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The example of offshore oil and gas and offshore wind energy in Esbjerg, Denmark

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ABSTRACT: When investigating the emergence of relatedness between two previously unrelated industries - the offshore oil and gas industry and the offshore wind energy industry in Esbjerg, Denmark, - we argue that relatedness is a system property, whose emergence should be visible via organizational search processes in the other industry. While network positions were important when companies began explorative searches in the other industry, regular search processes in the other industry coincided with the formation of new organizational arrangements. With these findings in mind, we propose that relatedness emerges when relationships between two industries are institutionalized.

KEYWORDS: relatedness, institutions, organizational search, emergence, offshore industries.

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Introduction

In recent years, relatedness has become a key concept in economic geography (Boschma and Frenken 2011; Boschma and Wenting 2007). Relatedness describes a pattern of innovation and diversification where companies and industries benefit from knowledge transfers from and into what are usually technologically related areas (Breschi et al. 2003; Frenken et al. 2007). Since these knowledge transfers take place in specific locations via, for example, labour mobility (Breschi and Lissoni 2001), spin-offs (Klepper 2007), knowledge spillovers (Jaffe et al. 1993) and inter-company relationships (Owen-Smith and Powell 2004), relatedness is a key concept in economic geography (Boschma et al. 2013).

However, the question is how relatedness emerges and how previously unconnected industries become related. The typical argument used to explain why actors connect and relate different types of knowledge in geographical proximity is that of Jacobs' externalities (Desrochers and Leppälä 2011; Jacobs 1969). Glaeser (1992, p. 1132) summarized this argument as follows: "Because cities bring together people from different walks of life, they foster transmission of ideas". However, Jacobs' externalities do not explain how these connections at individual level lead to relatedness at group level, i.e., between two industries. Another argument refers to branching processes when outlining the emergence of relatedness between two industries (Boschma and Frenken 2007). But branching does not explain how relatedness emerges between industries with no genealogical connection, which is a common concept demonstrated by several studies (see e.g. MacKinnon 2011, Castaldi et al. 2015). In conclusion, there is insufficient research to explain how relatedness emerges between two previously unrelated industries.

In order to investigate the emergence of relatedness, we use a processual case study of an offshore oil and gas industry and an offshore wind energy industry from the Danish city of Esbjerg. These industries formed due to transplantation (Martin and Sunley 2006) and there was no inherited relatedness between the two industries. Yet, they are shaped by multiple exchanges today.

We conceptualize relatedness as a system property, whose emergence becomes visible via a change in behaviour of the parts of the system (Martin and Sunley 2012). In the wake of this, our analysis comprises two levels. The first level focuses on companies and how and under what conditions they form relationships with another industry (Rowley et al. 2000). Here, we use the concept of organizational search (Nelson and Winter 1982). Usually, companies search for solutions within their established capabilities and relationships, this being known as local search (Nelson and Winter 1982; Stuart and Podolny 1996). In contrast, explorative search often spans both technological and relational boundaries (Rosenkopf and Nerkar 2001). The second level of analysis is the system and how system dynamics are connected to company-level search processes.

The paper is organized as follows. Section 2 presents the concept of relatedness. Section 3 connects relatedness to organizational search processes at micro level. Section 4 describes relatedness as a system property at macro level. Section 5 outlines the research method applied. Section 6 introduces the case study on the emergence of relatedness. Section 7 describes how changes in organizational search processes of companies in Esbjerg coincide with dynamics at system level. Section 8 presents a three-phase model on the emergence of relatedness. Section 9 concludes and introduces three hypotheses regarding the emergence of relatedness as well as the geographies and knowledge complexities involved.

Relatedness

The concept of relatedness posits that certain types of knowledge are more easily transferred, combined and connected than others. The principle of relatedness, as coined by Hidalgo et al. (2018), stresses that a "region enters (or exits) an economic activity as a function of the number of related activities present in that location" (Hidalgo et al. 2018, p. 452). Although there are different types of relatedness such as institutional and social relatedness (Boschma and Frenken 2011), relatedness is often defined technologically.

Relatedness is performed in several ways. These include diversification (Breschi et al. 2003), knowledge transfers (Nooteboom 1999) and labour mobility (Timmermans and Boschma 2014). These three forms have particular spatial expressions. Neffke et al. (2011), for example, revealed that company diversification is a regional process. Castaldi et al. (2015) concluded that the existence of related industries enhances innovativeness at regional level. Timmermans and Boschma (2014) showed that intra-regional labour mobility between related industries has a positive impact on productivity growth. Given the spatial particularities of these knowledge flows between industries, what is related might differ from one region to another (Boschma 2017).

There is compelling evidence for a general principle of relatedness as proposed by Hidalgo et al. (2018). However, at least two critiques aim to put relatedness into context. The first critique is based on the dominant methodological approach and the underlying theoretical assumptions. Most studies on relatedness use an econometric approach (see e.g. Breschi 2003; Rigby 2015; Essletzbichler 2015). This approach allows for identifying patterns and regularities. For example, it uses network approaches to describe how products in one industry depend on inputs from another industry (see e.g. Boschma et al. 2013). This approach does not directly investigate how actors actually combine and use different knowledge. Desrochers and Leppälä (2011), for example, show multiple forms by which actors combine different knowledge over different technological and geographical distances. The second critique is based on the technology-centred view of relatedness and argues that other forms of relatedness have an influence on what knowledge actors combine. Tanner (2014), for example, describes the importance of actors such as universities in the construction of relatedness. Vale and Carvalho (2018) showed with the biotech industry in the Centro Region of Portugal that institutions affect which kind of knowledge becomes related. Menzel and Adrian (2018) showed that the onshore wind energy industry in Hamburg became related to the local aviation industry because of comparable manufacturing principles, resulting from similar market structures. What these two critiques on relatedness have in common is that they consider relatedness not as something that is pre-defined, but as something that is constructed and performed in a specific context. Therefore, an analysis of the emergence of relatedness must investigate how actors combine different areas of knowledge, what knowledge they combine and under what conditions they combine and integrate knowledge from different areas.

Relatedness and organizational search

In order to examine the emergence of relatedness, we start at company level with the capabilities of companies to integrate knowledge from other industries (Breschi et al. 2003, Boschma 2017). Studies on organizational learning show the benefits for organizations when they venture into new areas and form relationships in new fields (Teece et al. 1997; March 1991). However, a search for solutions usually takes place in a narrow space within established competencies (Stuart and Podolny 1996), using established heuristic searches (Dosi 1982) and established relationships (Rowley et al. 2000). Thus, companies as organizations usually perform organizationally local searches (Stuart and Podolny 1996).

Katila and Ahuja (2002, p. 1184) describe organizations that perform local searches as follows: “organizations that search locally address problems by using knowledge that is closely related to their pre-existing knowledge base”. Stuart and Podolny (1996) suggested three reasons why organizational search processes are overwhelmingly local: (1) because of bounded rationality, actors do not have complete knowledge of the range of possible solutions, (2) actors repeat search behaviours that worked well in solving prior problems, and (3) research will produce better results when it is based on established competencies.

