agent-based simulation study. Journal of Cleaner Production, 112, 4353–4366.
4. A. Golev, G.D. Corder, D.P. Giurco (2015). Barriers to Industrial Symbiosis: Insights from the Use of a Maturity Grid. Journal of Industrial Ecology, 19, 141-153
5. L. Fraccascia, D.M. Yazan (2017). The role of information for the emergence of self-organized industrial symbiosis networks: an agent-based simulation approach. In ISIE-ISSST Conference 2017: Science in Support of Sustainable and Resilient Communities, 25th-28th June 2017, Chicago (USA).
6. A.K. Hewes, D.I. Lyons (2008). The Humanistic Side of Eco-Industrial Parks: Champions and the Role of Trust. Regional Studies, 42, 1329–1342.