

Industrial symbiosis exchanges

developing a guideline to companies

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Abstract

Current Industrial Symbiosis (IS) research focuses to a large extent on either 1) how likely different factors and conditions are to lead to the development of IS exchanges, 2) barriers to IS or 3) on network theories. There is less focus on how to realize actual exchanges between companies. The purpose of this paper is thus to operationalize current theories and knowledge of such IS barriers in order to provide a guideline on realization of IS projects and hereby make the knowledge of the scientific community applicable in the everyday work of companies. The findings of previous IS research are combined with both research on two companies currently in the process of establishing an IS exchange, as well as practitioners working with facilitation of such exchanges. Lastly, the findings and research are combined to determine what should be the content of a guideline on IS, so that it provides motivated companies with knowledge on potential barriers and opportunities in a way that is directly applicable to their everyday work. The study shows that important barriers for realizing IS-exchanges that can be influenced by companies are mainly related to a lack of resources in the form of money, time, and knowledge, technical issues and collaborative issues. This leads to the recommendation that the contents of a guideline should address information about the concept and benefits of IS, local facilitation programs, if available, and what to be aware of, if there are no facilitation programs or if the companies decide not to take advantage of them.

Keywords: Industrial Symbiosis, Guideline, Companies, Barriers, Enabling factors, Facilitation

Introduction

Current research on Industrial Symbiosis often takes a systemic approach. Focus tends to be on either 1) how likely different factors and conditions lead to the development of IS exchanges [1-5], 2) barriers to IS [3, 4, 6, 7] or 3) on network theories [8, 9]. Less focus is given to how actual exchanges between companies can be realized. In this paper, we seek to make this knowledge applicable in the everyday work of companies by operationalizing theories on barriers. By focusing on which barriers can be influenced by companies who wish to engage in IS, and what they can do to overcome them, the research uncovers what should be the content of a guideline directed to companies wanting to initiate and IS-exchange.

In many countries IS facilitation programs already provide useful help to realizing IS- exchanges. Paquin and Howard-Greenville [1] show that such facilitation programs consist of both serendipitous and goal-directed processes. In goal-directed processes the facilitators intentionally bring the companies together to achieve certain goals set up by the companies or the program [10-12]. Serendipitous processes on the other hand are not directed by an overall goal and develop in an undirected manner [13]. They grow slowly [14, 15] but help develop a relatively high level of trust between companies participating in the program, compared to programs that operate mainly on goal-directed processes, and are necessary for the long-term resilience of the program [1]. A way to assist serendipitous processes is by increasing awareness of the IS concept, in a way that makes it clear to companies how they can benefit from IS and that enables them to start thinking in terms of IS. This is also addressed in the recommendations for the guideline.

In order to establish recommendations for the content of such a guideline, a literature review has been conducted. Furthermore, data has been collected both through a case study on two companies currently in the process of establishing an IS-exchange and through interviews with practitioners working with facilitation of IS-exchanges. These mixed methods help to identify both the barriers and the enabling factors for the realization of IS-exchanges, as well as the working methods of the facilitators. Important barriers that can be influenced by companies are mainly related to a lack of resources in the form of money, time and knowledge, technical issues and collaborative issues. The information gathered in the study is combined so as to determine the required content of a useful guideline on realizing IS; Information about the concept and benefits of IS, local facilitation programs, if available, and what to be aware of if there are no facilitation programs or the companies decide not to take advantage of them.

Methodology

The data collection of the study is based on a mixed methods approach, conducted by triangulation to ensure the validity of the study [16-18]. This means that data is obtained from three sources: a literature review, empirical data from a case study and empirical data from interviews with practitioners who work with the facilitation of IS-exchanges. A theoretical framework obtained from the literature on IS guides the data collection in all three parts of the study.

The literature review provides an overview over the latest knowledge on barriers and enabling factors to IS-exchanges available in current literature. By putting this knowledge into a concrete context, a case study provides deeper insights into the details and complex relations of real-life situations [19]. The case study in this paper investigates the barriers and enabling factors that two companies face in their everyday work and in particular in the process of establishing an IS-exchange of surface water. The practitioner interviews also focus on barriers and enabling factors of setting up IS-exchanges. Thus, the practitioner interviews serve to confirm the findings of the literature review and the case study, and hereby expand the empirical basis of the study as they draw on the experiences of everyday experts. Compared to what would be valid based solely on the case study, this expanded empirical basis broadens the generalizability of the study. In addition, the practitioner interviews also investigate how the practitioners work in order to overcome some of the barriers and how they take advantage of the enabling factors. The research design is illustrated in Fig. 1.

