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The Ties That Bind

Symbiotic initiatives and collaborative factors

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Abstract

Transnational actors such as the European Union, encourages and promotes the development of circular economics. The rationale is financially based, but it also comes from a perspective of sustainability. Funding is provided to programmes and projects with this intent in mind. *Symbiosis* is a concept within circular economics in which public and private actors can utilize each other's residuals and wastes more efficiently. The Urban Baltic Industrial Symbiosis (UBIS) project is an EU-funded project with the goal of functioning as a 'display' for how symbiosis could be implemented and the benefits of doing so. In this thesis, we will take a closer look at the UBIS-project and its activities in the Swedish region of Skåne. The perspective is sociological, and a specific focus will thus be placed on the collaborative aspects of symbiosis. Empirical data on the UBIS-project have been gathered through interviews and documentations and a previously developed conceptual model will be used to make sense of the data. Previously conducted research includes findings on policies which may facilitate the emergence of symbiosis. The thesis has found that previous histories of symbiotic ties seem to be an important factor in the development of new ones. This finding is however, limited to the context under study.

Keywords: Circular Economics, Symbiosis, UBIS-project, Policy, Public-Private.

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1.1 Introduction

Issues and questions regarding the climate are taking an increasing amount of space in political contexts as well as in economic ones. The Sustainable Development Goals, as the name implies, emphasizes development with sustainability in mind and does so within currently established frameworks. SDG 11 on sustainable cities and communities, subsection 11.B specifically, targets resource efficiency amongst a few other points (United Nations, 2020). The European Commission walks a similar path. Their Eco-Innovation Plan highlights sustainability and circular economics (European Commission, 2016). Furthermore, funding is provided to various projects promoting and encouraging circular economics within the European Union through programmes such as Interreg South Baltic, which focuses on developing the Baltic region (Interreg South Baltic, 2020). Within the sphere of circular economics, we find the concepts of *urban* and *industrial* symbiosis. This is one approach to sustainable development of industries and cities that work with many of the tools and methods already at our disposal. This approach is what this text is interested in exploring further. While research already exists on the technical and physical aspects of the concepts, and several of these authors add a paragraph or two on the necessity of social factors (Celander et al., 2013; Chertow, 2007; Mulder, 2016; Mulder & Vernay, 2016), very few have based their own work on researching these factors. There thus exists a gap in the literature.

1.2 Background

As there clearly exists an interest in circular economics from transnational actors, this paper will keep the perspective on the concept of symbiosis broad. A major focus will be placed on a pilot-project which took place in the Baltic region, involving actors from Poland, Denmark, and Sweden amongst others. The Urban Baltic Industrial Symbiosis project (UBIS) acted as a sort of 'display' for symbiosis and what it could be used for (Jensen & Nielsen, 2019). One of the technical pilot-sites and several of the actors reside in the south of Sweden which makes accessibility to them less of an issue. As such, I have talked to some of them and their thoughts and inputs will be used in the paper to discuss the specific context of UBIS in Sweden. This limitation is mostly done for the sake of accessibility, but it also keeps the scope limited to the perspectives of a developed nation, the Swedish region of Skåne specifically.

1.3 Purpose and aims

A study on the case of UBIS in Skåne, may yield a better understanding of how these more abstract EU-ideals of circular economics and symbiosis are operationalized and put into practice

in the region. Furthermore, implementations of symbiosis require several actors from both the public and private sphere to collaborate. This collaborative aspect of the concept is of interest for this thesis. As such, focus will be placed on investigating how the collaborative processes took shape in the UBIS-project. In an article titled *Critical factors for industrial symbiosis emergence process* (2019), Mortensen and Kørnøv provide a conceptual model which helps explain the emergence process of industrial symbiosis, focusing on the *actions* of involved actors. This paper is however heavily reliant on academic sources and is missing, as the authors themselves recognize, the perspectives of people working in the field. One of the aims of this thesis is to add one part of this perspective to this gap.

1.3.1 Research question

This thesis is driven by the purpose and aims as stated above. Drawing on those aims with the goal to increase our understanding of the concept of symbiosis, the guiding research question is as follows:

In what ways have the UBIS-project implemented the concept of symbiosis in the Swedish region of Skåne?

This question will be tackled from a sociological perspective and focus will thus be put on the collaborative aspects necessary for symbiosis to emerge. By answering this question, we will hopefully gain much needed knowledge on how these types of symbiotic relations arise. The long-term goal being that development of cities and industries could possibly be done with resource efficiency and sustainability in mind. By deepening our understanding, we may possibly be able to design policies and techniques which encourages and facilitates development of this kind. First however, we need to have a basic understanding of the technical aspects and a grasp of the research that has previously been conducted.

2.1 Previously Conducted Research

The term ‘symbiosis’ has its roots in the field of biology and means interaction between organisms. It is used to describe interdependencies between species in eco-systems. As Lybæk, Christensen, and Thomsen (2019) puts it, the term ‘symbiosis’ is used as an analogue to biological systems and it originated in an article titled *Strategies for Manufacturing* (1989) written by Frosch and Gallopoulos which developed the concept of industrial ecology. In many ways, this was the beginning of this type of sustainable thinking relating to industries. Not to say that it was the first or only of its kind as the examples by Coelho, Morales, and Diemer

(2017, p. 192) illustrates. In very simple terms, and at risk of sounding cliché, the old adage that 'one man's waste is another man's treasure' is suited for illustrating the philosophical underpinnings of symbiosis. The concept of symbiosis can be seen as the connection of outputs with inputs resulting in cost-savings through the minimization of waste and optimization of energy flows. While the various forms may look different, one key distinction between industrial symbiosis and urban symbiosis is the benefactors of the symbiotic tie. Urban symbiosis tends to benefit both the private and the public sphere whilst the benefits of an industrial symbiosis tends to cluster in the private sphere. The environmental benefits are presumably intrinsic to both but has seldom been carefully measured (Chertow, 2007).

One of the examples[1] mentioned by Frosch and Gallopoulos (1989) is the in-house recycling of PVC-plastics in the automotive industry. Rather than discarding scraps and trimmings, they get mixed with the next batch of virgin materials, minimizing the amount of waste produced as well as the amount of material purchased, thus resulting in cost savings. As such, the environmental benefit in this case is not the main motivating factor. Due to the high chlorine content of PVC-plastic, it is the "worst case example of the problems of plastics pose" (1989, p. 3). By switching over to PET-plastics, which share many of the physical properties of PVC but contain no chlorine and is already used in the production of plastic beverage bottles, further benefits can be gained. Recycling of the materials used for the bottles already occurs and, in some U.S states, mandatory deposit laws exists which further encourages recycling.

Within this example, we find a few points of interest that I would like to highlight. These things do however not necessarily occur in this order.

1. An industry (*automotive*) looking to reduce costs through reusing and reducing materials (*PVC*).
2. An alternative material (*PET*) that shares similar physical properties being widely used in another industry (*beverage brewing*).
3. The biproduct or waste created after consumption (*plastic bottles*) of the second industry's product (*beverages*).

[1]For the sake of brevity, many of the technical aspects related to the production process have been purposely omitted. Furthermore, context is important to keep in mind. The article is written three decades ago, and the specific example refers to the United States. The reason for including the example is for its ability to clearly illustrate the connection between different actors.

4. A third industry (*recyclers*) which collects and recycles said biproduct.
5. An infrastructure which facilitates the collection (*recycling stations, deposits*) and repurposing of the material.
6. Legislation encouraging the collection of the material and consequentially, development of said infrastructure.

Thus, by connecting the output of the recyclers with the inputs of the automotive industry, environmental strains can be reduced, and costs kept low due to the higher price of oil and its necessity in the production of virgin plastics in comparison to the lower price of recycled PET-plastics. The example clearly shows how this connection is only made possible by the various actions taken by several different actors and how interdependencies could develop between seemingly unrelated firms. That is however not to say that PET-plastics overtook and replaced PVC in the automotive industry. It is still used as the total amount of plastic in personal vehicles increases. PET is however also part of that equation (Khemka, 2019).

While this example does not showcase a true symbiosis, (the definitions will be clearer in the theoretical framework segment) it highlights the different actors relevant to the emergence of a symbiosis and places the concept in a context which indicates that these actors have an opportunity to link their respective productions if they wish to.

Nonetheless, previously conducted research on the concept of symbiosis tend to put much weight on the aspects necessary for its implementation and deployment. These aspects include policies and regulations which may facilitate the transition from one production process to another, and third-party intermediators which acts as driving forces for these transitions in differing ways. Some have developed concepts, heuristic tools, and terminologies which describes aspects of symbiosis such as how it looks and how it emerges (Chertow, 2007; Chertow, Ashton, & Espinosa, 2008; Mortensen & Kørnøv, 2019). A conceptual model of industrial symbiosis emergence developed by Mortensen and Kørnøv (2019), will be elaborated on in the theoretical framework. For now, I would like to discuss two major themes, prevalent in the literature.

