

NETWORK ORCHESTRATION IN INDUSTRIAL SYMBIOSIS

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ABSTRACT

Economic and societal stress has pushed companies in various industries to create new ways to reduce their environmental load and improve sustainability. One way to achieve this has found to be the formation of industrial symbiosis networks, in which companies collectively pursue to competitive advantage by physical exchange of materials, energy, water, and by-products. Usually a hub firm is orchestrating these industrial symbioses. However, the processes to orchestrate industrial symbiosis have remained unclear. Still, industrial symbiosis is an increasingly common way to enhance eco-efficiency in companies. The present study leans on the strategic network literature and suggests a conceptual framework for orchestration in industrial symbiosis. By doing that the present study contributes to the literature on industrial symbiosis.

Track: Managing Sustainability in Global Networks

Keywords: Industrial Symbiosis, Industrial Ecology, Network Orchestration, Strategic Networks, Case study

PAPER TYPE

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INTRODUCTION

Industrial ecology has aroused a substantial amount of interest at the recent years. Reasons such as the increasing amount of waste and the decreasing amount of natural resources, have driven companies to build collaborative systems to overcome the challenge. With collaborative systems these companies attempt to decrease their costs that may occur from waste disposal, and on the other hand, to increase their revenues by selling their by-products. Conceptually this kind of collaboration is termed as industrial symbiosis, in which traditionally separate industries with a collective approach pursue competitive advantage through the physical exchange of materials, energy, water, and by-products (Ashton, 2011; Chertow and Miyata, 2011). The keys to industrial symbiosis are found to be collaboration and the synergistic possibilities offered by geographic proximity (Chertow, 2000). These participating companies are identified to improve their individual economic and environmental performances, as well as the regions where they are located are argued to benefit through enhanced environmental quality (Ashton, 2011).

In industrial symbiosis group of companies collectively approach to competitive advantage and simultaneously realize economic and environmental benefits (Ashton, 2008). Thus, the industrial symbiosis may be understood as a network of actors. However, the processes to orchestrate industrial symbiosis have remained unclear, even though there are some studies shedding light to the dynamics of industrial symbiosis (Boons, Spekkink, and Mouzakitis, 2011). Ultimately the purpose of an industrial symbiosis is to create sustainable growth, for example by selling and purchasing by-products, which are not the core business of companies. This differing nature of business requires new kind of operation models and practices, in order to be profitable and ecological industrial symbiosis.

The context of industrial symbiosis is approached in this study with the strategic network literature (e.g. Jarillo, 1988, Gulati, Nohria, and Zaheer, 2000). More specifically the industrial symbiosis is studied through network orchestration processes performed by a hub firm of that symbiosis. According to Dhanaraj and Parkhe (2006, p. 659) network orchestration is “the set of deliberate, purposeful actions undertaken by the hub firm as it seeks to create value (expand the pie) and extract value (gain a larger slice of the pie) from the network”. These hub firms are understood as companies setting up the network and taking case if it with a pro-active attitude. (Jarillo, 1988). Dhanaraj and Parkhe (2006, p. 659) define a hub firm “as one that possesses prominence and power gained through individual attributes and a central position in the network structure, and that uses its prominence and power to perform a leadership role in pulling together the dispersed resources and capabilities of network members”. Grounding on this theoretical base the present study attempts to increase understanding *what is the role of hub firm in the industrial symbiosis and what kind of orchestration processes are needed in industrial symbiosis?*

The present study takes the formerly suggested frameworks for orchestration in network as the starting point (Dhanaraj and Parkhe, 2006; Nambisan and Sawhney, 2011) and further develops those more suitable for industrial symbiosis. The present study suggests a conceptual framework for orchestration in industrial symbiosis. Finally, the framework is going to be further developed and defined with empirical evidence. The present version of the paper is organized as follows. First, the extant literature on business networks introduced briefly. In the chapter the most

suitable theoretical tradition on business networks is selected and justified. In addition, the discussion on orchestration in network is introduced. Second, the concept of industrial symbiosis with its specific characteristics is briefly depicted. Based on that, the conceptual framework for orchestration in industrial symbiosis is built. Finally, the tentative research design and some expected results as well as conclusions are introduced.

