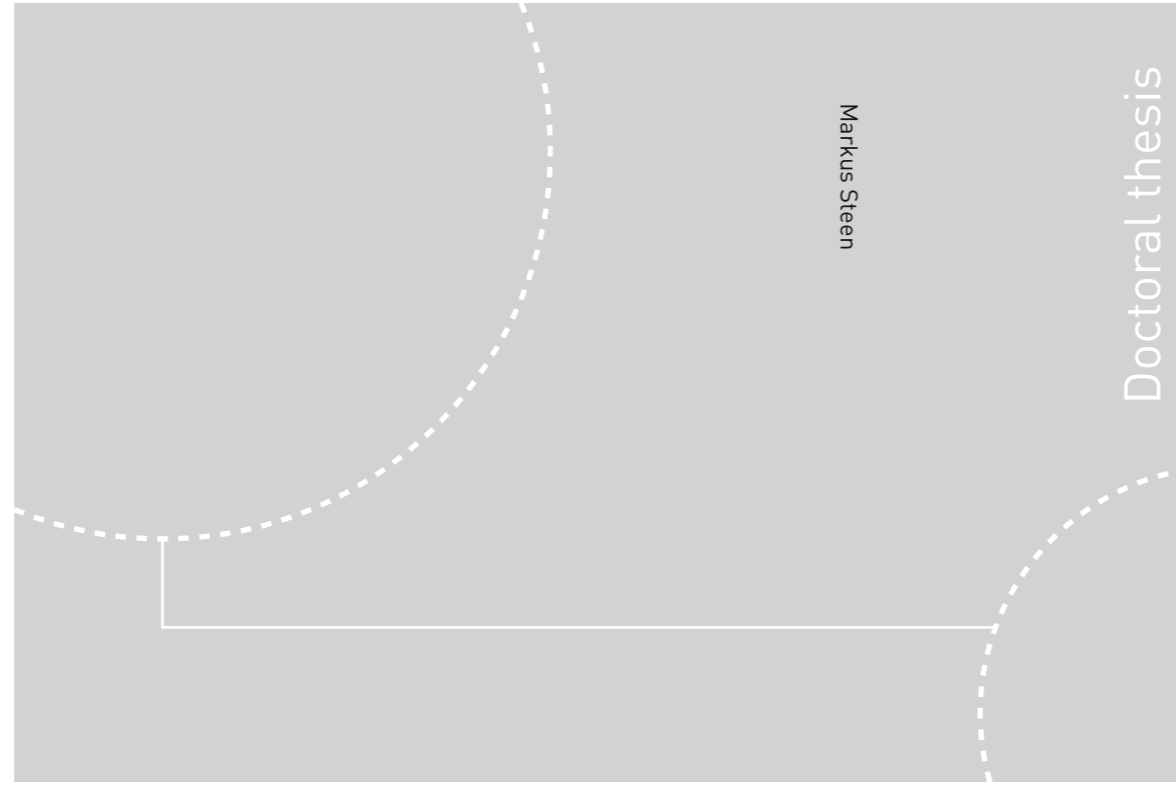


ISBN 978-82-326-1808-8 (printed ver.)
ISBN 978-82-326-1809-5 (electronic ver.)
ISSN 1503-8181



Doctoral theses at NTNU, 2016:235

Markus Steen

BECOMING THE NEXT ADVENTURE?

Exploring the complexities of path creation:
The case of offshore wind power in Norway

Doctoral theses at NTNU, 2016:235

NTNU
Norwegian University of
Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Social Sciences and
Technology Management
Department of Geography

 **NTNU**
Norwegian University of
Science and Technology

 **NTNU**
Norwegian University of
Science and Technology

 **NTNU**

Markus Steen

BECOMING THE NEXT ADVENTURE?

Exploring the complexities of path creation:
The case of offshore wind power in Norway

Thesis for the Degree of Philosophiae Doctor

Trondheim, September 2016

Norwegian University of Science and Technology
Faculty of Social Sciences and Technology Management
Department of Geography



Norwegian University of
Science and Technology

NTNU

Norwegian University of Science and Technology

Thesis for the Degree of Philosophiae Doctor

Faculty of Social Sciences and Technology Management
Department of Geography

© Markus Steen

ISBN 978-82-326-1808-8 (printed ver.)
ISBN 978-82-326-1809-5 (electronic ver.)
ISSN 1503-8181

Doctoral theses at NTNU, 2016:235

Printed by NTNU Grafisk senter

Abstract

The point of departure for this thesis is the path dependence/path creation debate in economic geography. This thesis explores complexities of path creation processes, focusing empirically on the development of an emerging offshore wind power (OWP) industry in Norway. The OWP industry can be seen as a distinct new industry - a new 'industrial development path' - albeit one with strong linkages to various established industry paths and – in Norway - the offshore oil and gas (O&G) industry in particular. In the first decade of the 2000s, OWP became framed as a potential new 'industrial adventure' in Norway. In analysing the development of this industry, the thesis revolves processes of technological change, innovation and transformation at the intersections of firm, industry and institutional dynamics.

The main aim of this thesis is to contribute to economic geography theorizing on path creation. Although the development of new industries is high on both research and political agendas across the globe, the actual emergence of novelty in many respects lacks explanation. A variety of theoretical concepts and debates inform the thesis. In particular, the thesis aims to contribute to evolutionary economic geography (EEG). As such, it questions some of EEGs theoretical underpinnings and provides both supplementary and alternative perspectives that are of particular relevance to understanding path creation processes, especially within sectors such as energy.

The thesis comprises a first introductory part and a second part made up of two published and two submitted (in review process) research articles. The introductory part outlines the theoretical and empirical background of the thesis, describes research approach and data, and presents overall conclusions and contributions. The research articles address four different themes relevant to path creation processes. The first theme concerns the issues of relatedness, related variety and knowledge spillovers. The article *Same Sea, Different Ponds: Cross-Sectorial Knowledge Spillovers in the North Sea* departs from a questioning of the notion of relatedness in EEG and analyses knowledge spillover processes between established industries (focusing on offshore oil and gas (O&G) and OWP. The second theme relates to the regional context of path creation. The article *Path creation in a single-industry town: The case of Verdal and Windcluster Mid-Norway* employs an open non-constraining perspective on path dependent evolution to analyse how the cluster initiative came about and was shaped by past trajectories as well as emerging opportunities. The third theme relates to the need for a broader perspective on path creation than the firm-centred explanations that dominate EEG. The article *Barriers to path creation: the case of offshore wind power in Norway* analyses the broader OWP path formation process in Norway, using a framework which focuses on key conditions (and barriers) to path creation. The fourth theme is more conceptual and relates to theoretical perspectives and methodological approaches for understanding the role of agency in path creation or industry emergence. The article *Reconsidering path creation in economic geography: aspects of agency, temporality and methods* argues that whilst it is well established that 'history matters' economic geographers have largely overlooked the generative power of expectations (i.e. anticipations concerning the future) on path creation processes, implying that also 'futures matter' for understanding the evolution of economic landscapes.

Acknowledgements

Just as entrepreneurs are not 'lone heroes' but dependent on (many) others for launching new businesses, so this thesis is not a product that I could have made without the help of a great many people. I do however – of course - take full responsibility for any mishaps, mistakes or omissions.