2.2 Third-party intermediators

A third-party intermediator exists outside of firms, organisations, and other kinds of actors with opportunities for symbiotic initiatives. This role can be ascribed to many different entities. It entails properties such as the dissemination of knowledge, and it has catalytic characteristics. Intermediators in this context, are the organizations, institutions, and individuals which

facilitate symbiosis implementation in various ways, dependent on their own degree of capacity. Regarding industrial symbiosis, Chertow (2007) highlights academic institutions and business associations as potential intermediators. Academic institutions are good at spotting opportunities for symbiotic transitions and spreading information on the possibilities of such transitions, as well as how they are to be configured physically and technically. Mortensen and Kørnøv (2019) adds that research and educational institutions "feed valid information" into the network of actors. This facilitates collaboration through a mitigation of asymmetries in knowledge between stakeholders. Business associations assist on the business-side of things for example through supporting the development of business models. In cases of urban symbiosis, Mulder and Vernay (2016) discusses an instance where a group of residents in an area, organized, and acted as the intermediator between firms, due to their own stake in a potential partnership. Additionally, Mortensen and Kørnøv (2019) discusses the role of intermediators through different levels of abstraction. One singular individual could be 'championing' the cause so to speak, and so to can organisations and institutions.

The shared argument between these authors, is that symbiotic ties seldom develop on their own and that the presence of an 'outsider' facilitates emergence. Just to give a clear example of how a third-party intermediator has functioned in reality, in the case of Kalundborg Symbiosis in Denmark, this 'outsider' came from an unexpected place. These types of exchanges already occurred in Kalundborg before they were 'uncovered', to use Chertow's (2007) terminology. Local high school students made a scale model and mapped out the pipes and connections of the involved actors for a school project back in 1989 (Christensen, J. 1998 cited in Chertow, 2007). It was this event which 'opened the eyes' of the involved actors at Kalundborg to what had already transpired, and the possible opportunities of continuing to connect inputs and outputs. The different levels of abstraction of the third-party intermediator that Mortensen and Kørnøv (2019) discusses, is illustrated in this case.

2.3 Policies and regulations

The second theme of prevalence in previous research is that of policies and regulations. Policy landscapes differ and context matters as the findings of Petríková, Borseková, and Blam (2016) and Lybæk et al. (2019) suggests. The question of which types of policies and regulations that actually have an effect on promoting the deployment of industrial symbiosis, is asked by Lybæk et al. (2019) in a conference paper. The article contains a literature review which focuses on the "national policies and framework conditions provided by the European Union (EU), the United Nations (UN) and the Organization for Economic Cooperation and Development (OECD),

which support or hinder development of industrial symbiosis" (2019, p. 1). The findings of this review are then applied to a case in Denmark, followed by the authors' conclusions and recommendations for policy initiatives. Out of interest for this thesis, is that both the studied case, and the literature review found that policies targeting the implementation of industrial symbiosis directly had less of an impact on its emergence than indirect policies did (Lybæk et al., 2019). One example the authors provide of an indirect policy measure is a biogas feed-in tariff.

In the article titled *Industrial symbiosis in European policy* (2016), written by Petríková et al., we find an example from Russia, where the policy landscape is quite different than that of Denmark. A producer of kernel and oil from cedar pine nuts started to use its own biproduct (pine nutshells) as the fuel for its boiler installation. Up until 2006, the biproduct had been used to fill in cavities in highway pavements as well as nearby ravines. The pine nutshells were of course free of charge. Note that the authors describe this case as "symbiosis development". In Chertow's (2007) terminology, the terms 'kernel' or 'precursor' could be applicable here. Petríková et al. (2016, p. 94) adds that if the shells had been dumped in an open landfill, the company would have been charged for the waste disposal. Furthermore, Russian environmental regulations "do not encourage voluntary exchanges among industrial neighbours". The only motivating factor is to "achieve private benefits or reduce private costs" (2016, p. 90). As such, the regulatory conditions in Russia does not seem to promote environmentally sustainable production practices but rather, they are the outcome of economically motivated decisions which happen to also bring environmental gains. As a result, indirect policy measures focusing on the penalization of some business practices, seem to be an effective mean of achieving environmentally beneficial actions, even if the motivations for complying are rooted in the economic side of things. Interestingly enough however, is that Russian law assumes environmental quality standards that are higher than European ones. The problem is the lack of enforcement. Authorities tend to utilize fines associated with the regulations on pollution to finance current needs, not just for environmental protection (2016, p. 90). Petríková et al. (2016, p. 91) concludes that "environmental policy interventions could be viable means of motivating wastes and by-products flows among firms, but not in the case of Russia".

The findings and conclusions of Lybæk et al. (2019) and those of Petríková et al. (2016) regard different policy landscapes. Additionally, there exists a difference in the levels of 'faith' so to speak, in the ability and willingness of authorities to implement and enforce policy measures for the environmental benefits alone. Nonetheless, the impact of indirect policies for the sake

of establishing symbiosis (or ‘kernels’ at the very least) is evident by the way the biproduct (pine nutshells) in this case were handled. Lybæk et al. (2019) also suggests that a need for easy funding is beneficial. Long-term contracts and low-interest loans for the expansion or connection of firm infrastructures, could add incentives to interested actors through the increase of project stability rather than volatility (Lybæk et al., 2019).

2.3.1 Innovations, backcasting and policy modes

Technology is one crucial aspect of symbiosis. Mulder (2016) discusses the necessity of circumventing ‘lock-ins’ and cost barriers. Regarding lock-ins from a technological perspective, they occur when technological solutions have been stacked on one another and are so intertwined that any major alterations require massive investments. This makes the implementation of new innovations difficult as they must function in relation to what is already present. *Policies* and *regulations* can also represent lock-ins through licensing or demands on production processes, for example. What Mulder (2016) suggests as a solution to circumventing these lock-ins and cost barriers, is the process of ‘backcasting’. By starting with a vision of the future, and working backwards from that, obstructions can be dealt with at an earlier stage. Addressing organisational or policy changes that are needed to reach a vision can also be done through the process of backcasting. Furthermore, the process creates a framework which can act as a “guidepost for innovation” (Mulder, 2016, p. 4).

In an article titled *Policy Modes, Firms and The Natural Environment* (2004) written by Aseem Prakash and Kelly Kollman, the authors lists various kinds of policy measures which are used in terms of regulations regarding the environment. These range from hard-hitting policies from authorities which command how certain production processes should function, to more voluntary based codes developed by private actors. The policies which ‘command and control’ tend to cost more as they need to be monitored and enforced. Additionally, the “technology-forcing aspect of this policy mode could decrease incentives to innovate” (2004, p. 112). The benefits of this policy mode, however, is that it tends to be effective in maintaining high environmental standards. Nonetheless, policies within this mode seem to be based on a future vision from the governments perspective, and ‘backcasted’ from there. As Prakash and Kollman (2004, p. 124) conclude in their findings “from a policy design perspective, it is critical that the benefit–cost calculus of the key targets of regulation be taken into account”. The costs of certain types of policies may outweigh their benefits and thus, by shifting responsibilities to private actors, environmental gains can be achieved at a lower cost. Prakash and Kollman (2004) goes more into detail on the specifics and limitations of such an approach. However, the main

arguments in this sub-heading, is that innovation is a necessary aspect for the emergence of symbiosis, and that through the process of 'backcasting', policies which promotes symbiosis can be designed whilst still keeping high environmental standards a priority. A shift in future visions from EU-level regulatory agencies is already underway (Johnsen et al., 2015, pp. 23-25).

3.1 Theoretical Framework

The theoretical framework will begin by elaborating on and more clearly defining the concepts of industrial and urban symbiosis. This will be followed by a presentation of the conceptual model we will use to analyse the gathered data, and to facilitate our understandings of the collaborative aspects of symbiosis.

3.2 Industrial Symbiosis

In the conference paper by Lybæk et al. (2019, pp. 1-2), the authors describe "the overall raison d'être of industrial symbiosis" as a mean for companies to "simultaneously achieve cost reductions and environmental benefits, by using by-products and wastes generated by some companies, as new raw materials inputs for other companies". They go on by adding that the concept may also involve the sharing of infrastructures, the supply of energy and water as well as "various other types of resources, etc" (Petríková et al., 2016 cited in Lybæk et al., 2019). The addition of Chertow's, Ashton's, and Espinosa's consideration of three primary opportunities for resource exchange, from an article titled *Industrial Symbiosis in Puerto Rico* (2008), is helpful as well. The authors list them as: (1) Biproduct reuse. (2) Utility infrastructure sharing. (3) Joint provision of service. The argument here is that resource exchanges can take different forms and involve different kinds of resources, thus industrial symbiosis is not exclusively related to the production process, but also to the overall needs of a firm. With this definition, one small scale example of this could be an office building housing more than one organisation, providing a shared canteen for the employees and splitting the costs of running the printer.