BUSINESS NETWORKS

THEORETICAL TRADITIONS ON BUSINESS NETWORKS

To obtain broader focus on the studied phenomena, researchers have turned their focus from individual actor and relationships of two actors to study networks and actors in those networks. Networks as a structure or a metaphor have been the object of interest in various disciplines, such as sociology, computer science, and business studies. In these manifold studies, several approaches to understand networks have emerged. In the field of business studies the variation of utilized network approaches and perspectives is as well extensive.

The strategic research tradition on strategic groups has found that they can be defined by objective characteristics (Porter, 1985; McNamara, Deephouse, and Luce, 2003) or established by a shared understanding on diverse companies (Reger and Palmer, 1996; Osborne, Stubbart, and Ramaprasad, 2001). In addition, the channel management literature embodies individual business relationships as unique entities, claiming that companies have to respond appropriately to changes in their business environment (Guiltingan, 1974; Stern and Reve, 1980; Achrol, Reve, and Stern, 1983). It is also argued in the strategic marketing discourse that business networks are value-creating systems, in which companies cooperatively create value for customers (Normann and Ramirez, 1993; Möller and Svahn, 2006; Möller and Rajala, 2007).

A commonly known and utilized theory that has offered understanding on the relationship between social and technological artifacts is the actor network theory (Latour, 1987). These actors can be either human (one or many) or non-human (factors, machines, or patents). However, subsequent to Bruno Latour, Michel Callon, and John Law introducing this universal theory to understand networks, it has become substantially fragmented. Based on the industrial marketing and purchasing group's work on business relationships and interactions within them, the industrial network approach has been developed to understand business networks (Ford, 1980; Ford, Håkansson, and Johanson, 1986; Håkansson and Johanson, 1992). The approach is based on the epistemological perspective that markets are interconnected webs of dependent exchange relationships that are built on actors' bonds, activity links, and resource ties (Håkansson and Johanson, 1992; Anderson, Håkansson, and Johanson, 1994; Easton and Håkansson, 1996). Describing the industrial symbiosis network is consistent with the ARA model (Håkansson and Snehota, 1995). Actors capture the horizontal and vertical dimensions of industrial symbiosis networks. Actors can be positioned vertically, i.e. downstream and upstream in the value chain of the hub firm, as well as horizontally (e.g. auxiliary service providers). Activities reflect the links between the members of the industrial symbiosis network and the resource ties are built on the by-products and services in that network.

According to the industrial network approach, network is not owned by any particular company, nor can it be centrally managed in its entirety, although all companies try to manage within it. Also, although many companies might believe that they are at the “center”, no company is the hub of the network as there is no center (Ford et al., 2003). In that sense, since the purpose of the present paper is to understand focal actor’s operations to steer an industrial symbiosis towards eco-efficiency, the theory has its limitations for our purposes.

The research on strategic networks is a theoretical approach with established position to understand networks in the discourses of business studies and strategic management (Jarillo, 1988, Gulati, Nohria, and Zaheer, 2000). According to the theory, these strategic networks are based of inter-organizational ties, with strategic significance for the including companies and relatively stable on their nature (Gulati, Nohria, and Zaheer, 2000). In addition, these strategic networks include strategic alliances, long-term buyer-supplier partnerships, and joint ventures (Das, Sen, and Sengupta, 1998; Gulati, 1999; Gulati, Nohria, and Zaheer, 2000; Gerwin, 2004).

Among the researchers on strategic network there has evolved a discussion on the networks with low-density and high-centrality (Dhanaraj and Parkhe, 2006; Nambisan and Sawhney, 2011). These are typically characteristics of, for example, innovation networks and industrial symbiosis. Although the extant network theory remains largely focused on structures, relations, and outcomes (Cook and Whitmeyer, 1992), the academic discussion on hub firms in a strategic network has evolved to further understand these kinds of centralized networks. These central actors in networks are referred to with various concepts, such as hub actors (Jarillo, 1988; Dhanaraj and Parkhe, 2006), brokers (Lingo and O’Mahony, 2010), key actors (Knoke, 1994), triggering entities (Doz, Olk, and Ring, 2000), strategic centers (Lorenzoni and Baden-Fuller, 1995), and flagship firms (Rugman and D’Cruz, 2000). Dhanaraj and Parkhe (2006) define a hub firm through prominence and power concepts that are gained through individual attributes and a central position in the network structure. Furthermore, they note that a hub firm uses its prominence and power to perform a leadership role in pulling together the dispersed resources and capabilities of network members (Dhanaraj and Parkhe, 2006). Since, the strategic network research stream focus on the focal actor’s operations and role in a network as well as the steering activities of the network, the approach is selected as theoretical ground for the present study.

