The role of firm-level actors and systemlevel actors in processes of new regional industrial path development

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Where do I begin? After attending interesting PhD courses in different countries, presenting at my first international conference, publishing my first article, undergoing endless article revisions, and withstanding pressure when finalising the last details of my thesis, it is clear that this PhD journey has truly been an incredible mix of joy, frustration, patience and excitement.

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Nina Kyllingstad

Summary

This doctoral thesis departs from the understanding that regional industrial restructuring is important for handling challenges, such as globalisation, sustainability and digitalisation. Regional industrial restructuring can include changes in the existing industry as well as the development of completely new industries.

The combination of the regional innovation system (RIS) approach and the theory on new path development, emerging from evolutionary economic geography (EEG) literature, leads to an understanding that industrial development happens within (open) regional systems. RISs consist of actors and networks that are embedded in an institutional framework. While one of the critiques of the RIS approach has been that it focuses too much on the system and not enough on its actors and their agency, the primary critique of the EEG approach is that it has an aggregated firm focus.

This thesis addresses these criticisms by focusing more in-depth on the different actors within the regional innovation system and the interaction between them. One way this is done is by differentiating between firm-level actors and system-level actors. This research also focuses on the various ways these two groups of actors contribute, such as by building cross-industry innovation capability and through an entrepreneurial discovery process, to change the RIS and influence new industrial path development. These different paths lead to different forms of regional economic restructuring.

This thesis consists of four articles, three of which have been published in peer-reviewed journals. The fourth has been through a first review and can be published subject to major revisions. Preceding the articles is the ‘kappa’, which is an introductory chapter presenting the central theoretical concepts, analytical framework, and findings and contributions. It also accounts for the research design and methodology applied. The research design in this thesis is inspired by critical realism. A qualitative method, more specifically, semi-structured interviews, is used in all four articles. The empirical focus is on different regional innovation systems in Norway.

One finding has been to acknowledge the influence that the regional context has on actor-driven processes, such as cross-industry innovation capability building and entrepreneurial discovery processes. Thus, being aware of the regional setting might contribute to choose the relevant area for changing RIS to become more supportive towards new regional industrial path development. The thesis also finds it useful to distinguish between firm-level actors and system-level actors, particularly in entrepreneurial discovery processes, because they play distinctive roles and complement each other. The distinction enables us to understand the importance of the different actors in the different stages of entrepreneurial discovery processes and to promote initiatives based on this knowledge. However, there needs to be an alignment between the initiatives and actions employed by the two groups of actors.

Overall, the articles aim to develop a more in-depth understanding of the role of firm- and system-level actors in processes of new regional industrial path development.

Keywords: Regional innovation systems, regional industrial path development, firm-level actors, system-level actors, entrepreneurial discovery process, Norway.

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List of tables and figures

List of acronyms

CIIC	Cross-industry innovation capability
CR	Critical realism
ED	Entrepreneurial discovery
EDP	Entrepreneurial discovery process
EEG	Evolutionary economic geography
FLA	Firm-level actor
MNC	Multinational corporation
NCE	Norwegian Centre of Expertise
NIS	National innovation system
R&D	Research & development
RIS	Regional innovation system
SFI OM	Centre for research-based innovation (Offshore mechatronics)
SLA	System-level actor
SI	System of innovation

List of publications

1. Elisabet S. Hauge, **Nina Kyllingstad**, Natalia Mæhle & Ann Camilla Schulze-Krogh (2017) Developing cross-industry innovation capability: regional drivers and indicators within firms, *European Planning Studies*, 25(3), 388-405. DOI: 10.1080/09654313.2016.1276158

2. **Nina Kyllingstad** & Jan Ole Rypestøl (2018): Towards a more sustainable process industry: A single case study of restructuring within the Eyde process industry cluster, *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography*, 73(1), 29-38. DOI: 10.1080/00291951.2018.1520292

3. Arne Isaksen, **Nina Kyllingstad**, Jan Ole Rypestøl & Ann Camilla Schulze-Krogh (2018): Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustration from three emergent clusters, *European Planning Studies*, 26(11), 1-16. DOI: 10.1080/09654313.2018.1530143

4. **Nina Kyllingstad** (2019): Breaking barriers for new regional industrial path development: The role of a centre for research-based innovation. Has been through a first review in the journal *Growth and Change: A Journal of Urban and Regional Policy*, and can be published subject to major revisions.

1 Introduction

Restructuring of industries and economic development of regions have long been popular topics on the research agenda within extant evolutionary economic geography (EEG) and regional innovation system (RIS) literature. A regional innovation system comprises actors, networks and institutions, and 'encompass all regional economic, social and institutional factors that affect the innovativeness of firms' (Asheim, Grillitsch, & Trippl, 2016, p. 48). While RIS literature has been criticised for being too static and focussing to a lesser degree on the different actors in the system (Asheim, Isaksen, & Trippl, 2019; Uyarra, 2010), the EEG approach has been criticised for its aggregated firm focus and firm-led changes (Hauge, Kyllingstad, Maehle, & Schulze-Krogh, 2017; Strambach & Halkier, 2013). One way of addressing RIS literature's static nature has been to combine the concept of path development from EEG literature with RIS literature, and with that, highlight how RIS influences different mechanisms for new path development (Asheim et al., 2019). Although empirical studies have been conducted on actors' role for regional industrial development, many of these focus on actors such as firm entrepreneurs and often place too little emphasis on other actors in the 'environment' needed for robust new industrial path development (Isaksen & Jakobsen, 2017). The thesis addresses this by focussing on these individual firm-level actors' importance, as well as their connection to other actors and the system in which they are embedded. Further, the thesis also inquires how these actors contribute to change RIS and influence new regional industrial path development in different ways. Regional industrial path development can lead to various forms of regional economic restructuring and will be explained further in sub-chapter 2.4.

In addition to contributing to the scientific community, the thesis should also carry implications for society, which can happen in terms of bettering our understanding of, for example, grand societal challenges and how to address them. These days, we are faced with issues such as the oil crisis, an increased focus on sustainability, fighting social exclusion, unemployment etc. These issues create a need for changes in technology and our understanding of how to conduct business. Thus, knowing more about how different actors can contribute to industrial and societal changes is important and may, in turn, lead to policy

lessons that are important for addressing some of the grand challenges mentioned.

1.1 Aim and contribution

This thesis examines new regional industrial path development and aims to contribute to extant literature by gaining a deeper understanding of firm- and system-level actors in the RIS, as well as how they can contribute to changing the RIS to stimulate new regional industrial path development. Although new path development is dependent on both actors (Isaksen, Jakobsen, Njøs, & Normann, 2019), the need for them and the role they play vary, e.g., based on the composition of the RIS and path outcomes. Firm-level actors' role is important, but the literature gap is greater when it comes to understanding the system-level actors' role in changing RIS. Thus, a better understanding of system-level actors would enrich both EEG and RIS path-development literature. Thus, this thesis explores and adds to extant literature on how different actors can contribute to changing the regional innovation system and influencing new regional industrial path development.

The four articles in this thesis view different actors' roles and importance from different perspectives. The way in which the articles in this thesis address the two different actor types is explained below briefly. Following this is a supplementary overview of the four articles, in which key elements – such as research questions, gaps in extant literature, the article's aim, case, data and findings – can be found.

Before proceeding to an overview of the articles, it is important to clarify the use of certain concepts. As seen in the presentation below, I mostly use the concepts of firm- and system-level *entrepreneurs* in the articles, while in the 'kappa', I use the concepts of firm- and system-level *actors*. It is important to understand that these concepts are the same, but because extant literature on differentiated actors is evolving, the concepts will change and develop as well. Although this thesis uses the concept of actors, I also acknowledge the growing body of literature on agency. According to Emirbayer and Mische (1998), *agency* is understood as actors' engagement to reproduce and transform structures. Thus, in this thesis, agency's role is understood by investigating actors' role, i.e., this thesis can also

contribute to extant agency literature. The strong emphasis on agency and actors in recent literature is another reason why I deviated from using the concept of firm- and system-level entrepreneurs, and instead focus on the actors. In practice, this means that when I refer to the articles in the 'kappa', I will change the wording from 'firm- and system-level entrepreneurs' to 'firm- and system-level actors'. However, I will not change the wording when summarising each article below.

Article 1 focuses mostly on path development's firm-level aspect. According to extant literature, it is important with knowledge recombination for branching and diversification. This often is discussed in literature on the aggregated level or system level. However, this article explores in more depth how branching and diversification specifically happen by studying the firm's cross-industry innovation capabilities in different regional contexts.

Article 2 addresses the need for a better understanding of different actors in restructuring processes. The article combines the concepts of entrepreneurial discovery processes and path development. Furthermore, the article offers a deeper understanding of both firm- and system-level entrepreneurs, as well as the interplay between them, in the restructuring process.

While Article 2 is a single case study, **Article 3** studies how different regional contexts influence the entrepreneurial discovery process and, in turn, how this affects path development. Articles 2 and 3 distinguish between firm- and system-level entrepreneurs in entrepreneurial discovery processes, but while Article 2 focuses on the entrepreneurial discovery processes' characteristics, Article 3 focuses on how path development would be affected by the regional context and its capabilities.

Article 4 focuses on the types of barriers that both firm- and system-level actors may face in a certain RIS type and how these barriers might be broken or lowered by the introduction of a new knowledge organisation, namely a centre for research-based innovation (SFI[1]). Because the SFI, to a certain degree, works

[1] SFI is the Norwegian abbreviation for centre for research-based innovation.

as a system-level actor, it highlights in particular how a system-level actor might contribute to new path development.

1.2 The articles

This thesis comprises four articles preceded by a 'kappe', which aims to explain further each article's individual contributions and the overall contribution of the thesis. Articles 1-3 all have been published in peer-reviewed journals, while Article 4 has been accepted for publication by a peer-reviewed journal subject to major revisions. The first three articles have been written together with colleagues from the University of Agder and Western Norway University of Applied Sciences. In all three, the names are listed alphabetically, and all authors contributed equally to their respective articles[2]. The fourth article is a single authored article.

1. *Developing cross-industry innovation capability: Regional drivers and indicators within firms (2017)*

Authors: Hauge, E. S., Kyllingstad, N., Mæhle, N., & Schulze-Krogh, A. C.
Motive: The oil crisis and the financial crisis
Research Question (RQ): What are the indicators of cross-industry innovation capability (CIIC) in firms and how is CIIC influenced by regional conditions?
Gaps: Extant literature usually focuses more on the aggregate firm level when discussing regional renewal. Thus, one literature gap is the processes happening within individual firms during processes of regional renewal.
Aim: To introduce the concept of CIIC building in firms and discuss how conditions for innovation and learning in a region drive this process. *CIIC* is a firm's ability to transform knowledge and ideas from different industries into new products, processes and systems and/or its ability to adapt existing products, processes and systems to new industries. We also identify CIICs drivers and indicators.
Case: Small firms in three regional innovation systems: Agder; Hordaland; and Rogaland.
Data: Primary data comprise 15 interviews with small and medium-size firms using a semi-structured interview guide.

[2] Signed co-author declarations have been provided.

Findings/contributions: The article describes eight indicators of CIIC. Empirically, we see that organisationally thick and diversified regions are more favourable for firms' abilities to develop CIIC and engage cross-industry innovation activity.

2. *Towards a more sustainable process industry: A single case study of restructuring within the Eyde process industry cluster (2019)*

Authors: Kyllingstad, N., & Rypestøl, J. O.

Motive: Increased attention on environmental issues that increases the need for a better understanding of sustainable restructuring.

RQ: The article addresses two research questions:

1. What type of key actors take part in and drive the restructuring process in the Eyde cluster, and how does the process unfold?

2. To what extent is the suggested analytical framework likely to be useful in empirical studies intended to improve our understanding of regional industrial restructuring processes?

Gaps: Extant literature lacks a deeper understanding of the different actors in restructuring processes.

Aim: To combine the concept of entrepreneurial discovery processes and path development theory to improve our understanding of actors in a restructuring process. This is done in a stepwise analysis. The actors are divided into firm-level and system-level entrepreneurs based on their motivations. The article also analyses, conceptually, the link between spontaneous entrepreneurial discovery processes and regional industrial path development.

Case: The analytical framework is tested out on the Eyde process industry cluster and its work towards becoming more sustainable.

Data: Secondary data, such as old applications for the cluster program, research reports, newspaper articles and websites. In addition, we were privy to 23 interviews collected by a colleague at a previous time. Primary data comprised five semi-structured interviews.

Findings/contributions: The analysis demonstrates that both entrepreneurs were important in the restructuring process. The system-level entrepreneur was the key actor in the initiation phase, while firm-level entrepreneurs had to utilise the new opportunities provided. We also argue that the analytical framework, which combines EDP and path dependency, is useful because it adds a structural dimension, making it easier to identify and categorise the

stages in a change process. It is also useful to differentiate between the two types of entrepreneurs due to their distinctive roles and how they complement each other.

3. *Differentiated regional entrepreneurial discovery processes: A conceptual discussion and analysis of three emergent clusters in Norway (2018)*

Authors: Isaksen, A., Kyllingstad, N., Rypestøl, J. O., & Schulze-Krogh, A. C.
Motive: The need to create more jobs to fight unemployment and social exclusion. This can be met by creating new industrial paths.
RQ: The article addresses three research questions:
1) Is the distinction between firm- and system-level entrepreneurs useful, and tend system
level entrepreneurs to be increasingly important in thin versus thick RISs?
2) Is the establishment of new knowledge creating and diffusion organizations vital in distinguishing between entrepreneurial discovery processes in various RISs? Tends the establishment of such organizations to be increasingly important in thin versus thick RISs?
3) Is it useful to explore the results of entrepreneurial discovery processes as different path developments? If so, tend path changes to be less radical in thin versus thick RISs?
Gaps: Extant literature lacks a deeper understanding of EDPs and regional industrial growth.
Aim: To provide a deeper understanding of EDPs and regional industrial growth by examining: 1) how different regional contexts affect entrepreneurial discoveries, and 2) how entrepreneurial discoveries support specific types of industrial path development in different regions. The article also tries out one approach to study entrepreneurial discovery by focussing on key actors and RIS changes that initiate cluster-building processes.
Case: Three Arena cluster projects (the application process). The establishment of an Arena project was viewed as one type of materialisation of an entrepreneurial discovery. The three cluster projects were iKuben, Heidner, and Oslo EdTech).
Data: Secondary data, such as information on web pages, applications to the Arena programme, newspaper articles and databases. Primary data comprised four Oslo EdTech, four iKuben and five Heidner semi-structured interviews

with actors involved in the process of applying for Arena. In addition, an Internet-based survey was sent out to 74 firms in the three clusters, eliciting 44 responses.

Findings/contributions: The paper contributes to extant literature by conceptually linking RISs, EDPs and path development. The empirical findings demonstrate that: 1) A distinction between the two entrepreneurs is useful for highlighting their importance. 2) Changes in an RIS are part of an EDP, and that institutionalisation of the process is important for further cluster building. In addition, we also find that the establishment of new knowledge-creating and diffusion organisations is a distinguishing factor between the cases. 3) It is useful to analyse potential regional industrial path development resulting from entrepreneurial discoveries because different path development signifies a qualitative change, either by creating new industries or strengthening existing ones. Empirically, the changes are greater in thick and diversified RISs.

4. *Breaking barriers for new regional industrial path development – the role of a centre for research-based innovation (in review)*

Authors: Kyllingstad, N.

Motive: Examining the downturn in the oil and gas sector, which greatly affected the case region. At the same time, funding for a new knowledge organisation, with an oil and gas focus, was awarded. Could the crisis affect the work conducted in the centre?

RQ: The article addresses two main research questions:

1) What are the barriers in different parts of the regional innovation system for new industrial path development? And what are potential ways of lowering or breaking these barriers?

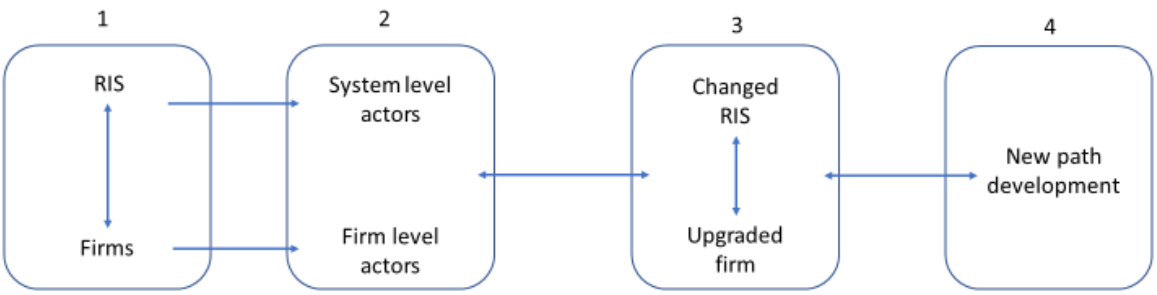
2) What are the barriers in the organisationally thick and specialised region of Agder facing new industrial path development, and how has the SFI Offshore Mechatronics contributed to breaking down these barriers?