In particular, I wish to thank:

- Professor Asbjørn Karlsen at the Department of Geography for excellent supervision, patience and critical feedback throughout the process. Asbjørn - just as I have valued your support I have appreciated and enjoyed our research collaboration. Let's keep it going!
- Gard Hopsdal Hansen, who had just started doing his post doc when I started my PhD. We shared both theoretical and empirical interests and decided to collaborate on fieldwork, starting in the autumn of 2010, and the rest is (our) history. Gard – it's been (overall) a pleasure! B*****age, tech terrains... I look forward to it!
- Tyson Weaver, Jens Hanson and Håkon Normann at CenSES; I've learned a lot from you guys and appreciate all the great discussions++ I look forward to further establishing our emerging collaboration, and we must get ourselves back to Cham! A special thanks to Tyson for comments on article 1 and 4.
- A huge thanks goes to all informants and respondents who used of their valuable time to answer questions and complete surveys. Without your contributions this thesis would never have materialized. In particular I wish to thank Viggo Iversen in Proneo/Windcluster Mid-Norway.
- Colleagues at the Department of Geography at NTNU (2010-2014) for providing a supportive and friendly atmosphere in which to conduct demanding brainwork. A special thanks goes to Radmil, Bodil, Anette, Rita and Sunni for help with various practicalities.
- I also want to thank colleagues at SINTEF, where I have been employed since mid-2014, for discussions, helpful advice and heaps of encouragement (and understanding)!

Many others have provided comments to papers and presentations, and many more have served as helpful discussion partners on various topics relating to the project. A big thanks goes to:

- Paivi Oinas, Örjan Sjöberg and Erik Stam for early project feedback at the Turku School of Economics PhD course on "Firms and regions" in 2010.
- Michael Jones for helpful comments, and Catriona Turner for proof reading, on article 2.
- Phil Cooke for feedback at the geography doctoral course in Trondheim in 2011.
- Stuart Dawley and Danny MacKinnon for discussions on both theoretical and empirical issues. A special thanks for feedback on article 3.
- Robert Hassink for inviting me to Kiel for a two-week stay in 2013. A big thanks also goes to Xiaohui Hu for providing great company in the office there and the best cup of tea I've ever had!
- Ron Boschma and Gregor Kungl for constructive feedback on an early version of article 4 at the EU-spri conference at CIRLE/Lund in 2013.
- Arild Aspelund, Roger Sørheim and Tage Koed Madsen for feedback on article 3 at the CenSES writing workshop at Oppdal in 2014.
- Arne Isaksen and Britt Dale for extremely helpful comments at my 'final PhD seminar'.

- Bård Tommy Iversen and Kyrre Svarva (both at the IT section at the Faculty of Social Sciences and Technology Management at NTNU) for help with the survey, and Kyrre also for help with SPSS.
- The thesis was financed by a Faculty scholarship. I thank the Faculty of Social Sciences at NTNU for providing me the opportunity to pursue my research interests.
- CenSES (Centre for Sustainable Energy Studies) and centre director Asgeir Tomasgard –for letting me attend seminars and workshops and for indirectly funding parts of the empirical work. Thanks to people at CenSES for many interesting discussions – and thanks to Olav Wicken and Erling Holden (also CenSES management group) for helpful advice!

Lastly: Berit, Sigurd and Mari - you make my every day.

Markus Steen

San Francisco 28 March 2016

List of articles

This thesis includes the following four articles:

- I. Steen, M. and G. H. Hansen (2014). Same Sea, Different Ponds: Cross-Sectorial Knowledge Spillovers in the North Sea. *European Planning Studies* 22(10): 2030-2049.
- II. Steen, M. and A. Karlsen (2014). Path creation in a single-industry town: The case of Verdal and Windcluster Mid-Norway. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography* 68(2): 133-143.
- III. Steen, M. and G. H. Hansen (2015). Barriers to path creation: The case of offshore wind power in Norway. *Submitted to a journal, December 2015.*
- IV. Steen, M. (2015). Reconsidering path creation in economic geography: aspects of agency, temporality and methods. *Submitted to a journal, December 2015.*

Contents

| | |
|---|-----|
| Abstract | i |
| Acknowledgements | iii |
| List of articles..... | v |
| PART 1 | 1 |
| 1 Introduction..... | 3 |
| 1.1 Background and motivation | 3 |
| 1.2 Main aims | 4 |
| 1.3 Research objectives..... | 7 |
| 1.4 Structure of the thesis..... | 8 |
| 2 Empirical background..... | 11 |
| 2.1 Setting the scene: energy | 11 |
| 2.1.1 World energy supply and demand | 11 |
| 2.1.2 Developing new renewable energy..... | 12 |
| 2.2 Offshore wind power..... | 13 |
| 2.2.1 Why offshore wind power? | 14 |
| 2.2.2 Value chain, costs and challenges | 15 |
| 2.3 Norway - energy | 16 |
| 2.3.1 The Norwegian energy system (electricity)..... | 16 |
| 2.3.2 The Norwegian oil and gas industry | 17 |
| 2.3.3 Offshore wind power in Norway | 18 |
| 2.4 Summary of chapter | 19 |
| 3 Theoretical background..... | 21 |
| 3.1 Setting the scene: explaining industry emergence | 21 |
| 3.1.1 The place of the thesis in the economic geography field..... | 21 |
| 3.1.2 Innovation and technological change | 23 |
| 3.2 Path dependence – origins and debates | 24 |
| 3.2.1 Economic geography and path dependence..... | 25 |
| 3.2.2 Windows of locational opportunity and life cycle perspectives | 26 |
| 3.3 Towards 'open' perspectives on path evolution | 28 |
| 3.4 Path creation: context, mechanisms and agency..... | 32 |
| 3.5 Socio-technical (sustainability) transitions..... | 34 |
| 3.5.1 The MLP and TIS approaches..... | 35 |
| 3.5.2 The sociology of expectations | 37 |
| 3.6 Summary of chapter and reflections..... | 39 |
| 4 Research design and methodological reflections..... | 41 |

| | | |
|-------|--|-----|
| 4.1 | Researching path creation with a (primarily) qualitative approach..... | 41 |
| 4.1.1 | The case study approach..... | 42 |
| 4.1.2 | Employing mixed methods..... | 44 |
| 4.2 | The research process: data production and analysis..... | 45 |
| 4.2.1 | Interviews and (participatory) observation..... | 47 |
| 4.2.2 | Preparation and analysis of qualitative data..... | 48 |
| 4.2.3 | The online survey..... | 49 |
| 4.3 | Trustworthiness, positionality and reflections..... | 51 |
| 4.4 | Summary..... | 53 |
| 5 | Conclusions and outlook..... | 55 |
| 5.1 | Summary of main contributions and findings in the articles..... | 55 |
| 5.2 | Overall contributions..... | 56 |
| 5.3 | Directions for future research..... | 59 |
| | References part 1..... | 61 |
| | PART 2..... | 75 |
| | Article 1: Same Sea..... | 77 |
| | Article 2: Verdal..... | 99 |
| | Article 3: Barriers..... | 113 |
| | Article 4: Reconsidering..... | 141 |
| | Appendix A List of interviewed firms..... | 165 |

PART 1

1 Introduction

Over the last couple of decades, the idea that technologies, industries and regions follow path dependent trajectories has become somewhat of a theoretical cornerstone in economic geography. Path dependence theory, as developed within evolutionary economics and subsequently employed in economic geography and the wider social sciences, emphasizes continuity over change and is based on ideas of equilibrium and lock-in (Martin 2010). For economic geography research topics this, however, does not fit easily with empirical observations. Although often slow and constrained by the past, economies and/or industries do change, and are seldom in a state of equilibrium or 'lock-in' to a specific trajectory. Moreover, 'canonical' path dependence theory as associated in particular with the work of Arthur (1994) and David (1985) does not provide compelling explanations for how new paths emerge. More recently, path dependence theory has therefore been recast in more open 'path-as-process' approaches suggesting that path evolution is driven by competing stabilizing and disruptive forces (Martin and Sunley 2010; Strambach 2010; Simmie 2012). These perspectives suggest that there is a complex interplay between established and emerging technologies and industries – and the actors, activities and institutions linked to these.