ORCHESTRATION IN NETWORKS

Originating from the literature on the loose coupling and complex systems (Simon, 1962; Orton and Weick, 1990), the concept of network orchestration is developed in the strategic network literature stream to understand the management activities of a hub firm in a network. Thus, the perspective has extended its focus from the dyadic-level (e.g. alliance capability) to network-level. In that sense the discussion has taken more holistic view, discussing the activities in the terms of network orchestration (Dhanaraj and Parkhe, 2006; Nambisan and Sawhney, 2011; Ritala, Armila, and Blomqvist, 2009).

One of the early frameworks for orchestrating networks is suggested by Dhanaraj and Parkhe (2006). They divide the orchestration activities to three orchestration processes: managing knowledge mobility, managing innovation appropriability, and managing network stability. The management of knowledge mobility includes three sub-processes that an orchestrator needs to

take care of. Those sub-processes are knowledge absorption, network identification, and inter-organizational socialization. In addition, the orchestration process of managing innovation appropriability includes the sub-processes of trust, procedural justice, and joint asset ownership. Finally, managing network stability process is composed of the sub-processes of enhancing reputation by lengthening the shadow of future and by building multiplexity.

Nambisan and Sawhney (2011) continue the line of argument by studying network orchestration with two roles played by the hub firm, as an innovation integrator and as a platform leader. They complement the Dhanaraj and Parkhe's (2006) framework by explaining the processes of managing innovation leverage, and managing innovation coherence. According to Nambisan and Sawhney (2011), innovation leverage refers leveraging (reuse and redeploy) innovation assets (e.g. technologies and processes) of other members in the network to utilize them in their own innovation. This kind of innovation leverage is perceived to generate additional value in the network and to make the network more attractive for the future members. Managing innovation coherence is divided to the internal and external coherence. The internal coherence includes the coordination and alignment of processes and outputs of the members within the network (Gerwin, 2004). The external coherence refers the alignment of the network's goals and outputs to coincide the external market and technological environment (Nambisan and Sawhney, 2011).

However, since the extant literature has its focus on innovation networks and the focus of our study is on the industrial symbiosis, the extant framework for orchestration is not necessary suitable as it is to our purposes. Thus, we take extant frameworks for orchestration in innovation network as a template to further develop them to be suitable in the context of industrial symbiosis. At the following the specific nature industrial symbiosis is introduced more thoroughly and the framework for orchestrating in industrial symbiosis is proposed.

ORCHESTRATION IN INDUSTRIAL SYMBIOSIS

INDUSTRIAL SYMBIOSIS AS A RESEARCH FIELD

Industrial symbiosis refer to a group actors reusing the byproducts and waste formed by each other's activities as raw materials for other processes, forming symbiotic relationships viewed analogously to those found in nature (Ashton, 2008; Boons, Spekkink, and Mouzakitis, 2011; Chertow and Ehrenfedd, 2012). Industrial symbiosis activities commonly include the reuse of byproducts and waste, infrastructure sharing as well as pooled use of resources such as water and energy, leading to improved business and environmental performance (Lombardi and Laybourn, 2012).

The existing literature on industrial symbiosis distinguishes between two main forms of development for the networks: designed industrial symbiosis networks and emergent industrial symbiosis networks (Baas, 2011). Designed networks refer to cases where an authority, such as a governmental organization is responsible for designing an eco-industrial park and recruiting suitable industrial companies to locate there. Such parks have been planned, for example in several projects across the US, with mixed results (Gibbs and Deutz, 2005). Another related approach is referred to as facilitated industrial symbiosis, where the network is formed around existing business relations between industrial companies, but a coordinating organization is in

charge of developing the network by brokering knowledge on new opportunities for industrial symbiosis. An example of this is the National Industrial Symbiosis Programme (NISP), which coordinates industrial symbiosis activities on a national wide scale in the UK. (Paquin and Howard-Grenville, 2012)

The second form, emergent industrial symbiosis networks, has received the most attention from academics. These networks are self-organizing systems where industrial symbiosis relations are gradually uncovered from existing business relationships, and awareness of the environmental benefits is spread among the networks members, leading to the formation of network-level common goals and norms (Chertow and Ehrenfedd, 2012; Ashton and Bain, 2012; Paquin and Howard-Grenville, 2012). A commonly used example of this type of industrial symbiosis network has been formed in the area of Kalundborg, Denmark. In Kalundborg, companies from various industries, such as oil refining, energy production and agriculture work together in a symbiotic network. The Kalundborg network was formed by self-organizing business relations between actors, but eventually the environmental benefits were uncovered, and the Kalundborg example specifically gave rise to much of the interest in industrial symbiosis (Chertow, 2007). Emergent industrial symbiosis networks in particular are often characterized by socially embedded relations between actors with similar values, leading to a community that fosters eco-innovation through knowledge sharing (Lombardi and Laybourn, 2012; Ashton, 2008).