Gaps: Extant literature lacks a deeper understanding of barriers in the regional innovation system facing new regional industrial path development. Several factors can contribute to new industrial paths, which have been neglected in extant literature. By implication, when discussing what might contribute to new industrial path development, the discussion should also touch on how these same factors might act as barriers.

Aim: To better understand barriers in a thick and specialised RIS for new regional industrial path development, and to explore how a new knowledge organisation can help break these down.
Case: The subject of the case is the centre for research-based innovation offshore mechatronics (SFI OM), while the object of analysis is the SFI OM's ability to break down barriers in the Agder regional innovation system.
Data: Secondary data include mid-term self-evaluations from regional partners and SFI OM's management, which the Research Council of Norway requires, as well as readily available information online. Primary data comprised rounds of interviews using a semi-structured interview guide: the first round in 2015 (15 interviews) and the second in 2019 (nine interviews).
Findings/contributions: The article contributes to extant literature by focussing on barriers to new regional industrial path development and includes barriers at all three levels of an RIS, which avoids limiting the analysis to systemic- or actor-specific barriers. In addition, the article presents an analytical framework that explains the barriers and highlights how a new knowledge organisation potentially can lower or break down these barriers. The article also contributes to a deeper understanding of SFI as a policy tool and shows that the composition of partners creates different possibilities in terms of its output and how the RIS might benefit.

1.3 Analytical framework

As previously mentioned, the aim of this thesis is to provide a deeper understanding of new regional industrial path development by focussing on the different actors and their roles in changing the regional innovation system (RIS). The analytical framework displays where the four articles in this thesis contribute with insights to better our understanding of the process towards new regional industrial path development. This is shown by the numbers in parentheses behind each of the articles listed below Figure 1.



1. Developing cross-industry innovation capability: Regional drivers and indicators within firms (1, 4, 3*)

2. Towards a more sustainable process industry: A single case study of restructuring within the Eyde process industry cluster (1,2,3,4)

3. Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustrations of three emergent clusters (1,2,3,4)

4. Breaking barriers for new regional industrial path development: The role of a centre for research-based innovation (1,2,3,4)

*mostly in terms of firm upgrading

Figure 1 Analytical framework

In addition to displaying each article's contributions, the framework also guides the 'kappa'. Each of the four boxes is a sub-chapter in the theoretical section, i.e., the *first chapter* will address the first box, which is the regional innovation system and the firms. Here, I will provide a brief run-through of the concept of the regional innovation system and the role that firms have played.

In the *second chapter*, I will focus on the different actors. Historically, much has been written about firm-level actors, such as entrepreneurs and their role in economic development. However, recent extant literature has begun to focus more on system-level actors. Thus, this chapter will focus on the development of the distinction between firm-level and system-level actors, and how they contribute to change RIS and upgrade firms towards new regional industrial path development.

The *third chapter* continues the discussion on how the actors contribute to changing the RIS and upgrading the firms. This section also includes the barriers that can be found in the regional innovation system, as discussed in Article 4. Finally, the *fourth chapter* will discuss the concept of new regional industrial path development and how its inclusion in the RIS literature has made the RIS concept more dynamic.

Although the analytical framework might appear linear, I have tried to incorporate the dynamism by making the boxes relatively open. The composition of the RIS, the ways in which the two actors might change the RIS, and how this, in turn, will lead to new regional industrial path development are not specified. As the articles will show, this can happen in different ways.

1.4 Thesis structure

The thesis is structured in four main chapters. Chapter 2 provides an overview of the main theoretical building blocks used in the four articles. Chapter 3 discusses the philosophy of science and how my position as a critical realist has influenced the overall research design used in this thesis. Chapter 4 provides an overview of the findings from the articles, as well as theoretical, empirical and policy lessons that can be learned from this thesis. Chapter 5 contains the reference list. Finally, Chapter 6 includes all four articles in full text.

2 Theoretical background

As shown in the analytical framework, the theoretical section is divided into four sub-chapters. The first discusses the regional innovation system (RIS) approach. The second revolves around firm- and system-level actors. The third discusses how the regional innovation system and the two types of actors might contribute to changing RIS and upgrading firms. Finally, the fourth focuses on the outcome, in the form of new path development of the process discussed in the previous three chapters.

2.1 Regional innovation system

2.1.1 Background

The concept of regional innovation system arose out of the more generic concept of system of innovation (SI). An SI includes perspectives such as national, sectoral and regional systems of innovation and employs historic and evolutionary perspectives (Edquist, 2005). National and regional systems resemble each other, with the national innovation system (NIS) approach predating the RIS approach. According to Lundvall (2010), Christopher Freeman was the first to write about the concept national system of innovation in an unpublished paper from 1982[3], and he was also the first to add the modern version 'national innovation systems' to extant literature in 1987. In the book *National Systems of Innovation*, Lundvall starts by discussing how the initial idea of the national innovation system aimed to add to the understanding of the neo-classical economic system.

Lundvall (2010) views theories in social science as 'focussing devices' and sees works on national innovation systems as a supplementary focussing device that emphasises interactive learning and innovation. Two assumptions have guided this work. The first is that knowledge is fundamental for the modern economy, with the learning process of upmost importance. The second assumption is that learning is an interactive process in which the institutional and cultural context needs to be considered (Lundvall, 2010). Furthermore, innovation should be viewed as a result of interactive learning and non-linear processes involving

[3] Published in 2004.

several actors in the system (Edquist, 2005; Kline & Rosenberg, 1986; Lundvall, 2010). This moves innovation research towards a systemic understanding of innovation (Lundvall, 2010).

The understanding and importance of the concept of innovation translates to the development of innovation policy. The systemic approach recognises that systems (national or regional) vary and that innovation policy should be tailored to the different needs in a system and the linkages between parts of the system (Lundvall & Borrás, 2005).

The national innovation system approach, in certain ways, has led to the regional innovation system approach. As Lundvall points out, the two approaches both state that innovation systems are localised because of local and tacit knowledge. In addition, both try to explain geographical units' economic performance (Lundvall, 2010, p. 319). The RIS approach was introduced in the early 1990s (Cooke, 1992), and the broad definition of *RIS* is that 'RIS encompass all regional economic, social and institutional factors that affect the innovativeness of firms' (Asheim et al., 2016, p. 48). This understanding of RIS also separates it from its other antecedents, such as industrial districts and industrial clusters, due to their focus on co-located interrelated firms in one or related industries, while extant RIS literature is more general and encompasses organisational and institutional support structures, as well as potentially more than one industry cluster (Asheim et al., 2016). The RIS approach has also been used to design, implement and evaluate regional policies in different regions (Herstad & Sandven, 2017), which coincides with the notion that one size does not fit all when it comes to innovation policy (Tödtling & Trippl, 2005).

2.1.2 Regional innovation system in the articles

The regional innovation system has been important in characterising the regional contexts in all four articles. Although definitions and descriptions may vary slightly, the core factors of the RIS concept are actors, networks and the institutional settings in which they are embedded, which is in line with the broad understanding of RIS. In Article 1, RIS is described as '(…) a specific framework in which close interfirm interactions, knowledge and policy support infrastructure, and sociocultural and institutional environments may stimulate collective learning, continuous innovation and entrepreneurial activity' (Isaksen

& Trippl, 2016, p. 70)[4]. The article also conceptualises RIS in terms of production structure, knowledge infrastructure and support structure (Isaksen & Nilsson, 2013). In Articles 2 and 3, RIS is described as comprising two subsystems embedded in an institutional framework: knowledge creation (e.g., universities and R&D institutions) and knowledge exploitation (e.g., firms, individual actors and clusters) (Tödtling & Trippl, 2005). In a recently published book, *Advanced introduction to regional innovation systems*, Asheim et al. (2019) describe RIS as comprising three core elements – actors, networks and institutions – with interdependence between them. Because this book is one of the latest and most extensive contributions to RIS literature, it makes sense to follow the same understanding in this 'kappa', which is why this is the preferred definition of an RIS. This is also the definition used in Article 4.

The thesis applies the typology of organisationally thick and diversified RIS, thick and specialised RIS and thin RIS (Isaksen & Trippl, 2016). The first is identified by its multiple and different industries; knowledge organisations (as R&D institutions) and support organisations, and mainly located in metropolitan areas. The second RIS type has a more specialised industry structure and an associated narrow knowledge and support structure, and it often is found in old industrial areas or university towns. Although the firms and clusters might be strong, they are only within a few sectors. The last type is recognised by its less-developed industry and R&D structure and often is found on the periphery (Isaksen & Trippl, 2016).

RISs are also understood as open systems, i.e., they source knowledge not only from within the system's geographical borders, but also from extra-regional production and innovation networks (Asheim et al., 2019). A growing body of literature acknowledges that 'innovation activities are increasingly coordinated on the global scale' (Isaksen & Trippl, 2017, p. 123). Regarding this, it is important to understand that exogenous sources and their influence may differ in different RISs. According to Trippl et al. (2018), the different RISs vary when it (i) comes to the need for exogenous sources, as well as its (ii) attractiveness and (iii) absorptive capacity (Trippl et al., 2018). The first refers to whether an RIS has knowledge available locally, while the second can be exemplified by the

[4] The reference used in Article 1 is to a working paper from 2014.

argument that thick and diversified RISs, to a larger degree, are more attractive to exogenous sources compared with thick, specialised and thin RISs, while the third factor refers to whether an RIS has the absorptive capacity to turn knowledge from exogenous sources into new growth paths (Trippl et al., 2018). In addition to varying in input and influence concerning exogenous knowledge sourcing, extant RIS literature also supports the notion that different RISs have varying potential to support innovation and entrepreneurship, as well as further influence new path development (Isaksen & Trippl, 2016). Because this discussion revolves around path development, I will elaborate more on this in sub-chapter 2.4.1.

The idea that regions have different potentials is addressed from different perspectives in the articles. Article 1 discusses how the different RIS types affect the potential for cross-industry-oriented development. Article 2 discusses how a successful firm-level initiated EDP can be identified by changes and developments in RIS, and how a system-level-initiated EDP starts out with a desire to change systemic factors. In Article 3, we argue that the importance of firm-level and system-level entrepreneurs varies between different RIS types, and that they further hold different potentials for new regional industrial path development. In Article 4, the focus is on a thick and specialised RIS and the barriers this RIS is facing for new regional industrial path development.

Moving on from the systemic view, the next section focuses more on the need for a deeper understanding of the actors in the RIS (Uyarra, 2010). The concept of system-level actors in particular has been an issue that scholars have raised in searching for a more dynamic understanding of the concept (Asheim et al., 2019; Grillitsch & Trippl, 2018; Hassink, Isaksen, & Trippl, 2019). This dynamic turn helps explain how RISs need to change and how certain RISs support and hamper certain growth paths (Asheim et al., 2019).

Thus, the next sub-chapter will focus on firm- and system-level actors, both in terms of who or what they are and the different potentials they hold for changing the regional innovation system towards new regional industrial path development. Following this, I briefly will discuss recent extant literature on how to change or transform RISs.

2.2 Actors

With an RIS approach more focussed on structural elements (Uyarra, 2010) and extant path-development literature focussed more on aggregated firm-led changes (Hauge et al., 2017; Strambach & Halkier, 2013), this thesis aims to provide a more nuanced view of who the different 'change actors' are, what influences them and how they can contribute to new path development. Regardless of whether the change maker is a firm-, or system-level actor, they both hold agency, which is explained as the way both 'economic and other actors create, recreate or alter paths' (Martin, 2014, p. 619). As mentioned in the introduction, by investigating actors' role, the thesis may also contribute to the agency literature, as *agency* is understood as engagement by actors to reproduce and transform structures (Emirbayer & Mische, 1998).

Article 1 focuses on firm-level actors, Articles 2 and 3 focus on both firm- and system-level actors, and Article 4 views actors' role from a different perspective, in the sense that actors might contribute to breaking down barriers to new path development.

2.2.1 Firm-level actors

Even though both the RIS and path-development approaches include a certain firm-level focus, they do not focus in depth on what happens within firms and organisations. It is known that recombining knowledge for branching or diversifying is important (Frenken, Van Oort, & Verburg, 2007; Uyarra, 2010), but less research has been conducted on the mechanisms of how knowledge recombination happens. Thus, Article 1 addresses firms specifically and their ability to develop cross-industry innovation capability (CIIC). *Cross-industry innovation* is a process in which '[…] already existing solutions from other industries are creatively imitated and retranslated to meet the needs of the company's current market or products' (Enkel & Gassmann, 2010, p. 256). These capabilities are important mechanisms for regional renewal, especially in regions with a specialised industry structure (Hauge et al., 2017). This article contributes by introducing the concept of CIIC, which is defined as 'the firm's ability to transform knowledge and ideas from different industries into new products, processes and systems and/or its ability to adapt existing products, processes and systems to new industries' (Hauge et al., 2017, p. 389). Although the focus is on

the firms, we connect CIIC to path-development literature by arguing that if a large-enough number of firms within a region possesses high CIIC, the potential for path renewal is greater, as opposed to path extension or, potentially, path exhaustion. The article is also tied to extant RIS literature because RIS is understood here as the context that affects the ability to develop CIIC (Hauge et al., 2017).

When discussing firm-level actors, it is natural to discuss more traditional entrepreneurs who innovate and contribute to economic development. This can include innovations that cause creative destruction (Schumpeter, 1934), recognised by the entrepreneurial mode of innovation (Schumpeter Mark I) or the routinised mode of innovation (Schumpeter Mark II) (Fagerberg, 2003; Winter, 1984), in which the former is recognised by many small entrepreneurial firms as being the driving force, while the latter is recognised by big firms with large R&D capacities (Fagerberg, 2003; Winter, 1984). Other innovations can include those caused by routine-resisting entrepreneurs who monitor the market for business opportunities (Kirzner, 1997). Although Schumpeter expanded his view with what is referred to as Schumpeter Mark II, no framework was in place (Fagerberg, 2003). Nelson and Winter (1982) continued the work, applied Schumpeter's principles and focussed explicitly on organisations. Furthermore, in the 1980s and 1990s, an increased understanding emerged of social and economic structures revolving around entrepreneurship and innovation (Fagerberg, Srholec, & Verspagen, 2010; Lundvall, 2010), leading to a more holistic and dynamic way of viewing innovation and economic development, as described in Chapter 2.1 (RIS).

In Article 2, we discuss firm-level actors' role in EDP (see sub-chapter 2.4.2) as 'individuals or organisations that either launch new venture or perform innovation activities within an existing organisation' (Kyllingstad & Rypestøl, 2019, p. 2), while in Article 3, we make it explicit that organisations can also be universities or regional development agencies. Thus, in addition to including traditional firm entrepreneurs, firm-level actors can also take different roles. While firm-level actors are more profit-oriented, system-level actors aim to build or improve on systemic factors (see Articles 2 and 3). In Article 3, we discuss how the importance of the different actors varies between regions and how the role they play in an EDP will occur differently.

2.2.2 System-level actors

Although firm-level actors play an important role, and have for many years been the main focus when it comes to entrepreneurship, recent extant literature (Asheim et al., 2019; Grillitsch & Trippl, 2018; Hassink et al., 2019; Isaksen et al., 2019; Isaksen, Kyllingstad, Rypestøl, & Schulze-Krogh, 2018; Kyllingstad & Rypestøl, 2019; Sotarauta & Mustikkamäki, 2015) has examined the presence and need for addressing system-level actors' role in the processes of RIS changes towards new path development.

One argument for making the RIS approach less static has been the inclusion of actors such as institutional entrepreneurs, at least in terms of its institutional framework (Grillitsch & Trippl, 2018). Institutional entrepreneurs are actors who '(1) initiate divergent changes and (2) actively participate in the implementation of these changes' (Battilana, Leca, & Boxenbaum, 2009, p. 68). These entrepreneurs need to both challenge existing rules, as well as institutionalise them. *Institutionalisation* is defined as 'a process of a new practice, activity, norm, belief, or some other institution, becoming an established part of an existing system, organization or culture' (Sotarauta & Mustikkamäki, 2015, p. 343).