However, that is not to say that the exchange of biproducts, scraps and residual resources in production processes have not previously occurred throughout history. Nor the sharing of services and infrastructures. What mainly differs within the concept of an industrial symbiosis is the interdependency that develops along with more complex forms of resource exchanges. In an article titled *Uncovering Industrial Symbiosis* (2007), Marian Chertow utilizes a "3-2 heuristic" to more easily identify cases of industrial symbiosis. This heuristic tool can be used

to define the concept of industrial symbiosis as a minimum of three different entities which must exchange a minimum of two different resources. Only then can the exchange of resources be referred to as a basic type of industrial symbiosis. Furthermore, none of these entities should be primarily engaged in recycling-oriented businesses. By meeting these criterions, the 3-2 heuristic allows for the recognition of more complex relationships rather than linear one-way exchanges (Chertow, 2007).

Lybæk et al. (2019) does however add to the definition that it is possible to argue for a 3-1 heuristic were only one type of resource is exchanged between several entities. What remains is the key focus on the interdependencies through symbiotic relations between several actors. In the case of industrial symbiosis, the main benefactors of the symbiotic relationship are the involved firms. Whilst environmental benefits are presumably also gained, they are hardly the main motivating factor for the implementation of a symbiotic relation. Again, the environmental benefits have seldom been measured carefully (Chertow, 2007).

3.3 Urban Symbiosis

This type of symbiosis is a strategy which refers to the creation of a more efficient "metabolism of cities" as Karel Mulder and Anne Lorène Vernay states in an article titled *Organising urban symbiosis projects* (2016). Cities are complex. Within any given city, elaborate grids and systems exist which provide water, energy and heating to the inhabitants and industries residing in the area. Materials and other types of resources do of course also flow within the limits of a city. These are parts of the metabolism of cities and the idea of urban symbiosis is to make these flows more efficient. By combining the generation of certain flows such as heat and power for instance, the overall efficiency of the production of both can be boosted, as Mulder illustrates in a conference paper titled *Urban Symbiosis, A New Paradigm in the Shift Towards Post-Carbon Cities* (2016). By extension, so too can the overall metabolism of the city be boosted. As such, the concept focuses on "the built environment and refers to initiatives that aim at closing material and energy flows within a given urban area" as Mulder and Vernay (2016) puts it.

Whilst the concepts of industrial and urban symbiosis share many similarities, what primarily separates them is the connection to the public sphere within urban symbiosis. These types of initiatives tend to favour the public in some ways and not only the private sphere. One example of this could be by running pipes underneath sidewalks which dissipates heat from a nearby industries production process. This could be used for heating of the pavement during the winter,

keeping the streets free from snow and ice. The specific streets heated could be those close to nodes for public transportation, promoting its use by making it more accessible for the residents in the area during the colder part of the year. This was the idea in the case of the municipality of Bjuv (Jensen & Nielsen, 2019) which will be discussed in more detail and is the subject of analysis in this thesis.

To summarize so far, Frosch and Gallopoulos (1989) provided a lens in which we can consider industries as part of an ecosystem in which almost anything deemed as waste or a biproduct, can be used by someone for something else. This allows for the residual heat from a production process to be seen as a resource to be utilized, rather than a problem to solve or get rid of. This leads us to symbiosis. At the core of symbiosis, we find the connectivity between actors and their use of residuals, biproducts, and sharing of services and infrastructures, subsequently establishing an interdependency. The interdependency is what makes this way of optimizing resources function at all. It is however also the source of many of the barriers that needs to be hurdled.

3.3 The process of emergence

Now that a basic understanding of the concepts and what a symbiosis could look like have been established, this thesis will move on to discussing the emergence of such connections and the underlying processes. The article by Mortensen and Kørnøv (2019) provides us with a conceptual model (*figure 1*, p. 30). This model defines three phases: (1) Pre-emergence. (2) Emergence. (3) Post-emergence. The second phase, emergence, is as Mortensen and Kørnøv (2019, p. 58) puts it, "the dynamic (social) process between pre-emergence and post-emergence phases". Chertow (2007) uses the words 'kernel' and 'precursor' to describe instances where a bilateral or multilateral exchange is taking place but does not yet meet the fuller definition of the 3-2 heuristic. They do however have the potential to expand and it is within this phase they do so. Mortensen and Kørnøv (2019) go on by gathering the different kinds of events that occur in this phase, into three groups: (1) Awareness and interest in industrial symbiosis. (2) Organizing. (3) Reaching out/Exploration of connections. These events may facilitate the emergence of symbiosis and includes activities such as "partner search" or "local actors engage in collective learning". For the full list of events, please check *Table 1* in the appendix, page 31. Furthermore, the events in these three groups do not occur chronologically but rather simultaneously or at the very least, not in a linear order (Mortensen & Kørnøv, 2019). Within these groups, there are five factors of relevance regarding the context and the actors involved. The level of importance and the specific role of the factors vary depending on which group they

are active in. For a simplified overview, a figure has been provided in the appendix which visualizes the process and should add some clarity (*figure 1*, appendix page 30). Additionally, a table elaborating on the contents of *figure 1* and summarizing the findings of Mortensen and Kørnøv (2019), have been created and provided (*table 2*). The value of this model is that it provides a framework to place activities and events within as well as policies and more context specific aspects such as cultures, localities, and previous encounters with symbiosis. It does however focus exclusively on the emergence of industrial symbiosis and not on urban symbiosis. By altering the perceived importance of certain actors within the groupings and considering the change in benefactors of the symbiosis, I believe the model could be adapted to fit more in line with urban symbiosis as well. To develop a new conceptual model is however not within the scope of this thesis and we will as such (albeit with some limitations) use the model provided by Mortensen and Kørnøv (2019) to assist our understanding of the emergence of symbiosis. This conceptual model will be applied to the UBIS-project with a focus on their pilot-site in the municipality of Bjuv. This site represents a case of urban symbiosis.

Additionally, Mortensen and Kørnøv (2019) acknowledges that the research they have conducted is heavily reliant on academic sources and as such, may miss out on the thoughts and inputs of those actually actively working with symbiosis. By including interviews with active actors in the field, this thesis will attempt to add to the blocks, bridging the gap recognized by the authors.

4.1 Method and Data

This segment will begin with a brief discussion on the issues of conducting social science and motivate why a certain method has been used. It will be followed by a presentation of how data was gathered, why the data was selected, and how it was analysed.

We begin by encountering the issue of constructing social science on the basis of universal laws and grand narratives. Alejandro Portes illustrates in his book *Economic Sociology - A systematic inquiry* (2010, p. 7), the impossibility of such an approach. These types of grand narratives and 'laws' proclaiming how the world functions, cannot be used to accurately predict outcomes, and before we even begin this task of prediction, we must ask ourselves "what are the phenomena to be predicted" and "what tools can be used for this task" (2010, pp. 3, 7-8). At least three types of phenomena can be predicted within the field of economic sociology: trends, steady states, and events (2010, p. 7). To do so, Portes (2010, pp. 3-5) promotes the use of Max Weber's methodology, the ideal type.

Social science is historically bound (2010, p. 3). We can learn from history and create theories and concepts which help us explain our present-day realities and perhaps even predict what they may lead to, as history has indicated. It is however important not to confuse trends with outcomes (2010, pp. 7-8). In doing so, we limit ourselves to a deterministic outlook where everything can be predicted but nothing ever is. Universal laws are thus not helpful to base social science in as there will always be an outlier, an anomaly, or otherwise divergence from these laws which renders them unusable for the task of predicting and enhancing understandings of reality. This is why the limitations the ideal type places on theory is of importance. Taking a step back from generalizations and grand abstractions of the world, but not fully engaging in low-level notions of localized and particular findings, the midrange level of theoretical abstractions is where the useful ideal types reside (2010, pp. 4-5). The explanatory mechanism of the ideal type residing at this level does thus not become limited to a specific context or so abstract that it is applicable anywhere and everywhere. By "rubbing" the ideal type against empirical evidence, we can put order in actual experience, highlight relevant qualities, and "establish whether theoretical expectations – implicit in the concept – actually hold" (2010, p. 3). By treating concepts and theories as ideal types, we can 'rub' them against reality to see whether their assumptions hold or not. This is the lens this thesis will use to assist in explaining the emergence of symbiosis. 'Rubbing' them against the empirical evidence gathered through interviews and documents from the case of UBIS, will provide us with a way of 'putting order' to reality. This also tests the concepts and theories, forcing them to bend and adapt to reality, "which is how scientific knowledge actually advances" as Portes puts it (2010, p. 4).

4.2 A conceptual model for *urban* symbiosis?

For our aims and purposes, the conceptual model developed by Mortensen and Kørnøv (2019) which was discussed earlier in the thesis, can be treated as an ideal type of the emergence of industrial symbiosis. This model will be 'rubbed' against reality. Reality in this case is the urban symbiosis project which took place in the municipality of Bjuv. We face an obvious issue straight away by applying this model to urban symbiosis which it was not initially intended for. While many similarities between the two notions exist as the previous segments clarify, some differences remain. However, the treatment of the conceptual model as an ideal type allows us to engage in a form theory testing. The question of whether or not this model can assist in explaining urban symbiosis as well is of interest, but not a priority of the thesis. The empirical material consists of interview data and documentations from the UBIS-project. The conceptual

model will be ‘rubbed’ against this data and with the addition of previously conducted research, a better understanding of symbiosis in the region of Skåne will hopefully be reached.

