Yazan D.M., Yazdanpanah V., Fraccascia L. (2017). Learning fair play in industrial symbiotic relationships. In: Fantin V., Mancuso E. (Eds.), Methods and tools for the implementation of industrial symbiosis. Best practices and business cases in Italy, pp. 49-50. http://openarchive.enea.it/bitstream/handle/10840/9067/V2017_SUN-Proceedings.pdf?sequence=1

LEARNING FAIR PLAY IN INDUSTRIAL SYMBIOTIC RELATIONS

Devrim Murat Yazan*, Vahid Yazdanpanah, and Luca Fraccascia
Department of Industrial Engineering and Business Information Systems, University of Twente, THE NETHERLANDS.
(E-mail: d.m.yazan@utwente.nl, v.yazdanpanah@utwente.nl, l.fraccascia@utwente.nl)

Abstract In this paper, we provide practical decision support to managers in firms involved in Industrial Symbiotic Relations (ISRs) in terms of strategy development and test the hypothesis that in the long-term, playing a fair strategy for sharing obtainable ISR-related benefits is dominant. We employ multi-agent-based simulations and model industrial decision-makers as interacting agents that observe their history of cooperation decisions in ISRs. The agents are able to: learn from their past, deviate from relations in which their partner plays unfair, and change their strategy to reach higher long-term benefits. Results show that in a long-run, industrial decision makers learn to play fair in ISRs. In addition to managerial support for developing long-lasting ISRs, our work introduces the concept of learning as a notion that links the micromotives in ISRs to their macrobehavior.

Keywords: Industrial Symbiotic Relations, Strategy Management, Learning in Industrial Relations, Industrial Symbiosis Evolution, Multiagent-Based Simulation

1. Introduction

To improve the implementability of Circular Economy (CE) in the industrial context, providing practical insights about Industrial Symbiotic Relations (ISRs) and their evolution fosters the shift from CE in theory to practice as it supports industrial decision-makers while getting engaged in ISRs. For such a purpose, understanding the long-term behavior of ISRs aids the decision makers learn about the effects of different strategies applicable for sharing obtainable ISR-related benefits. Accordingly, this work is focused on the long-term behavior of industrial agents and the evolution of cooperation decisions in ISRs. In such relations, two possible fair and unfair benefit-sharing strategies are taken into account. Applying a fair strategy implies that the firm is available to obtain a minimum acceptable benefit value while an unfair firm takes the major part of ISR-related obtainable benefits, which might be triggered by several reasons such as power asymmetry between companies, market image or existence of governmental regulations. Considering these strategies, we test the hypothesis that in the long-term, firms learn to implement the fair strategy. The rationale is that in case a firm A applies the unfair strategy, in the long-term other firms that are in relation with A learn that they can benefit more by defecting the relation (and joining other relations). Such collapses of relations are costly for A as it has to establish new ISRs and pay corresponding costs. This approach captures the *path dependence* phenomena and organizational learning processes in the context of industrial symbiosis [1,2].

2. Methods

We test our hypothesis using multi-agent-based simulations. In particular, we simulate multi-round games among industrial agents. The generic i^{th} agent is provided with the following three parameters: 1) $\pi(i)$ represents the probability that i plays the fair strategy when starting a new game; 2) $\psi(i)$ represents the probability that, if at time $t-1$ the agent i and its partner were cooperating, both of them playing the fair strategy, at time t the agent i changes its strategy and plays the unfair strategy; 3) $\chi(i)$ represents the probability that agent i interrupts its current relationship because it is playing the fair strategy and its partner is playing the unfair strategy. We

consider 100 resource-provider firms and 100 resource-receiver firms interacting with each other for 600 runs. At the end of the simulation, we collect: 1) the average value of π. The higher this value, the more firms learned the fair play in ISRs; 2) the average value of χ which is about agents learning that they can gain greater economic benefits by breaking the relationship with unfair partners; and 3) the average value of ψ. The higher this value, the more firms learned that opportunistic behaviors stemming from changing from fair to unfair strategy when the partner is playing the fair strategy is detrimental for long-term ISRs. Simulations are replicated 10000 times to give statistically significant results. All values are averaged across the replications.