Although institutional entrepreneurs are similar to what this thesis denotes as system-level actors, the institutional aspect is too narrow. This can be seen in Article 2, in which *system-level actors* are defined as 'actors whose primary motivation is to build or improve systemic factors, which are recognised as structural and cognitive conditions that can affect future regional industrial development' (Kyllingstad & Rypestøl, 2019, p. 2). These actors can include firms, individuals, non-profit organisations or knowledge-creating organisations. The need for a better understanding of the system level is also addressed in recent extant literature by Isaksen et al. (2019) when they discuss system-level agency's role in regional industrial restructuring. They refer to system-level agency as 'actions or interventions able to transform regional innovation systems to better support growing industries and economic restructuring' (Isaksen et al., 2019, p. 5). For new regional industrial path development to occur, most often both firm- and system-level agency have to be carried out by different actors in RIS (Isaksen et al., 2019).

Another central study regarding restructuring and new path development is Garud and Karnøe's (2003) study, in which they discuss agency's role in technological entrepreneurship. They conclude that 'the development of technologies entails not just an act of discovery by alert individuals or speculation on the future, but also the creation of a new path through the distributed efforts of many' (Garud & Karnøe, 2003, p. 296). They further discuss two ways in which this can happen: bricolage and breakthrough. The first is a bottom-up process driven by distributed agency (which includes not only the actor who discovers ideas, but also complementary assets such as institutional forums and demanding customers) and recognised by incremental innovations in technology. The second is recognised as a push by key actors to generate dramatic changes (Garud & Karnøe, 2003). The bricolage strategy and distributed agency demonstrate the importance of system-level agency (Isaksen et al., 2019) and, arguably, the role that system-level actors play in restructuring processes.

In sub-chapter 2.4.2, I will discuss in more detail different actors' roles in a process of entrepreneurial discovery that, if successful, leads to changes in RIS and possibly new path development.

2.3 Changing RIS and upgrading firms

RISs will always, to some degree, develop naturally, e.g., when old firms are removed and new firms are added (Tödtling & Trippl, 2013). However, larger changes can also occur that can lead to RIS transformation. Tödtling and Trippl (2013) distinguish between three types of RIS changes: changes in informal institutions; creation or fading of existing RIS elements; and changes to networks.

Miörner and Trippl (2017) also suggest a typology that demonstrates how actors can transform the environment from being constraining to enabling to new path development. They differentiate between three modes of changing an RIS' institutional and organisational support structure. These occur through gradual changes in support structure, e.g., in policies, institutions and organisations (layering); changes within existing institutions and organisations, e.g., adapting formal regulations (adaption); or changes through RIS elements' changing

impacts, such as new ways of using an existing policy (novel application) (Miörner & Trippl, 2017). 'Key actors induce changes in regional environment in order to turn constraining context into one that enables new industrial path development' (Miörner & Trippl, 2017, p. 482).

Regardless of the types or modes of transforming, these changes do not happen by themselves (Asheim et al., 2019). Thus, it can be argued that a need exists for 'a stronger integration of human agency into the RIS approach and the path dependence model to gain more insight into how regional industrial path development might take place' (Asheim et al., 2019, p. 52). Those carrying out the agency are, as argued, firm-level actors (FLAs) and system-level actors (SLAs). Examples from the articles on how RISs can be changed are described further in sub-Chapter 2.4.2 on entrepreneurial discovery processes.

Even though there might be intentions to change the RIS, barriers might exist that hinder such changes and further new path development. Thus, before addressing the concept of new path development, barriers to change will be examined briefly.

2.3.1 Barriers to change

Barriers to new path development often are found in different parts of a regional innovation system, namely at the actor, network and institutional levels. This is addressed further in Article 4.

One hurdle towards new path development can be what Grabher (1993) describes as lock-in. He uses the concept of lock-in to explain the decline in a mature cluster in Germany and refers to three interrelated types of lock-ins: functional; cognitive; and political (Grabher, 1993). Hassink (2016) describes in more detail how regional lock-ins explain why some mature industry clusters are more favourable to *adjusting* their operations, while others are more focussed on *renewal*. Adjustments entail increased emphasis on copying and cost reduction, while the case of renewal entails more emphasis on innovation and diversification (Hassink, 2016). The clusters where one finds the adjustment are those in which institutional resistance to restructuring is strong, while a cluster with weaker institutional resistance is more prone to setting up new industries, eliciting renewal (Hassink, 2016). The case from Article 4 demonstrates this, in

which the incumbent industry can be said to have strong institutional resistance to diversification. Clustering might not always prove to be positive. Much extant literature highlights that 'spatial concentration of similar or related firms is a key source of competitiveness, encouraging innovation and learning at local and regional scales' (Trippl & Tödtling, 2008, p. 203). The focus on clusters as being beneficial has been criticised by authors addressing the risks and harmful effects of geographically concentrated industries (Trippl & Tödtling, 2008). Even though Grabher discusses cluster decline, the characteristics of the different lock-in types are similar to additional extant literature on barriers to industrial renewal, such as system failures.

There has long been overlapping definitions and usages of the concept of system failures. Woolthuis et al.'s (2005) study aimed to clear up some of the confusion that has marked this discussion regarding national innovation systems. They identified several issues that may cause systemic failure. The first is *infrastructural* failure, which is tied to poor physical infrastructure and science and technology infrastructure. Second, *institutional* failure concerns both formal and informal institutions (North, 1991) and how these institutions might hinder innovation. Third, *interaction* failure is tied to the relationship between different actors and, thus, how overly strong or weak networks might create system failures. This is elaborated on further in extant social capital literature in terms of the 'strength of weak ties' (Granovetter, 1983). Finally, the fourth system failure is *capability* failure, which entails whether actors in the system have the necessary resources or capabilities (Woolthuis et al., 2005).

Adding to extant literature on system failures, Grillitsch and Trippl (2018) provide a place-based system failure framework to help policy makers design policies that help support economic renewal in region-specific contexts. Their argument is that structural approaches focus less on what is required for new industrial paths to succeed or when the whole innovation system needs a transformation. The older literature is more preoccupied with the existing industry structure and innovation system; thus, the innovation policy that a region might need to transform itself receives less attention.

Although Article 4 is the only article in this thesis that explicitly discusses barriers, the remaining three are also affected by barriers. In each article, we

discuss how different mechanisms, whether CIIC (Article 1) or an entrepreneurial discovery (Articles 2 and 3), can contribute to new path development. To follow up on the argument made in Article 4, when discussing what might contribute to change, one should also discuss how the same mechanisms might function as barriers to change.

2.3.2 Absorptive capacity

The concept of absorptive capacity (AC) is important for RIS changes, as Article 4 demonstrates. *Absorptive capacity* is 'the ability of a firm to recognize the value of new, external information, assimilate it, and apply it […]' (Cohen & Levinthal, 1990, p. 128). This can be seen in Article 1, in which the RIS type and the conditions for innovation and learning influence the AC of firms for developing CIIC. In Article 4, the AC of firms and the diffusion and translation capacity within the research institutes are identified as important to change the RIS and move towards new path development. When it comes to research institutes' diffusion and translation capacity, like the example in Article 4, its importance can depend on the type of knowledge exchange. If the exchange is static (knowledge transfer), it would require less from the 'sender', but if the exchange is dynamic (collective learning), it would require more from the 'sender' (Aslesen & Isaksen, 2007; Tödtling, Lehner, & Trippl, 2006). This is also connected to the notion of optimal cognitive distance (Nooteboom, Van Haverbeke, Duysters, Gilsing, & Van den Oord, 2007) and the inverted-U-shaped relationship that shows the relation between innovation performance and cognitive distance. The inverted-U shape shows that increased cognitive distance exerts a positive effect on learning through interaction. However, too large of a cognitive distance makes it difficult to utilise new opportunities that are presented through learning (Nooteboom et al., 2007). Thus, the inverted-U is a good expression of how too small or too large of a cognitive distance in knowledge exchange is less optimal for innovation.

Zahra and George (2002) extend the AC concept to differentiate between potential and realised AC. This differentiation can also contribute to explaining how knowledge created in the SFI (Article 4) is or is not exploited. Potential AC refers to the acquisition and assimilation of knowledge, while realised AC refers to transforming and exploiting such knowledge (Zahra & George, 2002). The two AC subsets coexist, but a firm might be capable of acquiring and assimilating

knowledge, yet be unable to transform or exploit it sufficiently to create profit or improve performance (Zahra & George, 2002). As discussed in Article 4, the firms, to a different degree, have been able to transform and exploit knowledge created in the SFI. An awareness of these dimensions is important when discussing knowledge exchange among firms (Article 1), in different clusters (Articles 2 and 3) and in the SFI (Article 4).

2.4 New path development

Following the analytical framework, the last box refers to new path development. This is connected to the concept of path dependency, which describes how 'previous events affect the probability of future events to occur' (Boschma & Frenken, 2006, p. 281). Thus, 'history matters', and choices made today will influence future decisions (Neffke, Henning, & Boschma, 2011). Path dependency in modern times stems from Paul David and Brian Arthur in the 1980s and 1990s, in which they discuss technology adoption and industry evolution (Martin, 2014).

The concepts of path dependency and new path development are important parts of extant evolutionary economic geography literature. Evolutionary approaches are characterised by firms and their routines being the main unit of analysis (Boschma & Frenken, 2006; Uyarra, 2010). It also regards regional economic restructuring as a result of firms regionally branching out, which leads to the emergence of new industries related to the industry structure (Boschma & Frenken, 2011). While earlier literature mainly focussed on developing existing paths, the 'evolutionary turn' in economic geography created an increased emphasis on path renewal and creation (Boschma & Frenken, 2006; Coenen, Moodysson, & Martin, 2015; Dawley, 2014; Martin, 2010; Martin & Sunley, 2006).

The different ways in which paths can be developed have turned into a fine-grained typology in which different paths can be recognised by their mechanisms (Asheim et al., 2019; Grillitsch & Trippl, 2018). This extant literature is important to the thesis because it explains and describes potential industrial path outcomes of processes related to the different actors and change processes previously discussed in this 'kappa'. A *new industrial path* is defined as 'a set of

functionally related firms and supportive actors and institutions that are established and legitimized beyond emergence' (Steen & Hansen, 2018, p. 4). Building on the works of Martin and Sunley (2006) and Grillitsch and Trippl (2018), the typology that I gravitate toward comprises path extension, path upgrading, path modernisation, path branching, path importation and path creation. The first type is *path extension*, which is recognised by incremental innovations in existing sectors, i.e., a continuation of the existing industry path. Although some industries function well with path extension, the lack of new knowledge input creates a risk of stagnation and gradual decline that, in turn, leads to negative lock-in and *path exhaustion* (Isaksen, 2015).

While path extension relates to continuity, the other path types relate to different degrees of change. *Path upgrading* entails intra-path development that is recognised, among other things, by a change in position in the global production network. This might happen as a result of more specialised or upgraded skills and technology upgrades (Grillitsch & Trippl, 2018). A second intra-path development is *path modernisation*, which is recognised by major changes from new technologies or organisational innovation (Grillitsch & Trippl, 2018). In Article 2, we discuss how the restructuring of the process industry in Agder can be characterised as a renewal (Tödtling & Trippl, 2013) of the path – either path upgrading or path modernisation. Due to the technological and organisational innovations we found during our empirical analysis, we found that the process industry could be understood as moving towards path modernisation (Kyllingstad & Rypestøl, 2019).

The last three types are more radical forms of structural change. *Path branching* is recognised by developing a new industry based on knowledge and competence from related industries (Boschma & Frenken, 2011). This is also known as related path diversification in the typology presented by Asheim et al. (2019). Path branching happens when incumbent firms branch into new fields by redeploying existing assets, or when new firms are established based on existing competencies in the industry (Grillitsch & Trippl, 2018). Although Article 4 only discusses potential path development resulting from a new knowledge organisation, one could assume that path branching would be possible because the incumbent industry, oil and gas, possibly could redeploy its existing assets in new ways in collaboration with other centre members, then applied in new fields.

Path importation refers to transplantation of industries that are new to a region. The ways in which this can happen include foreign firms settling in the region, qualified personnel with competencies that cannot be found in the region or through extra-regional networks. These firms and personnel also must link up to regional firms and become embedded in the region (Grillitsch & Trippl, 2018).

The most radical path development type is *path creation*. This 'refers to the rise and growth of entirely new industries based on new technological and organisational knowledge assets' (Grillitsch & Trippl, 2018, p. 340-341). Although path creation can happen by chance or as a result of an event, it is based most commonly on the region's pre-existing assets, such as an excellent scientific base or high-skilled workers (Grillitsch & Trippl, 2018).

As stated above, the path-development theory has become fine-grained and has been developed further during my four years working on this thesis. That explains why the four articles use different typologies. In Article 1, we discuss a less fine-grained typology, i.e., path extension, path renewal and new path creation. In Article 2, the aforementioned typology is used. This is also the case for Article 4 (except path upgrading). Finally, in Article 3, we distinguish between path extension, path diversification and path creation. Although the typology differs somewhat, the same knowledge-creation and combination mechanisms are central to describing the different path outcomes.

2.4.1 Linking new path development and RISs

The different path outcomes are first linked to RIS changes in that different paths to varying degrees require RIS changes. An example of this is how path modernisation, as an intra-path change, first and foremost require actions from the regional industry, while path creation, as the most radical path-development type also, requires larger changes to the innovation system.

Second, and as previously mentioned in sub-chapter 2.1.2, different type of RISs have varying potentials to support innovation and entrepreneurship (Isaksen & Trippl, 2016), and, thus, influence new path development differently. The combination of different types of knowledge is especially important, and this, again, is supported by both geographical and cognitive proximity when

discussing the potential that each RIS has for path development (Asheim et al., 2019; Frenken et al., 2007).

In their recent book, Asheim et al. (2019, p. 50) illustrate how different measures contribute to explaining why certain RISs are more prone to certain path developments than others. Due to their high diversity in firms, industries, knowledge organisations and support organisations, as well as their high degree of institutional heterogeneity and high regional and global knowledge links, *thick and diversified RISs* have greater potential for both related and unrelated path diversification,[5] as well as new path creation (Asheim et al., 2019)

Due to their relatively low diversity of firms, industries, knowledge organisations and support organisations; their low degree of institutional heterogeneity; their high degree of regional knowledge circulation; and both high and low degrees of global knowledge linkages, *thick and specialised RISs* have stronger potential for path extension, path upgrading and related path diversification (Asheim et al., 2019).

Due to their low scores on diversity of firms, industries, knowledge organisations and support organisations, and their low scores on degree of institutional heterogeneity and regional and global knowledge links, *thin RISs* have the highest potential for path extension, upgrading and importation (Asheim et al., 2019).

2.4.2 Entrepreneurial discovery process

The analytical framework of this thesis suggests a route to new path development by different actors reconfiguring the RIS in different ways and with different outcomes. An entrepreneurial discovery process (EDP) is an example of such a process, thereby connecting the four boxes. The 'entrepreneurial discovery is the essential phase, the decisive link that allows the system to reorient and renew itself' (Foray, 2014, p.495). This means that the outcome of such a process

[5] The typology used in Asheim et al. (2019) varies from the one used in this thesis. While related path diversification is described as path branching in this thesis, unrelated path diversification is not included, nor included in the typology. Unrelated path diversification happens when firms diversify into new industries by combining knowledge that is unrelated (Asheim et al., 2019).

includes more than simple innovations, but a structural change of the regional economy (Foray, 2014). Although related variety is the fundamental aspect of structural change resulting from EDP (Foray, 2014; Frenken et al., 2007), there is also an outcome that has no links to existing structures. Thus, EDP outcomes coincide with the typology of path development.

The literature differentiates between the spontaneous and the planned process of EDP (Foray, 2014; Kirzner, 1997). The spontaneous tradition stems from the Austrian microeconomics approach of understanding the competitive market process. This approach was led by Ludwig von Mises and Friedrich Hayek in the early to mid-20th century and critiques the equilibrium model in particular in understanding the market economy (Kirzner, 1997). They emphasise three concepts that are important for understanding entrepreneurial discovery: entrepreneurs; discovery; and competition (Kirzner, 1997, p. 69). The entrepreneur's role is to drive the market process by finding and exploiting business opportunities, thereby functioning as a routine-resisting market participant. This contrasts with the neoclassical tradition, in which characteristics such as imagination and drive are irrelevant to decision making (Kirzner, 1997). Regarding the discovery aspect, the concept distinguishes itself from a successful search by involving a 'surprise which accompanies the realization that one had overlooked something in fact readily available' (Kirzner, 1997, p. 72). This theoretical framework put forward by the Austrian school offers a way of understanding the market, which carries implications for areas such as economic policy (Kirzner, 1997).