However, in order for relatedness to emerge, companies must connect to previously unrelated industries (Castaldi et al. 2015) and integrate knowledge over cognitive distances (Nooteboom 1999; Menzel 2015). Therefore, organizational searches have to be explorative, which entails high costs and unclear outcomes (March 1991). Despite these circumstances, actors search exploratively for several reasons. March (1991) argued that actors need to do so in order to maintain long-term competitiveness, but also conditions outside the organization can lead to explorative searches. Rowley et al. (2000) described how actors apply explorative strategies to cope with a changing business environment, and Menzel et al. (2017) showed that introduction of venture capital led to change in institutional settings that rewarded explorative searches. Thus, actors apply different forms of organizational searches, depending on the particular environment in which they operate.

Furthermore, search patterns also affect organizational capabilities. Companies learn by permanently searching in a particular industry. Previous searches make subsequent searches easier, as actors build repetitive capabilities and establish relationships in other industries (Stuart and Podolny 1996). Thus, there is a sequence of organizational search processes that describes how companies start to acquire knowledge on a regular basis from another industry: organizational search processes change from local search processes (which ignore the other industry) via explorative search processes (which form the first connections to the other industry) to altered local search processes (which regularly involve the other industry in search processes). This organizational search sequence forms the basis for investigating the emergence of relatedness between two industries.

Relatedness as a system property

As can be seen above, relatedness between two industries is based on organizational search processes. However, relatedness is a system-level concept. This quality means that it is necessary to go from the micro level of the company to the level of the industry, and to investigate the conditions under which not only single, but industry-wide organizational search processes change from local search processes via explorative search processes to altered local search processes.

In order to address this dynamic at system level it is relevant to define the term emergence. Emergence is often considered as the appearance of something new (Corning 2002; Martin and Sunley 2012). In contrast, Goldstein (1999, p. 50) describes the properties of emergence as follows: emergence creates a coherence of lower-level components resulting in a higher-level unity, emergence occurs at macro level, emergence is dynamic, and the emergent phenomenon is recognized. Hence, emergence is a system property that serves to stabilize the particular phenomenon (Decan 2005; Martin and Sunley 2012).

Emergence is a self-organized process via the interaction between the micro and the macro level. There are different ontological foundations of the interaction between these two levels.

One states that an emergent property is based on the interactions of its individual parts as for example described in complex system dynamics and network theory, and the other states that the system level has a dynamic of its own that transcends the interaction between its parts.´(c.f. Sawyer 2001). However, both bodies of thought state that there is a downward causation of emergence, i.e. an emergent property at system level has an effect on the parts of the system and can therefore be detected via the parts of the system (Deacon 2003; Sawyer 2001).

These remarks imply that relatedness as a system property can be detected via the particularities of organizational search processes. There are already studies that show how particular system properties affect relatedness. For example, Boschma and Capone (2015) use a variety of capitalism approach (Hall and Soskice 2001) to show that relatedness is more important in coordinated market economies than in liberal market economies. Our intention, however, is to investigate how relatedness becomes a system property. This system property does not become visible at the time of the first connection between two industries, but when many companies start to integrate knowledge from and into another industry. Therefore, relatedness can be said to emerge when dominant organizational search processes change to altered local search processes. How and under what conditions these changes take place allows us to derive assumptions on how relatedness as a system property emerges.

Research method

Emergence is a temporal phenomenon (Martin and Sunley 2012). This quality requires a process study that is able to investigate how the particular phenomenon, in this case the emergence of relatedness between two previously unrelated industries, unfolds over time. Langley et al. (2013) describe it as a crucial quality of a process study that it takes time seriously, as the temporal order of events is important in explaining the evolving phenomena.

Process studies can be both quantitative and qualitative. We adopt a qualitative approach as we are investigating not only the emergence of relatedness, but also the processes that result in its emergence. Langley et al. (2013) also suggest temporal bracketing as an analytical heuristic process for qualitative process studies. Temporal brackets "are constructed as progressions of events and activities separated by identifiable discontinuities in the temporal flow" (Langley et al. 2013, p. 7). This bracketing allows the comparison of different temporal sequences that can be distinguished via their particular process dynamics.

As our intention is to build theory, we use a case study for this process analysis (Yin 2013). Eisenhardt (1989) suggests theoretical sampling as an approach for selecting cases. The case should be suitable to show the processes, relationships and configurations of interest and therefore is chosen for theoretical reasons. Eisenhardt and Graebner (2007) further suggest a selection of polar cases that help to observe contrasting patterns. These poles are represented by the changing relatedness between the two offshore industries. When the offshore wind energy industry formed, there was no relationship with the offshore oil and gas industry (Markard and Petersen 2009). Furthermore, the two industries were considered as non-complementary, in particular due to different approaches regarding the environment and energy production (Karlsen 2018). Nowadays, the two industries are closely related via different knowledge transfers, diversifications and labour mobility. The comparison between contrasting poles of low and high degrees of relatedness comes close to the ideal in case study research when comparing different cases (Eisenhardt and Graebner 2007), the only difference being that we do not compare different cases at the same point in time, but the same cases at different points in time.

Our research followed an abductive approach. The abductive approach “refers to an inferential creative process of producing new hypotheses and theories based on surprising research evidence” (Timmermans and Tavory 2012, p. 170). In doing so, the abductive approach proposes to move between theory and data as multiple theoretizations are needed to find out which theory can explain the observations. If findings do not fit into existing theories, researchers have to go back into the field with recalibrated expectations and try out the new assumptions deductively. This approach resulted in data acquisitions in two phases between April 2012 and May 2018.

In phase one, 27 personal interviews were conducted (see Appendix). The interviewees represented a broad range of actors from and related to the two industries, and the interviews focused on four themes: the development of the offshore industries, the geography of the offshore industries, the technological and business agenda in the offshore industries as well as the actors, resources and activities within the offshore industries. In phase two, 13 personal interviews and one focus group interview were completed (see Appendix). The personal interviews were conducted with the aim of gaining a deep insight into the knowledge transfers between the two industries, and the focus group interview was designed to present and challenge the findings from the personal interviews. The interviewees for this line of interviews were chosen based on their industry acumen and their experience with and involvement in the knowledge transfers between the two industries. All 41 interviews followed semi-structured interview guides with open-ended questions, and they lasted between 30 minutes and one hour, with the exception of the focus group interview, which lasted two hours.

The interview data was also complemented with data gathered from diverse databases and web pages. Triangulating this data helped to put events into a more precise sequence. Finally, industry and energy experts and professionals commented on different versions of the case description in order to minimize errors and increase validity.

The emergence of relatedness between two offshore industries

The case study outlines how an offshore oil and gas industry and an offshore wind energy industry from the Danish city of Esbjerg became related. The case study focuses on wind energy companies and investigates how their organizational search processes have changed from local search processes (which ignores the offshore oil and gas industry) via explorative search processes (which form the first connections to the offshore oil and gas industry) to altered local search processes (which regularly involve the offshore oil and gas industry in search processes). The case study is structured around this tripartition of local search processes, explorative search processes and altered local search processes, and describes the dynamics at system level as well as their particular geographies.