Although emergent industrial symbiosis networks are viewed from a perspective of self-organization among a community of diverse actors, the networks often include a large company with a central position in the network, with multiple ties to other network members. For example, in the case of Kalundborg, the network includes six industrial companies together with the municipality. One of the companies, a power producer, has ties to five other members of the industrial symbiosis network, giving it a central position (Domenech and Davies, 2011). The power producer can be viewed as a hub firm in the network, which suggests that it is also involved in orchestrating the network activities to some extent. However, the perspective of network orchestration has received little attention in the industrial symbiosis literature which emphasizes self-organizing processes, with the exception of the view on facilitated industrial symbiosis where the separate coordinating organization can be seen as an orchestrator (Paquin and Howard-Grenville, 2012). Our research aims to shed light on the orchestration activities of private-sector industrial companies, which generally have a core function that is not related to the coordination of industrial symbiosis activities in their networks.

BUILDING A FRAMEWORK FOR ORCHESTRATION IN INDUSTRIAL SYMBIOSIS

As introduced above the extant research has proposed frameworks to orchestrate a network (Dhanaraj and Parkhe, 2006; Nambisan and Sawhney, 2011). However, these frameworks have focused especially on the innovation networks, which are quite different on their nature compared to the network in industrial symbiosis. There are many reasons for pursuing industrial symbiosis, beginning with the most basic desire of businesses to be profitable and competitive, which is also a driver for innovation networks. However, important social, environmental, and regulatory drivers play also a substantial role that may not occur in the innovation networks (Chertow, 2008). According to Dimitrova, Lagioia, and Gallucci (2007) applying environmental management strategies, such as integration into the natural system, energy and water

management and sustainable design, is the main difference between a traditional industrial cluster and industrial symbiosis. In addition, industrial symbiosis builds on the three types of activities: byproduct exchange, utility sharing, and service sharing, which are differing from the activities of innovation network (Ashton, 2011). Furthermore, in industrial symbiosis the variety of stakeholders is traditionally quite substantial, and although the common goal is to enhance sustainability profitably, the individual actors involved to the symbiosis may have quite differing goals. Thus, the suggested frameworks need to be re-considered and focused to the context of industrial symbiosis.

Our suggested framework, pictured in Figure 1, follows the logic of Boons, Spekking and Mouzakitis (2011), whereby IS can be characterized as a process consisting of: 1) a set of conditions that act as antecedents for the IS operations, 2) the mechanisms that affect the development of IS network and 3) the outcomes of the IS network operations, such improved environmental quality, knowledge sharing between firms and a long-term culture change for eco-efficiency and sustainable development. The focus of this study is on the mechanisms that affect the development of IS, and thus we do not study the causal relations between antecedents, mechanisms and outcomes of IS networks. While the framework by Boons et al. (2011) focused on the institutional mechanisms that affect the transmission of IS related practices in a network, we suggest that the orchestration activities of the hub firm in a IS network play a large role in the development of the network. Thus, based on existing literature on IS, our framework includes the management of 1) knowledge mobility, 2) network stability, 3) eco-efficiency, 4) social embeddedness, 5) proximity, 6) variety of stakeholders and 7) relationship between core and non-core business as the key orchestration processes which affect the development of an IS network. This section will describe these processes in more detail.