This thesis explores complexities of path creation processes, focusing empirically on the development of an emerging offshore wind power (OWP) industry in Norway. The OWP industry can be seen as a distinct new industry (i.e. a new 'industrial development path'), albeit one with strong linkages to (various) established industry paths and – in Norway - the offshore oil and gas (O&G) industry in particular. The core issues that this thesis revolves around, then, are processes of technological change, innovation and transformation at the intersections of firm, industry and institutional dynamics. In the remainder of this introductory chapter, I specify my motivation for undertaking this particular research and present the necessary theoretical and empirical background to contextualize, frame and justify the main aims of the study and the research questions that the thesis answers. I also outline the structure of the thesis.

1.1 Background and motivation

When this PhD project began in the summer of 2010, my motivation for studying the emerging OWP industry was twofold. First, from a concerned citizen perspective, I wanted to study development and innovation processes in the energy sector in light of the grand challenge of shifting from fossil to non-fossil fuel sources. According to the IPCC (2014, 5), it is *"extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together."* The slow and difficult transition to low carbon economies is primarily a result of rigidity or – indeed - path dependence in energy systems (Lovio, Mickwitz, and Heiskanen 2011), yet there is beyond doubt a greening of energy systems underway (Mathews 2013). However, this does not imply a smooth transition, nor is the 'greening process' a steady one with non-fossil energy sources gradually replacing hydrocarbons, as indicated by the rapid rise of shale gas and oil as major fuel stocks in the US over the last decade (Qian, Acs, and Stough 2013). Moreover, places, regions and nations face different challenges and have different opportunities in meeting what is essentially a threat to modern civilization as we know it (Rockstrom et al. 2009). By 'meeting' I mean both how to transform current energy systems as well as to facilitate and develop (new) value creation around novel energy solutions.

Second, and linked to the above, I wanted to contribute to the burgeoning literature in economic geography dealing with 'green' industrial change and sustainability issues (Cooke 2010; Simmie 2012; Hansen and Coenen 2015). As such, I was interested in studying change in large-scale and complex industries such as those of the energy sector from an innovation perspective, here broadly understood as the introduction of new products and processes. My theoretical starting point was work in economic geography employing evolutionary perspectives on innovation, industrial change and territorial development, particularly ideas relating to the role of existing resources, assets and capabilities for the formation of new related sectors (Martin and Sunley 2006; Frenken and Boschma 2007).

The Norwegian OWP industry that began emerging around the turn of the millennium to a large extent involved diversifying firms from the established O&G and maritime industries (Volden et al. 2009), and thus appeared to fit well with this background theoretical interest. In 2009, the Minister of Petroleum and Energy (at the time Terje Riis-Johansen from the Centre Party, part of the Red-Green Coalition Government led by the Labour Party) referred to OWP as the 'next industrial adventure' in Norway, reflecting the large market opportunities seen at the end of the 2000s with strong market growth in Northern Europe. Installed energy production capacity in OWP increased by 51% from 2009 to 2010 (the year when the work on this thesis began) clearly illustrating the novelty and rapid growth of the sector (EWEA 2011). As larger OWP farms were developed further from shore in deeper waters, competence from the (offshore) O&G industry became increasingly relevant (Markard and Petersen 2009). This linkage between the emerging OWP sector and the established O&G industry allowed for exploring topics related to for instance knowledge and resource transfer between sectors through firm diversification and other mechanisms, issues that are seen to be at the core of path creation processes (Martin 2010).

I also found the empirical field interesting because the Norwegian OWP discourse in 2010 was (and still is) rather politicized. That is, the debates on what OWP could or should be in Norway (e.g. a way of producing renewable energy vs. an industrial (export) opportunity) tied in with discussions about domestic energy production, electrification of offshore O&G installations (to reduce domestic CO₂ emissions), the Norwegian debate on 'life after oil', and the role of Norway as a potential 'green battery'¹ for Europe. As evidenced and explained in this thesis, the Norwegian OWP has faced a substantial set of barriers, not least due to lack of state support for domestic market formation (Normann 2015). Nonetheless, OWP is one of six key priority areas in the national strategy for research, development, demonstration and commercialization of new energy technologies. This prioritization of OWP is based on the recognition of "*knowledge fields in which Norway has comparative advantage in future energy markets through natural resources, technology and knowledge base, and industrial experience*" (ENERGI21 2014, 5 (author's translation)).

1.2 Main aims

The main aim of this thesis is to contribute to economic geography theorizing on path creation, here understood as the emergence of new industrial development paths. Although the development of new industries is high on both research and political agendas across the globe, the actual emergence of novelty in many respects lacks explanation (Menzel and Fornahl 2010; Martin and Sunley 2010;

¹ The notion of 'green battery' refers to Norway's large hydropower production capacity, which could provide energy storage capacity in a European energy system with considerable shares of intermittent renewable energy sources (such as wind and solar energy) (Gullberg 2013).

Sæther, Isaksen, and Karlsen 2011; Binz, Truffer, and Coenen 2015). A reason for this could be that few contemporaneous studies of emerging industries have been conducted (Feldman and Lendel 2010). Emerging industries are challenging to study in part because aggregate data are missing. That is, relevant activities and processes are not labelled under one particular industry heading (Gustafsson et al. 2016) or within a specific industry category according to standard industrial classification schemes (Tanner 2014). Novelty is usually studied in hindsight, when the new is past and important actors, phenomenon and processes may be identified more easily. The emergence of OWP in Norway during the last decade or so, with a 'rise' in 2008-2010 (Normann 2015), provided the opportunity for a contemporary study of path creation (Binz, Truffer, and Coenen 2015). In this thesis I argue that contemporary accounts of path creation processes can contribute with new insights into key processes, mechanisms and contextual factors, but also poses methodological challenges.

Rather than presenting altogether alternative analytical frameworks, my ambition is to contribute to the development and refining of extant analytical perspectives and concepts through theory testing and theory building (George and Bennett 2005). These are in particular associated with what is commonly referred to as an evolutionary economic geography (EEG) perspective, and which centre on key notions such as relatedness and evolutionary branching (Boschma and Frenken 2011). Whilst this thesis focuses on firms and industry dynamics, the thesis goes beyond the firm-centred approaches typical in EEG by including non-firm actors and by paying more attention to institutional context. As such, and in attempting to make a contribution to the literature on path creation in economic geography, then, this thesis draws heavily on the work of Martin and Sunley (2006, 408), who argued that *"there is a need for a 'path as process' approach, wherein the process of economic evolution must be understood as an ongoing, neverending interplay of path dependence, path creation and path destruction that occurs as actors in different arenas reproduce, mindfully deviate from, and transform existing socio-economic-technological structures, socio-economic practices and development paths."*

Another theoretical aim of this thesis is to contribute to the economic geography literature on 'green' or sustainable energy technologies/sectors. In economic geography, the literature on green innovation and issues related to more sustainable economic systems is limited but rapidly growing (Cooke 2010; Bridge 2008; Patchell and Hayter 2013; Coenen and Truffer 2012; Truffer and Coenen 2012). The contributions that this thesis makes ties in with recent research by economic geographers, such as Simmie's analysis of path creation in the Danish wind sector (Simmie 2012), Fornahl and colleagues' work on the OWP sector in Northern Germany (Fornahl et al. 2012), Dawley and colleagues' analysis of regional path creation related to OWP in the UK (Dawley 2014; Dawley et al. 2015) and Martin and Coenen's (2014) analysis of the emergence of a biogas industry cluster in Sweden. Similarly to many of these contributions, the thesis draws on insights from the literature on socio-technical transitions, which sees transformative systemic (structural) change as a co-evolutionary process between institutions, markets, user practices, technological trajectories and industrial dynamics (Geels, Hekkert, and Jacobsson 2008). This body of literature complements economic geography perspectives in accounting for how new pathways can emerge in rigid and highly durable sectors such as energy (Simmie 2012).