Although EDP often occurs spontaneously, there are instances in which the processes are planned. These processes have come into prominence as an important aspect of the European Union's (EU) Research and Innovation Strategy for Smart Specialisation (RIS3). RIS3 is a diversification process in which targeted governmental intervention facilitates a new speciality development 'through the local concentration of resources and competences in a certain number of new domains that represent possible paths for transformation of productive structures' (Foray, 2014, pp. 492-493). To achieve a successful EDP, other actors must find the initial discovery meaningful so that agglomeration externalities can be realised. Finally, in this process, structural

change in the regional economy is needed for it to be successful (Foray, 2014). The structural change is illustrated in the analytical framework.

Arguably, the spontaneous entrepreneurial discovery (ED) was recognised by the traditional entrepreneur, but recent research has focussed more on the different types of actors, so it makes sense to broaden the concept to also include system-level actors. The use of the ED concept in this thesis should 'be understood broadly to encompass all actors (including individual entrepreneurs), organizations (including firms and universities through intrapreneurship, knowledge-based entrepreneurship and spin-offs) and agencies (technology transfer offices and public development agencies)' (Asheim, Grillitsch, & Trippl, 2017, p. 75). This broad understanding led us, in Article 3, to distinguish between firm- and system-level actors,[6] an aspect that has been addressed in the preceding chapter.

The thesis adds to extant EDP literature by discussing the different roles that actors play and how the regional context influences the process throughout. In Articles 2 and 3, we argue that either firm-level or system-level actors can make the initial discovery, but that throughout the process, they play different roles and contribute in different ways. The different actors' importance, and their role throughout EDP, will depend, as argued in Article 3, on the regional context. This is in line with the argument that Rodríguez-Pose and Wilkie (2017) made, in which regions that are institutionally sound will create better foundations for an EDP.

If the entrepreneurial discovery process is to create new activities and paths in the existing cluster, more than one innovation within a firm is needed, regardless of the innovation's possible radical nature (Simmie, 2013). An EDP is successful when it is recognised by a combination of both exploited opportunities in firms and system changes. In Article 2, the multitude of innovations is recognised in the greening of the NCE Eyde process industry cluster, while in Article 3, the EDP's success is manifested through the creation of the different cluster initiatives.

[6] The term *firm- and system-level entrepreneurs* is used in the article.

The analytical framework can be illustrated by using an example from Article 2. The actors in the NCE Eyde cluster are embedded in a regional innovation system. During the process of restructuring, the cluster administration and the core firms acted as system-level actors when trying to move towards more sustainable solutions. They worked to change the system both for their regional industry, as well as the processing industry on the national level. For it to be a successful process of entrepreneurial discovery (restructuring), the firms had to utilise new opportunities and create spill-overs, which happened as a result of the creative workshops they established. Finally, we recognised from the mechanisms (major changes based on new technologies and organisational innovations) that this was a process of path modernisation.

This example also highlights AC's importance in restructuring processes, as the actors in the NCE Eyde cluster understood that, regarding the projects they developed in their creative workshops: 'Once identified as interesting, R&D projects of sustainability are sorted into themes, and their destiny is left to cross-industrial and cross-functional teams' (Kyllingstad & Rypestøl, 2019, p. 6). If the different actors in the cross-industrial teams did not have enough AC, the projects would not survive, regardless of their potential. The cross-industry notion also ties this example to Article 1, in which we discuss how the regional context influences a firm's ability to develop CIIC. Based on this, we can expect a certain ability to develop CIIC based on the RIS in which the NCE Eyde cluster is located.

3 Research design and methodology

For all researchers, there will be certain world views guiding their work. Therefore, it is important to reflect on, and be honest about, assumptions that one might have about the world, i.e., society, in terms of what exists and what we can know about the world. These questions are addressed in literature on philosophy of science in which different approaches to science are discussed.

What knowledge is and how one arrives at knowledge, ontology and epistemology respectively, differs depending on where the researcher is placed on the spectrum of social research paradigms or approaches (Blaikie, 2009). Thomas Kuhn, mostly associated with paradigms, presented his thoughts on paradigms in his book from 1962, *The Structure of Scientific Revolution* (Kuhn, 2012). In his postscript, he wrote, 'The paradigm as shared example is the central element of what I now take to be the most novel and least understood aspect of this book' (Kuhn, 2012, p. 186). This phrase demonstrates this complex concept's novelty. In his book, critics found at least 22 different usages of the term *paradigm*, and as a result, Kuhn wrote an article that tried to clarify the concept even further, in which he ended up with two sets of understandings. The first is that a paradigm is global as it is 'embracing all the shared commitments of a scientific group' (Kuhn, 1974, p. 460), while the second is a subset of the first through isolation of a particular commitment. The first understanding is Kuhn's understanding, to which this thesis adheres. Even though Kuhn often is viewed as the father of paradigms, his original point of departure lied in theoretical physics, but his interest in knowledge as a field of study grew over time. When discussing paradigms in natural science, the paradigms usually replace each other, while in the social sciences, the old and new paradigms appear simultaneously (Arbnor & Bjerke, 2009). The different paradigms usually have followers and adversaries. Denzin and Lincoln (2013) use the history of the three paradigm wars in social science to better explain the current situation regarding paradigms. The first conflict, from 1970-1990, was between postpositivism-constructivism and positivism. The second conflict, from 1990-2005, was between competing postpositivism, constructivism and critical theory paradigms. Currently, the conflict is 'between evidence-based methodologists and the mixed-methods, interpretive and critical theory schools' (Denzin & Lincoln, 2013, p. 2).

A broad spectrum of paradigms describes the many, and somewhat overlapping, approaches stretching from positivism on one end of the spectrum to constructivism or post-modernism on the other end. Where on the spectrum a researcher is placed is based on the researcher's ontological and epistemological understanding (Blaikie, 2009) and can be characterised based on how researchers respond to these three questions:' (1) *Ontology*: What is the nature of the 'knowable'? Or what is the nature of 'reality'? (2) *Epistemological:* What is the nature of the relationship between the knower (the inquirer) and the known (or knowable)? (3) *Methodological:* How should the inquirer go about finding out knowledge (Guba, 1990, p. 18)'?

When I, as a doctoral student, started this journey of writing my PhD, I did not start out with reflections on the philosophy of science. However, not long after I started, I joined a seminar on the philosophy of science, which made me think twice about how I was conducting my research and why. Although I started to reflect on this, I found it difficult to commit 100 percent to any philosophy of science without learning more. Finally, after studying philosophy of science more closely, I find myself drawn to the tradition of critical realism because it views theoretically informed case studies as the recommended method for research, which is the preferred method in all four articles in the present thesis. Even though case study is the preferred method, CR also acknowledges other methods, depending on the study's object and purpose (Sayer, 2000).

Therefore, in this chapter, I will discuss the ontological, epistemological and methodological perspectives associated with critical realism and how these have guided the work on this thesis. Furthermore, the chapter will describe which methods have been used to collect and analyse the data.

The realism approach entered the realm of social science in the late 1970s and early 1980s (Sayer, 1992; Strydom & Delanty, 2003). Realism is 'based on the assumption that an external reality exist which is independent of human consciousness yet can nevertheless be known' (Strydom & Delanty, 2003, p. 376). However, reality is not easily observable and can be understood as unfolding and layered. In realism, social science is concerned with underlying structures (Strydom & Delanty, 2003).

Critical realism (CR) came about as an alternative to already-established philosophies. It criticises positivism for viewing the social world as if it followed laws similar to those in the natural sciences, as well as interpretivism, which reduces social life solely to the level of meaning (Sayer, 2000). In his book *Method in social science*, Sayer (1992) further explains shortcomings in the philosophy of social science and expresses the need for more contributions on empirical science methods to further understand, e.g., how different knowledge varieties hold different implications for empirical research. The book focuses on methods for realists as a counterweight to the methodological imperialisms of 'scientism', which is a strict understanding of science, and the opposite of this, which is reducing social science to that of interpretation (Sayer, 1992). Although interpretive understanding is useful, causal explanations remain (Sayer, 2000).

3.1 Ontological and epistemological perspectives

Ontology refers to what exists, and according to Sayer (1999), Bhaskar distinguishes between the transitive and the intransitive dimensions of knowledge. The first happens when theories change, but this does not mean that what the theory entails changes, which is the intransitive dimension (e.g., the world did not suddenly become round when the flat-earth theory was debunked). Another way of explaining the intransitive dimension is to view it as knowledge of things, but not produced by someone, i.e., it still would happen if humans ceased to exist, e.g., the power of gravity (Bhaskar, 1975, 2008). This supports the idea that the social world is socially constructed and that I, as a researcher, will not change any phenomenon that I study, even though my perception of it does (Sayer, 2000). Finally, the distinction between these two dimensions of science 'implies that the world should not be conflated with our experience of it, and hence that, strictly speaking, it is misleading to speak of the empirical world' (Sayer, 2000, p. 11).

In critical realism, we also find a stratified (layered) ontology that distinguishes between the real, the actual and the empirical (Sayer, 2000). The real is whatever exists (natural and social, but not necessarily an empirical object), and 'the real is the realm of objects, their structures and powers' (Sayer, 2000, p. 11), i.e., the limits are our understanding of the real, not the real itself. For example, our

knowledge of gravity will affect our understanding of it, but gravity is nonetheless real. These objects have structure and causal powers (emergent powers), which are ‘powers or liabilities which cannot be reduced to those of their constituents’ (Sayer, 1992, p. 119), thereby depicting a stratified world. For example, the power of water (in terms of fighting fire) exists on a different stratum from those of hydrogen and oxygen. These structures and powers are what we try to identify in the transitive dimension (Sayer, 2000)

The actual is what happens if and when the aforementioned structures and powers of objects are activated (e.g., labour power as the capacity one has pertaining to the ‘real’, while the actual working as exercising the power and its effects pertains to the ‘actual’) (Sayer, 2000). The empirical is the domain of experience. Observability is central in the sense that if something is observable, one can be surer of its existence. However, the existence of something is not dependent on it being observable.

Epistemological assumptions are assumptions concerned with what kind of knowledge is possible (Blaikie, 2009). And because critical realism deals with a stratified ontology, the ontology provides guidelines for the epistemology. This can be explained this way: ‘The world can only be understood in terms of available conceptual resources, but the latter do not determine the structure of the world itself’’ (Sayer, 1992, p. 83). The events we try to understand happen in the actual domain, and the observations are made and experienced in the empirical domain (Easton, 2010). This supports the notion that the world exists independently of our knowledge of it and, thus, the CR approach accepts that reality is socially constructed (Easton, 2010). Because our observations are fallible, no truths about different phenomena exist. Therefore, a researcher’s job is to collect data that might distinguish the different explanations and further have these explanations debated within communities of researchers (Easton, 2010). How a critical realist comes to observe and understand the world is explained further below.

Causation is an important feature of CR. According to realists, 'causation is *not* understood on the model of regular successions of events, and hence, explanation need not depend on finding them, or searching for putative social laws' (Sayer, 2000, p. 14). This means that in the search for explanations, the researcher should identify the causal mechanisms and further examine whether they have been activated (Sayer, 2000). While positivism views causation as a regularity of cause and effect, CR views it as illustrated in Figure 2 below (Sayer, 2000, p. 15):

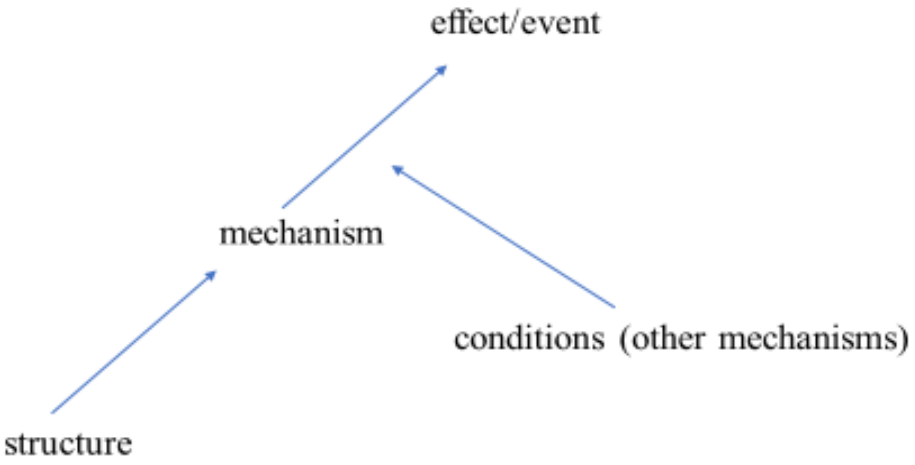


Figure 2 Critical realist view of causation

This latter notion and the figure above can be explained by the example of losing one's job. There are several reasons why that might happen; thus, the events are dependent on conditions that might alter how one expects the effect to be. Sayer (1999, p. 15) sums up the relationship like this: 'Events arise from workings of mechanisms, which derive from the structures of objects, and they take place within geo-historical contexts'.

This perspective on causation further acknowledges that the future is open. According to Sayer (2000) it is often tempting when trying to explain changes to assume that what happened was the only thing that could have happened. However, this is not the case, and how conditions might change the route from mechanism to event can be seen in Article 1, in which different RISs, which are the conditions, may influence the firm's capability of developing CIIC. In Article 3, we write, 'It aims for a better understanding of how different regional context

affect entrepreneurial discoveries' (Isaksen et al., 2018, p. 2), which shows that we believe regional conditions affect different actors and their motivations and the outcome of a successful EDP and path development.

The *objects* (or entities) can be organisations, people, relationships, etc., and are the basic theoretical building blocks for CR explanations. These entities have causal powers and liabilities, as explained above, and can be 'human, social or material, complex or simple, structured or unstructured' (Easton, 2010, p. 120). Structured entities suggest that an entity can comprise many entities. For example, an organisation can contain different departments and different people, and they may all affect each other. In Figure 2, the objects are recognised in the structures (Sayer, 2000). In this thesis, the objects are, for example, firms or clusters.

Mechanisms are causal powers of objects (Bhaskar, 1975; Easton, 2010). They can be explained as '[…] ways in which structured entities by means of their powers and liabilities act and cause particular events' (Easton, 2010, p. 122). Furthermore, activated mechanisms produce effects that may be unique: 'According to conditions, the same mechanism may sometimes produce different events, and conversely the same type of event may have different causes' (Sayer, 1992, p. 116). For example, in Article 1, the mechanisms are CIIC building in firms.

Events (or outcomes) are what is being investigated. It is the 'external and visible behaviours of people, systems and things as they occur, or as they have happened' (Easton, 2010, p. 120). However, the methods used in social science usually comprise reported data and are not necessarily observed, and the lack of expected events can also provide useful insight (Easton, 2010). An example could be when a firm implements a new computer system, and a researcher hears the reported outcomes from users, rather than observing its performance personally.

Context is time- and space-specific conditions that might influence the entities. 'Making sense of events require that we 'contextualize' them in some way' is how Sayer (1992, p. 60) explains context.

Figure 2 addresses some of the central concepts in CR that also are displayed in Table 1, where I display how these can be found in the four articles.

Table 1 Central critical realism concepts used in the articles

Central CR concepts	Article 1	Article 2	Article 3	Article 4
Objects (entities)	Firms	Actors in the NCE Eyde cluster	Three different 'official' clusters	Centre for research-based innovation Offshore Mechatronics (SFI OM)
Mechanisms	Cross-industry innovation capability	Firm- and system-level actors' motivation	Institutionalisation of entrepreneurial discovery process	R&D&I activity in the SFI OM
Events	Cross-industry innovation in firms	Entrepreneurial discovery process and new path development	Entrepreneurial discovery process and new path development	Barriers to new path development
Context	Three regional innovation systems: Hordaland (thick and diversified RIS) and Stavanger and Agder (thick and specialised RISs)	The NCE Eyde cluster	Three regional innovation systems: Oslo (thick and diversified RIS); Møre (thick and specialised RIS); and Hamar (fairly thin RIS)	Thick and specialised regional innovation system in Agder and the SFI OM

3.2 Methodology and method

3.2.1 Methodology

Contrary to natural sciences, in which components may be isolated and studied under the microscope, the social world is messy. Thus, there is a need for abstraction and conceptualisation when we try to make sense of the various components of what we are studying. Sayer (1992) highlights that contrary to popular usage, the word *abstract* does not translate to vague, but rather 'an abstract concept, or an abstraction, isolates in thought a *one-sided* or partial aspect of an object. What we abstract *from* are the many other aspects which together constitute *concrete* objects such as people, economics, nations, institutions, activities and so on' (Sayer, 1992, p. 87). Categories, such as those found in statistical databases, might not be abstracted properly, which often renders the rest of the analysis misleading. In CR, what comes after abstraction is not concrete synthesis, but rather an interpretation: 'To interpret what actors mean, we have to relate their discourse to its referents and contexts' (Sayer, 2000, p. 20).

