WHY COMPANIES DO NOT IMPLEMENT INDUSTRIAL SYMBIOSIS?

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ABSTRACT

This paper is aimed at highlighting the main barriers hampering the development of the industrial symbiosis (IS) practice. The study is divided into two parts. First, a systematic literature review was conducted, in order to identify the barriers mentioned in the literature. 77 papers published by scientific international journals were analyzed and the barriers to IS were classified according to their nature (i.e., technical, economic, legal, and strategic) and according to five steps of IS (i.e., awareness, feasibility assessment, partner identification, implementation, and operation over time). Then, a survey was designed, in order to collect feedback from IS experts on the extent to which the barriers identified by the literature review are perceived as significant.

Keywords: *Industrial Symbiosis, Barriers, Systematic Literature Review, Survey*

Introduction

Industrial symbiosis (IS) is a subfield of industrial ecology that engages separate industries in a collective approach to competitive advantage, involving physical exchanges of materials, energy, and services [1,2]. Through IS, companies can replace production inputs with wastes and by-products generated by other companies. As a result, companies can reduce their production costs and contribute to generate environmental and social advantages for the overall collectivity. Nevertheless, the adoption of the IS approach is not largely spread across companies. A recent work by Mortensen and Kørnov [3] highlights the critical factors impacting on the initial phase of creating symbiotic relationships. However, a comprehensive view on all the barriers that companies face when operating IS, not limited to the emergence phase but addressing also the implementation and operation phases, is lacking in the literature. Furthermore, there are no studies ranking these barriers according to their perceived importance. This paper aims at filling these two gaps. First, through a systematic review of the available literature, we identified the barriers for companies and categorized them according to their nature, as well as according to the steps of IS adoption. Then, we designed a survey, aimed at collecting information on the extent to which these barriers are perceived as relevant by experts of IS. The rest of the paper is structured as follows: Section 2 presents the methodology, Section 3 presents and discusses the results, and Section 4 describes the conclusions.

Methods

The study is based on a systematic literature review started on July 2019. The first step was to collect papers. The data were retrieved from Scopus, an academic citation indexing and search

service of Elsevier. The following research keywords have been applied to title, abstract, and keywords of papers to cover the largest possible selection: ("industrial symbiosis" OR "industrial symbiotic network*" OR "eco-industrial park*") AND "barrier", limiting the research to papers published in English in international scientific journals. As a result of the research, 77 papers were collected. For each of them, we analyzed the full text, aimed at collecting relevant information on the IS barriers mentioned. The main barriers to IS described in the analyzed papers were identified and categorized according to their nature (i.e., technical, economic, legal, and strategic), as well as according to five steps of IS (i.e., awareness, feasibility assessment, partner identification, implementation, and operation over time). Then, based on the barriers identified, a survey has been designed, aimed at collecting feedback from IS experts on the extent to which the above-mentioned barriers are perceived as significant. The survey is made by several statements: for each of them, respondents were required to select the extent to which they agreed or disagreed with that statement, according to a 5-points Likert scale (1 = full disagreement, 5 = full agreement). Ten respondents were selected, five academics and five company managers. Results were collected between September and October 2019.

Results and discussion

Table 1 shows the main barriers identified, categorized according to their nature (rows) and the IS step to which they belong (columns). It can be noted that, in the awareness phase, companies face barriers related to the strategic nature.
Legal barriers hamper the feasibility assessment phase. Finally, technical and economic barriers impact on the partner identification, implementation, and operation over time.

Table 1. IS barriers categorized according to their nature and the IS step to which they belong

		Awareness	Feasibility assessment	Partner identification	Implementation	Operation over time
Technical	Barriers related to the waste-to-input conversion		✓			
	Mismatch between demand and supply of wastes			✓		
	Lack of information			✓		
	Lack of space to stock wastes				✓	
	Fluctuations in the demand and supply of wastes					✓
Economic	Lack of economic incentives		✓			
	Investments required		✓			
	High transitions costs			✓	✓	
	Benefits not fairly shared among the involved companies				✓	
	High transportation costs				✓	
	Fluctuations in the waste disposal and input purchase costs					✓
Legal	Legal requirements and bureaucratic procedures		✓			
Strategic	Lack of awareness on the potential benefits of IS	✓				
	Lack of awareness of the IS basic concepts	✓				
	Low propensity to innovation	✓				
	IS is far from the core business	✓				
	Lack of trust among companies	✓				
	Lack of willingness to cooperate	✓				