The high-stake endeavour or grand challenge (Coenen, Hansen, and Rekers 2015) of realizing a 'green shift' from fossil to non-fossil energy sources merits attention from a wide range of academic

disciplines, so also economic geography (Patchell and Hayter 2013; Truffer and Coenen 2012). An ambition of this thesis is therefore also to make an empirical contribution in understanding the rapidly developing OWP sector. The sheer scale of the current plans for OWP farm development implies significant consequences related to energy development, job creation and innovation. The development of the Norwegian OWP industry has received limited attention, but some reports on industrial opportunities and challenges have been published (cf. Volden et al. 2009; NVE 2012). Njøs et al. (2013) analyses the relationship between firms and R&D actors in a OWP research centre (NORCOWE), whereas Normann (2015) analyses the development of OWP in Norway with a particular focus on policy development and framework conditions. Empirically, the thesis explores several issues that are highly relevant to both industry and policy, including resource transfer and relevancy of offshore O&G capabilities for OWP, firm innovation strategies and activities, and the suitability of incentives and policies for nurturing the creation of an OWP path in Norway.



Figure 1 Norway's only installed offshore wind power turbine: Hywind. Photo by Øyvind Hagen, Statoil

Regarding the empirical scope of the thesis, my primary object of study is the 'Norwegian OWP industry', which I see as an exemplar of an emerging renewable energy sector on a national scale. The choice of the national scale as the main empirical frame of analysis is due to the important role of the state and national level regulations and policies for path creation within highly regulated sectors such as energy (Buen 2006; Lewis and Wiser 2007; Bürer and Wüstenhagen 2009). It also has to do with Norway's unique feature being a large oil and gas producer and having an electricity system almost entirely based on hydropower, making this country very different from even its closest Nordic neighbours in terms of meeting the grand challenge of a 'green shift'. To some extent, this reflects variety in natural resources. On the other hand, theoretical perspectives such as national innovation systems (Lundvall 1992), 'competitive advantage of nations' (Porter 1990) and varieties of capitalism (Hall and Soskice 2004) all point to important differences between countries in terms of economic structures and institutions which condition opportunities for innovation, change and path creation.

Figure 1 depicts the floating Hywind offshore wind turbine (the floating foundation structure was developed by Statoil) which 7 years after it was installed in 2009 remains Norway's only OWP turbine – a situation which can largely be explained by lacking drivers (and thus lacking support) for

developing electric production capacity from OWP domestically (see section 2.3). This focus on the national scale however is not to relegate the relevance or importance of other spatial scales such as the regional (see for instance Dewald and Truffer 2012; Essletzbichler 2012; Hansen and Coenen 2015) to explaining particular socio-economic processes and outcomes such as the development of renewable energy production capacity and/or technologies. The thesis includes a separate case study on a regional level of analysis, and throughout the thesis I attempt to provide a multi-scalar contextualisation of the Norwegian OWP path creation process.

1.3 Research objectives

The main aims translate into a set of research objectives. On a general level, the objective of this thesis is to explore the key actors, resources and capabilities, processes and mechanisms involved in the OWP path creation process in Norway. The thesis is based on a mixed-methods (primarily qualitative) case study research design focusing on firms and industry dynamics. This, however, does not mean that the role of other actors (e.g. government, R&D, industry associations, business support agencies and other intermediaries) are neglected. On the contrary, an important issue in the thesis is the key role played by states and various public and quasi-public actors (on various governance levels) in stimulating, facilitating and/or supporting processes of innovation, technological development, industry network and market formation in emerging energy sectors. Non-firm actors are thus part of the case as well as important for understanding the context for path creation. As such, the thesis supports the view that research must move beyond the firm-centred accounts typical in EEG (Essletzbichler 2012; Dawley 2014; Binz, Truffer, and Coenen 2015). And in this sense, the case of OWP path creation in Norway is well suited to further develop economic geography explanations of how new paths are formed (or, conversely, hindered).

The four articles that constitute the core of this thesis focus on different themes. That is, they employ different theoretical concepts/frameworks and vary in their empirical focus, yet all relate to the topic of new industrial development paths. The first theme concerns the issues of relatedness, related variety and knowledge spillovers. The point of departure for this subtopic is that the core idea of 'related variety' (Boschma and Frenken 2011) from EEG, or the broader term of 'relatedness' (Cooke 2012), in my view lacks conceptual clarity. The thesis explores how various resources (knowledge, technology etc.) from offshore O&G and maritime sectors are (re)combined in the making of an OWP sector. It also opens up the 'black box of knowledge spillovers' in an attempt to shed light on what spillovers are made of and how they occur, and also analyses factors that enable or hinder cross-sectorial knowledge and resource transfer. This forms the core topic of article one, *Same Sea, Different Ponds: Cross-Sectorial Knowledge Spillovers in the North Sea* (Steen and Hansen 2014, published in *European Planning Studies*), hereafter referred to as A1/Same Sea. A1 addresses the following research questions: *What knowledge and other resources are transferred when firms from the mature O&G sector enter the emerging OWP sector, what variety does this contribute to in OWP, and what factors enable or hinder cross-sectorial knowledge spillovers?*

The second theme relates to the regional context of path creation. In article two, *Path creation in single-industry towns: The case of Verdal and Windcluster Mid-Norway* (Steen and Karlsen 2014, published in *Norwegian Journal of Geography*), hereafter referred to as A2/Verdal, focus is on the regional dimension of path creation processes. Single-industry regions are associated with a constraining context for new path creation, due to lack of diversity from which new recombinations can form (Isaksen 2014). More specifically, A2 analyses the initiative to create a regional wind energy

cluster with the historically single-industry town of Verdal in Mid-Norway constituting a node in this endeavour. The article addresses the following research questions: *First, what are the critical factors for transforming a single-industry town dominated by one very large company into the core of an emerging regional cluster within a different yet related industry? Second, what are the connections between the old path of offshore O&G and the new path of wind energy?* A2 traces the industrial history of Verdal back in time to identify critical events that led to changes in the local economic ecosystem and responses by both firms and non-firm actors to such events. Employing the concepts layering, conversion and recombination to analyse the dynamics of non-constraining path dependent development (Martin 2010), the article reveals how the cluster initiative can be seen as part of a process of shifting from a rather narrow path focused on offshore O&G (supplier industry) to a broader and more diversified industrial path including also offshore (and onshore) wind power.