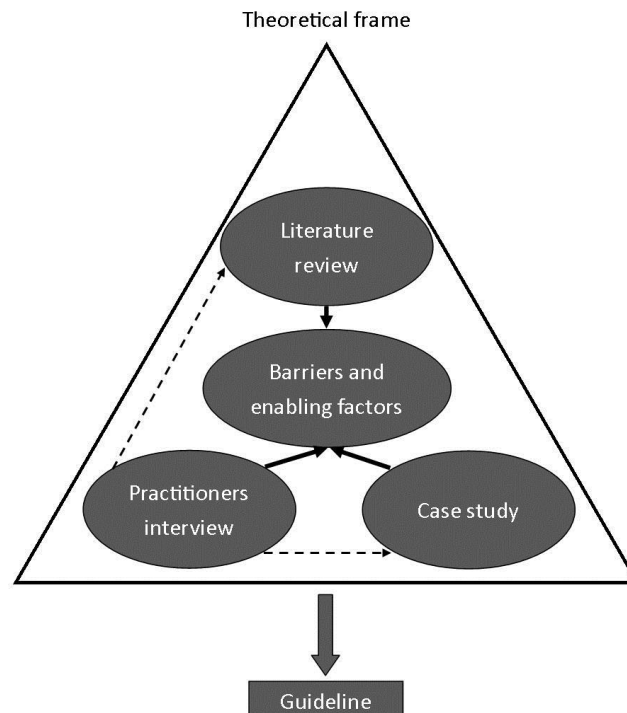


Fig. 1 Research design

As illustrated in Fig. 1 the three parts of the study share a common theoretical framework that guides the data collection. Furthermore, the results from the literature study and the case study are used to create interview guides for the practitioner interviews.

Theoretical framework

The theoretical framework has been developed on the basis of literature on barriers and motivations to IS [3, 4, 6, 7, 20] as well as implementation theory [21].

Barriers

The barriers found in the literature that serves as basis for the theoretical framework are summarized in grouped form in table 1. The grouping guides the data collection and is based on two parameters.

The first parameter is the type of barrier. These different types are inspired by Chertow [3, 6] and Cote and Grant [7] who divide barriers to IS in: technical issues, regulatory issues and business issues. In this paper, we have combined the business issues with the barriers related to knowledge and time from Fitchner et al. [4] to form the type resources. Likewise inspired by Fitchner et al. [4], we have included the motivation type.

The second parameter is the organizational level on which the barrier occurs. These organizational levels are inspired by implementation theory, originating from political science. Winter [21] describes how the final implementation of politics amongst other things are dependent on processes occurring on three organizational levels: The interorganizational level (between different governmental institutions), the intraorganizational level (internally in each institution), and the level of the fieldworkers (the workers who meet the citizens and execute the policy in its most concrete form). Fitchner et. al. [4] have a similar division into levels in their description of barriers to IS. Therefore we believe that these same levels are relevant to the realization of IS-exchanges between companies. In the theoretical framework of this study, the interorganizational level refers to the cooperation between the involved companies and the intraorganizational level refers to internal factors within the companies. The last level is renamed *the employee level*, referring to factors related to each individual employee in the companies.

Table 1 Theoretical framework: Barriers to realization of industrial symbiosis exchanges

Type of barrier / Level on which the barrier occurs	Physical/Technical	Regulatory	Resources	Collaboration	Motivation
Barriers on the Interorganizational level	-Difference between supply and demand [3, 4]	-Legislation [3,4,6,7]	-Unknown cost-benefit ratio[4] -Different investment cycles [4] -Costs [6,7] -Search -Negotiation -Enforcement	-Organizational structure of companies [4] -Assignment of costs and benefits between partners [4] -Dependence on partners [4] -insufficient communication [4] -Insufficient trust [4,7]	
Barriers on the Intraorganizational level	-Difference between supply and demand [4] -Infrastructure [6]	-Legislation [3,4,6,7]	-IS not a priority [4] -Costs [6,7] -Search -Negotiation -Enforcement -Lack of Knowledge [3, 4, 7]	-Organizational structure of companies [4]	-Lack of priority of environment/sustainability work [4,3] -Lack of economic incentive from market or regulation [3]
Barriers on the Employee level			-IS not a priority [4] -Lack of Knowledge [3,4,7]	- Lack of Promoters in companies [4]	