Offshore industries in the city of Esbjerg

The centre of Danish offshore energy activities is the city of Esbjerg. After the Second World War and until the 1970s, fisheries, shipbuilding and container shipping made up the industrial base of the city (Hahn-Pedersen 2001). During the 1970s and early 1980s, Esbjerg changed its industrial base because of the opening of oil and gas fields in the Danish part of the North Sea (Hahn-Pedersen 2001). Owing to these activities, an offshore oil and gas industry emerged, which focused on locating and extracting oil and gas resources. While fisheries, shipbuilding and container shipping were of regional importance, it was the offshore oil and gas activities that made the city a location of national and international importance. Around the millennium, the industrial base of Esbjerg changed again, this time due to a decision made by the Danish Parliament in the early 1990s to build an offshore wind farm in the North Sea, which marked the beginning of the offshore wind energy industry in Esbjerg (Langkilde et al. 2015).

Today, the offshore oil and gas industry provides almost 9,500 jobs in Esbjerg, while the offshore wind energy industry provides roughly 4,000 jobs in Esbjerg (Business Esbjerg 2016). The core of the offshore oil and gas industry is constituted by multinationals, including the oil and gas contractors Total, Wintershall and Hess. The offshore wind energy industry is centred around the offshore wind turbine manufacturers MHI Vestas Offshore Wind (formerly Vestas) and Siemens Gamesa (formerly Bonus Energy and Siemens Wind Power) and the wind energy contractors Ørsted (formerly DONG Energy) and Vattenfall. Numerous suppliers such as the engineering companies Rambøll and COWI, as well as the certifier DNV GL participate in both industries.

Despite the different specializations of the two industries, they enjoy extensive relationships. For example, knowledge transfers take place in regard to manufacturing as well as offshore installation and maintenance. Industry-supporting organizations provide forums and projects for collaboration between the two industries. Research and educational actors have established a shared knowledge base regarding, for example, offshore energy systems and offshore safety matters. Furthermore, labour mobility between the two industries is frequent and, in particular, suppliers from the offshore oil and gas industry have diversified into the offshore wind energy industry. Indeed, the two industries exhibit the knowledge transfers, labour mobility and diversifications that are expected from related industries.

However, these relationships had to form over time, as the offshore wind energy industry branched from the onshore wind energy industry and had no roots in Esbjerg or in the offshore oil and gas industry. Thus, the offshore wind energy industry in Esbjerg emerged from what Martin and Sunley (2006) call transplantation and the multiple interchanges between the two industries were by no means expected.

Local search phase until 2004

As mentioned, offshore wind turbine manufacturing branched from onshore wind turbine manufacturing. Before that happened, the first commercial offshore wind turbines were made by onshore wind turbine manufacturers, and the first ever offshore wind farms were built in Denmark: Vindeby was completed in 1991 and located at the entrance to the Baltic Sea, and Tunø Knob was built in Kattegat in 1995. Bonus Energy equipped Vindeby with 11 450kW turbines and Vestas provided ten 500kW turbines for Tunø Knob. Both manufacturers used turbines originally designed for onshore installation and mounted them on foundation structures provided by suppliers. The wind turbines at both of the offshore wind farms performed well. Indeed, they exceeded their planned operation time of twenty years and there was no reason to assume that organizational search processes and routines suitable for the manufacture of onshore wind turbines would not be suitable for the manufacture of offshore wind turbines.

The next offshore wind farms that were built in Denmark were Middelgrunden in 2000 and Horns Rev 1 in 2002. Compared to their 1990s predecessors, the turbine impact and overall size of these wind farms were considerably greater. Bonus Energy manufactured 20 2MW wind turbines for Middelgrunden, and Vestas made 80 2MW wind turbines for Horns Rev 1. However, Horns Rev 1 differed from the three other wind farms in one vital aspect. It is located in the North Sea. Figure 1 shows how this location changed the conditions under which the wind turbines operated. The wind turbines at Horns Rev 1 were installed in deeper waters, farther away from the shore, and were subjected to higher wind speeds and stronger waves than the previous wind farms.

These different offshore conditions caused significant damage to the wind turbines at Horns Rev 1. In 2004, Vestas had to remove all nacelles, because the gears, transformers, blades and generators, among other things, were unable to withstand the offshore conditions. Later, between 2006 and 2010, crumbling wind turbine foundation structures were discovered. Cementing the crossing between the monopile and the transition piece resulted in inflexible foundation structures that were unable to bear the changing loads under the offshore conditions. This procedure of cementing was normal for other water-based installations such as bridges and harbours, and the same foundation structures worked well at the Middelgrunden offshore wind farm. In short, local organizational search processes were sufficient to solve problems for near-shore wind farms located in calm waters. However, the example of Horns Rev 1 highlights the limitations of local search processes for wind turbine manufacturers when installing wind turbines in the North Sea.

Since the first four offshore wind farms were installed at different locations in Denmark, there was no national centre for the offshore wind energy industry. With Horns Rev 1, it was the first time that Esbjerg was used as an installation harbour, i.e., the harbour from which the offshore wind turbines and foundation structures were disembarked, installed and maintained. Esbjerg was chosen because of its existing physical infrastructure from the offshore oil and gas industry as well as its proximity to the location of the offshore wind farm. The other three offshore wind farms were, among others, installed via Hou, Onsevig and Copenhagen.