This research strategy of moving back and forth between the abstract and the empirics is called retroduction and is widely used by critical realists. This strategy starts with an observed regularity that needs explaining: 'Explanation is achieved by locating the real underlying structure or mechanism(s) that is/are responsible for producing the observed regularity, and identifying the context in which this happens' (Blaikie, 2009, p. 19). However, these structures and mechanisms are not always easily observable. Therefore, one needs to find evidence of their existence by identifying the consequences that they are expected to create. Within this strategy, the use of models is often developed at the outset, e.g., as conceptual or theoretical frameworks (Blaikie, 2009). The manifestation of retroduction is referred to by some as triangulation (Downward & Mearman, 2006). Due to the use of multiple methods, triangulation raises researchers above personal bias (Denzin, 1970) and increases the validity of the research.

One concept that is used widely in this thesis is case study. In all articles, we discuss case and context. Because CR is preoccupied with how concepts should

be explained, it seemed important to explain what can be meant when using the concept of case study, and how it is used in this thesis.

Case study has been used in several traditions, such as sociology, political science, business, management, etc. (Blaikie, 2009; Mills, Durepos, & Wiebe, 2009; Yin, 1994). It has also been used in economics, especially the type of economics closest to the one used in this thesis, namely when the research examines the structure of industries, regions and cities (Yin, 1994). The history of case study can be traced back to the 1920s (Blaikie, 2009; Mills et al., 2009). However, throughout the last century, it has been a contested field (Yazan, 2015), but has been frequently used. In his research, Blaikie (2009) addressed three ways to approach case study. First, it is viewed as a type of research design that is used commonly in textbooks on social research today and is the understanding I am working with. Second, case study is viewed as an umbrella for different research methods, such as participant observation and field research. Third, case study is a method for selecting data sources (Blaikie, 2009, p. 186)

Bedrettin Yazan (2015) tries to clarify the case-study field for novice researchers by reviewing the writings of three seminal researchers within case-study research: Robert K. Yin; Sharan Merriam; and Robert E. Stake. This is only one of the many articles written to try and clarify the case-study field and make it easier to choose the most purposeful tools for one's own work. As with all research, the case-study approach is subject to variations based on the researchers' epistemological commitments. One aspect of the research design that highlights this is the source of data. In an overview created by Yazan (2015), both Merriam and Stake make exclusive use of qualitative data sources and are leaning more towards constructivism as their epistemological commitment, while other researchers such as Yin and Eisenhardt lean more towards positivism and include both quantitative and qualitative sources in their data (Eisenhardt, 1989; Yin, 1994).

3.2.2 Method

While positivism and interpretivism are relatively strict in their use of methods, CR is compatible with several different methods, and it all depends on what one studies. One way to view it is as a triangle – with method, object and purpose as

its corners – and perceive these in relation to each other. Consequently, the method chosen will be appropriate for the specific object (Sayer, 2000).

In CR, a distinction is made between external or contingent relations, and internal or necessary relations. The first entails relations in which one can exist without the other (e.g., myself and the earth on which I walk), while the latter refers to relations in which one cannot exist without the other (e.g., a tenant and a landlord). Neither is more important than the other, and usually, when studying the social world, there will be combinations of relationships. To discover the structures, one should ask simple questions, such as: 'What does the existence of this object (in this form) presuppose? Can it exist on its own as such? If not what else must be present? What is it *about* the object that makes it do such and such?' (Sayer, 1992, p. 91). Thus, it is often important to ask qualitative questions about the nature of the objects. Regarding the use of quantitative methods, Sayer states that 'although structures are constituted by internal relations which must be understood qualitatively, they may in some cases be affected by size or quantities' (Sayer, 1992, p. 99).

As previously stated, it is important to ask qualitative questions about the nature of the objects. In all four articles, semi-structured interviews have been used to gather data. This interview method is used to address several predetermined questions or themes. The questions are not necessarily prepared in advance, but can evolve during the interviews. 'Semi-structured interviews are used when the researcher's goal is to compare participants' responses while simultaneously seeking to fully understand their unique experiences' (Mills et al., 2009, p. 496). In Article 1, 15 semi-structured interviews with small firms were conducted. In Article 2, five semi-structured interviews with central actors in the case we studied were conducted. In Article 3, 13 semi-structured interviews were conducted. And finally, in Article 4, 24 semi-structured interviews were conducted. In addition to the interviews, the articles also used secondary data, such as relevant documents available online and reports and documents that the interviewees sent to us. In Article 3, we also used a quantitative method by sending out a survey to 74 respondents, 44 of whom responded. This information provided additional information to what had already been collected using qualitative methods. In Articles 1-3, the interviews were recorded and transcribed. During the first round of interviews for Article 4, the interviews

were not recorded. However, two or three researchers took notes during the interviews. In the second round, all but one interview was recorded[7].

As mentioned, the process of abstraction is important in CR. In this thesis, I have dealt with abstraction by conducting literature reviews. The more knowledge one can acquire from theory about the object being studied, the better the foundation is for abstracting concepts properly. This process is conducted in the 'kappa', in which key concepts – such as regional innovation systems, firm-level and system-level actors, entrepreneurial discovery processes and new path development – are discussed and defined based on key extant literature. All four articles in this thesis are theoretically informed studies, enabling the use of models to better understand and abstract the concepts, as well as use the strategy of retroduction, in which we go back and forth between abstraction and empirics. For example, in Article 3, we use theory to abstract the concepts for advancing the understanding that EDP occurs differently with different outcomes in different RISs. In Article 4, the literature review on barriers led me to abstract several different concepts that I wanted to study further, e.g., the concept of conventions. All these different concepts would, in turn, contribute to understanding the larger objective concerning barriers to new regional industrial path development.

3.2.3 Triangulation

Triangulation, which is described as the manifestation of retroduction (Downward & Mearman, 2006) and initially used for referring to the combination of different types of methods (Blaikie, 2009), can be divided into four types: data triangulation; investigator triangulation; theoretical triangulation; and methodological triangulation (Downward & Mearman, 2006). The first type involves collecting data from different sources or at different times (Denzin, 1970; Downward & Mearman, 2006). This is done in Article 1, in which we interview different people representing firms from three different regional innovation systems. This is also done in Article 3, in which we interview different people from three different clusters. It also is done in Article 4, in which I interview both the same and different people, with four years between the interviews.

[7] One interviewee did not agree to have the interview recorded.

The second type is investigator triangulation, which is when more than one researcher collects and analyses data (Downward & Mearman, 2006). This was done in Articles 1-3, which were co-written with colleagues, and everyone participated in data collection and analysis. The process of co-writing has its benefits and challenges. This is best illustrated by the writing process for Article 1. After the interviews were transcribed (divided between us), we all read through the interviews and tried to categorise our findings in each of the CIIC boxes. Following this, we all sat together and compared our categorisations. If we disagreed, we discussed our differences until we reached an agreement. Thus, this process acted as quality assurance for our data, but as can be imagined, this process was time consuming and at times challenging.

The third type is theoretical triangulation, which involves referring to more than one theoretical tradition during analysis (Downward & Mearman, 2006). In Article 1, this is done by combining the newly introduced concept of CIIC with extant RIS literature. In Articles 2 and 3, we linked extant EDP literature with RIS and path development. In Article 4, the barriers in the regional innovation system are linked to new path development.

The fourth type is methodological triangulation, which can be either a *within method* or *between method.* The first refers to using the same method, but with different varieties, while the latter refers to different methods, such as quantitative and qualitative (Downward & Mearman, 2006). In Article 3, we used *between method* triangulation because we used descriptive quantitative analysis of the survey data that we collected, as well as qualitative analysis of the interview data collected. In all four articles, we used a *within method* in the sense that they all combine semi-structured interviews and document examination. Furthermore, three of the articles have received feedback from scientific scholars at different international conferences[8]. In addition, all four articles have been submitted to international journals. Articles 1-3 have been published after a

[8] The papers were presented at these conferences: 56th ERSA Congress in Vienna, 2016 (Article 1); Regional Studies Association Conference in Graz, 2016 (Article 1); Regional Studies Association Conference in Dublin, 2017 (Article 3); 14th Regional innovation Policies Conference in Florence, 2019 (Article 4); and the Regional Studies Association Conference in Santiago, 2019 (Article 4).

process of blind peer review that functions as a quality-control measure for scientific journals. Article 4 is currently being reviewed.

Addressing the philosophical approach is important because it has guided my research. Adhering to critical realism also provides me with an understanding of how to interpret the data in the articles. The next chapter discusses in more detail the independent contribution of each of the four articles, as well as the overall contribution of the thesis.

4 Findings and contributions

Each of the articles contributes to the literature with theoretical and empirical insight, as well as policy lessons to some degree. Combined, they aim to address the overarching theme of this thesis, which is to better our understanding of firm- and system-level actors' role in processes of new regional industrial path development. This chapter will first discuss contributions from each article before drawing up general theoretical, empirical and policy lessons. Finally, I will elaborate on issues that I believe future research should address. This section will also reflect on whether my research only holds true for my cases or if the contributions can be generalised to some degree.

4.1 The articles

Article 1: *Developing cross-industry innovation capability: Regional drivers and indicators within firms* (Hauge, E., Kyllingstad, N., Mæhle, N. & Schulze-Krogh, A.C., 2017)

This article focuses on firms and their cross-industry innovation capability (CIIC), as well as the influence from the region (RIS) in which the firms are embedded. Because of firms' heterogeneity, we argue that the micro-level perspective is important to study to better understand the bigger picture of regional industrial growth. We build on Lawson and Samson's (2001) notion of innovation capability and introduce the concept of CIIC, which is defined as 'the firm's ability to continuously transform knowledge and ideas from different industries into new products, processes and systems and/or the ability to adapt existing products, processes and systems to new industries' (Hauge et al., 2017, p. 390). To better understand what stimulates and influences cross-industry innovation, we ask the following research questions: What are the indicators of CIIC in firms, and how is CIIC influenced by regional conditions?

The analytical model is tested in three Norwegian regions: Hordaland; Rogaland; and Agder, which all gradually have become more oil dependent. The three regions are all characterised using the RIS typology described in Chapter 2.1. While Hordaland is a thick and diversified RIS, both Rogaland and Agder are

relatively thick and specialised. Empirically, we see that, based on the RIS characteristics and the identified CIIC indicators, the thick and diversified Hordaland region is more favourable to a firm's ability to develop CIIC and, consequently, better equipped to address economic decline. In the thick and specialised RIS, we argue that encouraging CIIC building in firms is an important mechanism for cross-industry innovation and regional path renewal. Thus, the analytical model can work as a tool to suggest which regional structures are favourable for CIIC and how to encourage building them.

The article contributes to extant literature by introducing the concept of CIIC and discussing how to explore its drivers and indicators. As seen from the empirics, the drivers vary in different regional contexts in terms of influencing a firm's absorptive capacity to develop CIIC, which is important for new path development.

Article 2: *Towards a more sustainable process industry: A single case study of restructuring within the Eyde process industry cluster* (Kyllingstad, N. & Rypestøl, J.O., 2019)

This article aimed to improve our understanding of regional industrial path development by introducing an analytical framework that combines the concepts of entrepreneurial discovery processes (EDPs) and path dependency. An EDP is divided into two phases: the actual discovery and the exploring actors, and the structural changes that need to follow for it to be a successful EDP. The article argues that the EDP concept allows us to delve more deeply into actors who contribute to restructuring the industry. In the article, we separate actors based on their motivation as either FLAs or SLAs. The path-dependency concept addresses EDPs' evolutionary nature and suggests what outcomes can be expected in terms of new path development (see typology in 2.4). The research questions are: 1) What type of key actors take part in and drive the restructuring process in the Eyde cluster, and how does the process unfold? 2) To what extent is the suggested analytical framework likely to be useful in empirical studies intended to improve our understanding of regional industrial restructuring processes?

Based on the theoretical concepts, we created an analytical framework that suggests a stepwise analysis comprising two routes to new regional industrial restructuring, in which Route 1 is initiated by firm-level actors and Route 2 is initiated by system-level actors. The article further discusses the importance and interplay between the actors at each step. The analytical framework is used as a 'focussing device' (Lundvall, 2010) to organise and focus the analysis of an ongoing restructuring process in the NCE Eyde processing industry cluster in southern Norway. The empirical findings show that the restructuring process in Eyde was initiated by SLAs due to their motivation to change the current system to strengthen the emphasis on sustainability. This common interest created identifiable structural changes, such as platforms for knowledge sharing, as well as a mutual cognitive understanding. The process following the initiation was characterised by increased knowledge sharing and new R&D projects, leading us to suggest that the processing industry is moving towards path modernisation.

The article argues that the combination of the EDP and the path-dependency concepts enables a deeper discussion of key actors in a restructuring process. It also argues that it is useful to distinguish between the two types of entrepreneurs, as they have distinct roles and complement each other in this process. The EDP framework adds a structural dimension, which is helpful when identifying and categorising various stages of change processes, i.e., from initiation through RIS changes and towards potential path development. Even though we find the analytical framework to be useful to better our understanding of regional restructuring, we also acknowledge that the framework lacks, to a certain degree, interactivity. Thus, an advanced framework should incorporate feedback loops between the different stages.

Article 3: *Differentiated regional entrepreneurial discovery processes. A conceptual discussion and analysis of three emergent clusters in Norway* (Isaksen, A., Kyllingstad, N., Rypestøl, J.O. & Schulze-Krogh, A.C., 2018)

In this article, we propose an analytical framework to link the concept of regional innovation systems (RISs), entrepreneurial discovery processes (EDPs) and new path development. Our aim is to contribute to extant literature on regional industrial path development by focussing on how the different actors and their

roles through EDPs can impact specific path developments in different regional settings.

The framework is used on three different cluster projects to test its relevance and usefulness. The RISs in which these cluster projects are embedded are categorised using the typology from sub-chapter 2.1. The Oslo region (EdTech cluster) is a thick and diversified RIS. The Molde region (iKuben cluster) is a comparably thicker and specialised RIS, while the Hamar region (Heidner cluster) is a comparably thinner RIS.

Three questions arose from the conceptual framework, which we used in our empirical investigation of the three cluster projects. Our aim was not to, for example, figure out whether all thin regions are initiated by SLAs, but rather whether the concepts and analytical framework are useful. The *first* question was whether the distinction between FLAs and SLAs is useful, and if SLAs tend to be of increasing importance in thin vs. thick RISs because thin regions are less dynamic and, thus, expect to have fewer FLAs to initiate EDPs. Our analysis found that a distinction is useful in both conceptual terms and for empirical studies because it may help substantiate our understanding of EDPs' beginnings, as well as recognise actors based on their motivations and actions. The SLAs were important as initiators of EDPs in all three cases, highlighting the importance of improving our understanding of SLAs in EDPs. The *second* question was whether the establishment of new knowledge-creating and diffusion organisations is vital in distinguishing between EDPs in various RISs and whether the establishment of such organisations is increasingly more important in thin vs. thick RISs. The analysis found that changes in RIS are part of EDPs and that institutionalisation of the EDP is important for further cluster building. In line with the conceptual framework, we also see that the establishment or adaption of such organisations is a distinguishing factor between the cases, found more often in Molde and Hamar, while in the Oslo region, the knowledge infrastructure was already well-developed and not as dependent on a new knowledge organisation. The *third question* relates to whether it is useful to explore the results of EDPs as different types of path development, and if so, do the path changes tend to be less radical in thin vs. thick RISs? We find it useful because different forms of path development suggest a qualitative change, whether it is the creation of new industries or the strengthening of existing ones.

And in line with the theoretical arguments, we found potential for more radical path changes in the thick and diversified RIS, compared with the other two RISs.

Article 4: *Breaking barriers for new regional industrial path development: The role of a centre for research-based innovation* (Kyllingstad, N., forthcoming)

This article aims to improve our understanding of barriers to new regional industrial path development. The article focuses on barriers at the three levels of a thick and specialised RIS: actors; networks; and institutions. This avoids limiting the analysis to either systemic-, or actor-specific barriers. The article poses two theoretical research questions: 1) What are the barriers in RIS for new industrial path development? 2) What are potential ways of lowering or breaking these barriers?

The article focuses specifically on how a new knowledge organisation may contribute to breaking down barriers to new path development. The case used is a new knowledge organisation, the Centre for research-based innovation offshore mechatronics (SFI OM), which is embedded in the thick and specialised RIS of the Agder region in southern Norway. Departing from the analytical framework, the article poses two empirical questions: What are the barriers in the organisationally thick and specialised region of Agder to new industrial path development, and how has the SFI OM contributed to breaking down these barriers? The analysis shows that most barriers from the analytical framework can be recognised in the case presented, even though not all ways of lowering the barriers are exhibited.