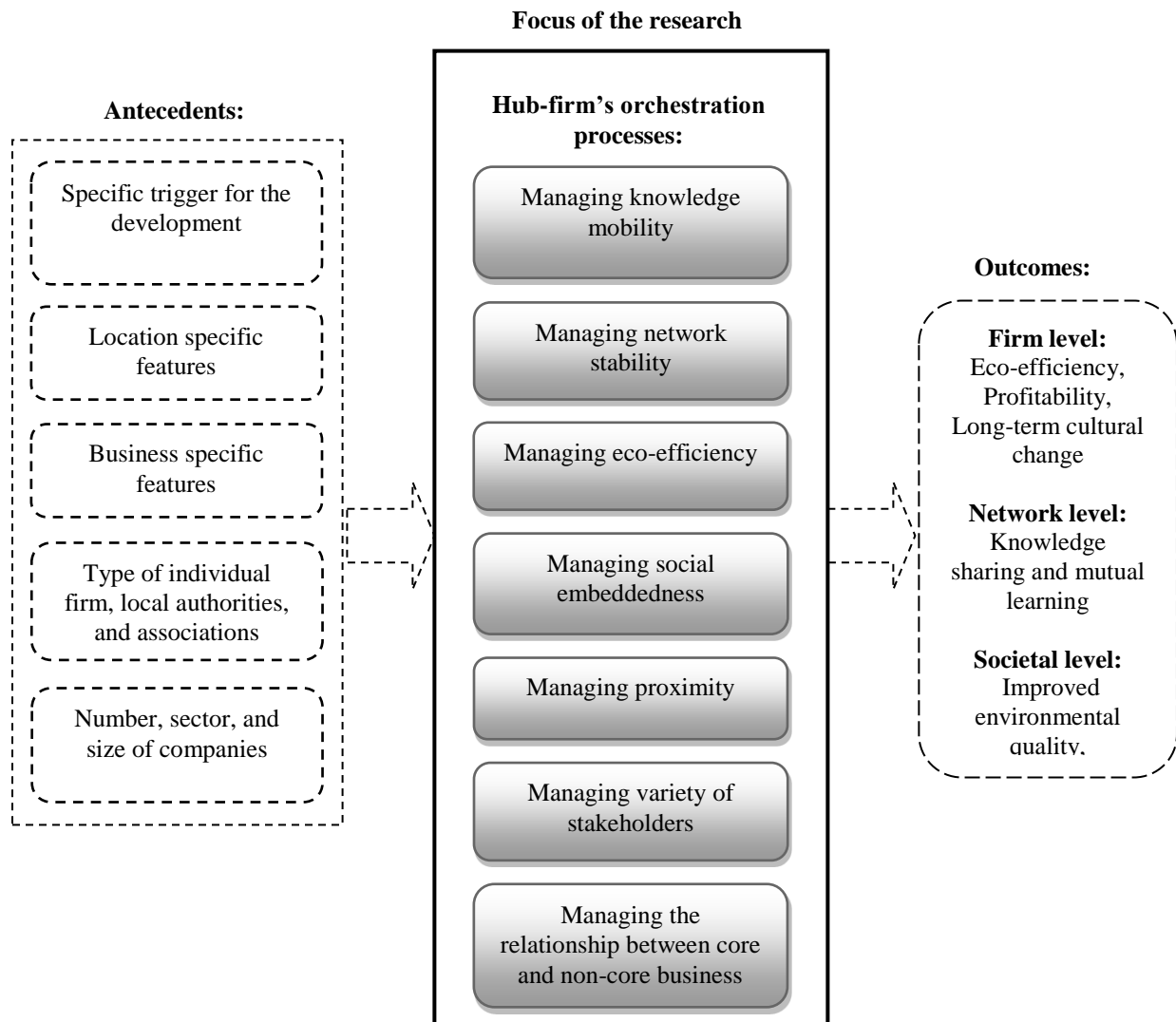


Figure 1. A framework for orchestration in industrial symbiosis

Development of industrial symbiosis is a social learning process, in which actors from various industry field attempts to learn from each other's business and that way found new business opportunities (Boons and Spekkink, 2012). Furthermore, according to Ashton (2008) new kinds of operation models and schemes of thinking, such as a byproduct being a material for some other company, requires regular and intensive communication and knowledge transfer between actors. The divergence of involved actors in industrial symbiosis even emphasizes the need for knowledge exchange. Thus, by leaning on the extant frameworks for orchestration in network, we also suggest that *the managing knowledge mobility* is a focal orchestration activity in the hub firms orchestration process in industrial symbiosis.