Enabling factors

Motivations for taking part in network activities and environmental cooperation have been mapped in a previous study on a business network in the area where the two case study companies of this paper are located, and that one of the companies are a member of [20]. Those motivations that seem relevant to industrial symbiosis as well are summarized in table2, together with motivations listed in Chertow [3]. Note that table 2 is created using the same groupings as **Error! Reference source not found.** In addition, the factors that constitute barriers in table 1 can be assumed to constitute enabling factors if they are present in their reverse forms. These are not included in table 2

Table 2 Theoretical Framework: Enabling factors to the realization of industrial symbiosis exchanges

Type of enabling factor / Level on which the enabling factor occurs	Physical/Technical	Regulatory	Resources	Collaboration	Motivation
Enabling factors on the Interorganizational level		-incentives [3]			-Earnings or savings [3,20] -New business opportunities [20] -Competitive advantages [20]
Enabling factors on the Intraorganizational level		-incentives [3]			-Earnings or savings [3,20] -New business opportunities [20] -Competitive advantages [20] -Values [20] -Branding [20] -Follow company strategy on sustainability [20]
Enabling factors on the Employee level					

Note that some of the barriers and enabling factors occur both on the interorganizational level and on the intraorganizational level. The reason for this is that while these barriers and enabling factors often manifest themselves in the collaboration between the companies (on the interorganizational level), the cause is often rooted in internal conditions within the companies (the intraorganizational level). Similarly, some barriers and enabling factors may occur both on the intraorganizational level and the employee level. For instance, if many employees lack a certain kind of knowledge this would lead to a lack of that specific knowledge in the company as a whole.

Identifying local factors

One part of the case study focuses on identifying physical, technical, economical and legal barriers and enabling factors related to the proposed IS-exchange. These factors are very much dependent on the location and the exchange in question. Therefore the required types of data will also vary. In this study, data was collected mainly from literature studies of district plans, various environmental authorizations, taxes and fees, raw material prizes, and weather data. In addition, the demand and supply of the resource in question was identified.

Interview methods

The other part of the case study consists of interviews with the two companies. These interviews are conducted as semi-structured interviews [22] by the use of a fictive timeline of the realization of the proposed IS-exchange. The companies were then asked to identify which barriers and opportunities or enabling factors they could see in the phases along the timeline [11]. There are advantages and disadvantages of both highly structured interviews and interviews with open-ended questions [17]. By the use of semi-structured interviews, we have

tried to improve the reliability of the results. To improve the reliability of the interviews, they have been made as identical as possible, hence the timeline. In line with the semi-structured form this has been combined with open ended questions, as recognition of the need to catch as much as possible of the complexity and open-endedness of social interaction.

A different approach is taken to the practitioner interviews. They are also semi-structured, but the practitioners are asked to describe their role in facilitating IS-exchanges. This is done to gain further insight into their competences within the field, and thus their validity as experts. Next, they are asked to describe their work process and –methods, and to identify important barriers and enabling factors for the realization of IS-exchanges.

To further improve the reliability of the interviews, all interviewees of both company and practitioner interviews have been given the chance to revise summaries of their interviews, hereby ensuring that we have interpreted their responses correctly.

Constructing a guideline

In order to operationalize the applied theories, the collected data is used to create a guideline for companies. In order to test the usability of the guideline, it is presented to companies who have participated in the study, as well as the participating practitioners.

Findings: Barriers and enabling factors

Based on the case study and the interviews with practitioners, a number of important barriers and positive factors have been found. As the focus of the study is to create the framework of the content of a guideline to companies, only the uncovered barriers and enabling factors that companies can realistically have an influence on are explained in detail below.

Resources

The type that most of the important barriers and enabling factors that can be directly influenced by companies were found to belong to was resources, in the form of money, time or knowledge.

Lack of knowledge on possible collaborators has shown to be a major obstacle for realizing industrial symbiosis projects. Often companies don't know what their neighbor is doing. The solution for removing this barrier is quite simple; to expand ones network. However, this is easier said than done. A proven solution is the use of facilitating organizations [3]. Often a central organization has the required overview and knowledge to help pair companies. Our recommendation for companies is therefore to use the options provided in some countries for facilitating industrial symbiosis projects as an effective way to overcome the network barrier.