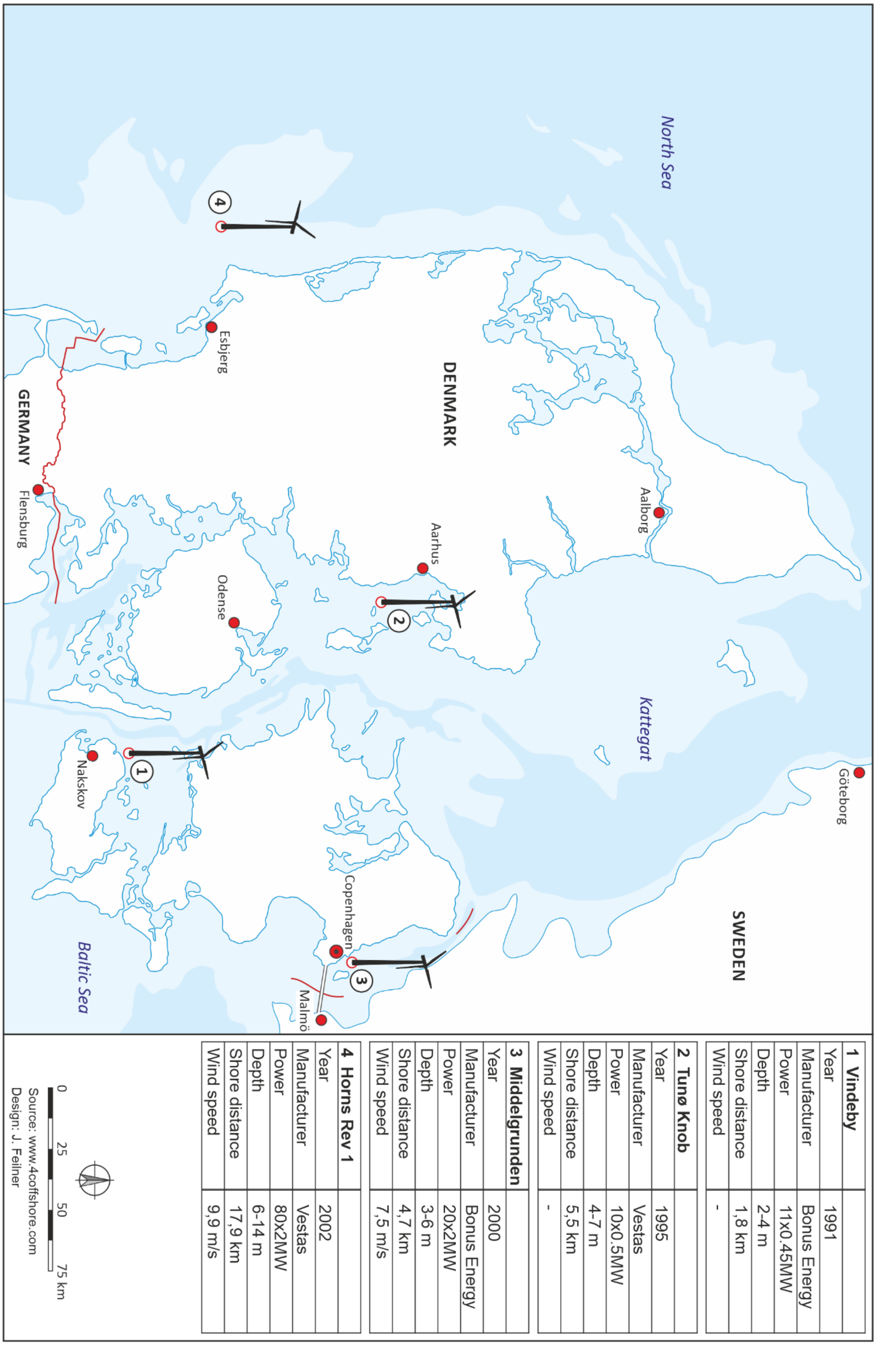

Figure 1: Overview of the first four Danish offshore wind farms

As a consequence of these scattered locations, no more than a few offshore wind energy companies were located in Esbjerg during the 1990s and early 2000s. Vestas, as provider of wind turbines for Horns Rev 1, opened an office in 2000, but turbine assembly took place at locations away from Esbjerg. Bonus Energy did not have a regular office in Esbjerg before 2012 (and by that time the company had become Siemens Wind Power). DONG Energy, as operator of Horns Rev 1, already had an office in Esbjerg for its offshore oil and gas activities, and a branch for offshore wind energy was included in 2002. Suppliers such as DNV GL, Rambøll and COWI already had offices in Esbjerg. However, these offices were related to offshore oil and gas or other activities, and the companies coordinated most of their offshore wind energy activities from their head offices located outside of Esbjerg. Hence, when organizationally local search processes were prevalent in the offshore wind energy industry, Esbjerg was by no means at the heart of the industry.

Explorative search phase since 2005

The damage at Horns Rev 1 made it obvious that knowledge of manufacturing onshore wind turbines was not sufficient to manufacture reliable offshore wind turbines. That discovery resulted in explorative organizational search processes. In 2005, DONG Energy and Rambøll started to transfer knowledge from the offshore oil and gas industry in order to address some of the challenges experienced at offshore wind farms. The solutions found in the offshore oil and gas industry were often simple. For example, at the start, short bolts were used to construct offshore wind turbines as they had proved to be sufficient for onshore wind turbines. However, they were unable to bear the loads of the offshore conditions and parts began to fall off. As a result, long bolts that have proved reliable in the manufacture of offshore oil and gas installations were used instead. A further example is coating. Coating is necessary to protect offshore wind turbines from corrosion, but the single layer of coating that was used for onshore wind turbines proved insufficient for offshore conditions. Thus, two layers of coating, which was standard practice in the offshore oil and gas industry, also became the standard in the manufacture of offshore wind turbines.

The companies that first recognized how knowledge of the offshore oil and gas industry could solve problems in the offshore wind energy industry were involved in both Horns Rev 1 and in offshore oil and gas fields. For example, DONG Energy as operator of Horns Rev 1 had experience from running the oil and gas fields Syd Arne-feltet and Siri-feltet, and Rambøll was involved in Horns Rev 1 as engineering consultant and had designed and planned the offshore oil and gas fields Halfdan-feltet and Syd Arne-feltet. In both companies, employees with experience in both industries, either through labour mobility or internal rotation, made this knowledge transfer possible.

In addition, like DONG Energy and Rambøll, other companies that were involved in both industries such as COWI (involved in the offshore wind farms at Vindeby and Middelgrunden and the offshore oil and gas field Syd Arne-feltet) and DNV GL (which certified the first four Danish offshore wind farms and most offshore oil and gas fields in the Danish part of the North Sea) started to transfer knowledge from the offshore oil and gas industry to the offshore wind energy industry. DNV GL, for example, participated in the process of transferring and adapting standards for health and safety such as OHSAS (working environment) and GWO (basic safety training) that were originally developed for operations in the offshore oil and gas industry and which are now implemented in the offshore wind energy industry.

Moreover, these companies that were involved in both industries also started to connect offshore wind energy companies with offshore oil and gas companies. DONG Energy, Rambøll and COWI connected Vestas and Siemens Wind Power with oil and gas service providers. Via this connection, the offshore wind turbine manufacturers acquired knowledge regarding both service guidelines for offshore installations and transportation systems that allow maintenance despite bad weather conditions. Overall, knowledge about the categories of offshore wind turbine installation and maintenance as well as offshore health and safety was transferred via these connections from the offshore oil and gas industry to the offshore wind energy industry.

The establishment of these relationships coincided with the increase in the location of offshore wind energy activities to Esbjerg. Around 2005, companies such as COWI, Rambøll and DNV GL moved some of their offshore wind energy activities to their established offices in Esbjerg, and in 2006 Vattenfall opened an office due to its new involvement in Horns Rev 1. Moreover, Siemens Wind Power decided, based on their participation in the offshore wind farms in Lynn and Inner Dowsing (United Kingdom) and Horns Rev 2 (Denmark), that Esbjerg should be their installation harbour. Nonetheless, Siemens Wind Power chose to manage these activities from its headquarters 80 km away, in the city of Brande, which is located in the Central Denmark Region.

This exploration phase was also shaped by increasing labour mobility from the offshore oil and gas industry to the offshore wind energy industry. At the start, this labour mobility was mainly not local, and the two labour markets were geographically separated. Employees who moved from the offshore oil and gas industry to the offshore wind energy industry usually moved from Esbjerg to other locations, especially Copenhagen and the Central Denmark Region. As companies started to locate more and more of their offshore wind energy activities in Esbjerg, labour mobility between the two industries also increased within the city.

Institutionalization of altered local search processes since 2010

From 2010, several industry-supporting organizations, projects and forums were launched with the aim of initiating and stabilizing the relationship between the two offshore industries in Esbjerg. One of the first of these projects was called Offshore Energy. It was launched by the industry-supporting organization Offshore Center Denmark, which was originally formed by Esbjerg-based oil and gas companies in 2003. The project also involved, among others, Vattenfall, Rambøll, COWI and the Esbjerg-based universities: the University of Aalborg and the University of Southern Denmark. The Offshore Energy project investigated, for example, how the two offshore industries could learn from each other and share resources, and how offshore-oriented education could be improved. The project lasted until 2013.