According to Tudor, Adam, and Bates (2006) a feature that describes industrial symbiosis (or eco-industrial parks) is that usually those systems are fragile on their nature. Industrial symbiosis' kind of small networks are vulnerable to one of the main actors leaving or looking elsewhere for its materials/products. That withdraw of the symbiosis may affect to the functioning of the entire network. Although the companies in industrial symbiosis face little competition on their byproducts (Ashton, 2009), the hub-company needs to manage the attractiveness of the industrial symbiosis in collaboration with other participants. Thus, as the extant research has pointed out, *the managing network stability* is an important orchestration activity for the hub firm of industrial symbiosis.

Operating in an industrial symbiosis requires efficient measuring of the advantages and disadvantages, since the operations made for the symbiosis has to be justified for the company management. Especially since doing business in industrial symbiosis is not usually the main business for the companies. In a broader level, the industrial symbiosis network needs to govern the eco-efficiency of the whole system, since the benefits of the system usually need to be communicated to the communal actors and even financiers (Ashton, 2011). Although, the collective benefits are found to be grater if actors optimize individual operations (Tudor, Adam, and Bates, 2006), industrial symbiosis needs to be managed as a whole in order to be collective approach to competitive advantage (Lombardi and Laybourn, 2012). Ultimately, an actor needs to take the management responsibility and thus, we propose that *the managing eco-efficiency* as a hub firm's orchestration activity.

The large extent of the literature of industrial symbiosis emphasizes the role of social embeddedness of companies and how it facilitates exchange among actors in networks (Ashton, 2008; Paquin and Howard-Grenville, 2012). Thus, the discussion leads straight to the core of social and organizational theories of embeddedness (Granovetter, 1985). The literature emphasizes especially the role of building trust, joint-problem solving, open communication, and multiplexity in industrial symbiosis (Baas, 2011; Domenech and Davies, 2011; Behera et al., 2012). The emphasized role of social embeddedness may be the cause of differentiating business drivers, since in the motivation to operate in the industrial symbiosis is not entirely the economical (Baas, 2011). In addition, contracts regarding to the byproduct streams are not usually as formal as in the case of primary business (Ashton and Bain, 2012). However, Paquin and Howerd-Grenville (2012) note that the extensive social embeddedness may also restrict identifying and utilizing new business opportunities exploiting byproduct streams. Since the pronounced role of building and maintaining social embeddedness, it should be governed in a controlled way. Third parties such as government, industry associations and other coordinating organizations may help to build it, for example by facilitating information sharing (Heeres, Vermeulen, and Walle, 2004), brokering relationships (Paquin and Howard-Grenville, 2012), championing shared services (van Beers, Coder, Bossilkov, and Berkel, 2007) and serving as anchor organizations (Chertow 2000). However, we suggest that building and controlling the social embeddedness in industrial symbiosis should be made centrally. Thus, *managing social embeddedness* is the fourth orchestration activity for a hub firm.

Geographical proximity is found to be a key for collaboration and the synergistic possibilities in traditionally separate industries (Chertow, 2000). Usually industrial symbioses are focused on a quite tightly framed area and thus benefit from the regional economy (Ashton, 2008). Favoring

geographically proximate actors as partners may be a cause of reluctance to invest logistical expanses when it is not related to the core business of the company. In addition, the ecological benefits usually diminish in relations to the distance to transport the byproducts between actors (Baas, 2011). Besides geographical distance, the actors of industrial symbiosis should have narrow cognitive distance, in order to collaborate and to found common business opportunities among the byproducts of partner's production (Lombardi and Laybourn, 2012). Furthermore, the suitability of a byproduct of a manufacturer for a raw material of another manufacturer may also be understood as proximity. In other words, the proximity of the output and the input should not be unacceptably wide between members of industrial symbiosis. Although, governing the proximity between two actors is ultimately an activity of the participants, at the system level the proximity should be managed by the hub firm of the industrial symbiosis. Thus, we suggest that *managing proximity* is a hub firm's orchestration activity.

Industrial symbiosis are also often characterized by a variety of involved actors, such as companies from different industrial sectors (Bansal and McKnight 2009; Ashton 2011). Some companies can be involved in industrial symbiosis through coercive processes, such as regulations or pressure from a large customers (Ashton 2008; Collins et al., 2007). Research has shown that the development of communities and associations that allow local companies from different sectors to interact with each other can foster the industrial symbiosis development (Bansal and McKnight 2009). Authorities and governmental agencies are often involved in creating various drivers for industrial symbiosis, such as incentives for participating companies, as well as planning the location and structure of eco-industrial parks (Dimitrova, Lagioia, and Gallucci, 2007). However, regulation can also become as a barrier for the development of industrial symbiosis, for example by making it difficult for companies to transport or reprocess industrial waste (Salmi and Toppinen, 2008). Additionally, other stakeholders such as business associations and non-governmental organizations may also be involved (Sakr et al., 2011; Ashton 2011). The variety of involved actors and stakeholders can make it difficult to transfer knowledge in the network and foster joint learning. Therefore it is important for the orchestrator to be able to *manage the variety of involved stakeholders* and their respective interests, to develop conditions that foster the development of industrial symbiosis networks.