Common responses from companies are that it is resource demanding and often not a part of their key competencies to initiate IS projects. The focus of companies tends to be on their products and markets rather than their by-product flows. A change of focus and particularly the tasks related to initiating IS-exchanges, i.e. finding partners and investigating the potential of the ideas, require resources, time and knowledge. Therefore, little focus is given to IS. In both the case study and the practitioner interviews, it was found that companies sometimes do have ideas about by-products or resource needs that could potentially become an IS project. However, due to the lack of focus on IS, tasks related to their main products tend to take priority. Again organizations established to help facilitate IS projects can be of help. as they are often able to provide assistance in funding and/or initiating projects like screenings of companies and education of the staff. The main issue related to education is found to be a need for provoking the employees to expand their focus from just the

product to their entire production. Not just by-products should be in focus but all materials coming in and out of the property. Related questions are:

- How is the flow of materials in the production organized?
- What kind of by-products does the company have?
- What are the options for separating by-products that have been mixed up, and thereby polluted?

Questions like these might help employees to broaden their focus.

Differences between the companies have also shown to be a barrier in more than one way, and appear under both the physical/technical type and the collaboration type.

Physical/technical

Differences between the amount of by-product a company can supply and the amount another company is capable of handling or willing to accept can make an IS difficult to realize. The amount of by-product can be too big for the other company to handle. In this case the supplying company will only be able to realize some of its IS-potential and solve a part of their by-product problem. This reduces the benefits of an exchange and thereby decreases the chances of the IS to be profitable, especially in cases where the IS is only possible with investments in infrastructure. On the other hand, the amount of by-product can also be too small for a recipient to be willing to accept the by-product. A joint project of more companies collecting the by-product is a way of fulfilling the demands of a larger recipient. The main issue in this case is to identify companies with similar by-products. However, companies within the same industry often have similar by-products, and thus industry associations could be an ideal place for locating companies with the same by-products. Again, network plays an essential role in the realization of IS.

On the other hand, differences between companies increase the chances for establishing IS, as different companies have different needs and different things to offer. Companies producing the same or similar products will often also have the same needs for materials and the same by-products. Therefore, the biggest chances of finding providers or recipients of by-products will logically be in other industries. Local business organizations or other industry organizations might be a good way of finding partners. In addition, this is an area where facilitation programs are very useful. In general, sharing of ideas is a good way of locating possibilities for IS, and might help bring some of the unexploited ideas into play.

Collaboration

A barrier related to the sharing of ideas, is the companies need for confidentiality. Trust is thus very important. In the case of local or industrial organizations, it is important for the companies to trust each other. This kind of trust might take time to build but will also result in stronger relationships between companies, and increase the likelihood of more serendipitous collaborations emerging, thus securing a flow of new exchanges [1]. Where facilitating programs are used, the required trust is between the facilitator and the companies. In order for the facilitator to gather information that enables him to match companies, the companies must trust the facilitator with sensitive or confidential information. It is therefore crucial that the companies can trust the facilitator not to reveal or exploit this information.

How to assign cost and benefits between the collaborating companies can be a major barrier, and since the assignment is made by the companies themselves it is also within their reach to influence it. However, since this issue is a matter of negotiation between the companies and can be expected to be highly dependent on the situation, it is hard to address in a general guideline.

In this study, the case consisted of one smaller company (80 employees) and a large international company. Interviews with key employees related to the realization of the IS showed a main barrier related to the differences in company size and the chain of command. The smaller company has a rather short chain of command. As a result, it is quickly decided whether a new idea is to be adopted, and it is fairly quickly implemented and tested in reality. In the larger company, the chain of command is longer and less clear. In fact, it was difficult for the interviewed employees to locate exactly who would be able to make the final decision. A great concern of the smaller company was therefore a slower decision-making process in the big company due

to its complicated chain of command. This made it less motivating to spend time and energy on starting a collaboration. Another difference was the amount of precautionary measures taken by the companies. The large company has a very closed structure and wishes to disclose as little information as possible. Also they operate with a comprehensive standard contract when collaborating with other firms. This is in order to ensure that in case anything goes wrong all legal matters and matters of responsibility are properly dealt with and thus does not risk damaging the company's brand. Such a big contract will be likely to discourage the smaller company from entering into a collaboration, as it will again slow down the process significantly when having to consider all this. Also, the smaller company may not have the legal competences for it, and thus will have to invest in hiring lawyers to ensure that their interests are safeguarded.