In the wake of this project and due to an interest expressed in industry and policy circles, Offshore Center Denmark was transformed into the industry-supporting organization Offshore Energy. Actors outside Esbjerg such as the Growth Forum of Southern Denmark, the offshore energy test facility LORC (Lindoe Offshore Renewables Center) and the Danish Wind Industry Association drove this transformation and became key stakeholders in Offshore Energy. This actor's main tasks are to organize knowledge transfers between the two offshore industries via seminars and match-making and to foster collaboration within and across the two industries via common projects and innovation forums. Moreover, local research and educational actors such as the University of Aalborg, the University of Southern Denmark and the Fredericia School of Marine and Technical Engineering support knowledge transfers by providing a knowledge and training infrastructure for both industries. This includes, for example, two education programmes, Offshore Energy Systems and Risk and Safety Management from 2013 and 2014, respectively, which were co-organized by the two universities.

With these organizational arrangements, knowledge transfers from the offshore oil and gas industry to the offshore wind energy industry grew in complexity. Even a shared health and safety knowledge base emerged. In addition, knowledge transfer also changed direction. For example, around 2011, Rambøll and COWI started to apply calculation techniques and software used for modelling, designing and optimizing installations in the offshore wind energy industry to projects in the offshore oil and gas industry. This was motivated by an increasing cost focus in the offshore oil and gas industry.

The pervasiveness of these knowledge transfers indicates altered local search processes. Searches in the other industry were regularly performed in areas in which companies in the other industry had particular expertise. For example, the offshore oil and gas industry has long-established competencies in constructing, installing and maintaining installations that are able to endure the offshore conditions in the North Sea. As a result, offshore wind energy companies search in the offshore oil and gas industry with the aim of making offshore wind turbines more reliable and advancing their installation and maintenance. In turn, offshore wind turbine manufacturers have more experience in batch production and production cost minimization. Thus, offshore oil and gas companies search in the offshore wind energy industry for solutions to refine manufacturing processes through standardization and organizational procedures. In conclusion, knowledge transfers between the two offshore industries were complementary or resulted in a shared knowledge base.

In addition, the proliferation of different organizational arrangements since 2010 indicates that searches in the other industry were no longer isolated events. Industry-supporting organizations assist these search processes, which had become institutionalized. The actors and their initiatives were established as a result of enhanced knowledge transfers between the two offshore industries. In this respect, the formation of such organizational arrangements is an indicator of institutionalized relationships between the industries.

During this institutionalization phase, organizational search processes became, geographically speaking, increasingly local. Not only were new organizational arrangements established in Esbjerg, but also actors outside the city pursued initiatives in Esbjerg and in doing so further condensed knowledge transfers in Esbjerg. Thus, this proliferation of organizational arrangements in Esbjerg institutionalized regular search processes in the other industry at local level.

The emergence of relatedness

We observed the emergence of relatedness between two previously unrelated industries via dominant search processes at company level, which changed from local via explorative to altered local search processes. Each phase coincided with particular dynamics at system level that affected the formation of the relationship between the two industries in different ways. In the following section, we investigate these dynamics in more detail, as well as their geographies and the changing knowledge dynamics during the different phases.

Dynamics leading to the emergence of relatedness

The first phase is characterized by local search processes. In the offshore wind energy industry, local searches began in 1989 with the planning of the Vindeby offshore wind farm. The phase lasted until the first damage at Horns Rev 1 in 2004. These 15 years are testament to the persistence of local organizational search processes and the respective relationships. The damage at Horns Rev 1 was perceived as industry-specific and not company-specific. Problems that are considered industry-specific and not company-specific have particular structures and can be described as technological discontinuities (Anderson and Tushman 1990). Technological discontinuities are not necessarily radical innovations since they often add no more than a few changes to the design of the product, the product architecture or the manufacturing process (Henderson and Clark 1990), but they might change an industry's knowledge externalities and enforce industry-wide explorative search processes. Thus, industry-wide local search phases are quite persistent and technological discontinuities indicate a change of dynamics at system level.

The second phase, characterized by explorative search processes, began in 2005. In this phase, certain dynamics were involved in connecting the two offshore industries. The first companies that linked the industries were DONG Energy, COWI, Rambøll and DNV GL. These companies were especially suited in this regard, as employees working in these companies had a particular network position, i.e. a structural fold. Vedres and Stark (2010) describe a structural fold as a position in which actor A is involved in different cohesive groups. In contrast to a structural hole (Burt 1992), where actor A is able to benefit from brokerage between unrelated actors B and C (*tertius gaudens)*, the position at a structural fold includes the relationship not only with otherwise unconnected actors B and C, but with the entire cohesive group of B and C. Consequently, actor A not only knows actors B and C, but also all other actors that are closely related to them. This connection to diverse cohesive groups deems an actor at the structural fold a multiple insider and provides a deep understanding about different areas. Hence, their position at a structural fold enabled employees at DONG Energy, COWI, Rambøll and DNV GL to recognize the value of knowledge from the offshore oil and gas industry in order to mitigate the problems of offshore wind turbines and their foundation structures.

Moreover, these companies started a process that Obstfeld (2005) calls *tertius iungens* i.e., the third who joins, where previously unrelated actors are connected via the introduction of a third actor that is related to both. Companies such as DONG Energy and Rambøll connected companies they knew in the offshore wind energy industry with companies they knew in the offshore oil and gas industry. The particularity of a *tertius iungens* orientation in contrast to the *tertius gaudens* strategy (Burt 1992) is that relationships are established intentionally in order to improve innovativeness at group level (Obstfeld 2005). Via involvement in different cohesive groups, actors at structural folds are in a special position to link these groups. Consequently, relationships between the two offshore industries emerged from a combination of a structural fold position and a *tertius iungens* process.

The third phase, characterized by altered local search processes, began in 2010 with the launch of a number of industry-supporting organizations, projects and forums in Esbjerg with the aim of initiating and stabilizing relationship between the two offshore industries. Organizations are considered as an expression of the institutional environment in which they operate (DiMaggio and Powell 1983), but organizations and institutions do not need to align and can deviate from each other (Zukauskaite et al. 2017). However, the qualities and behaviour of the actors reflect the qualities of the institutional environment in which they operate, and institutions as well as their changes are visible at actor level (Hall and Soskice 2001, Menzel et al. 2017, Menzel and Kammer 2019).

With the above rationale, the appearance of new organizational arrangements linking the two offshore industries indicates an institutionalization of organizational search processes in the other industry. This institutionalization is also visible in the way in which the companies form relationships between the industries. Although connections could be traced back to a structural fold position and a *tertius iungens* process in phase two, this was not the case in phase three. Because of these qualities, we consider that this institutionalization of exchange processes between the two industries indicates an emergent system property. Accordingly, relatedness between the industries emerged via the institutionalization of exchange processes between them. Figure 2 shows the above outlined connection between organizational search and system dynamics.