Lastly, byproduct business is often unrelated to the core business of an industrial company. Uncertainty results from the key characteristics of byproducts compared to main products: their availability is constricted by the demand for main products and thus cannot be optimized for the customer needs. Additionally, quality control for byproducts is often not possible in the same scale as for main products, and consequently byproducts often show more quality variance (Bansal and McKnight, 2009). Industrial symbiosis activities can also take various forms in addition to byproduct and waste reuse, for example the joint use of utilities such as energy, water and infrastructure; joint transportation; service sharing and information transfer, which are also usually not in the company's core business area (Ashton 2011). Existing research has shown that companies involved in industrial symbiosis identify more strongly with the materials and resources that they process rather than their end products, which in distinct contrast to a the typical view of a firm whose identity is formed around their core business and main products (Bansal and McKnight, 2009). We therefore propose *managing the relationship between core and non-core business* as the last of a hub firm's orchestration activities.

RESEARCH DESIGN

At the present phase of the work-in-progress paper the conceptual ground for the empirical research is created, and thus conducting the empirical research is only designed and planned. In that sense the research design, findings, and contribution are only delineations what will be done and what the outcomes of the research could be. On its nature, the research is abductively developing theory on orchestration in industrial symbiosis instead of attempting to test the theory. Thus, the suggested framework is only going to be further developed and defined with empirical evidence.

The complex social phenomenon is approached by an in-depth qualitative study. More specifically case method (e.g. Yin, 2008; Eisenhardt, 1989; Johnston, Leach and Liu, 1999; Halinen and Törnroos, 2005; Welch et al., 2011) is selected, since the phenomenon of orchestrating industrial symbiosis is quite difficult to study outside its natural setting, and since there is no extant framework or theory for the phenomena in the context, quantifying the phenomenon is cumbersome (Bonoma, 1985). In addition studying phenomena that take place in rich context means that there are too many variables to consider for the number of observations made (Yin, 2008). Consequently, the application of standard experimental and survey designs may not be appropriate. Furthermore, there is relatively little knowledge of the phenomenon on its context and thus case study is a suitable method for in-depth understanding (Yin, 2008).

The present study leans on multiple case studies to enhance the trustworthiness of the results. According to Johnston, Leach and Liu (1999) advantages of multiple cases is the investigation of theorized differences across cases, replication in multiple settings, and the possible disproving of rival hypotheses. In addition, multiple-case designs are found to be more compelling and make the overall study more robust (Herriot and Firestone, 1983).

Johnston, Leach and Liu (1999) suggest that developing research design in case studies, there are three important considerations: (1) select the unit of analysis, (2) select the appropriate cases to study, and (3) decide to what data to collect and how to collect it. We follow that guideline in the planning of the research of the present study.

The first step to when developing research design of case study is the selecting the unit of analysis (Yin, 2009). According to Johnston, Leach and Liu (1999) the selection depends on the research questions addressed. Based on the research questions introduced at the beginning of the paper, we have determined our unit of analysis to be the hub firm in industrial symbiosis network. The industrial symbiosis network is included as a necessary context, since the studied phenomenon requires considering multi-actor perspective to understand the orchestration process.

The second step is the selection of the appropriate cases to study. The step is one of the critical events in case study (Eisenhardt, 1989; Yin, 2008). Utilizing statistical generalizability theory and to conceptualize case studies as “sampling units” would be controversial, since considering cases to be sampling units, the objective would be to randomly choose a sample of cases from a population of cases (Johnston, Leach and Liu, 1999). This is often inappropriate or impossible in practice (Bonoma, 1985). According to Yin (1993) the multiple-case studies should follow a

replication, not sampling logic. Thus, each case should be treated as a study, and in that sense the focus shifts to choosing the case or cases that are best suited to study the theory (Johnston, Leach and Liu, 1999). The objective is to found replication in the results and thus have more confidence in the overall results (Yin, 1993).