Table 2. Main results from the survey (T = technical, E = economic, L = legal, S = strategic)

T	E	L	S	Statement	Average value
	✓			Companies are willing to implement IS synergies only if they are economically convenient	4.25
	✓			Low waste disposal costs drive companies to dispose of their wastes without implementing alternative solutions	4.25
			✓	Companies are focused on their core business and IS is not perceived as a strategical activity	4.25
	✓			IS synergies have to be convenient enough for all the involved companies. Hence, the benefits created by the synergy should be fairly shared among the involved companies	4.17
	✓			When companies are not close-by, waste transportation costs are too high in comparison to the potential benefits	4.17
	✓			Economic benefits from IS might fluctuate over time	4.08
✓				The mismatch between potential demand and supply of wastes is affected by the lack of information and communication among companies	4.08
✓				There are relevant operational problems, e.g., concerning quantity and quality of wastes, as well as transportation time and mode	4.08
		✓		Some legal requirements ruling waste exchanges are old and hamper the establishment of IS synergies	4.08
		✓		Some bureaucratic procedures ruling waste exchanges are too complex and hamper the establishment of IS synergies	4.08
			✓	Companies do not implement IS because they face difficulties when integrating this practice into their current business models	4
		✓		The lack of a clear legislation on waste exchanges hampers the establishment of IS synergies	4
			✓	If companies do not take into account the need of their symbiotic partner(s), the risk of failure of IS relationships is high	4

Table 2 shows the main results of the survey. In particular, the statements characterized by average score higher than or equal to four are shown. Each statement is categorized according to the nature of the related barrier. Statements are ordered by decreasing value of average score.

It can be noted that five of the first six statements concern economic barriers. In this regard, companies would like to implement only IS relationships economically convenient and, in some cases, the low waste disposal costs and input purchase costs are perceived as strong barriers. In fact, the higher these costs, the higher the economic benefits coming from IS, and therefore higher the economic convenience of IS will be, ceteris paribus [4]. Furthermore, all the involved companies have to gain sufficient benefits from the relationship, otherwise they are not interested to cooperate. This means that the overall economic benefits created by IS should be fairly shared among the involved companies.

Finally, the transportation costs limit the geographic scale of IS relationships. This means that, for companies located not close-by, the IS relationship might be not convenient enough because transportation costs erode the economic benefits created by IS.

Concerning the technical barriers, two operational problems are perceived as strongly relevant, i.e., the mismatch between demand and supply of wastes and issues related to the waste quality. From the strategic perspective, companies are focused on their business and IS is not perceived as a strategic activity.

However, even companies able to overcome this barrier might face problems when integrating the IS practices into their current business models. Finally, from the legal perspective, the respondents to the survey agree on the fact that legal requirements and bureaucratic procedures are, in some cases, too complex to deal with, or the legislation concerning waste disposal is not clear enough with reference to the IS practice.

Conclusions

This paper was aimed at identifying the main barriers hampering the creation of IS relationships among different companies and clarifying the extent to which these barriers are perceived as relevant by experts of IS. According to the findings, economic and technical barriers are perceived as the most significant. Overcoming these barriers is fundamental in order to promote the development of IS. Policymakers can have an important role in such direction. For instance, they can design economic incentives for companies adopting IS, with the aim to increase the economic profitability of investments in IS [5]. Furthermore, they are in charge for reducing the legal barriers to IS, in particular by making the legislation ruling the waste exchanges clearer and less complex. Technical barriers are more difficult to address. In this regard, future research should address how to tackle the operational problems of IS, aimed at providing solutions able to ensure the match between demand and supply of wastes, as well as to solve logistic issues. Furthermore, further analysis is required to verify whether different perceptions of the same barrier might arise when considering experts from different geographic areas.

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