The third theme relates to the need for a deeper understanding of the broader processes that shape path creation. Article three, *Barriers to path creation: the case of offshore wind power in Norway* (Steen & Hansen 2015, submitted to a journal), hereafter referred to as A3/Barriers, analyses the broader OWP path formation process in Norway. Similar to A2/Verdal, A3 expands on 'open' or 'hybrid' perspectives on path evolution (Martin and Sunley 2010; Simmie 2012). The article develops a framework for understanding path creation processes which focuses on key conditions and barriers, and pays particular attention to (shifting) institutional contexts, co-creation and interdependencies between established industries and the focal emerging industry. This framework is employed to analyse the development of Norway's OWP path from an initial enabling pre-formation and early path creation phase, to a more constrained context which led to a weakening of momentum of key reinforcing mechanisms. The overarching research question guiding the analysis in A3 is *what hindered path creation processes in the Norwegian OWP sector?*

The fourth theme is more conceptual and relates to theoretical perspectives and methodological approaches for understanding the role of agency in path creation or industry emergence. Article four, *Reconsidering path creation in economic geography: aspects of agency, temporality and methods* (Steen 2015, submitted to a journal), hereafter referred to as A4/Reconsidering, argues that whilst it is well established that 'history matters' (Martin and Sunley 2010), economic geographers have largely overlooked the generative power of expectations (i.e. anticipations concerning the future) on path creation processes. Put simply, A4 suggests that the future also matters, and that seeing human agency as inter-temporal (i.e. simultaneously past and future oriented) can increase our understanding of the micro-level determinants of path creation processes. This also has methodological implications, in short favouring qualitative over quantitative approaches for studying nascent phase industries. A brief and illustrative analysis explores the following research questions: *how are Norwegian offshore wind firms' strategies and activities linked to experience, current circumstance and expectations and how does expectations impact on path creation processes?*

1.4 Structure of the thesis

The thesis is comprised of two parts and is structured as follows. Part 1 has five sections (including this introduction) and elaborates on empirical/contextual, theoretical and methodological issues. I believe it is important to see theoretical frameworks and methodology in relation to the empirical context of the thesis. In the next section I therefore present and discuss the empirical background (or context) of the thesis. The third section provides the theoretical foundations of the thesis, and serves to contextualize and discuss relations between key concepts and theoretical frameworks employed

in the articles. In section four I describe and discuss the research design and methodological approach, whilst section four provides a summary, overall conclusions and considers their wider implications. Part 2 comprises the four articles described in section 1.3.

2 Empirical background

Development efforts in new renewable energy (NRE) technologies such as wind and solar are mounting world-wide as the world increasingly recognizes environmental and climate challenges on the one hand, and growing energy demand and security issues on the other (Wüstenhagen, Wolsink, and Bürer 2007; Mathews 2013). More recently, NREs and other 'cleantechs' have become increasingly associated with notions of 'green' (OECD 2009) and 'sustainable' (EC 2010) industrial development and economic growth (Bridge et al. 2013). However, the grand scale transformation to sustainable energy systems is a cumbersome, highly complex and lengthy process (Lovio, Mickwitz, and Heiskanen 2011). This chapter provides the empirical background for the thesis. It describes the current global energy system and particular challenges associated with development of renewable energy technologies, focusing on offshore wind power (OWP) and the Norwegian setting.

2.1 Setting the scene: energy

2.1.1 World energy supply and demand

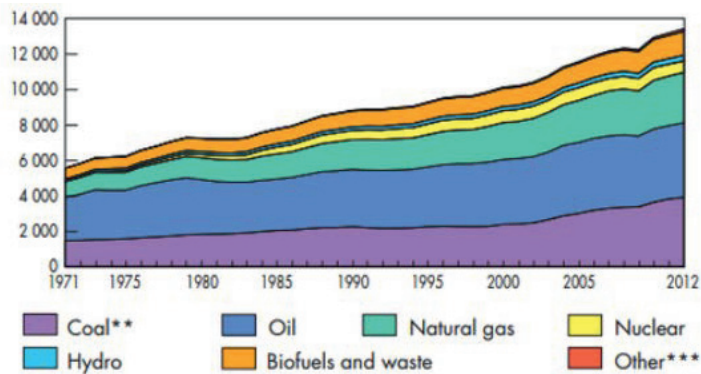


Figure 2 World total primary energy supply (TPES) from 1971 to 2012. Source: IEA 2014

In 1973, hydrocarbons (oil, natural gas and coal) provided 87 % of world total primary energy supply (TPES), which at the time amounted to approx. 6100 MTOE² (IEA 2014). The remaining 13 % of TPES was mainly provided by (traditional) biomass³, biofuels and waste. By 2012, world TPES had more than doubled to approx. 13300 MTOE (see Figure 2), and the share of hydrocarbons (combined) remained high at 82% (see Figure 3), implying a tremendous absolute growth in hydrocarbon consumption (especially driven by economic growth in the BRIC countries and other emerging economies).

² MTOE = Million tons of oil equivalents.

³ Traditional biomass refers to wood/charcoal/agricultural residues/animal dung used for cooking and heating in the residential sector. Supply is often unsustainable and conversion efficiency tends to be very low (10% - 20%). Traditional biomass remains a highly important source of energy especially in rural parts of the developing world.

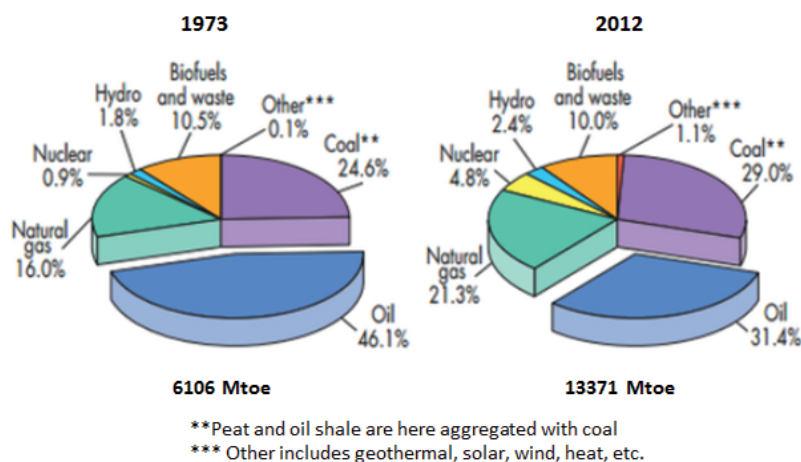


Figure 3 1973 and 2012 shares of TPES. Source: IEA 2014

By 2012, nuclear had also developed strongly, to provide almost 5% of TPES, whilst the share of hydropower had more than doubled to 2.4%, whereas biofuels and waste remained its relative share of approx. 10%. In 1973 NRE, by which I refer to renewables excluding hydro power and traditional bioenergy, provided a meagre 0.1% share of TPES. By 2012, the share of these energy sources in the global energy mix had increased to 1.1% of TPES, mainly in the form of onshore wind and solar. In other terms, no energy sources rival the relative growth in new renewables over the last four decades. That having said, it is fair to say that NRE sources currently play a very small role in world energy systems.

2.1.2 Developing new renewable energy

The debates on the future of energy systems are laden with expectations and visions associated with 'green' or 'sustainable' growth. However, NRE technologies such as offshore wind power (OWP) face several challenges that need to be overcome in order to compete with established energy technologies. Emerging NRE technologies deliver the same product (KWh) as mature technologies such as coal power, but to a higher price. It should be noted that global subsidies to fossil fuels are massive (IMF 2015), and from a sustainability perspective it may be argued that the problem is not that renewable energy is too expensive, but that fossil fuels are too cheap.

Environmental innovation nonetheless suffers from the 'double-externality problem', which refers to the situation that the innovation costs are born by the innovator, whilst the benefits are societal (Beise and Rennings 2005). Because NRE technologies have a cost disadvantage compared to existing technologies (Lund 2009), development and upscaling depends on various policy initiatives and instruments to stimulate technological development and innovation on the one hand, and market demand on the other. However, there are also *"huge uncertainties about the feasibility and reliability of renewable technologies for large-scale electricity supply as well as about which renewable technologies might prevail and be cost efficient"* (Frederiksen and Davies 2008, 493). Future markets and regulations are therefore fraught with uncertainties (Geels, Hekkert, and Jacobsson 2008), which is augmented by the inherent uncertainties associated with technological development itself. The diffusion of NRE technologies could furthermore be counteracted by incumbent actors in the established energy system, who have vested interests and could be prone to influence institutional

frameworks in order to ensure continued policies advantageous to them, and resist or counter innovations (Markard and Truffer 2006).