Summary of barriers and enabling factors

Table 3 and table 4 summarize the barriers and enabling factors relevant to companies found in this study. The literature studies of Maes [23], Bojsen and Ulhøi [24] and Almasi et al. [25] have shown that many of the listed barriers and enabling factors in Table 3 and Table 4 correspond with the findings of these studies. However, the findings do differ in a few aspects. In the studies by Maes [23] and Bojsen and Ulhøi [24], a number of other technical barriers have been found. This difference may be due to the, in technical terms, rather simple case that have been examined in this study. The study by Bojsen and Ulhøi [24] has found cognitive barriers related to the paradigm about IS. Bojsen and Ulhøi [24] however, have a much more philosophical approach, why it cannot be expected that this study finds the same barriers. In general, the reviewed literature has only focused on enabling factors related to motivation and economic incentives.

Beside the ones covered above, a number of other relevant barriers and enabling factors were found. Although relevant for companies wanting to initiate IS, these barriers cannot be influenced through the everyday work of the companies. Therefore, they have not been found relevant to the creation of the guideline framework. The main barrier in this category is found to be economy. Companies have a strong focus on profitability and if the pay-back time of a given exchange is too long, it will most likely not be initiated. Legislation, practices of the authorities and physical barriers are also important barriers to be aware of. Physical barriers can be the lack of infrastructure or local physical barriers as geological conditions, rivers, mountains, pollution etc.

Notice that the type of barrier/enabling factor named "society" has been added to the theoretical framework. This was done because an enabling factor was found that did not fit into the original categories. This was the case for barriers related to academics' understanding of IS. One of the practitioners found that academics mainly focused on IS as 'end of pipe' activity, where the practitioner considered the true potential of IS to be in process improvement, innovation, knowledge transfer and culture change. The enabling factor of society's demand for circular economy would by first glance seem to also belong to this type. However, this enabling factor addresses the fact that the discourse of resource efficiency and circular economy has grown so strong that companies are beginning to feel a need to deliver on this agenda, making it a motivational factor for companies to engage in IS.

Table 1 Barriers to industrial symbiosis relevant to companies

Type of barrier / Level on which the barrier occurs	Physical/Technical	Regulatory	Resources	Collaboration	Motivation	Society
Barriers on the Interorganizational level	<ul style="list-style-type: none"> -Harder to find buyers than suppliers -<u>Mismatch of quantities</u> -<u>Physical surroundings</u> 	<ul style="list-style-type: none"> -Limited interpretation of industrial symbiosis 	<ul style="list-style-type: none"> -Uncertain profit -<u>Low raw material price</u> -Lack of knowledge about other companies 	<ul style="list-style-type: none"> -<u>Size difference</u> -<u>Priority of the collaboration</u> -Lack of trust -<u>Assignment of costs and benefits between partners</u> 	<ul style="list-style-type: none"> -Different interests -Different levels of motivation 	<ul style="list-style-type: none"> -Limited interpretation of industrial symbiosis
Barriers on the Intraorganizational level	<ul style="list-style-type: none"> -<u>Mismatch of quantities</u> -<u>Physical surroundings</u> 	<ul style="list-style-type: none"> -Unsynchronized working processes between companies and authorities -<u>Lack of internal communication in municipalities</u> -<u>Legislation</u> -Limited interpretation of industrial symbiosis -Lack of clear policy signals/investment 	<ul style="list-style-type: none"> -Uncertain profit -Lack of knowledge about other companies -<u>Economy</u> -<u>High priority of profitability</u> -<u>Prioritization of employee resources</u> -<u>Sticking to key competences</u> -Lack of expertise -Lack of knowledge of IS 	<ul style="list-style-type: none"> -<u>Closed company culture</u> 	<ul style="list-style-type: none"> -Lack of priority of environment/sustainability work 	<ul style="list-style-type: none"> -Limited interpretation of industrial symbiosis
Barriers on the Employee level			<ul style="list-style-type: none"> -Lack of knowledge of IS -Lack of expertise 			<ul style="list-style-type: none"> -Limited interpretation of industrial symbiosis

Barriers found in the case study are underlined

Barriers found in the practitioner interviews are **bold**

Barriers found in both the case study and the practitioner interviews are both **underlined and bold**