3. Results

Simulation results are shown in Figure 1. In particular, Figure 1-Left shows the values of π, ψ, and χ for resource-provider firms whereas Figure 1-Right shows the values for resource-receiver firms.

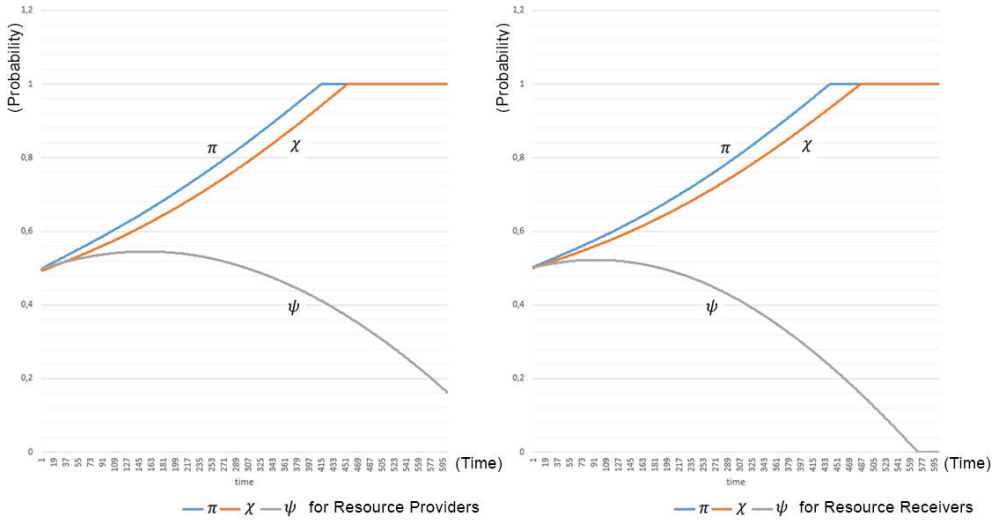

Figure 1: *Evolution of ISR parameters π, ψ, and χ for resource-providers (Left) and resource-receivers (Right).*

4. Discussion and Conclusions

First, we can note similarities between corresponding values for resource receivers and providers (e.g. $\pi(A)$ and $\pi(B)$). These similarities are because we have considered the ISRs as a form of symmetric relations and mainly focused on the temporal behavior of ISRs. Our results show that in the long-term, playing fair strategies increases the probability that an ISR arises. Moreover, firms learn that the opportunistic behavior (i.e. aiming to take more advantage from existing ISRs) is detrimental for their economic results. These results are in line with the literature highlighting the key role of collaboration for the success of the IS practice [3]. In addition to managerial decision support to industrial firms and suggesting the implementation of fair strategies in ISRs, we contribute to theoretical understanding of the relation between motives of individual industrial agents and the failure/establishment of long-term relations. We show that the macro-level behavior of ISRs (e.g., simultaneous emergence of multiple ISRs and their evolution) is not simply the aggregation of micro-level motives, e.g., to maximize the benefits regardless of the opponent's benefits (see [4]). Our results show that the ability of industrial decision-makers to learn, from their past experiences, bridges ISR micromotives to macrobehaviors and explains the dominance of fair ISRs in the long-term. This is, in a long-run, agents learn to play fair in ISRs.

Yazan D.M., Yazdanpanah V., Fraccascia L. (2017). Learning fair play in industrial symbiotic relationships. In: Fantin V., Mancuso E. (Eds.), Methods and tools for the implementation of industrial symbiosis. Best practices and business cases in Italy, pp. 49-50. http://openarchive.enea.it/bitstream/handle/10840/9067/V2017_SUN-Proceedings.pdf?sequence=1

References

1. Boons, Frank, and Jennifer A. Howard-Grenville, eds. 2009. *The social embeddedness of industrial ecology*. Edward Elgar Publishing.
2. M.R. Chertow, 2007 “Uncovering” industrial symbiosis. Journal of Industrial Ecology 11(1) :11-30.
3. M.R. Chertow, 2000 Industrial symbiosis: literature and taxonomy. Annual review of energy and the environment 25(1) 313-337.
4. Schelling, Thomas C. 2006 *Micromotives and macrobehavior*. WW Norton & Company.