2.2 Offshore wind power

Rather than being the result of some radical innovation, OWP first emerged through incremental innovation in the onshore wind industry. Denmark pioneered OWP with the first offshore farm (Vindeby) in 1991. More precisely, this farm and the ones that followed were near-shore OWP farms developed in shallow waters. In countries with well-developed or even saturated onshore wind markets, such as Germany and Denmark, OWP offers continued growth within the wind energy sectors, (Breton and Moe 2009; Markard and Petersen 2009). For several countries in Northern Europe struggling to meet the EU2020 goals⁴, OWP is now established as an important part of the solution (EWEA 2009; Hall 2011; Jacobsson and Karltorp 2012).

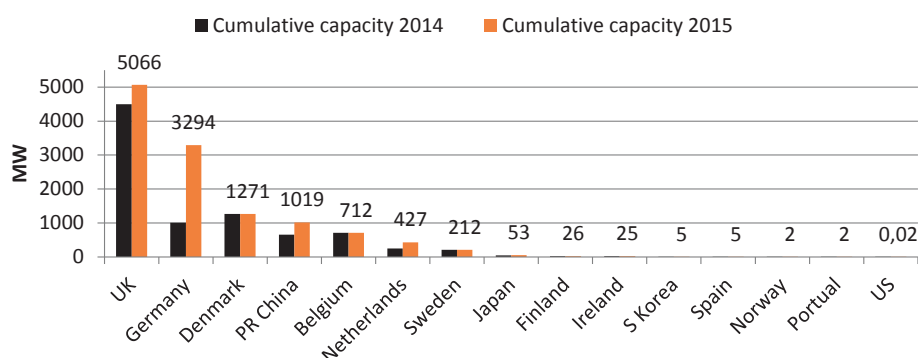


Figure 4 Global cumulative offshore wind capacity in 2014 and 2015. Source: GWEC 2015

Figure 4 illustrates how growth in installed OWP production capacity almost exclusively has been driven by Northern European countries, with the UK, Denmark and Germany as the top three countries. This growth in production capacity has been facilitated by various forms of public support, such as subsidies and tax breaks (Verhees et al. 2015). In the UK, for example, government incentives (Renewable Obligation Certificates) available for OWP were double those for onshore wind power from 2009 to 2014 (Toke 2011).

In the second half of the 2000s, China launched ambitious plans to develop OWP production capacity, but investments were stalled resulting from a number of challenges (Chen 2011; Da et al. 2011; Korsnes 2014). Growth in OWP elsewhere on the planet has been limited. In the US, early proposals for OWP farms were stalled by public opposition (Portman et al. 2009). South Korea, Japan and (more recently) India have signalled that OWP will be a target area in boosting renewable energy capacity in years to come, but similar to the US these markets are still in an embryonic phase (GWEC 2015).

Social science research on OWP to date has addressed policy issues (cf. Green and Vasilakos 2011; Söderholm and Pettersson 2011; Toke 2011; Normann 2015), public responses (cf. Firestone and

⁴ In 2007 (enacted in 2009) EU leaders identified security of supply, competitive markets and sustainability as three pillars on which to base European energy policy. The following targets were set for 2020: min. 20% reduction of CO₂ emissions compared to 1990 levels, 20% increase in energy efficiency, and 20% of energy (consumed) from renewable energy sources.

Kempton 2007; Ladenburg 2010; Haggett 2011; Heidenreich 2015) economic issues (cf. Blanco 2009; Snyder and Kaiser 2009; Weaver 2012) and the formation of innovation systems (Wieczorek et al. 2013; Wieczorek et al. 2015). The development and build-up of value chains has also been analysed (Lema et al. 2011), as has structural change in the wind energy industry as an effect of the 'offshore trend' (Markard and Petersen 2009). More detailed accounts of supply chain formation, technological status and industry challenges have mainly been dealt with in consultancy reports (cf. BVG Associates 2009; Wiersma et al. 2011) and reports from organizations such as the European Wind Energy Association (EWEA 2009, 2011, 2014). Economic geography research on the OWP industry has hitherto been marginal, with a few notable exceptions (Fornahl et al. 2012; Dawley 2014; Dawley et al. 2015).

2.2.1 Why offshore wind power?

There are several good reasons for locating wind farms offshore (see Table 1). Offshore winds are stronger and more sustained than winds over land, and other logistical solutions allows for larger turbines to be transported and installed (Wilhelmsson et al. 2010; Taylor 2004; Wisser et al. 2011; Breton and Moe 2009). Being 'out at sea and out of sight' implies that OWP is also less conflict-prone than its onshore counterpart in terms of amenity disadvantages (Houghton 2009). On the con side, the offshore environment is demanding in terms of transport, logistics and construction technologies, a major cause of current high cost levels both in capital and operational expenditure. Growth in OWP has also been contingent on technological progress, upscaling of industrial capacity and the introduction of specialized turbines and installation and deployment technologies for the offshore market (Kern et al. 2014; EWEA 2014).

As the OWP industry has developed, OWP farms have been developed in increasingly deeper waters further from shore using larger turbines in greater quantities. The 'further, deeper, larger' trend implies that OWP projects are becoming more complex and resource demanding. In turn, this requires that a range of specialized solutions (both products and services) are developed along the entire value chain (Breton and Moe 2009). It also requires increased industrial and financial capacity as OWP farms are generally larger and more costly than their onshore counterparts. This trend then is accompanied by structural change in the OWP industry in which established actors from the offshore O&G industry especially and maritime industries more generally are taking key roles (Markard and Petersen 2009; Scottish Enterprise 2011).

Table 1 The pros and cons of offshore vs. onshore wind power. Sources: Markard and Petersen (2009), Bilgili, Yasar, and Simsek (2011), EWEA (2011), own research

| <i>Pros</i> | <i>Cons</i> |
|--|--|
| Large continuous areas are available for major projects giving rise to scale effects | More complex and time consuming planning |
| Visual impact and noise eliminated | More costly integration to grid + increased coastal grid capacity |
| Higher wind speeds, increasing generally with distance from shore | More costly installation procedures + restricted access due to weather |
| Less turbulence – more effective energy harvest | Limited access for operations and maintenance during operations |
| Lower wind-shear allows for shorter towers | Marine foundations are more costly |
| Fewer transport restrictions allows for larger turbines | Larger turbines requires up-scaling of vessels, foundations etc. |

One may assume that developing a wind farm offshore is fairly akin to building one onshore, and that meshing competencies and solutions from onshore and offshore sectors will bring about the right combination of technologies and solutions. This has been a pivotal idea in discussions of technological progress and cost reductions in OWP (Scottish Enterprise 2011). However, this idea has been contested. For instance, Jørgen Kildahl (Lie 2012, author's translation), director of EON (Europe's largest energy company, a major player also in OWP) argues that offshore wind power

“is a discipline entirely on its own. Setting up an offshore wind farm is essentially different from what the oil industry is doing, and naturally totally different from what the energy sector is doing onshore (...) On the technology side oil firms probably have lots to offer. But in terms of logistics: setting up hundreds of wind turbines in very short weather windows and operating them, is something completely different from setting up oil platforms.”

As argued by Jacobsson and Karltorp (2013), therefore, OWP is not the result of 'simple diversification' from the onshore wind turbine industry. For example, whereas standardization is central to the onshore wind energy industry, offshore industries are to greater extent marked by customized specialization for 'one-off' projects. In taking part in the OWP market, industry actors from sectors such as offshore O&G meet demands from OWP developers in the form of standardization, especially to reduce costs (Karlsen 2014). OWP farms also need to adhere to other (maritime) regulations than onshore farms. Taken together, these trends result in OWP developing into a distinct industrial sector (Snyder and Kaiser 2009; Brown 2011), albeit with multiple overlaps (in actor configurations, ownership structures, value chains etc.) with onshore wind energy as well as other sectors (O&G, maritime, utility, construction etc.).