Table 2 Enabling factors for industrial symbiosis relevant to companies

Type of enabling factor / Level on which the barrier occurs	Physical/Technical	Regulatory	Resources	Collaboration	Motivation
Enabling factors on the Interorganizational level	<ul style="list-style-type: none"> -<u>Extending existing exchanges</u> -Collection scheme 	<ul style="list-style-type: none"> -Clear and encouraging policies/incentives 	<ul style="list-style-type: none"> -Facilitation schemes -Workshops 	<ul style="list-style-type: none"> -Knowledge about neighbor companies -Trust -Think out of the box, across sectors and borders -Workshops -Industry organizations with good knowledge sharing 	
Enabling factors on the Intraorganizational level		<ul style="list-style-type: none"> -<u>Constructive collaboration with public authorities</u> -Clear and encouraging policies/incentives -Relatively simple application procedures for funds -Financial support for investigation / test-production 	<ul style="list-style-type: none"> -Networks with technical research and development -Evidence base of IS results -Proven tools and techniques for IS -Focus on by-products -Facilitators write applications for funds 	<ul style="list-style-type: none"> -Trust -Society's demand for circular economy 	<ul style="list-style-type: none"> -<u>New business opportunities</u> -Good experiences lead to more activity and culture change -Clear results -<u>Follow company strategy</u> -<u>Economy</u> -<u>Dormant ideas</u> -Competitive advantages -Society's demand for circular economy
Enabling factors on the Employee level				<ul style="list-style-type: none"> -<u>Internal ambassadors of IS in companies</u> 	<ul style="list-style-type: none"> -Professional Pride -Society's demand for circular economy

Enabling factors found in the case study are underlined

Enabling factors found in the practitioner interviews are **bold**

Enabling factors found in both the case study and the practitioner interviews are both **underlined and bold**

It is noteworthy how the barriers and enabling factors listed in the tables are distributed. In table 3 the barriers at the intraorganizational level are mainly barriers related to regulatory and resource issues. The distribution is much scattered at the interorganizational level but with many barriers related to collaboration. The picture is more or less the same when looking at the enabling factors in table 4, although it is clear that motivational factors occur mainly on the intraorganizational level.

Guideline recommendations

Based on these findings, in order to provide companies with the required knowledge in an easily understandable and hands-on way, it is outlined in the following what should be included in a useful guideline. The content of the guideline should be a basic introduction to the concept of industrial symbiosis as well as examples of benefits of IS from concrete projects. Providing concrete evidence of the effects of the symbioses should help convince skeptical companies of the possibilities, and enhance the motivation of companies that are already interested. As it was found that facilitation programs are an appropriate way of dealing with many of the barriers listed above, a quick overview should be provided over any available facilitation schemes (if such schemes are available to the companies in the target group). In this overview, the services and possibilities for financial support offered should be included. However, a facilitation program might not be available to some companies, or even if it is, they might not want to take part in one. Therefore, advice should also be offered on what to be aware of if a company chooses to take on realizing an IS-exchange on its own. The advice should describe how to start thinking in terms of industrial symbiosis as well as ways to expand ones network. The companies should also be aware of possible barriers to communication due to differences in company sizes and working processes. Likewise looking into the technical aspects of the project, getting an overview over relevant legislation and incentives as well as area-specific regulations are important. Lastly advice should be offered on ways to deal with a mismatch of quantities.

Discussion

As it was shown in table 3 and 4, the results from the literature review, the case study and the practitioners' interviews overlapped to some extent. However, some of the results differed, especially between the case study and the practitioners' interviews. Rather than taking this as a sign of inconsistency between the data sets, this can be seen as a result of the triangulation approach. By having datasets that see the researched object from different points of view, we have been able to get a fuller picture of the barriers and enabling factors in play, and how to overcome or exploit them. This forms a stronger basis for the recommendations, compared to results gained with only one of the methods. Likewise, with one exception being the barriers related to academics' understanding of IS, the two datasets fitted well into the theoretical frame, which also supports the reliability of the study. In general, the study has confirmed the literature. In some areas, we have been able to add more detail to some of the known barriers. The study have found quite a few additional enabling factors. This can be a result of the equal attention to barriers and enabling factors of this study. This is contrary to many studies from the literature, which tend to focus mainly on the barriers. Many of these barriers can be said to be reverse enabling factors. Thus, the enabling factors are to some extent already accounted for in the literature. For instance economic incentives are a barrier if they lack, but an enabling factor if they are present. Others are efficient working methods of the IS practitioners.