This article does not provide a snapshot of a historic process, as is often seen in case studies within this field (Uyarra, 2010). In these cases, a clear path outcome can often be observed, while in this article the path development process is ongoing, making it impossible to say whether a certain path outcome will emerge as a result of the introduction of the new knowledge organisation. However, based on the findings, we can argue whether the changes made hold potential for leading the industry beyond path extension or modernisation. The article's aim is not to demonstrate that this specific region has achieved certain change, but to demonstrate the barriers and struggles of new path development that many thick and specialised RISs presumably face in economic restructuring processes. The

article also contributes to a deeper understanding of the SFI as a policy tool and shows that the composition of partners creates different possibilities in terms of its output and how the RIS might benefit. The analysis, for example, shows how an SFI with many competitors might struggle with trusting partners with their core competencies, which might, as in this case, lead to generic technology as the main output.

4.2 Empirical findings

Although RISs are more prone to path extension and upgrading, Chapter 2.4.1 discusses briefly how this may differ between the different RIS types. Thick and diversified RIS hold potential for related path diversification, unrelated path diversification and new path creation. Thick and specialised RIS hold potential for path extension, path upgrading and related path diversification, while thin RIS hold potential for path extension, path upgrading and path importation (Asheim et al., 2019). Thus, if the goal is to move towards new path development it might require changes in the RIS such as changed or new organisations, changed relationships between organisations or changed formal and informal institutions (Asheim et al., 2019). This thesis explores how different RISs can contribute to different path outcomes by focussing on the actors, either through actors' role in increased cross-industry innovation capability (Article 1), in entrepreneurial discovery processes (Articles 2 and 3) or in ways of overcoming and breaking down barriers to new path development (Article 4).

More specifically, in Article 1 the importance of context is illustrated in the analytical framework as something that influences CIIC capability, which, in turn, can influence new path development. The findings show how the firms in the thick and diversified RIS have stronger CIIC compared with the two specialised RISs. This result resonates with extant literature stating that diversified industry structures are more favourable for knowledge flows and cross-industry collaborations (Asheim, Boschma, & Cooke, 2011). The article further argues that the firms in thick and specialised RIS should focus more on developing CIIC to promote new path development and avoid self-reinforcing mechanisms that might lead to organisational path dependency (Sydow, Schreyögg, & Koch, 2009).

How the structure in specialised RIS can hinder industry growth beyond strong or incumbent industries is also evident in Article 4, in which the barriers found in the actors, networks and institutional dimensions are all mostly connected to the strong oil and gas industry in the Agder region. Article 1 demonstrates further how a thick and specialised RIS can be a challenging environment for new path development. One of the informants reflected on this situation by stating that: 'Everything is focussed towards the oil and gas industry, so I believe people wanting to establish something outside of this industry will meet a huge disadvantage because of the massive establishments within this industry'. By being aware of the regional context, both the CIIC concept and different barriers can be used in certain ways to promote new path development in terms of where and what to focus on, e.g., with policy initiatives.

Because new growth paths usually are rooted in existing structures (Martin, 2010), an EDP is arguably also influenced by the context. Article 2 argues that an EDP will affect future industrial path development differently depending on the EDP's characteristics. The discussion on how the context, in turn, will affect these characteristics is explored further in Article 3, in which we add to the analytical framework the argument that the regional context will influence the EDP process.

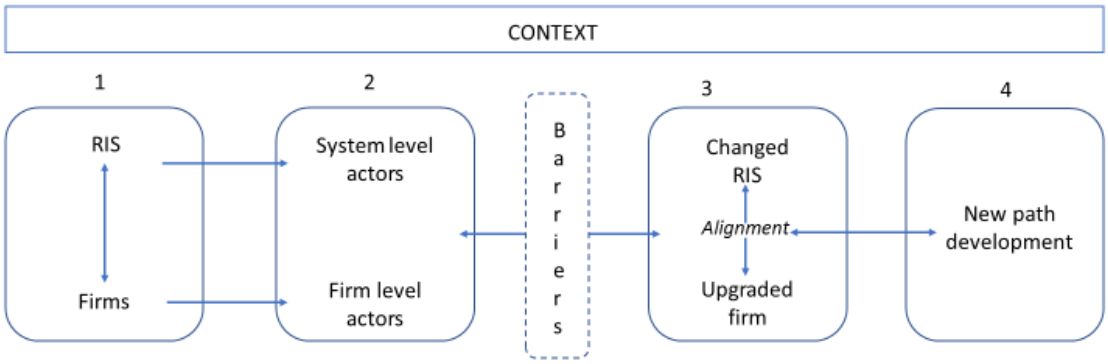
One example that illustrates the significance of context for EDP is that it determines the importance of introducing a new knowledge creation and diffusion organisation to a region. Article 3 found this type of organisation to be more important for stimulating new industrial path development in thick and specialised RISs and thin RISs compared with thick and diversified RISs. Even though we do not maintain that the establishment of such organisations is always more important in thick and specialised RISs and thin RISs, it still shows its importance. The introduction of new knowledge creating, and diffusion organisations can also be found in Article 4, in which the SFI OM serves as an example for a new knowledge organisation. Although the SFI OM is set up to strengthen the incumbent industry, it still demonstrates the potential that such organisations have for stimulating new path development, e.g., by increasing external knowledge linkages and creating platforms for collaboration between industry and research. The cases in Article 3 also resonate with the analytical framework, which suggests a possible relationship between RIS type and the

radicalism of path changes, pointing to more radical path changes in the thick and diversified Oslo region, compared with the other two regions.

4.3 Theoretical findings

Departing from the analytical framework (p.9), the aim of this thesis has been to contribute with new theoretical insight, especially concerning the role of firm- and system-level actors in processes of changing RISs and in facilitating new regional industrial path development.

The analytical framework's function was initially to guide the 'kappa' and present an overview of the important theoretical concepts and connections among the four articles. However, during the development of the thesis, two additional concepts in particular have been of importance and should be incorporated into an updated version of the analytical framework. Thus, an updated version is presented below, which includes the barriers between Boxes 2 and 3, as well as the importance of alignment between a changed RIS and an updated firm, which will be explored further in this chapter



1. Developing cross-industry innovation capability: Regional drivers and indicators within firms (1, 4, 3*)

2. Towards a more sustainable process industry: A single case study of restructuring within the Eyde process industry cluster (1,2,3,4)

3. Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustrations of three emergent clusters (1,2,3,4)

4. Breaking barriers for new regional industrial path development: The role of a centre for research-based innovation (1,2,3,4)

*mostly in terms of firm upgrading

Figure 3 Analytical framework - revisited

The role of SLAs is explicitly discussed in Articles 2 and 3. According to the analytical framework in Article 3, we expect that system-level actors' role will be increasingly important in thin RISs compared with thick and specialised and thick and diversified RISs because thin regions are less dynamic, with fewer FLAs to initiate EDPs. Our expectations were not supported by the empirical findings, but the empirics still demonstrate system-level actors' importance in all three cases.

In Articles 2 and 3, we found it useful to separate FLAs and SLAs because they have distinctive roles and complement each other in EDP processes. By separating the two, we make it possible to identify and categorise the various actors and stages of an EDP.

The role of alignment is not addressed sufficiently in the articles. What I mean by *alignment* can be illustrated by using the logic of the analytical framework in Article 2. In this framework, a route 2 towards regional restructuring is recognised by the SLA being the initiating actor, i.e., they uncover or create new opportunities while working on changing the systemic factors, such as RIS elements. The alignment between the two types of actors is crucial in the following process. If there is to be a successful EDP, the FLAs must identify the new opportunities created by SLAs and utilise them. If they do, what can follow is transformation in existing firms and formation of new and related firms, leading to knowledge spillovers and innovation, which push the regional industry towards new path development. Thus, alignment illustrates that the work and focus of an SLA would lead nowhere if the FLA did not have the will and ability to utilise the new opportunities.

While not explicitly described, Article 4 also deals with the concepts of FLA, SLA and alignment. The SFI OM, as a new knowledge organisation, has the potential of reconfiguring the RIS and acting as an SLA. However, even if the SFI OM is changing the RIS and creating new opportunities to move the industry towards new path development, they are conditioned by the FLAs and their willingness to utilise these opportunities. Article I discuss how absorptive capacity is important for the industry partners and the research partners to be able to utilise each other's input and research. Alignment follows the same logic and describes how important it is that both SLAs and FLAs are aligned in terms of

the future development of a particular industry, as well as capabilities to be able to achieve the desired development.

The second concept that has been added to the analytical framework of this thesis, and which is important to address, is barriers. A better understanding of barriers towards new regional industrial path development is arguably important. As written in Article 4: 'By implication, when discussing what might contribute to new industrial path development, the discussion should also touch upon how actors, networks and institutions can act as barriers'. This sentence is meant to illustrate how an assumed positive factor might also act as a barrier under different circumstances. Thus, as a researcher, one should consider that something that is assumed to be a promoting factor for new path development, e.g., the presence of multi-national corporations (MNCs) or funding, like the SFI scheme, under different circumstances, might act as a barrier. Different RIS types and different types of industries, e.g., an incumbent industry or a relatively new industry, might influence whether these examples are promoting or hindering new path development.

Although not sufficiently addressed in Article 4, oil- and gas-related MNCs in the region seem to focus primarily on business as usual, acting as a potential barrier for moving the strong oil and gas industry beyond path extension. In Article 2, we focus on the processing industry. This industry is also strong, and it is embedded in the same region as the oil and gas industry from Article 4. However, in this industry, the MNCs are a contributing factor for restructuring (referred to as path modernisation). Thus, we have two strong industries in the same RIS in which MNCs are acting as both hampering and promoting actors for new path development. This example illustrates how important it is to acknowledge that barriers can take different forms based on circumstances (such as type of industry and regional context).

4.4 Policy lessons

In addition to empirical and theoretical contributions, the thesis also aims to contribute to policy. Through the four articles, different policy lessons are discussed. In addition to the individual contributions, some overarching connections exist that should be addressed further. Viewed together, the four

articles demonstrate how policy should focus on both system-level changes and firm-level innovation capabilities.

Article 1 discusses how future policy should put a stronger emphasis on linkages between internal firm characteristics and RIS to contribute to the firms' absorptive capacity for developing cross-industry innovation. Many of the policy instruments or support schemes and funds that firms can apply for today are focussed on R&D collaboration, networking, etc., in one specific sector. This means that it might be difficult to secure support for cross-industry innovation activities. Thus, if policy combines the knowledge on CIIC and how to link firms to extra-regional knowledge sources in especially thick and specialised RISs (Isaksen & Trippl, 2016), the potential to move beyond path extension is greater.

Articles 2 and 3 are not as explicit in terms of policy lessons, but they both illustrate that we should have an awareness of FLAs and SLAs' roles in restructuring processes (Article 2) and for new path development in general (Article 3). Article 2 demonstrates that different policy approaches will be needed in different EDP phases, while the cases in Article 3 demonstrate that the establishment of new knowledge and diffusion organisations is a significant RIS change that should be focussed on in studies of EDP, and which varies between regions. Thus, actors in thin RISs and thick and specialised RISs should be aware of policy instruments that might help with the introduction of or changes in such organisations.

This also ties into Article 4 and policy lessons that can be drawn from this case. The SFI OM is a new knowledge organisation that holds the potential of contributing to RIS changes and new path development. However, what should be addressed in terms of policy is how such an organisation contributes in different ways, depending on the context in which it is embedded, as well as its composition. The article's empirics illustrate particularly how the composition of such a centre might create different challenges and possibilities that, to a larger degree, should be addressed by such policy schemes' creators.

4.5 Future research

The thesis addresses gaps in extant literature on the differing role of actors in changing the regional innovation system to further support new regional industrial path development. Although the four articles suggest future research that hopefully will corroborate, as well as expand on, the contributions in this thesis, some overarching topics also should be mentioned.

First, the CIIC concept should be developed further, both theoretically and empirically, to better understand the micro-level of change processes. This can involve adding more cross-industry innovation indicators (if needed) and further measuring how both small and large firms in different regional contexts score on the indicators. Methodologically, research on firms' cross-industry capabilities will benefit from survey data based on the CIIC concept. This will enable larger quantitative studies and, thus, wider comparisons between different regional contexts, perhaps providing insight on the relationship between CIIC in firms and regional industrial renewal.

Second, the interaction between firm-level and system-level actors, and its importance in processes of new path development, should be researched further. This can be done by conducting more studies on how the regional context influences this interaction. It can also be done by bettering our understanding of entrepreneurial discovery processes by including cases that are not cluster projects.

Third, more research on how to break down or lower barriers to new regional industrial path development in different regional contexts should be conducted. In addition to the already described barriers, the path development literature can also be used to explain barriers. Besides the concept of path exhaustion, most path literature only describes positive path development. Recent contributions to the path literature, however, argues that not all types of path development are positive, and introduces three trajectories of decline: path downgrading, path contraction and path delocalisation (Blažek, Květoň, Baumgartinger-Seiringer, & Trippl, 2019). Blažek et al. (2019) further argue that different regions have different capacity for softening the effects of these declining paths differing

capacities for redeploying assets in new ways for new path development. Thus, it would be interesting if future research focuses to a larger degree on how FLAs and SLAs can contribute, e.g., by revitalising declining paths, as well as destabilising paths more strategically.

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6 Articles in full

Article 1: Developing cross-industry innovation capability: regional drivers and indicators within firms

Article 2: Towards a more sustainable process industry: A single case study of restructuring within the Eyde process industry cluster

Article 3: Differentiated regional entrepreneurial discovery processes. A conceptual discussion and empirical illustration from three emergent clusters

Article 4: Breaking barriers for new regional industrial path development: The role of a centre for research-based innovation

Breaking barriers for new regional industrial path development:

The role of a centre for research-based innovation

Abstract

How regional industries can develop in an economically sustainable way is high on the research agenda. While the literature on regional change focuses mostly on historical case studies, it says less about the barriers against arriving at the desired change. This article aims to contribute to a better understanding of barriers in the regional innovation system that hamper new regional industrial path development. Further, the paper analyses how a new knowledge organisation, the Centre for Research-based Innovation Offshore Mechatronics in the Agder region in Norway, can contribute to breaking down these barriers. The centre, which is a policy program funded by the Research Council of Norway, aimed to contribute to path extension or potentially path modernisation. However, since the time of its initiation, oil prices dropped severely, resulting in new conditions for the centre and its partners. The article concludes by discussing whether and how the centre has contributed to breaking down the barriers against moving beyond path extension.

Keywords: Regional restructuring, barriers, regional innovation system

1. Introduction

All regions have a constant need for industrial renewal, and this becomes more evident in times of globalisation and digitalisation (Frangenheim, Trippl, and Chlebna 2018). Evolutionary economic geography is a strand of literature occupied with explaining the development of new regional industrial paths. However, in recent years, shortcomings in the established literature have been observed due, amongst other factors, to their neglect of multi-actor approaches, multi-scalar perspectives, the integration of expectations and vision and intra-path relations (Hassink, Isaksen, and Trippl 2019). Other scholars have focused on such aspects as key conditions and reinforcing mechanisms for path development as well as barriers for the materialisation of these conditions, which had previously received less attention (Steen and Hansen 2018). These shortcomings represent a multitude of additional factors that might explain the lack of development of new industrial paths. Although not encompassing all perspectives, much of the recent literature can be structured into aspects of the regional innovation system addressing actors, networks and institutions. By implication, when discussing what might contribute to new industrial path development, the discussion should also touch upon how actors, networks and institutions can act as barriers, which has received less attention in the literature. Thus, this article poses the theoretical research question: What are the barriers in different parts of the regional innovation system for new industrial path development? And what are potential ways of lowering or breaking these barriers?

Barriers are often discussed in the sense of factors hindering innovation that have been acknowledged in retrospect. It is not possible to say in advance whether innovations would have occurred in specific situations had there not been barriers. However, based on the literature, barriers facing new industrial path development in the regional innovation system

have been identified, along with potential strategies to break them down. An example of a barrier is what Grabher (1993) refers to as cognitive lock-in, when actors in the regional innovation system cling to old knowledge and ways of thinking. Such a barrier can potentially be lowered by the supply of new knowledge through changes in existing knowledge organisations or the establishment of new knowledge organisations. Thus, the article focuses on how a new knowledge organisation in the regional innovation system may contribute to breaking down barriers for new path development.