2.2.2 Value chain, costs and challenges

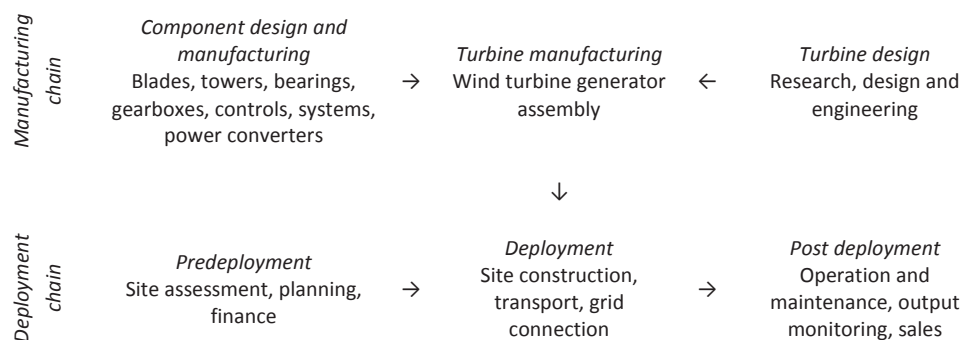


Figure 5 The offshore wind power value chain. Source: Lema et al. (2011)

As illustrated in Figure 5 the OWP value chain can be separated into a manufacturing and a deployment chain (Lema et al. 2011). Compared to the onshore wind value chain, OWP farms are considerably more technologically complex in the pre-construction, construction and operational phases. In the pre-construction phase, a broad set of surveys (sea floor mapping, sea birds, marine life etc.) are necessary. Deployment takes place at sea, requiring a range of different vessels and costly subsea grid-connections. Due to the size of OWP turbines and substructures, key production facilities need to be located in ports (e.g. Bremerhaven in Germany and Esbjerg in Denmark) (Jacobsson and Karltorp 2013) that are in geographical proximity to OWP deployment areas, implying

that the spatial patterns of the OWP production network in some respects differs considerably from that of onshore wind energy. Maintenance is necessarily also more demanding because of the need to access installed equipment during 'weather windows' providing a safe working environment. The natural conditions offshore are harsh, and winds, waves, precipitation and salinity create challenges that need to be overcome both in designing, engineering and fabricating products, in installing equipment and in operating, maintaining and (eventually) decommissioning OWP farms.

Both capital (CAPEX) and operational (OPEX) expenditures are therefore high in OWP compared to onshore wind (Snyder and Kaiser 2009; NVE 2012). Whilst turbines typically constitute 70% of CAPEX for onshore wind farms, both CAPEX and OPEX are more distributed across the OWP value chain. An important reason for this are the higher costs associated with offshore logistics and installation and other maritime activities. And as distance to shore and water depths increase, the costlier and more demanding logistics and other offshore operations become. This has created recurrent calls for new vessels, port facilities and procedures that minimize time usage and risk. Technological challenges relate for instance to grid systems, transport, installation, energy system integration and maintenance. New technologies could also require changes in supply chain set-ups and contract regimes. The uncertain development trajectories of both technologies and organizational forms are coupled with *"lacking regulatory frameworks (...), lack of skilled personnel, competition for space with other marine users (such as oil and gas exploration) (...), incompatibility with existing grid infrastructure, and insufficient integration into the energy system"* (Offshorewind.biz 2011).

2.3 Norway - energy

A basic understanding of the Norwegian economy and energy system is necessary in order to understand the opportunities and challenges confronting OWP path creation. Energy in the form of hydropower and O&G is a core component of Norway's resource-based economy (Hanson, Kasa, and Wicken 2011; Sæther, Isaksen, and Karlsen 2011; Reve and Sasson 2012; Rusten 2013; Underthun 2013). In 2010, the 27 EU countries had a total combined installed hydropower capacity of 136 GW, whilst Norway alone had 30 GW (EURELECTRIC 2011). In 2011, Norway was the world's seventh largest oil exporter, the fourteenth largest oil producer, the third largest exporter of natural gas, and the sixth largest gas producer (OED 2013).

2.3.1 The Norwegian energy system (electricity)

With 99% of its electricity production being based on hydropower, Norway is in a *"remarkable position with respect to renewable energy"* (Borup et al. 2008, 45). However, the abundance of hydropower means that Norway lacks strong incentives to invest in new renewables and change its energy system, such as climate gas mitigation or strengthening energy security (Hansen 2013). Apart from hydropower, renewable energy sources are therefore still relatively untapped in Norway. By the end of 2014, Norway had installed approx. 800 MW wind power onshore, whilst solar panels are mainly installed on off-grid leisure homes (OED 2015).

Hydropower delivers cheap and reliable energy, against which new renewable energy projects (for instance wind farms) are not competitive without subsidies. Following a lengthy period of uncertainty regarding new subsidies for renewable energy production, a Green Certificate Scheme⁵ (GCS) was introduced in January 2012. The aim of the GCS was to unleash investments into 26.4 TWh

⁵ In A3/Barriers, Tradable Green Certificates (TGC) are used to denote the same scheme.

of new renewable energy production capacity (electricity) in Norway and Sweden combined by 2020 in order for the two countries to achieve its agreed targets complying with the EU Renewables Directive. The GCS is technology neutral, implying that all new production capacity based on renewable energy pursuant to the Renewable Directive receives the same level of support. The technology neutrality of the GCS implies that it favours more mature and less costly (in CAPEX terms) energy technologies than OWP (Bergek and Jacobsson 2011). By contrast, countries with substantial OWP production capacity have used various technology specific (or differentiated) support schemes to support investments into more immature technologies such as wave, tidal and OWP.

Norway now finds itself in a "*paradoxical situation regarding the role that new production of energy from renewable energy sources should play in the Norwegian energy system*" (Karlstrøm and Ryghaug 2014, 657). There is as such debate on the need for developing additional energy production capacity in Norway (see Hanson, Kasa, and Wicken 2011), reflecting competing visions on the development of the domestic energy sector (Murphy 2015). One argument against increased production capacity is that it is simply not needed because demand-supply has levelled out, and that measures to enhance energy production in Norway in practice implies not only subsidizing European energy production (through exports from Norway), but also large losses on behalf of municipalities and the Norwegian state which are owners of the major share of Norwegian utility companies (NRK 2013). Solutions to the 'overcapacity' problem could be to use electricity to power offshore O&G installations (thus replacing conventional natural gas turbines), or to 'electrify' the transport sector, which represents a considerable share of Norwegian greenhouse gas emissions. An argument for increased production capacity is that Norwegian hydropower capacity could play an important role as a 'green battery' for European energy markets increasingly based on intermittent energy sources such as wind and solar (Gullberg 2013). The realization of the 'green battery' idea then requires additional build-up of production capacity in Norway⁶, and investments in grid infrastructure (subsea cables) to major energy markets in Northern Europe to which Norway is already a large supplier of fossil energy.

2.3.2 The Norwegian oil and gas industry

Since its beginnings on the Norwegian Continental Shelf (NCS) in the late 1960s, the offshore oil and gas (O&G) or petro-maritime industry has become a fundamental cornerstone in the Norwegian economy (Underthun 2013). The extraction of fossil fuels on the NCS currently generate tax revenues amounting to approx. 25% of GDP, and represent approx. 50% of total exports, making the petroleum sector Norway's largest industry sector (OED 2013). This natural resource based industry, which evolved on the basis of long historical traditions within maritime activities and ship building, has developed into a highly knowledge-intensive and specialized industry (Vatne 2008; Reve and Sasson 2012) with a distinct spatial industrial pattern, giving rise to some of Norway's most successful regional industry clusters built upon specialized suppliers and skilled labour (Isaksen 2008).