4.3 Empirical material

4.3.1 Interviews

For this thesis, three interviews have been conducted with people actively working with symbiosis in the region of Skåne. The addition of their thoughts and insights will help us anchor some of the theoretically heavy aspects of the thesis to a more grounded perspective. Additionally, their experience in the field has yielded some suggestions for facilitating symbiosis initiatives, as well as some problems they have encountered which may be harder to overcome. Since the overall number of interviews is quite limited, the data cannot be quantified to draw conclusions from it in a meaningful way. Due to the nature of the pilot-project the respondents were involved in, the data can be used as an insight into conducting such types of projects. Similarities and conflicts between personal insights and academic literature can be used as a guideline for further research which seeks to utilize a similar approach. For this reason, I have chosen to use a broader tactic when interviewing the respondents. Their knowledge is valuable as guiding inputs, not as generalizable and context-free facts to be applied anywhere.

4.3.2 Documents

In addition to data gathered through interviews, documents published by the UBIS-project will be used as well. The final report, *UBIS Evaluation of Pilots* (2019) was used due to it encapsulating the whole of the UBIS-project and providing specifics on the context of Bjuv. This document was treated as containing relevant information on the overall activities and specifics of the project. The content regarding the municipality of Bjuv was of most interest from this report. UBIS also published a text titled *Business models for Industrial Symbiosis* (N.D) which was used to better understand the business aspects of the UBIS-project. Additionally, it highlights the way in which business actors were approached by the project. This document also contains some information on the issues of attempting to establish industrial symbiosis. These texts were used to add information to the three tables presented in the analysis section.

4.4 Why a qualitative approach?

A quantitative approach to data gathering for the sake of this thesis would be problematic for several reasons. Firstly, getting a sufficient number of respondents would be difficult and secondly, the selection of respondents would enhance the first problem substantially. In order

to answer the research question, and to reach the aims and objectives of this thesis, we require the knowledge from people in decision-making positions within the UBIS-project. This group of potential respondents have had to deal with other actors, policies, regulations, and the balancing of budgets amongst other things. Their inputs and thoughts are valuable due to the limited quantities such knowledge and experience exists in. As such, a qualitative approach is an ideal option, as it is appropriate for gaining in-depth knowledge from the respondents. By using a qualitative approach, in-depth knowledge is more likely to be gained on the activities of UBIS as well as some personal inputs and thoughts from the respondents. Due to the ongoing epidemic at the time of writing, the interviews were done by phone in one-on-one sessions, and notes were taken as the interview proceeded. Additionally, the interviews were conducted in Swedish.

4.4.1 Ontology and epistemology

There are many ways to consider the respondent and the information they are sharing. In a book titled *Kvalitativ Intervju* (2004) (Qualitative Interview) written by Anne Ryen, we find an overview of the various paradigms one could possibly use when conducting a qualitative interview (pp. 29-42). The paradigm of naturalism is described by Ryen (2004, p. 42) as viewing the interpretation of the respondent as representative of the truth, or as their own reality. Our respondents are thus responding from their own perspective and within their own perceptions of the world. This means that some of the information they share is subjective in a sense. Furthermore, naturalism requires us as researchers to perceive the information as most likely true and the respondent as 'a vessel full of answers' (2004, p. 42), despite the subjective nature of the respondent. The naturalistic approach is appropriate for the context as we are not interested in the respondents' emotions or what they possibly meant by how they phrased the information. We are interested in their experience, their thoughts, and their inputs on the subject of symbiosis. The questions asked and the analysis of the answers is thus done with the paradigm of naturalism in mind.

4.4.2 Sampling

The interviewees were chosen based on their connection to the UBIS project. The UBIS- project was meant to show what was possible to do with symbiosis and several of the actors involved reside near me. Researching background and context is thus less of a strain in order to understand the frames in which they operate. Furthermore, the project was in many ways directly involved in promoting the emergence of symbiosis through for example, its involvement as host for events meant to rouse interest and support from a plethora of actors.

Aspects of the UBIS-project are thus of great interest for this thesis and by talking to some of the involved individuals, we may gain insight and a better understanding of what worked, what did not, and why. The pool of potential respondents was not very large as a focus was put on individuals with a decision-making capacity or otherwise managerial position, as they were deemed to hold information of most value. We can thus refer to them as key informants. Additionally, the same group of names kept surfacing while researching the UBIS-project. They were contacted through email and in one case, a phone call. Those who responded were helpful and three of them seemed happy to assist this thesis with an interview.

4.4.3 Ethical considerations

The information provided by the interviewees has been shared under the assumption of ethical practices by me as the researcher. As such, it is my responsibility to represent the provided data in a fair and honest manner without altering the meaning or twisting intents (Ryen, 2004, pp. 162-163). To avoid any intrusion of personal bias, and since naturalism is the guiding method, my personal values had no place in the interview sessions, as well as during the analysis of the data (Bryman, 2012, pp. 289-290; Ryen, 2004, pp. 164-166). The task of complete objectivity is however near impossible. Awareness of the issues my own personal values and biases present was part of the process. Minimizing their impact on the data has been done to the best of my ability and I believe awareness of them to be a first step. Moreover, in the beginning of each interview, I informed the interviewees of the thesis and the context in which the information they shared would be presented in. Two of the interviewees requested to remain anonymous which of course, they will. I will thus refer to them as interviewee one, and interviewee two. The third interviewee was Bengt Fellbe, the business coordinator in the municipality of Bjuv.

4.4.4 Interview technique

Martyn Denscombe describes the process of interviewing in his book titled *The Good Research Guide* (2009). In accordance with the guidelines for semi-structured interviews, a set of (three) subjects of interest and (five) main questions were prepared in advance (2009, p. 234). Denscombe also describes the existence of a spectrum between semi-structured and unstructured interviews, and that most interviews conducted with these strategies in mind, tend to move back and forth along this spectrum (2009, p. 235). The question of “control” or “discovery” is of essence here (2009, p. 235). The number of respondents is limited, and all of their knowledge is not possible to obtain from academic sources alone. The idea of ‘controlling’ every aspect of the interview would not be as fruitful as allowing them to speak openly and ‘discover’ what they believe is important to discuss on the subject of symbiosis. The interviews

did as such, drift back and forth between the prepared questions, follow-up questions, and discussions more loosely related to the subjects, as we talked. This allowed for information to surface which I could not have prepared questions to cover, which was helpful in guiding the thesis in general. However, the main problem faced due to the lack of structure is that the interviews will be harder to compare between each other in the analysis. This is nonetheless not a huge problem due to the nature of the respondents as key informants.

4.5 The data

The data gathered from the interviews can be described as a collection of notes. The interviews were not recorded and as such, no exact transcript of them is available. This is problematic for several reasons as it is hard to treat the data as the exact words of the respondents. The notes taken throughout the interview were however carefully written as to not infuse personal interpretations and meanings to the content. The notes do as such, sum up what was said, not how it was said. This lack of specificity from the data is circumvented through the naturalistic approach, the care taken when gathering it, and the method of analysing it. Nonetheless, the possibility of data being outright missed due to the lack of recordings is problematic.

4.5.1 Analysing interview data

A prudent approach to the analysis of the interview data is the utilization of a thematic analysis. Alan Bryman, author of *Social Research Methods*, describes thematic analysis as an approach to analysis that has not been "outlined in terms of a distinctive cluster of techniques" (2012, p. 578). What you are engaging with however, is the search of themes. A set of themes were decided upon before the analysis of the data started and as the process went on, new themes surfaced and were added to the list. The data was then analysed a second time, whilst searching for the newly added themes. This process continued until data saturation was achieved.

4.6 Limitations

A problem faced during this thesis process was a general difficulty in finding specific data to fill certain gaps of the conceptual model. The initial idea for the interviews was not planned around the conceptual model as the decision to use it was made at a later stage. This puts a limit on the amount of interview data which is applicable. The UBIS-published documentation was of course not designed with the model in mind and as such, some gaps in the model can likely be explained by these factors. Due to the nature of the study's focus on a single case, the generalisability of the findings is limited. They are not necessarily limited to the specific context

of study, but to draw a wide conclusion based on the findings would not be possible. This, however, represents a basis for further research.

5.1 Analysis

The analysis section will begin by describing the UBIS-project and one of their pilot-sites. The three groupings and five sub-categories found in the conceptual model of industrial symbiosis emergence, developed by Mortensen and Kørnøv (2019) will be used to guide the analysis. I have created a table which summarizes the definitions of the conceptual model (*table 2*, pp. 32-33). Three additional tables have been created as well, one for each grouping with some minor adaptations to better fit the *urban* symbiosis context of UBIS. These can be found in text in the analysis. The data gathered through interviews and documentations from UBIS have been placed in these tables. The activities and relevant actors of the UBIS-project are thus represented in these tables and will be analysed with the addition of threads from previously conducted research.