The empirical case in this article is the new knowledge organisation, the 'Centre for Research-based Innovation Offshore Mechatronics' (SFI OM), which is tied to the oil and gas industry in the Agder region of southern Norway. The region can be categorised as a specialised RIS with a strong history of sub-contractors to the oil and gas industry. According to Herstad and Sandven (2017), there has been continued growth in the collaboration between local research partners and industry in this region. However, this collaboration and innovation has tended over the same period to become more specialised, due to the dominance of industry partners from oil and gas. Thus, the Agder region is in danger of becoming over-specialised. Their advice is to strengthen the RIS by broadening the technology and sector scope (Herstad and Sandven 2017)

The SFI scheme is a policy instrument funded by the Research Council of Norway (RCN). There are currently 23 SFIs distributed throughout the country. The scheme aims to stimulate innovation capability and internationalisation among Norwegian businesses through long-term research in collaboration between research active firms and excellent research milieus. When the partners submitted the SFI OM application to the RCN, the oil and gas industry was at its peak. However, after the application was granted, oil prices dropped, leading to substantial lay-offs and decreasing turnover in oil supplier firms in Agder. This offers the opportunity to study how these changing external conditions affect an SFI heavily involved in

the oil and gas industry. The promotion of an already strong industry through policy initiatives is in line with arguments in favour of building on regions' unique capacities. However, scholars are starting to recommend that a strategy of only maintaining existing specialisations in a region is not sufficient for long-term competitiveness (Asheim, Boschma, and Cooke 2011; Isaksen et al. 2019).

With the SFI's initial aim of strengthening the already strong oil and gas industry in the region, the most likely outcome of the activities would arguably have been *path extension*, where incremental innovation only leads to a continuation of the already existing industrial path (Isaksen, Tödtling, and Trippl 2018), or in a best-case scenario to *path modernisation*, industrial renewal through major changes based on new technologies or organisational innovations (Isaksen, Tödtling, and Trippl 2018). The literature on new industrial path development acknowledges that development is not only a result of exogenous shocks, but rather based on several regional factors such as resources and competences (Martin 2010). In this context, the SFI OM case serves as a good example to study to what extent, and in what ways a new knowledge organisation can contribute to breaking down barriers in the way of new regional industrial path development. The argument is that the downturn in the oil and gas industry might have altered the SFIs original focus on strengthening the existing, leading industry in the region and promoted more diversified thinking. The outcome of the SFI is intended to be generic knowledge and technology and could be applied in other sectors, which means the centre has the potential to contribute to new industrial path development. Thus, the empirical research question is: What are the barriers in the organisationally thick and specialised region of Agder facing new industrial path development, and how has the SFI OM contributed to breaking down these barriers?

The next section introduces the theoretical building blocks that lay the foundation for the analytical model that follows. Then the context and methods of the study are discussed before

continuing with the empirical findings. The final section of the article presents its conclusions including a discussion on the implications of the study and prospects for future research.

2. Theoretical framework

This section elaborates on such central theoretical concepts as regional innovation systems, path development and barriers in the regional innovation system confronting new regional industrial path development. Later in this section, the article will address how a new knowledge organisation might contribute to breaking down these barriers.

2.1. Regional innovation systems

The oil and gas industry and the SFI OM operate in a regional context and is thus part of a regional innovation system (RIS). A RIS consists of three main components, which are the actors, networks and institutions (Asheim, Isaksen, and Trippl 2019). The RIS literature argues that innovation does not occur in isolation but is dependent on interactive learning that takes place between actors in subsystems (Asheim, Isaksen, and Trippl 2019). Thus, if the RIS functions less effectively, for example by having insufficient knowledge flow and interactive learning among its actors, it may serve as a factor that hampers new regional industrial development. This reflects some of the system failures conceptualised by Woolthuis, Lankhuizen, and Gilsing (2005).

All RISs are not alike, as shown by the typology from Isaksen and Trippl (2014) that distinguishes organisationally thick and diversified RIS, organisationally thick and specialised RIS, and thin RIS. The first category can be identified from its relatively large number of different industries and its multiple R&D institutions and support organisations. The second type is marked by its specialised industry structure accompanied by a narrow support structure. The third RIS shows less developed forms of both R&D and industry structure. The Agder region is characterised as organisationally thick and specialised due to its dependence

on the oil and gas industry and the robust support structure promoting this industry, which for example contains industry clusters, a centre for research-based innovation and a mechatronics innovation lab. The increased specialisation is evident in a report from Herstad and Sandven (2017) as they explore how Norwegian RIS configurations have evolved from 2004–2012. Regarding the Agder region, they highlight that 'innovation activity in general and local research system collaboration, in particular, has become more specialised, that is, more dominated by a limited number of industries that presumably are strongly dependent on growth impulses from the Oil & Gas industry' (Herstad and Sandven 2017, 49).

2.2. Path development

The concept of RIS has often been criticised for being too static. However, the path development literature has contributed to the understanding of dynamism and change within a RIS. The concept of path development is a key concept in evolutionary economic geography and states that future industrial development is dependent on history (Martin and Sunley 2006). Further, from this perspective, insights to how the new regional industrial paths emerge are explored in works discussing paths as a process (Martin 2010; Martin and Sunley 2006), in works on related and unrelated variety (Boschma and Frenken 2011; Fagerberg 2005; Frenken, Van Oort, and Verburg 2007), as well as in some of the literature on RIS (Asheim and Gertler 2005; Isaksen 2014).

As with the explanatory factors behind new regional industrial path development, the terminology used for describing the different paths also varies. This paper follows a strand of literature that uses new path development as a general term covering different typologies of regional industrial paths (Isaksen and Trippl, 2014; Isaksen, Tödtling, and Trippl 2018). Isaksen, Tödtling, and Trippl (2018), build on previous work by the same authors (Isaksen 2014; Tödtling and Trippl 2013) as they describe five main types of regional industrial path development and their distinguishing mechanisms. The first type is *path extension*, which can

be described as 'business as usual' where there is a continuation of the existing path. The other four types describe new path development. While the mechanisms defining *path modernisation* describe a form of renewal, the three remaining types – *path branching, path importation* and *path creation* – are recognised from their mechanisms as promoting new regional industries. As noted, this article focuses on an organisationally thick and specialised region. Because this type of region is lacking 'internal diversity of industries, knowledge bases, supporting organizations and institutional forms that is seen as critically important for developing new regional industrial paths' (Asheim, Isaksen, and Trippl 2019), they most often promote path extension or modernisation. One example would be the difficulty of having too much specialised knowledge within the RIS, leaving little room innovation through the connection of unrelated knowledge. Thus, the focus is on how a new knowledge organisation in a thick and specialised RIS might contribute to moving beyond path extension and modernisation.

2.3. Barriers in organisationally thick and specialised RIS

Stable RISs, such as the specialised RIS in the Agder region, are more likely to be geared to generate incremental innovation and to be less adaptable to radical innovation (Boschma et al. 2017). The barriers faced by industrial renewal have been discussed from different perspectives for many years, e.g. in the literature on lock-in and system failure (Grabher 1993), innovation system failures (Chaminade et al. 2009; Woolthuis, Lankhuizen, and Gilsing 2005) and transformation failure (Grillitsch and Trippl 2016; Weber and Rohracher 2012). The barriers tied to these concepts are usually more focused on issues in the system itself, while the individual actors are paid less attention. However, in their article on regional industrial restructuring, Isaksen et al. (2019) discuss the role of a firm or organisational agency as well as what they call system agency. Although important, this article follows the

argument of Grillitsch and Trippl (2016) who discuss barriers against restructuring regarding both actors, networks and institutions in the RIS.

2.3.1 Actors

When it comes to the actor-level barriers new path development may face, the actors in RISs might lack the resources, knowledge, competencies or ability required to create new knowledge (Chaminade et al. 2009; Woolthuis, Lankhuizen, and Gilsing 2005). In thick and specialised RISs, the actors' knowledge tends to be very specialised, which might lead to challenges when adaptation to new technologies becomes essential, for example. Even though knowledge might be created within the RIS, Asheim, Isaksen, and Trippl (2019) argue that for thick and specialised RISs, the existing knowledge base is not enough to move the system beyond path extension or modernisation. These RISs have deep knowledge that is limited to a few domains, thus creating a need for non-local linkages to inject new or complementary knowledge (Trippl, Grillitsch, and Isaksen 2018). The success of this injection depends on the absorptive capacity in the RIS (Cohen and Levinthal 1990), which may be weak in a thick and specialised RIS (Trippl, Grillitsch, and Isaksen 2018).

Recent literature has defined actors who can contribute to changing RIS in terms of firm-level entrepreneurs and agency, and system-level entrepreneurs and agency (Isaksen et al. 2019; Isaksen et al. 2018; Kyllingstad and Rypestøl 2018). Firm-level agency relates to how actors start new organisations or initiate new activities in existing ones; in either case these innovations might lead to changes in the RIS and possibly new growth paths (Isaksen et al. 2019; Isaksen et al. 2018; Kyllingstad and Rypestøl 2018). System-level agency on the other hand 'is based on actions or interventions able to transform regional innovation systems to better support growing industries and economic restructuring' (Isaksen et al. 2019, 5). Although the barriers are related to knowledge at the level of the firm, both firm- and system-level agency can contribute to breaking them down.

Given the barriers mentioned above, there is a potential for a new or altered knowledge organisation to break down these barriers at the firm level in thick and specialised RIS. A new knowledge organisation can introduce new knowledge into the RIS either by developing it themselves, combining it with knowledge held by already existing actors or introducing non-local linkages and novelty from the outside. The combination and development of new knowledge might, in turn, contribute to increasing the capacity of industries to move beyond path extension and modernisation. The potential for new regional industrial path development may also be higher if the new knowledge organisation can offer support for the restructuring of the regional economy, consequently acting as a system-level entrepreneur.

2.3.2. Networks

In a RIS, several relationships or networks connect the different organisations within the system. Characteristics of these relationships – such as too much or too little interaction – can create interaction failures (Woolthuis, Lankhuizen, and Gilsing 2005). In an organisationally thick and specialised RIS, the industrial base is narrow, and knowledge and support organisations are tailored to this base (Asheim, Isaksen, and Trippl 2019). Such an environment creates strong interdependencies and connectedness, which signal the potential for a strong network failure where the infusion of new knowledge from outside the network is limited. This low capacity to receive new and relevant knowledge is also referred to as functional lock-in (Grabher 1993). As a way of breaking down the barriers facing networks, a new knowledge organisation may contribute to opening the network up to knowledge flow from both internal and external actors. Establishing such new knowledge links does not automatically make the knowledge useful. A thick and specialised RIS needs external links, but typically holds barriers against extra-regional knowledge linkages within the system. For example, the capacity of thick and specialised RIS to *attract* talented individuals or innovative organisations tends to be rather low (Trippl, Grillitsch, and Isaksen 2018).

2.3.3. Institutions

The institutional setting in which a RIS is embedded includes both formal and informal institutions, often referred to as the 'rules of the game' (North 1991).

Formal institutions

Traditionally, the promotion of already existing industries has been a common approach by which policymakers offer support to regions (Porter 1998). This orientation can also be found in the innovation policy literature, where path dependency has been attributed to policy lock-in and risk-averse policymakers (Nauwelaers 2011). In turn, such an approach makes it difficult to adapt to new challenges, such as the oil and gas crisis. The literature on institutional failures and political lock-in also expresses challenges arising from inadequate policy (Woolthuis, Lankhuizen, Gilsing 2005) or complications that follow from having policy strongly tied to the existing industry (Grabher 1993). Recently, however, there has been a shift in this understanding, recognising that the maintenance of leading industries in a region is not sufficient to ensure long-term competitiveness (Asheim, Boschma, and Cooke 2011; Isaksen et al. 2019). This, in turn, has led to such changes in innovation policy as smart specialisation, with an increased focus on industrial diversification within policy development (Foray 2014).

Informal institutions

Barriers regarding informal institutions can relate to norms, values, culture and low levels of trust on the regional level that hamper innovation. Problems with these institutions can lead to institutional failures (Woolthuis, Lankhuizen, and Gilsing 2005). One example would be a lack of mutual trust that inhibits knowledge flow between actors in the RIS. Informal institutions can also promote cognitive lock-in among economic actors (Isaksen 2018). In general, this discussion addresses a general perception that RIS literature has underplayed the

role of actors. Isaksen (2018) conceptualise actors' behaviour using as a framework the concept of conventions 'that are implicit rules of what to do in specific situations' (Isaksen 2018, 5). In thick and specialised RISs, conventions might be built at the individual level to support the existing modus operandi. This is because thick and specialised RISs tend to be dominated by the conventions within their leading industries.

Another aspect of informal institutions is the notion of directionality failure. According to Weber and Rohracher (2012), the conventional system failure arguments, while valid, are somewhat restrictive and incomplete. They argue that long-term transformative change requires collective priority setting which in turn requires strategic policy. Setting a particular direction entails not only trying to generate innovations as efficiently as possible, but also responding to such external factors as major identified societal challenges (Weber and Rohracher 2012), e.g. the pressure for industry to become more environmentally sustainable. To deal with directionality failure, actors must first understand external requirements, then interpret them and orientate all actors in the system towards these challenges. Further, under specific circumstances, alignment can be promoted by establishing shared future visions (Weber and Rohracher 2012). This may be a challenging task, made even more challenging when the incumbent industry must alter its vision in the direction of long-term transformative change.

A new or altered knowledge organisation can potentially break down barriers relating to both formal and informal institutions. This knowledge organisation might, for example, lobby with policymakers to promote new priority industries. As for informal institutions, the knowledge organisation would have to create an understanding of, and a focus on, the new opportunities and visions they see for the region. A new perspective on the industry and how it can evolve might contribute to changing the existing conventions that have developed over time (Isaksen 2018).

2.4. Analytical framework

The analytical framework set out in Table 1 draws on the theoretical concepts discussed above. The proposed model sets out both the typical barriers new regional industrial path development may face and the potentials a new or altered knowledge organisation may have to break them down. As mentioned, a thick and specialised RIS is the focus of this case study; therefore, the analytical framework is targeted for this type of RIS. On the actor level, barriers are tied to the lack of new knowledge. Meanwhile, on the network level the barriers are connected to networks being too strong, while the institutional level discusses how both formal and informal intuitions might be hampering new industrial path development.

Table 1. Analytical framework

	Barriers facing new industrial path development in thick and specialised RIS	**Potential of a new/altered knowledge organisation to break down barriers in thick and specialised RIS**
Firm-level actors	Lack of knowledge, competence and ability to create new knowledge due to highly specialised knowledge and skills already possessed.	Development and combination of new knowledge for the region.
Network	Networks between known or existing actors are too strong.	Opening networks for new knowledge to flow from new internal and external actors.

Institutions	Institutional rigidity Formal – policy supporting path extension Informal – hampering norms, values, culture, low trust. Conventions that support existing industries and lack of shared vision towards transition.	Institutional flexibility Formal – lobbying for new policy Informal – focus on new opportunities and create a shared vision for taking the industry in new directions.

3. Context and method

The empirical part of the article contains a case study, which includes both a subject and an object of analysis (Thomas 2017). The subject of the case is the centre for research-based innovation (SFI OM), while the object of analysis is the ability of the SFI OM to break down barriers in the Agder RIS and support new industrial path development. Thus, the context that needs further elaboration is the RIS in Agder and the SFI OM.

The Agder region has approximately 300,000 inhabitants and lies in the southernmost part of Norway. The core of the region is often referred to as the 'drilling bay' due to the number of firms connected to the drilling division of the oil and gas industry. In 2014, 17% of the employed labour force in the western part of the region, and 10% in the eastern part, were connected to the oil and gas industry (Blomgren et al. 2015). The industry has been strengthened through the establishment of an industry cluster in 2006, which has now reached global centre of expertise[1] status (GCE Node) and consists of 100 firms connected to the industry. In addition, the region has an innovation lab, university study programmes and a centre for research-based innovation (SFI) tied to the field of mechatronics, thus strengthening the already existing industry.

Centres for Research-based Innovation (SFI) is a policy instrument from the Research Council of Norway (RCN), where each centre receives funding for five years (with a three-year extension contingent on an evaluation). The overall aim of an SFI is to stimulate the innovation capability and internationalisation of Norwegian businesses while also contributing to enhanced quality and efficiency in the public sector. The centre is intended to stimulate innovation through long-term research collaboration between research-intensive firms and the creation of excellent research environments. The funding for each centre is a joint responsibility between the Research Council of Norway (RCN), the host institution and various partners, with the RCN contributing 50%. The host institution may contribute in the form of infrastructure, equipment, personnel or strategic funding, while industrial partners may contribute with budgetary funding or in-kind contributions. In total, the budget for each year is approximately 20–30 million NOK or 2.2–3.4 million USD.