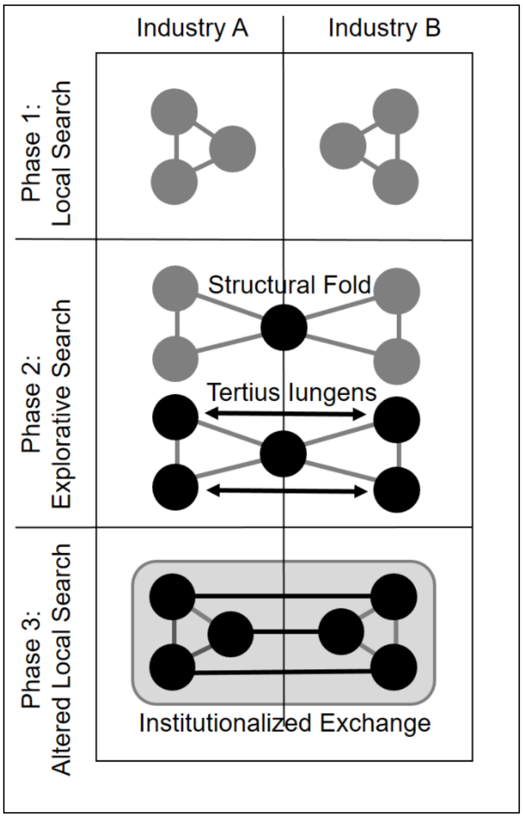

Figure 2: The emergence of Relatedness

The geography of the emergence of relatedness

Each of the dynamics that coincided with the emergence of relatedness had a specific geography. Network studies usually show that relationships between actors in technological and cognitive distance are formed more easily in geographical proximity (Menzel 2015; Ter Wal 2013). In addition, the position of an insider in different cohesive groups is easier to achieve and maintain when these groups are in geographical proximity, as for example described in Grabher's (2002) study on the involvement of actors in the London advertisement industry. Also, triadic closure via *tertius iungens* has its particular geography. Especially in younger industries where trajectories are unclear and cognitive distances might be large, triadic closure follows social relationships, which are often regional (Ter Wal 2013). Thus, there are many reasons why relationships between two industries should emerge via their co-location. However, our study showed that actors were geographically dispersed when initial relationships were established and labour mobility from one industry into the other began. Geographical proximity was created afterwards when offshore wind energy companies moved their activities to Esbjerg.

In contrast to these network dynamics, the institutional dynamics took place locally. Local exchange processes intensified when an institutional environment emerged, which initiated and stabilized the relationship between the two offshore industries. This is in accordance with the literature that argues that institutional solutions are found at regional level to solve particular coordination problems (Malmberg and Maskell 2002; Peck and Theodore 2007). It also indicates the multiscalarity of institutions (Gong and Hassink 2019), as the coordination problems that were to be solved at local level had an industry-wide impact.

Knowledge dynamics of the emergence of relatedness

During the emergence of relatedness, the knowledge dynamics also changed. Whether relatedness expresses knowledge symmetry or asymmetry and whether relatedness describes knowledge similarity or complementarity is an ongoing debate (Boschma 2017). As regards knowledge symmetry or asymmetry, our study indicates that it depends on time. In phase two, it was clear which problems in the offshore wind energy industry needed to be addressed by knowledge from the offshore oil and gas industry. As a result, knowledge was transferred asymmetrically from offshore oil and gas to offshore wind energy. However, in phase three, the knowledge transfer became more symmetrical, as companies in the offshore oil and gas industry used knowledge from the offshore wind energy industry.

With regard to whether relatedness describes knowledge similarities or complementarities, we found evidence for both. Several situations were outlined where organizational search processes sought knowledge complementarities. An example of this was when solutions to the damage at Horns Rev 1 were found in the offshore oil and gas industry. However, in areas with a comparable problem structure, for example in the case of offshore health and safety, a common knowledge base evolved because of knowledge similarities.

During the emergence of relatedness, not only the intensity and direction of knowledge transfers changed, but also the complexity of knowledge. Sorenson et al. (2006) define the complexity of knowledge based on the interdependencies between knowledge components. By interdependencies they mean that a change in one piece of knowledge requires a change in another piece of knowledge, and the larger the knowledge interdependencies, the larger the knowledge complexity. The first knowledge that was transferred between the two offshore industries was simple and included, for example, knowledge about coating and bolts for offshore wind turbines. The complexity increased via the transfer of standards and calculation techniques to the organization of technology systems in phase three. Hence, the institutionalization of relatedness entails a rise in the complexity of transferred knowledge.

Conclusion

We began this paper by asking how relatedness emerges between two previously unrelated industries. We used the offshore oil and gas industry and the offshore wind energy industry in Esbjerg as examples, since these were shaped by a high degree of interaction, but had no genealogical connection. Our fundamental assumption was that the emergence of relatedness as system property should be observable via the parts of the system, i.e. in our case, companies and their search processes. In doing so, we distinguished between three dominant organizational search phases: local search processes (which ignore the other industry), explorative search processes (which form the first connections to the other industry) and altered local search processes (which regularly involve the other industry in search processes).

We found that the initial relationship between the two industries was based on company strategies and particular network positions. Relatedness as system property, however, did not emerge until exchanges between the two industries were institutionalized and became prevalent. This finding that relatedness requires a certain intensity of connection is also found in quantitative studies, which usually define a certain threshold for relatedness (see e.g. Essletzbichler 2015). We present a theoretical argument for such a threshold and argue that a threshold results from downward causation due to institutionalization of exchange between the two industries. Therefore, we propose hypothesis 1:

> Hypothesis 1: Relatedness between two industries emerges from an institutionalization process.

The case study also illustrates the particular geography during the three phases of the emergence of relatedness. Relatedness was not caused by geographically-bound Jacobs' externalities. The dynamics that initiated the connection between the two industries took place between spatially dispersed actors. Geographical proximity between offshore oil and gas companies and offshore wind energy companies followed these dynamics and geographical proximity was more a result than a facilitator. However, the institutionalization of knowledge transfer, i.e. when relatedness emerged, took place locally. Therefore, we propose hypothesis 2:

> Hypothesis 2: Relatedness between two regional industries emerges when exchanges between the two industries are institutionally supported and these institutions are based at regional level.

A third finding was the increasing complexity of transferred knowledge when relatedness emerged. This indicates that knowledge transfers depend not only on the capabilities of the actors involved (see e.g. Boschma 2017), but also on the institutional environment in which this knowledge transfer takes place. Therefore, we propose hypothesis 3:

> Hypothesis 3: The emergence of relatedness between two industries entails an increase in the complexity of knowledge transferred between them.

Our intention to build theory from a case study is limited. For example, we did not investigate a case shaped by a branching process (Frenken and Boschma 2017). In fact, relatedness via branching describes the opposite of our case, and connections between the host and the branching industry usually disappear over time (Storper and Walker 1989; Boschma and Wenting 2007). However, we would assume that if there is a sustained relatedness between the host and the branching industry, there would be an institutionalized connection between them. A further limitation is that we defined the institutionalization of relatedness via the appearance of new organizational arrangements. However, institutional change does not need to be visible via organizational change (Zukauskaite et al. 2019). Despite these limitations, our study shows that relatedness should be considered as an emergent system property and although the outcome might be regional, the origin might be somewhere else (Trippl et al. 2018).

References

Anderson, P. and Tushman, M. L. (1990), "Technological Discontinuities and Dominant Designs - a Cyclical Model of Technological-Change", *Administrative Science Quarterly*, Vol. 35No. 4, pp. 604-633.

Boschma, R. (2017), "Relatedness as Driver of Regional Diversification: A Research Agenda", *Regional Studies*, Vol. 51, No. 3, pp. 351-364.