5.2 The case of UBIS

The Urban Baltic Industrial Symbiosis (UBIS) is a project that started in 2017 and lasted for three years. The project was made up of ten partners, representing both the public and private sphere, from five countries in the Baltic region. One of the most cited cases as successful symbiosis, the Kalunborg Symbiosis in Denmark, was one of the partners. The 'priority axis' of the project was to minimize pollution and promote blue and green growth in the Baltic region (Gdansk University of Technology, 2017). In the evaluation report, the project is described as aiming to provide a "source of inspiration for other stakeholders willing to explore development of local industrial symbiosis across multiple sectors and geographies" (Jensen & Nielsen, 2019, p. 3). Furthermore, the total budget of the project was almost two million euros, and more than 75 percent of the funding came from the European Regional Development Fund (ERDF) (Gdansk University of Technology, 2017). At the start of the project, sites with 'symbiosis potential' were identified and four of them was used as pilot sites. One of these sites is located in the municipality of Bjuv in the Swedish region of Skåne. This site will be of primary focus for our analysis in addition to the other non-site related activities the UBIS-project engaged in.

The case of Bjuv has previously been mentioned in the text as an example of what an urban symbiosis could look like. What was not mentioned is that the municipality of Bjuv has a history of symbiotic ties or 'kernels', within its city limits. Residual heat from local industries was already used for district heating in the city before involvement in the UBIS-project. However,

the temperature of the water as it returned to the industries was still in need of further cooling. By running the 'return-pipe' through sidewalks and outdoor seating instead of straight back into the industrial processes, residual heat is dissipated, the sidewalk defrosted during winter, and even cooler water returns to the industries. The initial plan did however include a bus-stop to be heated, but due to issues with regulations and approvals from the regional traffic company, alterations had to be made (Jensen & Nielsen, 2019). Furthermore, the initial plan did not include sensors, which were installed in order to automate the regulation of the system, as Bengt Fellbe, business coordinator at the municipality of Bjuv, told me during an interview. Additionally, he highlighted a few aspects of symbiosis in Bjuv which I believe to be crucial for the emergence of this specific case of urban symbiosis.

One of these aspects is the history of symbiosis in Bjuv and how the municipality has learned from previous encounters. When asked about how Bjuv knew there was an opportunity for a resource exchange, Bengt Fellbe mentioned that resources and flows in the municipality were already mapped. This seems to be an important explanatory factor and will be further discussed throughout the next segments.

5.3 The three groups

The three groups found in the conceptual model will provide the structure for this segment of the thesis. Each grouping will be discussed, and the activities conducted by the UBIS-project will be placed in the context of the model, 'rubbing' the ideal type against reality so to speak. The three tables below can be used as an overview of where these activities fit into the conceptual model. This information is sourced from interviews, documentations, and websites related to UBIS and its partners and financers. Some parts are left blank. This can likely be explained either through a lack of data on the subject, or as the model not 'sticking' completely to the context of an *urban* symbiosis.

5.3.1 Awareness and interest in symbiosis

This group of processes is described by Mortensen and Kørnøv (2019) as 'collaborative' and 'co-creational'. These are the conditions, contexts, and activities which can create *awareness* and generate *interest* in the economic and environmental gains of symbiosis. The table below highlights the various elements of this grouping and how the UBIS-project fits in with these elements. Along with this table, a discussion of its components will follow. For an explanation of each aspect within the table as Mortensen and Kørnøv (2019) describes them, please check *table 2* in the appendix pages 32-33.

Technical and social infrastructure can generate interest and awareness in symbiosis by facilitating good symbiosis examples (Mortensen & Kørnøv, 2019). UBIS can be perceived as representative of such infrastructures. UBIS with the goal of promoting symbiosis (Jensen & Nielsen, 2019), hosted a set of networking events for potential actors (UBIS, 2020). A particular policy or regulatory change, occurring at the time which may have influenced the deployment of UBIS, is the selection of industrial symbiosis in 2012 as one of seven 'top priority areas' by the European Resource Efficiency Platform (EREP) (European Commission, 2013; Johnsen et al., 2015). This may have been one of the motivating factors behind the focus on this type of development in the Baltic region and as such, may have set the *contextual conditions* in terms of policy for UBIS to exist.

	Contextual conditions	**Actors**	**Actors' role**	**Actors' characteristics**	**Actors' activities**
Awareness and Interest in symbiosis	*Policy* – Somewhat open for interpretation but an interest in the concept exists at an EU-level, which may encourage the emergence of symbiosis. EREP 'top 7 priority'. *Funding* – Majority of funding came from the ERDF. *Timing and history* – The municipality of Bjuv has a history of IS.	*Research and education institutions* – The Gdansk University of Technology was one of the ten involved partners. So was the University of Rostock. Specifics unclear. *Public bodies* – Municipality of Bjuv (local), Skåne Energy Agency (regional public body), Interreg South Baltic (EU-Programme). *Businesses* – Industries involved in Bjuv.	*Businesses* – Industries in Bjuv perhaps acted as anchor tenants. *Facilitator* or *Coordinator* – Possibly the business coordinator in the municipality. *Public bodies, businesses,* and *universities* – Can at this phase play roles as facilitators and *champions* for other organizations. Since it is an urban symbiosis, the municipality championed its own constituents.	*Human characteristics* – The economic motivation in this case is the cooling benefits the industries gained. This benefit may have motivated the tie as well as the funding was provided through UBIS. *Organizational characteristics* – Awareness and interest could possibly be understood as present due to the history of symbiosis in Bjuv. *Institutional embeddedness* – History of a supportive cultural context seems to present as symbiosis was no new notion in Bjuv.	*Capacity building activities* – Began with invitations to events and seminars. *Context transformative intervention* – Municipality with other agents backing it, drives the emergence process in this particular case.

Funding was provided by the EU to the project through Interreg South Baltic which is an EU-programme with the aims of "unlocking South Baltic's potential for blue and green growth through cross-border cooperation" (Interreg South Baltic, 2020). To paraphrase interviewee one, Interreg paid for UBIS as a display window, and the target group were private actors. UBIS can thus perhaps be viewed as an EU-initiative, promoting awareness and interest in symbiosis, through 'good symbiosis examples', and by facilitating the technical and social infrastructure

needed for symbiosis emergence. *Timing and history* also set the stage for the implementation of symbiosis in Bjuv. Previous encounters with symbiosis in the municipality, seems to have had a large effect on their enthusiasm to engage with UBIS when the time came. Regarding *actors* and their *roles*, resource flows in Bjuv were already mapped and as such, we can possibly understand the industries in the municipality as a collective form of *anchor tenants*, offering their pool of resources to 'tap into'. These resources were however, already 'tapped into' as residual heat was used in the district heating system. Chertow's (2007) 3-2 heuristic with the addition of Lybæk's et al. (2019) understanding of it as a 3-1 heuristic is applicable here. Several industries already exchanged their residual resource (heat) with the district, and 'kernels' could additionally be claimed to be present. With the expansion of the heat exchange to include the public as well, we could argue that a service, in terms of defrosting sidewalks etc., was added to the exchanged resources. Due to this case being one of urban symbiosis, the residents in the municipality can perhaps be viewed as the 'organisation' whose interests the municipality acted as a *champion* for by focusing on improving public transportation. Even though no know push came from the public. This is one way the content of the conceptual model must be adapted and understood in a different way from the intended one in order to fit more in line with urban symbiosis, and civic society as a stakeholder. To paraphrase what Bengt Fellbe told me during the interview, few of the residents were aware of the concept of symbiosis, and one of the thoughts that the municipality had with this project was to get the public engaged, and to increase their awareness. The 'display window' aspect of UBIS could thus be assigned to residents as well, making them spokespersons for symbiosis.

The *actor's characteristics* plays a big part in their levels of interest. It is found that the largest motivating driver during the awareness and interest phase, is the economic motivation (Mortensen & Kørnøv, 2019). This is of course in cases of *industrial* symbiosis. We could, however, argue that the industries involved in this urban symbiosis case had economic motivations as well. After the installation of the new heat-dissipating pipes, the temperature of the returning coolant was lower, resulting in cost-savings as the need to further cool it was reduced. Furthermore, it is unclear to what extent UBIS funded the installation and if costs where split, but it is fair to say that some of the cost were covered through UBIS, further strengthening the argument of economic motivations as a driver for the emergence of symbiosis. As interviewee one emphasized, symbiosis is never implemented unless there are economic incentives; companies never save the world, they create profit for their owners (paraphrased).

Organizational characteristics can be understood as the mentality of an organization. Closed loop thinking and adopting a different mindset is beneficial for the emergence process. *Institutional embeddedness* can be understood as the norms, trust, and communication between the involved and potential actors. Both the *organizational characteristics* and the *institutional embeddedness* are factors which seem to have been well developed and cultivated from the onset of UBIS in Bjuv. This can likely be explained by the existing history of symbiosis in the municipality. Nonetheless, the UBIS-project hosted several meetups and events in an attempt to cultivate features as these in potential firms and actors. These types of activities can be referred to as *capacity building activities*. They contribute to the formation of a potential network consisting of actors co-located in a region (Mortensen & Kørnøv, 2019). The idea is to make these actors share knowledge and visions, further enhancing interest, and awareness in symbiosis. Another aspect of this are the *context transformative interventions* were actors from industries, and actors from public entities engage with each other. This occurs at various levels and the outcome of these engagements has the potential to "shape the social, economic, cognitive, etc. contexts" (Mortensen & Kørnøv, 2019). This is about persuading actors with decision-making capacities. The example mentioned earlier in the text regarding a community organizing itself and acting as a stakeholder (Mulder & Vernay, 2016) is a clear-cut example of a context transformative intervention. This raised the levels of awareness and interest from the residents in the area as well as in the firms they engaged with. In the context of Bjuv, the municipality with UBIS backing it up can be perceived as a context transformative intervention. Again, the history of symbiosis in Bjuv, most likely already influenced the involved actors and their mindsets.