The SFI for offshore mechatronics (SFI OM) is a consortium of seven research institutes and higher education institutions, twelve manufacturing companies and one cluster administration, where eleven of these actors are from the region. The centre was established in 2015 and supports the already strong support service industry for the oil and gas sector in the Agder region. At the end of 2017, there were twenty-two PhDs and two post-doctoral researchers in the centre. Their goal is to work towards autonomous offshore operations and ultimately a fully automated oil and gas platform. In addition, they aim to contribute significantly to growth and innovation in the industry, creating jobs and businesses within the target sector and beyond. According to the RNC, ‘patience is required’ because the required innovations may be 7–10 years away. Thus, at this time, it will be difficult to discuss anything other than the potential for new regional industrial path development.

The data employed in this paper was collected through document studies and two rounds of interviews with SFI OM members. The document study collected readily available

information about the SFI OM and mid-term self-evaluations from members and from the management of the centre. The first round of interviews was conducted in 2015 and consisted of fifteen semi-structured interviews lasting between 30–90 minutes. At that time, the rationale behind choosing interviewees was to include both regional and extra-regional partners as well as partners from academia and research and also from industry. The second round of interviews was conducted in 2019. To increase the regional focus, this round of interviews consisted of nine semi-structured interviews with leaders in regional firms and research institutions. Thus, the interview results would help to evaluate whether, and how, the SFI OM is contributing to the reconfiguration of the RIS and a potential for new path development. These interviews lasted between 45–90 minutes and were recorded. To ensure anonymity, the article will only refer to the interviewees as industry partners or research partners.

4. Empirical analysis

Departing from the case studied, this article sets out to explore the barriers new path development may face at the actor, network and institutional levels in the Agder region, an organisationally thick and specialised RIS. In addition, the empirical analysis discusses how the SFI OM, as a new knowledge organisation, might contribute to breaking down these barriers.

4.1. Actors

In the Agder region, as with other thick and specialised RISs, a central challenge for new path development is the lack of diverse knowledge or competencies. This becomes especially crucial in times of crisis and external shocks when changes might be necessary to maintain employment in key regional industries. In 2015, the SFI OM application was granted by the RCN. At the same time, the oil price was halved from over 100 USD per barrel, and in less

than a year, the price dropped to under 30 USD per barrel. According to an informant, two of the largest employers in Agder had to dismiss over 3,000 engineers, and over 6,000 were dismissed in total among the partners in the SFI. This downturn in the industry can be characterised as the result of an external shock that would make new knowledge input more pertinent. The new knowledge organisation, SFI OM, is connected to and was established to support the oil and gas industry. They aim to *'contribute significantly to growth and innovation in the industry, creating jobs and business with potential both within the target sector, and beyond, such as maritime industry, with a net positive impact on society'*[2]. Thus, the centre intends to improve an already strong industry, as opposed to working towards new industrial path development. However, with the crisis affecting the partners on a large scale, the members could see this as an opportunity to move beyond 'simply' oil and gas.

According to the analytical framework set out above, a new or altered knowledge organisation might contribute to breaking down barriers hindering new industrial path development by developing or combining new knowledge for the region. The SFI OM is creating knowledge within the confines of the centre, meaning that other actors in the RIS will not have direct access to the knowledge developed. However, it can still be argued that the knowledge developed in the centre might contribute to new industrial path development. First, the members of the centre consist of the largest companies in the industry in Agder, as well as research institutes and higher education in the relevant fields. In addition, these large industry partners have a buyer–supplier relationship with several smaller regional firms in the industry. Thus, steps taken by these actors may hold the potential to affect key parts of the RIS. Secondly, as stated in the midway self-evaluation provided by the centre management: 'Since the centre has partners which operate and compete in the same business segment, it has been decided that the research in the centre should focus on core technology, software, methods and building blocks which the companies can develop further and integrate in their internal

R&D and product development processes'. Thus, the knowledge being generated is generic and may be more readily transferable and applicable in other industries.

According to informants from both industry and research milieus, there have been challenges regarding the development of new knowledge in the SFI OM. The knowledge developed has been mainly a result of research conducted by doctoral students and professors. When this knowledge is transferred to the industry partners that traditionally have depended heavily on experience-based competencies for their practice, the new knowledge is incomprehensibly complex for many, thus rendering the research useless for the industry. While some industrial partners would appreciate a more easily understood version of the research, the research partners would appreciate a higher competency level in the firms. This means that for a new or altered knowledge organisation to contribute to new path development, a certain level of absorptive capacity is required (Cohen and Levinthal 1990) in the regional firms, along with diffusion and translation capacity within the research institutes. Finding a balance of complexity and comprehensibility within the research programme has been challenging. One research informant discusses whether the findings of research should be simplified for the industry, stating: 'Perhaps we need that, or perhaps we need to raise the level of the firms when it comes to that. I am afraid that we want to be world-leading, with something complicated without having the competence or the will to do it.' At the same time, some industrial partners have their own understanding of the situation, suggesting that 'there are some [within the research milieus] who refuse to see that the research is supposed to be of value to the companies. There is a complete disconnect from reality'.

Although there are some challenges involved in developing knowledge, the SFI OM also serves the purpose suggested in the analytical framework, which is to create new knowledge

for the region. One way to achieve this goal is through the development of spin-off projects. This has been an important focus for the centre, as explained by one of the research partners: 'we have many spin-off projects. At this time, the spin-off projects have received the same amount of funding as the SFI itself. And many of these spin-offs are directed towards restructuring'. During the first five years, a total of ten direct spin-offs and three related parallel projects have emerged from the centre and its partners. According to the midway evaluation, one reason to create spin-offs is so that the industry partners can continue working with the generic technology in a confidential manner, which may also be achieved through a confidential Master's thesis. The knowledge spill-over happens in both formal spin-offs projects and directly with students working with assignments related to the SFI. The importance of these students is highlighted by one of the research partners in this way: 'I believe this is the best way to create innovation. That Master students, and especially PhD candidates, continue their work in a firm making it a smooth transition'. So far, the SFI is linked to ninety-four Bachelors' and Masters' theses from different universities. Even though many of the spin-offs are connected to the oil and gas industry, there have also been examples of spin-offs involving other industries. One example is collaboration with a new e-health centre at the university where methods developed in the SFI are applicable. Another example is the way the results from one of the spin-off projects contributed to one of the SFI OM partners becoming involved in a project working on the first-ever zero-emission, autonomous ship.

Another way the SFI OM can develop new knowledge for the region is to contribute to change in the forms of output expected from research partners. Specifically, the SFI OM has, in collaboration with a commercialisation partner, developed a tool called Research Impact Canvas. So far, this tool has been employed with all of the PhDs in one of the work packages.

The process has led to potential innovation ideas being discovered, which could potentially be commercialised by other partners outside the centre. The potential for innovations within the SFI is seen to be enormous, but so far most of its output has been publications and not innovations or patents. As a research partner explains, '1 % [of research] goes via patents and DOFI (Disclosure of inventions). I want to increase the number of patents and DOFI, but this deals with the culture and mentality. For a PhD candidate, a patent process can easily take two years, but he or she needs to publish to receive a PhD'. The SFI OM has acted to change this mentality by presenting everyone who hands in a DOFI at the centre's yearly conference with an award. This creates an awareness of the potential this research may have. Thus, the importance of breaking from old ideas should not be limited to new business models, but also includes new ways of using and viewing research.

According to informants representing both industry and research perspectives, the SFI OM has also contributed to the establishment of something more tangible, namely, the mechatronics innovation lab (MIL) in the region. The lab is a national centre for innovation, piloting and technology qualifications. Thus, it contributes to developing and combining new knowledge outside of the local oil and gas industry. One industry partner highlights the importance of the interaction between regional initiatives as opposed to viewing the significance of each independently: 'It is important to understand the limitations of the SFI. The SFI focuses on a specific theme that can lead to many interesting things. However, it is important to understand that the building blocks are not always big. Thus, the interaction between clusters, MIL, the SFI and future initiatives is the important bit'.

Based on the above-mentioned initiatives, the SFI OM shows how it may contribute to moving the region beyond path extension and modernisation. However, the potential for new path development is mainly dependent upon the SFI OM partners and knowledge spill-over among them, because regional actors outside of the SFI OM are largely denied access to 'SFI-

created knowledge'. If partners do not see the potential advantages of sharing knowledge outside the SFI-network, creating spin-off firms or creating new firms, the only access point for outsiders would be through what can be garnered from published articles.

4.2. Networks

As illustrated in the analytical framework discussed above, the barriers at the network level in organisationally thick and specialised RISs often consist in networks that are too strong, resulting in a lack of new knowledge input. While the knowledge exchange between the centre's industrial partners and research partners suffers from a lack of absorptive capacity, the knowledge exchange among the centres' industrial partners suffers from a different problem. In Norway, most SFIs usually have industrial partners representing different segments of the value chain. In the SFI OM, the largest and most significant regional partners are in direct competition with each other, and the focus of the SFI OM relates to their core competencies. This was well known when the application was written, and according to a research informant, this emphasis was also necessary to put sufficient weight behind the application. Although this risk was recognised, it has created more challenges than initially expected. As one industry informant stated, 'it is restraining having competitors. It requires awareness to rise above the competition'. Even though they are hesitant to share information in the SFI, the industry partners have a strong pre-existing network resulting from initiatives organised by the industry cluster. The analytical framework suggests that breaking down barriers would entail opening the network to the flow of new knowledge. On paper, the SFI delivers on this by having regional, national and international industry and research partners connected to the SFI. However, informants do not agree on the level of success achieved to date, when it comes to new relations and improved networks. Several informants state that few new relations or networks have been created in the SFI, with one research partner stating that he had not expected more network building, but he thought the SFI management might

have. On the other hand, one of the industry partners explains that, through the SFI, they have been connected to new people in firms they are already familiar with, thus creating a stronger bond to those firms. This might not contribute to breaking down the barrier represented by 'too strong' networks. However, the same person explained how ties to a non-regional actor can create new potential, in this way: 'There is a big company, which is working on many different things, and we have, via this network, met with a different part of their company working on smart cities and such. So, there are these detours that have nothing to do with the SFI, but it makes you build connections with the people sitting there'. Another hurdle that can make opening the network more difficult is the lack of ownership some of the SFI personnel might have. One informant set out the problem that the personnel who decide how the firm should contribute to the SFI might not be the same ones who end up working in the SFI. Thus, the feeling of ownership of the SFI might not be as strong as one hoped.

As described in the theory section, attracting external knowledge links can also be difficult in a thick and specialised RIS. In the Agder region, the presence of MNCs has automatically created external links. However, according to Aslesen, Hydle, and Wallevik (2017), MNCs involvement in global innovation networks can both stimulate and hamper path renewal in thick and specialised RISs. They can stimulate interactive learning and 'loose coupling' of different units in order to combine knowledge. They can also inhibit these links, depending on the support they receive from their HQ to explore new knowledge combinations as well as their level of absorptive capacity (Aslesen, Hydle, and Wallevik 2017). Although the influence of MNCs is less of a focus in this article, they might play a role in why there has been less interest in creating new networks. Currently, it seems as though the SFI is not contributing to a large degree in breaking down potential barriers for new path development.

4.3. Institutions

4.3.1. Formal

In the Agder case, the industry has benefitted from several policy instruments that are committed to the oil and gas sector and contribute to strengthening it, such as the SFI OM, the MIL and the GCE Node, as well as study programmes at the University of Agder tailored to the industry. This can be seen as coordinating the industrial and the scientific partners but suggests, in turn, that a potential new path might struggle to find policy support. Even after experiencing the effects of the oil crisis, the SFI OM has not altered its focus in terms of either overall strategy or individual work packages. They appear to be concerned primarily about further developing the already strong industry and have not been lobbying for changes to promote the development of a new industrial path. According to the analytical framework presented here, the latter approach would be required to break down policy barriers that currently support path extension. Although lobbying for new policies is not the main priority of the SFI, one informant recognises the challenges the industry is facing and explains the potential need for new path development: 'Personally, I see the oil and gas industry struggling ahead. There will be a need for restructuring, and these are some of the region's largest employers so this can either become really painful or a slow transition. I see some firms that have started on this slow transition, but others will go down swinging'. If the SFI firms that are transitioning gradually are to experience the best conditions for success, SFI partners would have to re-orient their approach towards a policy that supports a more diverse industrial structure.

4.3.2. Informal

The barriers resulting from informal institutions in organisationally thick and specialised RIS involve conventions at the regional level, such as an inherent support for the existing industry. As noted above, the formal strategy was not altered after the crisis in the oil industry. Some informants have attributed this to the strategic orientation and thorough analysis conducted in the application process. According to an informant, the selected themes were forward-

thinking in that they relate to data and automation instead of specific technology or products. These themes contributed to making the work conducted in the SFI more generic and thus potentially applicable in other industries. However, the SFI has clearly not contributed to breaking down the barriers resulting from informal institutions, as industry partners show no interest to date in moving in new directions. For this to occur, more voices would have to speak up, such as the informant above reflecting on the future of the industry. The need for transition this informant expresses serves to highlight the need to discuss not only system failures but also transition failures such as directionality failure. Until various actors realise the need for larger changes and a long-term strategy based on new and shared visions, this directionality failure will persist.

5. Conclusion

This article aims to contribute to a better understanding of barriers to new regional industrial path development. In its contribution to theory, the article focuses on barriers on three levels of a thick and specialised RIS, namely actors, networks and institutions. By doing this, the article includes all aspects of RIS and is not limited to either systemic or actor-specific barriers. In addition, the article presents an analytical framework explaining these barriers and emphasising how a new knowledge organisation might contribute to lowering them. The literature is filled with articles on how industries and regions change (Asheim and Gertler 2005; Fagerberg 2005; Martin 2010; Martin and Sunley 2006), but there is less focus on the barriers to achieve desired changes. The inclusion of directionality failure (Weber and Rohracher 2012) as an informal barrier is pertinent in this case because the oil and gas industry is facing increased pressure to become more environmentally sustainable.

While most of the barriers identified in the analytical framework can be recognised in the case presented, not all ways of lowering the barriers are exhibited within this RIS. On the actor level, the SFI OM exhibits signs of breaking down barriers new regional industrial path

development would face, by creating new knowledge that is generic, thereby working around the barrier of knowledge being too specialised. Although the generic nature of this technology might be positive for future path development, working in an SFI with competitors is not without its challenges. Much time and effort has gone into building trust and sharing knowledge, and the need for absorptive capacity on both sides has proven important. Regarding networks, it seems the potential for the SFI OM to infuse the region with new knowledge through new intra- and extra-regional linkages is relatively high due to its composition, representing research and industry. However, in practice few new linkages have been created. As the industry incumbents in the RIS consist overwhelmingly of oil and gas service companies, both formal and informal institutions are rigged in favour of this industry, as described in the theoretical section. In practice, there has not been a clear effort to lobby for changes in policy nor to work towards changing informal institutions within the RIS. A few informants see the need for branching out of the sector, but currently this is only a thought.

The paper also contributes to a deeper understanding of SFIs as a policy tool. The composition of an SFI will create different possibilities in terms of its output and how the RIS might benefit. In SFIs where the complete value chain is represented, and there are no competitors, a concrete product might be the result. In such a case, knowledge from the centre might be difficult to share with other RIS actors outside that specific value chain. However, in SFIs such as the SFI OM, the knowledge created is generic. In these cases, the RCN could emphasise the importance of sharing knowledge outside of the centre, and perhaps stimulate this phenomenon. One of the informants in SFI OM explicitly stated that the processing industry in the Agder region could benefit from the knowledge developed in the SFI. However, this informant did not know of clear mechanisms for how this could be done.

Although this article examines an organisationally thick and specialised RIS, the barriers might be similar in thick and diversified RISs and thin RISs. In thick and diversified RISs

where a more diverse industry structure is evident, the barriers against developing or combining new knowledge might not be as high as in a specialised RIS. Thick and diversified RISs may also experience fewer struggles against networks that are too strong, due to their inherent diversity. In thinner RISs, the barriers regarding knowledge development and networks would depend even more on external input than in the case studied. Barriers at the institutional level, especially informal ones, might be harder to predict for the different types of RIS. Thus, future research should study barriers in both thick and diversified RIS and thin RIS to examine how a new knowledge organisation can contribute to breaking them down. In addition, the influence of MNCs should be examined further, building on the work conducted by Aslesen, Hydle, and Wallevik (2017). For policy purposes, research comparing SFIs with different compositions (e.g. competitors vs. value chain partners) could provide useful insights for continued work relating to SFIs and similar policy tools.

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[2] From the SFI Offshore Mechatronics web page