In multiple-case study, each case should complement others, if a researcher is not attempting to study extreme cases, in which the purpose is to compare differences (Johnston, Leach and Liu, 1999). To ensure the possibility to replicate the results we have attempted to diminish the bias occurring from the incomparable cases by defining criterion for case selection. The case selection criterion is depicted at Table 1. Firstly, we ensure that the studied focal network is a proper type of network (industrial symbiosis). That is made by the four sub-criterion derived from the definitions of industrial symbiosis (Chertow, 2000; Ashton, 2008; Lombardi and Laybourn, 2012). Secondly, the studied case need to include identifiable hub firm that the orchestration processes of industrial symbiosis could be identified. The hub firm needs to fulfill the four sub-criteria, derived from the definitions of hub firm (Jarillo, 1988; Dhanaraj and Parhke, 2006). Thirdly, the industrial symbiosis should have relatively stabilized ways of actions. Thus, the orchestration practices would be visible and identifiable. Finally, the heterogeneity of actors should be relatively extensive, since usually the variation of the actor in industrial symbiosis is substantial (e.g. size, industry, positioning in the value chain, etc.). Thus, the effects of this special feature should be emerging from the data.

Table 1. Case selection criterion.

Criterion	Sub-criterion	Basis
Industrial symbiosis network	<ol style="list-style-type: none"> 1. Group of actors with collective approach to gain competitive advantage (Ashton, 2008) 2. Simultaneously attempt to realize economic and environmental benefits (Ashton, 2008) 3. Reuse of byproducts and waste (Lombardi and Laybourn, 2012) 4. Geographic proximity (Chertow, 2000) 	To ensure proper type of network
Identifiable hub firm	<ol style="list-style-type: none"> 1. Prominance and power (Dhanaraj and Parhke, 2006) 2. Central position (Dhanaraj and Parhke, 2006) 3. Leadership role in pulling together network members (Dhanaraj and Parhke, 2006) 4. Pro-active attitude (Jarillo, 1988) 	To identify the orchestration processes of industrial symbiosis
Stabilized ways of action		To identify the coordination practices would be visible and identifiable
Extensive heterogeneity of actors		To ensure sufficient diversity of the studied network

The third step to develop research design is to decide what data to collect and how to collect it (Johnston, Leach and Liu, 1999). Interviews are going to be used as main data collection method, since being suitable in research requiring in-depth understanding and study delicate issues. Furthermore, interviews provide opportunity for clarification (Eriksson and Kovalainen, 2008). Since we are studying the orchestration process of a hub firm, our natural focus is on the personnel in the identified hub firm of industrial symbiosis network. However, since our unit of analysis (hub firm in industrial symbiosis network) includes the focus on network, we'll attempt

to collect data also from the other actors in that industrial symbiosis network. Semi-structured interviews are going to be employed in the present study as these offer a method to combine theory based interview questions without restricting the opportunity to specify and discuss answers.

The data is going to be analyzed by the means of deductive content analysis (Miles and Huberman, 1994). The coding and analysis is made by utilizing the framework derived from the extant literature (Figure1). NVivo software will be used to support the analysis. The final version of the framework for orchestration in industrial symbiosis is adjusted and suggested based on the results of the empirical study.

EXPECTED CONTRIBUTION

The research will increase understanding on the role of hub firm in the industrial symbiosis and especially about the hub firm's orchestration processes. These findings are assumed to differ from the previously identified ones from the context of innovation networks (Dhanaraj and Parkhe, 2006; Nambisan and Sawhney, 2011). The orchestration processes are assumed to differ, since the purpose of industrial symbiosis is to create sustainable growth, for example by selling and purchasing by-products, which are not the core business of companies. In addition, the literature review made thus far supports this argument.

The study will contribute to the literature on industrial symbiosis (Chertow 2000; Ashton, 2008; Boons, Spekkink, and Mouzakitis, 2011; Paquin and Howard-Grenville, 2012) by shedding light on the processes of network orchestration in industrial symbiosis. For the researchers of industrial symbiosis the results will increase understanding on, *first* about the role of hub firm especially in industrial symbiosis, *second* about the processes to orchestrate industrial symbiosis, *third* about the special characteristics of industrial symbiosis. In addition, the study offers a preliminary framework to further develop and test. For companies operating in industrial symbiosis, the results offer a framework to enhance their operations at the company-level and network-level.

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