5.3.2 Reaching out/Exploration of connections

During this phase of the emergence process, the involved actors explore potential connections and how inputs and outputs can be fruitfully combined. This means that they need to talk to other actors. This process can be facilitated by several factors. The *contextual conditions* highlights how the implementation of industrial symbiosis seems to be greatly connected to *changes in existing regulation*, usually in the form of easing regulations which may act in obstructing manners (Ashton, 2009; Mortensen & Kørnøv, 2019). In Bjuv, such an obstruction was met as the project progressed, not from a public body, but from the regional transportation company, regarding the initially planned bus stop. This was however easily circumvented in this case and the plan was expanded to include outside seating furniture instead of the bus stop. Earlier engagement with the regional traffic company could possibly have resulted in a different

execution, however. This earlier engagement could possibly have been facilitated through an *infrastructure* containing tools for easier communication for example as well as databases with knowledge on other potential actors. This infrastructure is mostly technology dependent, and facilitatory for the exploration of connections. The UBIS project provided a platform for these talks to take place through a set of events and meetups, and Bjuv already had resource flows mapped out.

	Contextual conditions	**Actors**	**Actors' role**	**Actors' characteristics**	**Actors' activities**
Reaching out/Exploration of connections	*Change in existing regulation* – No change per-se but the existence of UBIS represents a regulatory interest in symbiosis implementation. *Infrastructure* – UBIS provided this platform infrastructure although aspects of it already existed in Bjuv. *Time* – Limitations of the projects run-time. Could of course continue after the final evaluation report was written. *Geographical proximity* – In Bjuv, the proximity of industry and the public transportation node made the whole ordeal possible. Perhaps not as clear-cut if pipes had to be installed over larger areas or across longer distances. *Pool of resources* – This type of knowledge already existed to some extent in Bjuv due to their history of symbiosis. Could have been enhanced through meetups, etc.	*Research and education institutions* – The Gdansk University of Technology was one of the ten involved partners. So was the University of Rostock. Specifics unclear. *Public bodies* – The UBIS project facilitated the participatory process. They funded and hosted events and seminars which bridged various gaps in knowledge in addition to building trust. *Businesses* – N/A *Associations* – N/A	*Bridging actors* – UBIS itself was a sort of bridging actor through awakening interest and pushing ideas forward to other actors. The municipality of Bjuv may have pushed the idea to the firm. *Champions* – Bjuv is championing the concept of symbiosis to its own constituents. *Facilitators* – UBIS facilitated communication and the building of relationships.	*Human characteristics* – Problematic to measure or even attain data on. *Motivate* – Through seminars and events, UBIS attempted to increase awareness and interest in symbiosis. By doing so, actors may be more motivated to engage themselves capacity building. *Organization characteristics* – Actors relevant in the case of Bjuv have a shared history of symbiotic ties which makes them more inclined to support and adapt new organizational changes. *Institutional embeddedness* – Increases in social proximity was generally facilitated by the UBIS project and again, the history of symbiosis in Bjuv, seems to have set the stage through a common culture and cultivated trust between the municipality and the industries in the area.	*Strategic network formation* – The network of actors was developed by UBIS and their role as a facilitator was to monitor and 'nurture' the network. To what degree of success UBIS achieved this task is not clear. *Incubation platform for IS emergence* – UBIS hosted networking events, supporting the exploration of connection processes.

It is thus quite possible that the regional traffic company was not part of this network, nor part of the platform or Bjuv's database which highlights the fragility and importance of this phase. The process of building these networks takes *time* and the UBIS project was limited to its

runtime of three years. To compare, the case of Kalundborg has existed for over fifty years (Jensen & Nielsen, 2019).

The *geographical proximity* of the involved actors in Bjuv is of course also a factor which facilitated in this phase. Across the whole of the UBIS-project, the proximity of actors may have been problematic as they are scattered throughout the Baltic region. The region of Skåne is however fairly small and easy to travel within which may have had a positive effect on the reaching out and exploration process for other actors. In terms of *actor's role*, UBIS can possibly be seen as the *bridging actor* as it pushed the concept of symbiosis onto others and assisted them with knowledge. Bjuv could potentially be seen in a similar manner in regard to the municipality acting as a bridge between public 'interests' and industries. It *championed* both interests of the public and the notion of symbiosis to its constituents.

Institutional embeddedness during this phase emphasizes trust which can be cultivated through *social proximity*. UBIS facilitated the social proximity through their networking platform and can in this way, through events, workshops, and seminars, increase the levels of *motivation* in actors, causing them to engage in capacity building. It is however unclear how well UBIS succeeded in this regard. Interviewee one explained that interest was high amongst the participants, but that the issue of *initiative* was more troublesome to overcome. The question of *who* should take the first step towards 'reaching out', and the cost of energy and time to the benefit of *whom*, is relevant. Bjuv possibly already had high levels of capacity for symbiotic developments, as did the industries in the municipality. Nonetheless, these types of networks must be carefully nurtured and UBIS with the role of *facilitator*, had a responsibility care for the network. *Strategic network formation* represents these acts of 'nurturing'. This can be achieved through monitoring of the network by UBIS and facilitating talks between the members when needed to. It is not clear exactly how UBIS went about this as data on the talks between business actors was not available. In any case, the network developed by UBIS may have acted in the capacity of an *incubation platform*, supporting the explorational aspects. Capacity building is not enough for symbiosis to emerge (Boons & Spekkink, 2012), and actors can use the space provided by UBIS for exploring connections and reaching out to others. This network is thus necessary for the development of *mobilization* capacity.

5.3.3 Organizing

During this third phase, activities in which actors can explore the viability of a symbiotic tie takes place. Activities in the *organizing* grouping revolves around planning and exploring

solutions of a potential implementation. Regulatory conditions and opportunities are crucial for the *contextual conditions*. For example, *policies* regarding tax reliefs for 'green investments' can be fruitful for symbiosis emergence. Actors testing newly developed drafts of business models in which several other actors are included, can be compared within existing policy frameworks, looking for grants, reliefs, and subsidies that could be applicable.

This leads us to *funding*. Financial support from governments can increase the possibility of symbiosis emergence. UBIS was funded by a transnational agency and acted as a funding entity itself, regarding its pilot-sites. Additionally, UBIS can perhaps be perceived as the embodiment of a policy framework supportive of symbiosis emergence. It would not have existed were it not for a political interest in symbiosis. The deployment of the project in Bjuv specifically, can possibly be explained by the existing knowledge of resource flows, enhancing the necessary *infrastructural* needs for symbiosis emergence.

	Contextual conditions	**Actors**	**Actors' role**	**Actors' characteristics**	**Actors' activities**
Organizing	*Policy* – The existing policy framework seems to be promoting and encouraging of symbiosis development. Also supporting of the involved actors. *Funding* – Most likely came from the UBIS project. No specific data available. *Infrastructure* – Previous knowledge on resources material flows in the municipality of Bjuv existed and had been mapped.	*Research and education institutions* – The Gdansk University of Technology was one of the ten involved partners. So was the University of Rostock. Specifics unclear. *Consultancy companies* – Sustainable Business Hub assisted in providing business models. Faced problems, however. *Public bodies* – In this case, the public bodies were drivers and thus, permits should not have been a problem to get. Yet it was. *Business organizations* and *interest associations* – N/A	*Facilitators* – The UBIS-project monitored and evaluated the site in Bjuv.	*Human characteristics* – Problematic to measure or even attain data on. *Organizational characteristics* – The capacity to mobilize and implement 'changes' to established processes. The municipality has the means to rebuild and construct urban infrastructure with little resistance. The involved company needed to reroute flows but with little change to the actual production process. *Institutional embeddedness* – Interests are shared between the municipality and the business partner. Levels of confidence and trust is hard to measure.	*Incubation platform for IS emergence* – UBIS provided this platform through meetups, seminars, and events where potential actors could discuss opportunities, etc.