Boschma, R. and Capone, G. (2015), "Institutions and Diversification: Related Versus Unrelated Diversification in a Varieties of Capitalism Framework", *Research Policy*, Vol. 44, No. 10, pp. 1902-1914.

Boschma, R. and Frenken, K. (2011), "Technological Relatedness, Related Variety and Economic Geography", in P. Cooke, B. Asheim, R. Boschma, R. Martin, D. Schwartz and F. Tödtling (Eds.), *Handbook of Regional Innovation and Growth*, Edward Elgar, Cheltenham, pp. 187-197.

Boschma, R., Minondo, A. and Navarro, M. (2013), "The Emergence of New Industries at the Regional Level in Spain: A Proximity Approach Based on Product Relatedness", *Economic Geography*, Vol. 89, No. 1, pp. 29-51.

Boschma, R. and Wenting, R. (2007), "The Spatial Evolution of the British Automobile Industry: Does Location Matter?", *Industrial and Corporate Change*, Vol. 16, No. 2, pp. 213-238.

Breschi, S. and Lissoni, F. (2001), "Localized Knowledge Spillovers vs. Innovative Milieux: Knowledge "Tacitness" Reconsidered", *Papers in Regional Science*, Vol. 80, No. 3, pp. 255-273.

Breschi, S., Lissoni, F. and Malerba, F. (2003), "Knowledge-Relatedness in Firm Technological Diversification", *Research Policy,* Vol. 32, No. 1, pp. 69-87.

Burt, R. S. (1992), *Structural Holes,* Cambridge MA: Harvard University Press.

Business Esbjerg (2016), *Invest in Esbjerg*, Business Esbjerg, Esbjerg.

Carvalho, L. and Vale, M. (2018), "Biotech by bricolage? Agency, institutional relatedness and new path development in peripheral regions", *Cambridge Journal of Regions, Economy and Society*, Vol. 11, No. 2, pp. 275-295.

Castaldi, C., Frenken, K. and Los, B. (2015), "Related Variety, Unrelated Variety and Technological Breakthroughs: An Analysis of UsS State-Level Patenting", *Regional Studies*, Vol. 49, No. 5, pp. 767-781.

Corning, P. A. (2002), "The re-emergence of “emergence”: A venerable concept in search of a theory", *Complexity*, Vol. 7, No. 6, pp. 18-30.

Deacon, T. (2003), "The hierarchic logic of emergence: untangling the interdependence of evolution and self-organization", in Weber, B., Depew, D. (Eds.), *Evolution and Learning: The Baldwin Effect Reconsidered*, MIT Press, Cambridge, MA, pp. 273-308.

Desrochers, P. and Leppälä, S. (2011), "Opening up the 'Jacobs Spillovers' Black Box: Local Diversity, Creativity and the Processes Underlying New Combinations", *Journal of Economic Geography,* Vol. 11, No. 5, pp. 843-863.

DiMaggio, P. J. and Powell, W. W. (1983), "The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields", *American Sociological Review*, pp. 147-160.

Dosi, G. (1982), "Technological Paradigms and Technological Trajectories", *Research Policy,* Vol. 11, No. 3, pp. 147-162.

Eisenhardt, K. M. (1989), "Building Theories from Case Study Research" *Academy of Management Review,* Vol. 14, No. 4, pp. 532-550.

Eisenhardt, K. M. and Graebner, M. E. (2007), "Theory Building from Cases: Opportunities and Challenges", *Academy of Management Journal,* Vol. 50, No. 1, pp. 25-32.

Essletzbichler, J. (2015), "Relatedness, industrial branching and technological cohesion in US metropolitan areas", *Regional Studies*, Vol. 49, No. 5, pp. 752-766.

Frenken, K., Van Oort, F. and Verburg, T. (2007), "Related Variety, Unrelated Variety and Regional Economic Growth", *Regional Studies,* Vol. 41, No. 5, pp. 685-697.

Goldstein, J. (1999), "Emergence as a construct: History and issues", *Emergence*, Vol. 1, No. 1, pp. 49-72.

Gong, H., and Hassink, R. (2019), "Co-evolution in contemporary economic geography: towards a theoretical framework", *Regional Studies*, Vol. 53, No. 9, pp. 1344-1355.

Grabher, G. (2002), "The project ecology of advertising: tasks, talents and teams", *Regional Studies,* Vol. 36, No. 3, pp. 245-262.

Hahn-Pedersen, M. (2001), *Fra Viking Til Borebisse: 50 Generationer Ved Vadehavet*, Fiskeri- og Søfartsmuseet.

Hall, P. and Soskice, D., Editors (2001), *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*, Oxford University Press, Oxford.

Henderson, R. M. and Clark, K. B. (1990), "Architectural Innovation - the Reconfiguration of Existing Product Technologies and the Failure of Established Firms", *Administrative Science Quarterly*, Vol. 35, No. 1, pp. 9-30.

Hidalgo, C. A., Balland, P. A., Boschma, R., Delgado, M., Feldman, M., Frenken, K., Glaeser, E., He, C., Kogler, D.,Morrison, A., Neffke, F., Rigby, D., Stern, S., Zheng, S., and Zhu, S. (2018), "The principle of relatedness",in Morales, A., Gershenson, C., Braha, D., Minai, A. A. and Bar-Yam, Y. (Eds), *Unifying Themes in Complex Systems IX. Proceedings of the Ninth International Conference on Complex Systems*, Cham, Springer, pp. 451-457.

Jacobs, J. (1969), *The Economy of Cities*, Vintage Books, New York.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993), "Geographic Localisation of Knowledge Spill-Overs as Evidenced by Patent Citations", *Quarterly Journal of Economics*, Vol. 108, No. 3, pp. 577-598.

Karlsen, A. (2018), "Framing industrialization of the offshore wind value chain–a discourse approach to an event", *Geoforum*, Vol. 88, pp. 148-156.

Katila, R. and Ahuja, G. (2002), "Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction", *Academy of Management Journal*, Vol. 45, No. 6, pp. 1183-1194.

Klepper, S. (2007), "Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the Us Automobile Industry", *Management Science*, Vol. 53, No. 4, pp. 616-631.

Langkilde, L., Kornum, L. F., Ingstrup, M. B. and Rasmussen, S. (2015), *Økosystemet i Offshoreklyngen i Region Syddanmark*, Syddansk Universitet, Institut for Entreprenørskab og Relationsledelse.

Langley, A. N. N., Smallman, C., Tsoukas, H., and Van de Ven, A. H. (2013), "Process studies of change in organization and management: Unveiling temporality, activity, and flow", *Academy of Management Journal*, Vol. 56, No. 1, pp. 1-13.

MacKinnon, D. (2011). Beyond strategic coupling: reassessing the firm-region nexus in global production networks. In: Journal of Economic Geography, 12(1), 227-245.

Malmberg, A. and Maskell, P. (2002), "The Elusive Concept of Localization Economies: Towards a Knowledge-Based Theory of Spatial Clustering", *Environment and Planning A*, Vol. 34, No. 3, pp. 429-449.

March, J. G. (1991), "Exploration and Exploitation in Organizational Learning", *Organization Science*, Vol. 2, No. 1, pp. 71-87.