In the case study, it became fairly quickly evident that the case project would not be economically profitable. This meant that most of the barriers and enabling factors were identified through what the interviewees perceived as barriers. Since the process of realizing the exchange never got further than the investigation stage, it was not possible to observe what role these barriers and enabling factors would play in the following stages. In addition, recent research finds that companies are more likely to initiate IS projects with greater economic value [2]. However, great economical values do not seem to be an enabling factor regarding actually completing the projects [2]. On this basis it would be relevant to investigate more projects, including profitable ones, in order to see what role the different barriers and enabling factors play in a profitable project and how they interplay with each other.

The creation of a guideline framework is meant as a tool to inform companies of the overall concept of industrial symbiosis and how they can begin the process on their own. It is therefore useful to both companies interested in

knowing more about industrial symbiosis and companies that are already wanting to get started with IS projects. As such, it can also be used by facilitators who can distribute such a guideline in order to raise awareness of IS in general and their specific program, as well as providing the companies they work with, with some general information in a condensed form.

The literature review covers studies carried out in the US, Canada, Flanders, England and Denmark. Based on the general consistency of the results of this study and the barriers and enabling factors identified in the literature review, most of the content in the guideline can therefore be assumed to be relevant to companies at least in the Western World. However, according to Flyvbjerg [19] the local factors must always be taken into account when one applies general understandings in a local context. Therefore, in order for a guideline, like the one created in this study, to be usable for companies it should take the local conditions into account. This means that the part of the general outline of the guideline contents dealing with local facilitation schemes should be adapted to the place in which such a guideline is meant to be used. Likewise, the examples of benefits from concrete IS-projects should be from a context as close to the context of targeted companies as possible. Examples of this type of context could be country or type of facilitation scheme. The literature review revealed that, with the exemption of the ones related to technological development, the barriers and enabling factors of IS seem to have been more or less consistent through the last 10-15 years. Assuming that this consistency will continue, most of the guideline content can therefore be assumed to be relevant for years to come. However, when providing detailed and local information it will always be necessary to ensure that this specific information is updated.

A guideline constructed after the recommendations provided in this paper could act as a support tool, to raise awareness on IS and help companies to get started in the IS-process. In some cases the advice offered in such a guideline will be enough for two companies to be able to set up a new IS-exchange. In other cases additional help, i.e. from a facilitation program, will be necessary, which is why it is emphasized that information about any such available programs should be included. It is difficult to say in which cases the guideline will be enough, as it will depend of the concrete mix of barriers and enabling factors at play in the situation, and of their relative weight.

Conclusion

This study has confirmed and expanded the literature on barriers and enabling factors.

The majority of barriers and enabling factors to new IS-exchanges that can be influenced by companies were found to relate to resources. The use of facilitation programs is a good way of dealing with many of these issues. Lack of knowledge about neighboring companies makes it hard to find collaborators to IS. This challenge is best overcome by expanding one's network, and here facilitation programs can play a key role. The creation and realization of IS ideas are often blocked by barriers related to lack of time and money, because IS is not considered part of the main production and therefore has low priority. Thus, an important enabling factor is for the companies to expand this product focus and also consider improvements in their by-product streams. Another enabling factor is likewise related to facilitation, as facilitators can assist the companies with resource demanding tasks i.e. by writing applications for funds and education of the staff.

Technical issues arise primarily due to differences between companies. A barrier of this type is differences in the supply and demand of by-product. Several companies joining in a collection scheme, to make quantities match, can sometimes overcome this barrier. Differences between companies can also be an enabling factor as companies from different industries tend to make better IS matches. However, lack of knowledge of other industries can be a barrier here. Once again, networks or facilitation programs can be of assistance in both technical issues.

Collaboration is also an important type of barrier, of which the most important barriers relate to issues of trust between companies, between companies and facilitators, as well as issues related to differences in company size and chain of command.

These results lead us to recommend that the contents of a guideline should address information about the concept and benefits of IS, local facilitation programs, if available, and what to be aware of, if there is no facilitation programs or the companies decide not to take advantage of them. A guideline addressing these issues will give motivated companies a

hands on tool to either get started or move further in the process of realizing IS-exchanges, thus taking the knowledge of IS built up in the scientific community one step further in making it applicable in the everyday work of companies.

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