Research and education institutions can provide knowledge and information, supporting the identification of ways to organize synergies in an efficient manner. The Gdansk University of

Technology, and Rostock university were two of the ten involved partners. The specifics of what they provided in Bjuv or to UBIS in general is unclear, but their facilitative role can be overtaken by *consultancy companies*. Sustainable Business Hub is one of these types of organizations. They focus on assisting firms with activities in the fields of environment and energy and provide a network of actors for its members. The organization is a non-profit one, owned and financed through its members. A large part of its funding comes from Region Skåne and the idea is that the members as well as the public should benefit from their projects, as interviewee two told me. To what degree their network was a part of the UBIS-project's network is unclear. Sustainable Business Hub was to provide assistance with the development of business plans for the involved actors (Sustainable Business Hub, N.D). Interviewee two told me about an issue they faced regarding those models. The problem was two-pronged. First, the projects did not expand so far as needing a business model. Second, each symbiosis case is different, and a generalized business model 'draft' is hard to design. This highlights how different entities are relevant for the facilitation of processes in the *organizing* phase, as well as difficulties the UBIS project faced in its attempt to support symbiosis deployments.

5.4 General findings of the analysis

Histories of symbiotic ties seem to be a facilitative factor to consider when implementations of symbiosis are studied, and when an attempt at implementing symbiosis is undertaken. As the three tables above summarize, the municipality of Bjuv's history and previously conducted mapping of flows and resources, can be used as explanatory factors in many segments and could most likely account for some of the project's success. When asked about UBIS in Bjuv, and how the project had gone, Bengt Fellbe answered positively that more than the initial goals of the investment had been reached (paraphrased). He further added that this sort of urban developments should be kept in mind during new constructions. This would facilitate further developments of its kind as the costs of excavating streets a second time would be avoided. Mulder's (2016) points on 'backcasting', thus seems to be another important aspect of the success in Bjuv. By planning from a future vision in mind, initial costs would be raised, proactively minimizing future costs, as well as the total costs, and thus, motivating the continuation of symbiotic behaviour. One issue related to backcasting which may have been detrimental to symbiosis emergence, is the problem of generalizable business models. Each individual case is different and thus, requires time and resources dedicated to the development of a 'plan'. Furthermore, it is easier for a municipality to plan for something as permanent as a city, but obviously much harder for an industrial actor to plan for shifting markets and

regulations. Backcasting may thus be much harder to successfully utilize for some actors. This ties in with the claims of Lybæk et al. (2019), regarding policies and regulations which add stability to projects rather than aggravating volatility.

Funding also seem to be of essence for the emergence of symbiosis. Accurate statements regarding the implementation in Bjuv, had it lacked the support from UBIS, are hard to make. We can however assume that UBIS had an effect through the provided funding and the general force for implementation that UBIS represented.

6.1 Concluding Remarks

The primary goal of this thesis from the onset was to enhance our understanding of the concept of symbiosis. By looking at the case of UBIS and how it operated in the region of Skåne, the thesis has highlighted several factors which may have acted as facilitators or barriers to the process of emergence in this specific context. It has done so from a sociological perspective, by focusing on collaborative aspects between public and private actors. The use of a conceptual model as an ideal type, 'put order' to reality and allowed us to make sense of raw data. By using findings from previously conducted research, aspects of the data could be better understood and viewed from a wider perspective. The model could however not explain every single aspect of the case in a satisfying way, nor was it expected to. This may be due to data missing, or due to the model being intended for a different type of symbiosis than that under study. The model did nonetheless provide a wide framework with explanatory capabilities even for the case being studied and did thus serve us well as a tool. Further research on the flexibility of the conceptual model could potentially lead to a different model, specifically intended for the task of explaining cases of *urban* symbiosis. One of the issues with the findings is that many aspects of the data seem to be explained by an existing history of symbiosis in Bjuv. This case is thus perhaps not the best suited for testing of the model in contexts of urban symbiosis. Why Bjuv has a pervious history of symbiosis and how it came to be, would be an interesting question for further research.

The general tone of the thesis has so far been fairly positive towards the concept of symbiosis. In this concluding segment, I would like to offer a few critical thoughts on the concept and how some aspects of it may be problematic from a development perspective. Symbiosis can at its surface be perceived as an environmentally friendly approach to industrial development. As mentioned earlier, these presumed environmental benefits have seldom been accurately measured (Chertow, 2007). In the *Roadmap to a Resource Efficient Europe* (2011), the

European Commission calculates the potential cost-savings and increase in revenues that a widespread implementation of industrial symbiosis could lead to. Furthermore, the context in which they speak of symbiosis is one of securing access to resources. The question is thus, for whom? As the previously conducted research and the findings of this thesis have shown, policy is incredibly important for symbiosis to emerge. The research on policy modes by Prakash and Kollman (2004), highlights how the intent of one type of policy can be achieved at a lower cost through another type of policy, but the cost may instead come to the detriment of environmental standards. This due to the fact that regulatory *demands* are more effective at maintaining high environmental standards than private voluntary codes are. The institutional framework to support the enforcement of such regulation for the 'right' reasons so to speak, is however also necessary as the example provided by Petríková et al. (2016) emphasizes.

Symbiosis can be facilitated through several types of policies. Authorities granting tax reliefs, subsidies and grants for 'green investments' is no bad thing in and of itself. Interests representative of the public and private can potentially be met through measures as these. The bigger issue lies in the discussion of private interests influencing policy-design. It is not a new discussion as the term ecological modernization and its critics illustrates (Evans, 2012, p. 65). Policy promoting innovation and technological solutions such as those found through industrial symbiosis, need to be carefully designed with public interests and high environmental standards at heart. Not with facilitation of private interests of profit as the end-goal. Urban symbiosis, however, seem to be an approach in which the public sphere benefits more clearly from these types of ties. Further research on this type of symbiosis, calculating potential environmental benefits as well as the benefits to the urban space could be of interest. Additionally, so to can a calculation of the environmental benefits of industrial symbiosis be. I believe this second suggestion to be of importance for continuing developments of this kind.

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8.1 Appendix

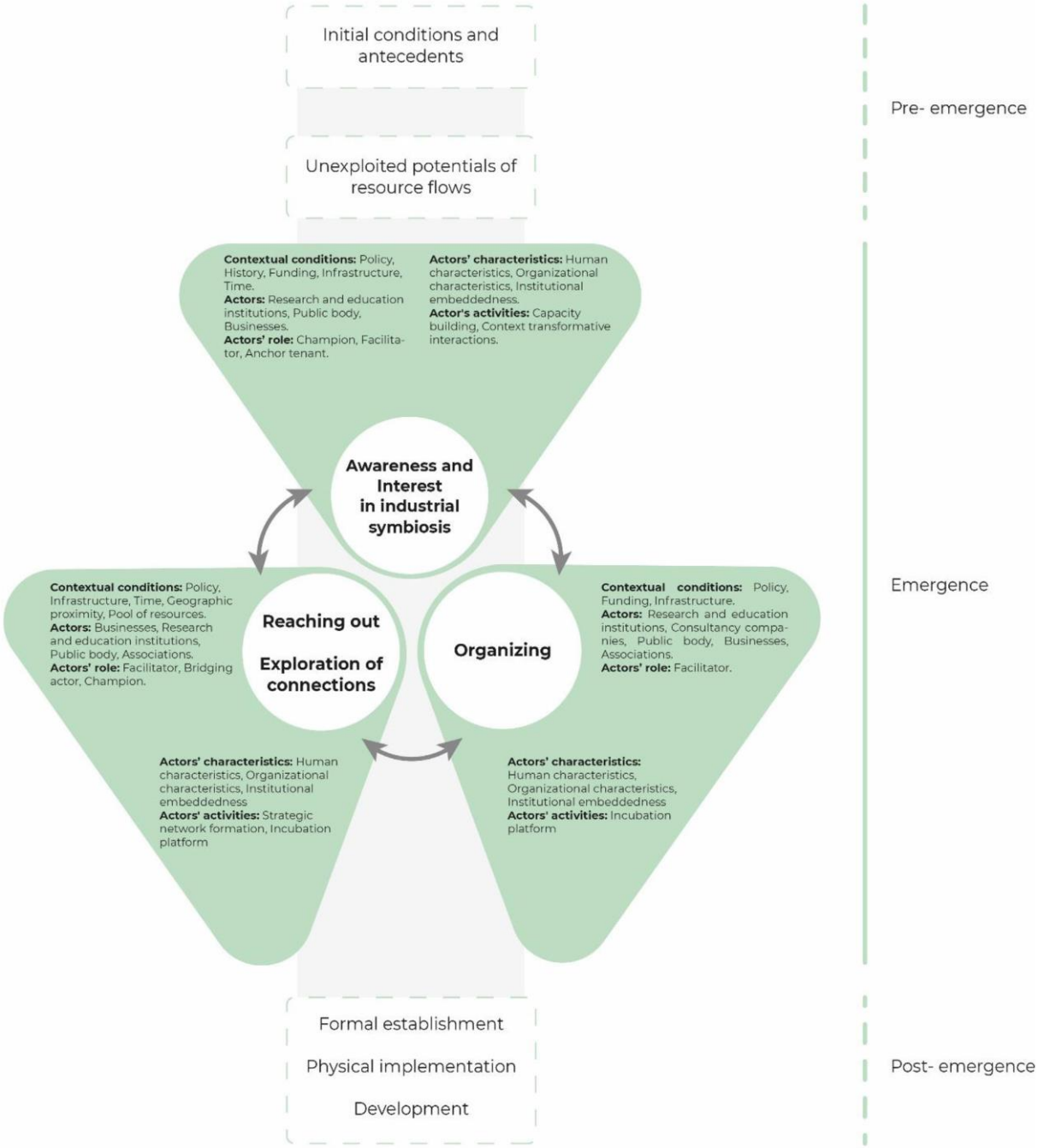

Figure 1. IS emergence model: Process and critical factors influencing the transition between phases (Mortensen & Kørnøv, 2019).