Markard, J. and Petersen, R. (2009), "The Offshore Trend: Structural Changes in the Wind Power Sector", *Energy Policy*, Vol.37, No. 9, pp. 3545-3556.

Martin, R. and Sunley, P. (2006), "Path Dependence and Regional Economic Evolution", *Journal of Economic Geography*, Vol. 6, No. 4, pp. 395-437.

Martin, R., and Sunley, P. (2012), "Forms of emergence and the evolution of economic landscapes", *Journal of Economic Behavior & Organization*, Vol. 82, Nos. 2-3, pp. 338-351.

Menzel, M.-P. (2015), "Interrelating Dynamic Proximities by Bridging, Reducing and Producing Distances", *Regional Studies,* Vol. 49, No. 11,pp. 1892-1907.

Menzel, M.-P., Feldman, M. P. and Broekel, T. (2017), "Institutional Change and Network Evolution: Explorative and Exploitative Tie Formations of Co-Inventors During the Dot-Com Bubble in the Research Triangle Region" *Regional Studies,* Vol. 51, No. 8, pp. 1179-1191.

Menzel, M.-P. and Kammer, J. (2019), "Industry evolution in Varieties of Capitalism: a comparison of the Danish and US wind turbine industries", *Industrial and Corporate Change (advance access),* pp.1-23.

Nelson, R. R. and Winter, S. G. (1982), *An Evolutionary Theory of Technical Change*, Harvard University Press, Cambridge.

Nooteboom, B. (1999), "Innovation, Learning and Industrial Organisation", *Cambridge Journal of Economics,* Vol. 23, No. 2, pp. 127-150.

Obstfeld, D. (2005), "Social Networks, the Tertius Iungens and Orientation Involvement in Innovation", *Administrative Science Quarterly,* Vol. 50, No. 1, pp. 100-130.

Owen-Smith, J. and Powell, W. W. (2004), "Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community", *Organization Science,* Vol. 15, No. 1, pp. 5-21.

Peck, J. and Theodore, N. (2007), "Variegated Capitalism", *Progress in Human Geography,* Vol. 31, No. 6, pp. 731-772.

Rowley, T., Behrens, D. and Krackhardt, D. (2000), "Redundant Governance Structures: An Analysis of Structural and Relational Embeddedness in the Steel and Semiconductor Industries", *Strategic Management Journal,* Vol. 21, No. 3, pp. 369-386.

Sorenson, O., Rivkin, J. W., and Fleming, L. (2006), "Complexity, networks and knowledge flow" *Research Policy,* Vol. 35, No. 7, pp. 994-1017.

Storper, M., & Walker, R. (1989), *The capitalist imperative*, Blackwell, Oxford.

Stuart, T. E. and Podolny, J. M. (1996), "Local Search and the Evolution of Technological Capabilities", *Strategic Management Journal,* Vol. 17(Summer), pp. 1721-38.

Tanner, A. N. (2014), "Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions", *Economic Geography,* Vol. 90, No. 4, pp. 403-427.

Teece, D. J., Pisano, G. and Shuen, A. (1997), "Dynamic Capabilities and Strategic Management", *Strategic Management Journal,* Vol. 18, No. 7, pp. 509-533.

Ter Wal, A. L. J. (2013), "The Dynamics of the Inventor Network in German Biotechnology: Geographic Proximity Versus Triadic Closure", *Journal of Economic Geography*, Vol. 14, No. 3, pp. 589-620.

Timmermans, B. and Boschma, R. (2014), "The Effect of Intra-and Inter-Regional Labour Mobility on Plant Performance in Denmark: The Significance of Related Labour Inflows, *Journal of Economic Geography,* Vol. 14, No. 2, pp. 289-311.

Timmermans, S., and Tavory, I. (2012), "Theory construction in qualitative research: From grounded theory to abductive analysis", *Sociological Theory*, Vol. 30, No. 3, pp. 167-186.

Trippl, M., Grillitsch, M., & Isaksen, A. (2018), "Exogenous sources of regional industrial change: Attraction and absorption of non-local knowledge for new path development", *Progress in Human Geography*, Vol. 42, No. 5, pp. 687-705.

Vedres, B. and Stark, D. (2010), "Structural Folds: Generative Disruption in Overlapping Groups 1", *American Journal of Sociology*, Vol. 115, No. 4, pp. 1150-1190.

Yin, R. K. (2013), *Case Study Research: Design and Methhods,* Sage, Los Angeles.

Zukauskaite, E., Trippl, M., and Plechero, M. (2017), "Institutional thickness revisited", *Economic Geography*, Vol. 93, No. 4, pp. 325-345.

Appendix: List of interviewees

Name of actor	Type of actor	Industry affiliation	Located in Esbjerg	Participated in per-sonal interview	Participated in focus group interview
Phase 1					
A2Sea	Company	Wind		X	
Aalborg University	Research and educational actor		X	X	
Blaaholm	Company	Wind	X	X	
Bladena	Company	Wind		X	
Business Esbjerg	Industry-supporting organization		X	X	
DONG Energy	Company	Oil and gas Wind	X	X	
Esbjerg Maritime Service	Company	Oil and gas Wind	X	X	
Esvagt	Company	Oil and gas Wind	X	X	
Force Technology	Company	Oil and gas Wind	X	X	

Hub North	Industry-supporting organization			X	
Liftra	Company	Wind		X	
Lindø Offshore Renewables Center	Test facility	Wind		X	
MacArtney	Company	Oil and gas Wind	X	X	
Maersk Oil	Company	Oil and gas	X	X	
MHI Vestas Offshore Wind	Company	Wind	X	X	
Ocean Team Group	Company	Oil and gas Wind	X	X	
Offshore Energy	Industry-supporting organization		X	X	
Port of Esbjerg	Company	Oil and gas Wind	X	X	
Rambøll	Company	Oil and gas Wind	X	X	
Region of Southern Denmark	Government			X	
Semco Maritime	Company	Oil and gas Wind	X	X	
Siemens Wind Power	Company	Wind	X	X	
Sihm Højtryk	Company	Oil and gas	X	X	

Technical University of Denmark	Research and educational actor			X	
Total Wind	Company	Wind	X	X	
University of Southern Denmark	Research and educational actor		X	X	
Vattenfall	Company	Wind	X	X	
Phase 2					
A2Sea	Company	Wind		X	
Blue Water Shipping	Company	Oil and gas Wind	X	X	X
Bureau Veritas	Company	Oil and gas	X		X
Business Esbjerg	Industry-supporting organization		X	X	
DONG Energy	Company	Oil and gas Wind	X	X	X
Lindvig Consulting	Company	Wind		X	
Maersk Oil	Company	Oil and gas	X	X	
Ocean Team Group	Company	Oil and gas Wind	X		X
Offshore Center Denmark	Industry-supporting organization		X	X	
Offshore Energy	Industry-supporting organization		X	X	
Port of Esbjerg	Company	Oil and gas	X	X	X

		Wind			
Rambøll	Company	Oil and gas Wind	X	X	X
Region of Southern Denmark	Government			X	
Semco Maritime	Company	Oil and gas Wind	X	X	X
Siemens Wind Power	Company	Wind	X	X	
University of Southern Denmark	Research and educational actor		X		X

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