Events	Event groups
Firm integrates vertically in one location Firm is split up into legally separate entities Actor creates market facilitation mechanism	Events generating potentials
Firms expect benefits from symbiotic exchanges Local actors engage in collective learning Anchoring activities provide an important role for IS emergence	Events generating, raising, and/or presenting awareness and interest
Actor aims for regional economic (re)development Actor pics up IS concept and translates it Concept is translated to local context Actor communicates best practices to other clusters Stakeholders are activated to shape development agenda Anchoring activities provide an important role for IS emergence	Reaching out events
Partner search Actor selects cluster of firms to test concept Stakeholders are activated to shape development agenda Symbiotic exchanges are explored as part of agenda Anchoring activities provide an important role for IS emergence	Exploration of connections events
Actor selects cluster of firms to test concept Actor evaluates results Actor develops rules, monitoring, and sanctioning	Events for organizing and final decision-making
Contract - closed	Establishment events

Table 1. Events within IS dynamics. Adapted from Boons et al. (2017) and Sun et al. (2017) by Mortensen and Kørnøv (2019).

	Awareness and Interest in industrial symbiosis	**Organizing**	**Reaching out** **Exploration of connections**
Contextual conditions	Can be created through technical and social infrastructure promoting IS consideration and facilitating the good IS examples. *Policy* – Changes in legislative or market contexts can create problems/opportunities for a waste resource flow. *Funding* – Financial support, incentives, financial policies such as 'green investment tax credits', innovation grants. Usually comes from public bodies and can be offered directly to companies or to actors facilitating such as research and educational institutions and other public entities. *Timing and history* – Existing relationships and history and habits of collaborations can influence new collaborations. Can also be problematic histories.	*Policy* – Here, companies can perform feasibility studies and explore the compliance of the new business model with regard to existing regulations. Policy is good for stimulating agreements and commitments within these two transition phases. *Funding* – Governmental financial support can increase the possibility of IS emergence. Can also come from business actors such as ports. Raising awareness and making companies understand the role of IS for their business development, could contribute to raising funds from commercial companies. *Infrastructure* – Available and accessible information through databases for example, can help organizations get an overview of resource flows.	*Change in existing regulation* – Can often initiate IS implementation. Continued interaction with regulators can contribute to solve the regulatory issues in the way for IS emergence. *Infrastructure* – Technology, equipment, databases, and platforms for stakeholder interactions. *Time* – Building IS networks is a long-term process. Bringing in new members and developing institutional capacity, mobilization capacity, fostering relationships, and trust takes time. *Geographical proximity* – Enables knowledge flow and innovation among stakeholders from different sectors. Transportation and transaction costs. *Pool of resources* – Knowledge of each other's available resources such as money, time, knowledge, and capacities.
Actors	*Research and education institutions* – Key stakeholders and are found to be the most crucial. Feeds information into networks and can act as champions. *Public bodies* – National, regional, and local entities. Early involvement by these actors can 'seed the innovation process' into a local context by providing support to companies, access to specialized knowledge, and incentives encouraging engagement, as well as promoting symbiotic thinking among other actors. *Businesses* – Can contribute to the implementation and dissemination of IS activities within a region.	*Research and education institutions* – Can contribute to the organization of different activities such as information forums to support the identification of the best way to organize the new synergies. *Consultancy companies* – Can overtake research and education institutions and play a more important role with the contribution of modelling and calculation of the new business models. *Public bodies* – As regulators and issuers of licences and permits. Can also acts as a funding body. *Business organizations* and *interest associations* – Contains a large pool of knowledge on companies and their data. Can through interventions, influence the social and economic context of the municipality. Provides support to other local actors. Ports can for example fund infrastructural initiatives.	*Research and education institutions* – Can contribute to the local coordination of activities, to the uncovering of 'kernels', to the monitoring, and disseminating information on the developments. Can also act as strategic advisors for the collaborative process. *Public bodies* – Considered an important component of the participatory process. Their role spans widely from coordinator and facilitator of the collaborative processes, facilitating contacts between other agents, funding body, consulting on planning and technical issues, catalysing, and themselves participating in the collaborative processes for IS emergence. Provides a bridge and builds trust. *Businesses* – Can become dominant and decisive for the symbiosis created by engaging themselves in coordination activities and playing the role of *champions.* *Associations* – Different organisations and industry representatives can be mediators between member companies, government, and the broader community.
Actors' role	*Businesses* – Can play the role of an *anchor tenant*. A large company or power plant offering a large pool of material flows to tap into.	*Facilitators* – Monitor the process of emergence and follow the implementation processes and end-results. The roles fulfilled by such actors depend on the actions taken at different times in	*Bridging actors* – Eases the process and pushes ideas forward to companies, public bodies, and other actors. Introduces ideas and awakens interests.

	Facilitator or *Coordinator* – Can be played by individuals or more organized entities. In the initial phase of IS emergence, their role is to activate 'the exchange of knowledge and relational resources' amongst other actors through different kinds of interactions organized. Are responsible for actors' capacity. *Public bodies, businesses,* and *universities* – Can at this phase play roles as facilitators and *champions* for other organizations.	the process of IS emergence. They can also embrace the concept of a form of 'formal governance'.	*Champions* – Various types of individuals and organizations. Can establish connections between different projects and actors. Develops local support through a bottom-up approach. *Facilitators* – Adopts more formal structures during this phase, to provide opportunities for interaction. Coordinates stakeholders' communication, relations, and exchanges. Attracts funding.
Actors' characteristics	*Human characteristics* – Are found to be critical in the process of IS emergence. It is found that actors' economic motivation is the largest motivation, driving actors' involvement in IS. *Organizational characteristics* – Fostering a different mindset and closed loop thinking through knowledge sharing in organizations can also support organizational interest in IS. *Institutional embeddedness* – Norms, trust, and communication. Developing embeddedness by cultivating trust and developing a supportive (cultural) context is crucial. All these characteristics can be built through capacity building events combined with context transformative activities.	*Human characteristics* – Includes factors such as a symbiotic mindset, proactive attitude, flexibility, high motivation, and willingness to open up for new relations. *Organizational characteristics* – It is mostly the mobilization capacity that is considered critical in combination with the above-mentioned characteristics. *Institutional embeddedness* – Built through consensus and the alignment of actors' interests. Necessitates openness between the possible resource partners and readiness for establishment and maintenance of confidentiality. Confidence and trust in the collaboration are prerequisites for negotiating a contract.	*Human characteristics* – Active participation. Willingness to actively invest time and resources in developing new knowledge and new relationships. *Motivate* – Awareness and interest in IS relations can motivate participants to develop a specific logic and strategic view, which encourages the engagement in institutional capacity building. *Organization characteristics* – Exemplified such as the companies' interest in IS, previous environmental practices, and the willingness and commitment to support/adopt new organizational changes and (environmental) activities. Need for confidentiality is accentuated and critical for (not) developing new relationships. *Institutional embeddedness* – In the process of reaching out and exploration of connections, a common culture and trust is cultivated among the actors along the 'shared vision'. The increase in social proximity decreases the effort required in building shared knowledge and understanding.
Actors' activities	*Capacity building activities* – Contributes to the formation of a potential network of stakeholders with a large potential for fostering IS relations. The network develops through various forms of information exchanges between industries co-located in a region. Information such as visions, problems, solutions, ideas, plans and knowledge of their processes to name a few. *Context transformative intervention* – "Stakeholder interventions are dynamic processes taking place at different levels and they can shape the social, economic, cognitive etc. contexts". A continuous dialogue engaging public bodies, shaping the community-industry and government-industry relationships is found to be the most context transformative intervention.	*Incubation platform for IS emergence* – Encouraged by actor activities in this phase through the creation of interaction spaces where sharing and discussions can take place. The sharing of information on enterprise, resources, 'material flow analysis', 'cost-benefit analysis', feasibility investigations and other relevant studies can be done here. The incubation platform could foster new joint projects and offer financial support as well as lobby for the spread of an IS approach through town-hall meetings for example.	*Strategic network formation* – Participation in these networks, drives and encourages the spread of knowledge on IS potentials. A facilitator has the responsibility to form and monitor the network, acquisition of knowledge and relationships, and formation of mobilization capacity. Activities such as on-site guidance, policy tours, periodical meetings, and face-to-face discussions, facilitation, and follow-up activities could help monitor and guide the network. *Incubation platform for IS emergence* – Capacity building activities is not enough for IS to emerge. A platform with events supporting the exploration of connection processes such as networking events and workshops are found to be crucial in facilitating the processes of reaching out and the exploration of connections.

Table 2. Conceptual model for IS emergence. Adapted from Mortensen and Kørnøv (2019)