The innovativeness of the Norwegian O&G industry reflects in part a matter of necessity as the production conditions in the Norwegian part of the North Sea are particularly demanding, making this resource region into a laboratory for the global petroleum industry (Jones and Hollier 1997; Cumbers 2000). Technology development and innovation in the O&G sector has also been driven by

⁶ As such, one argument for developing wind energy is that its intermittent power output can be used for 'pump-and-storage' in combination with hydropower. That is, when there is oversupply of (intermittent) energy output in the market, energy harnessed from wind can be used to pump water back (up) into hydropower reservoirs to be stored for periods with higher prices/higher demand/lack of wind.

the development of more marginal fields, and the opening of new resource areas in the Arctic North to O&G exploration (Steen and Underthun 2011). Whilst the latter has fuelled heated debates over O&G activities in 'vulnerable' areas such as the Lofoten archipelago and the Barents Sea (Kristoffersen and Young 2010), the quest for domestic usage of natural gas for industrial purposes and electricity production has also been an important topic in Norwegian energy/petroleum policies the last decade (Underthun, Kasa, and Reitan 2011).

State 'nurturing policies' were highly important in the early phase of the Norwegian petroleum industry (Vatne 2008; Engen 2009). However, following the decline in oil prices in the 1980s, policies gradually shifted from giving preference to Norwegian companies to a more competition-based allocation of exploration licenses. Norwegian membership in the EEC (1992) and the WTO (1995) also led to eradicating the basis for 'protectionist policies'. The state policies that nurtured the build-up of the petroleum industry have been replaced by anti-discriminatory legislation, and state measures are now to a larger extent directed towards facilitating international expansion (Underthun 2013).

Over the last two decades, the O&G-sector has changed in terms of shifting to subsea production equipment, increased international competition, increased firm internationalization and high CO₂ emission reduction targets, the latter becoming coupled to the demands for electrification of offshore O&G installations. These shifting selection pressures have fuelled processes of path renewal (Isaksen 2014) in the offshore O&G industry whereby supplier firms have developed new competencies (for instance in sub-sea technology), and petroleum producers such as Statoil have explored emerging international hydrocarbon resource regions in other parts of the world (e.g. offshore areas in East Africa and South America) and so-called unconventional petroleum resources (tar sands, shale gas etc.) in countries like Canada. However, 'peak oil'⁷ production in 2005 (Höök and Aleklett 2008) implies that long-term industrial prospects could look bleak, and as such constitute an underlying driver for firms currently operating within the O&G industry to explore OWP as a new market. In a more short-term perspective, price reductions in global O&G markets, as happened after the financial crisis of 2008-2009, have been an important factor influencing diversification of Norwegian O&G sector firms into the OWP market (Hansen and Steen 2015).⁸

2.3.3 Offshore wind power in Norway

The status of OWP in Norway is thoroughly described in the articles, and only a brief summary will therefore be provided here. The short story is: the OWP industry is in an early phase of development in Norway, with no (commercial) domestic market formation as of yet (unlike all other countries surrounding the North Sea). Norway currently only has 2.3 MW installed OWP capacity (the lone Hywind floating offshore turbine installed in 2009), and the Norwegian public support system does not favour the deployment of OWP, despite extensive natural resources (NVE 2012). As mentioned in the introductory chapter OWP is nonetheless one of the targeted areas for technological and industrial development in Norway's national energy strategy (ENERGI21 2014) and as of 2012 approx. 150 Norwegian firms were active in the OWP market. A general argument is that comparative advantages gained from decades (if not centuries) of offshore maritime activities and other economic sectors (see Table 2) should enable Norwegian firms to become key players in the emerging OWP

⁷ To be precise, what has actually peaked is cheap oil. There are plenty of hydrocarbons left in the North Sea, but these are to an increasingly extent 'marginal resources' that are costly and demanding to extract.

⁸ The recent 'collapse' in global oil prices (since mid-2014) is outside the empirical scope of this thesis. There are however multiple examples of Norwegian offshore O&G supplier firms that have diversified into the OWP industry recently.

industry. A statement from the Managing Director of Norwegian Renewable Energy Partners (INTPOW), Geir Elsebutangen (2011), is typical of the view on Norwegian comparative advantage in this regard: “As offshore wind projects and related grid solutions are developed further offshore, in deeper waters, Norway’s extensive heritage from offshore oil & gas activities represent an extensive competitive edge for many players willing to enter this new market.”

Table 2 The Norwegian offshore and energy heritage. Source: Multiconsult 2012

| <i>Offshore oil & gas</i> | <i>Maritime</i> | <i>Onshore power generation</i> | <i>Harbors & yards</i> | <i>Grid connection & transmission</i> |
|---|---------------------------------------|--|---|--|
| 40 years of offshore exploration and production | A leading nation in shipping industry | 100 years of renewables (hydropower, wind power) | Yards and port facilities suited for the deep sea offshore market | Both onshore and offshore, including interconnectors |

Despite lack of incentives and financial support for a domestic OWP market, the state has provided funding through several channels in order to promote OWP activities in Norway. According to a senior advisor in Innovation Norway (personal communication, 2015), the Norwegian state has used a total of 800 MNOK on OWP-related funding, mainly on R&D. As discussed in A3/Barriers, a key focus in state support has indeed been on large-scale dedicated R&D programs, notably the OWP dedicated research centres NORCOWE and NOWITECH, which are funded through the EnergiX programme of the Norwegian Research Council. Also, regional cluster development initiatives such as ‘Arena NOW’ and ‘Windcluster Mid-Norway’ and internationalization support through Norwegian Renewable Energy Partners (INTPOW) are part of the policy mix. The state also supports technological development for renewable energy production and provides various general support mechanisms through for instance the Research Council of Norway, Enova, Innovation Norway, The Industrial Development Corporation of Norway (SIVA) and The Norwegian Export Credit Guarantee Agency (GIEK). These are mentioned in the articles whenever relevant.

2.4 Summary of chapter

This chapter has provided an empirical context for the thesis. Current global energy usage is to an overwhelming extent based on fossil energy sources, and despite substantial growth in both development and deployment of renewable energy technologies, the world remains (depressingly) far away from a sustainable, carbon-neutral energy system. Norway is a country of paradoxes in this respect. On the one hand, Norway’s electricity system is powered by (relatively) cheap and reliable hydropower, which accounts to close to 100% of electricity consumption. National level ‘drivers’ for harnessing OWP are thus weak compared to many other countries. Nonetheless, Norway aims to develop export-oriented industries around NRE technologies. And on the other hand, reduced activity levels in Norway’s largest and economically most important industry - O&G – has spurred an increasing recognition that the Norwegian economy needs to be diversified.

3 Theoretical background

As stated in the introductory chapter, the key topic underlying this thesis is the question of how new industries emerge. This chapter presents the theoretical foundations of the thesis, and aims to provide a broader picture and positioning of the thesis in the economic geography debate on path creation. The specific theoretical frameworks which are presented and discussed in the articles are not covered in depth here. In addition to elaborating on key theoretical perspectives and concepts, the chapter includes some reflections which were not included in the articles due to length constraints.

3.1 Setting the scene: explaining industry emergence

Where do new industries come from? How do they arise? What is the role of different types of actors (firms, intermediaries, R&D institutions, government etc.) in new industry emergence, and what key processes and mechanisms drives the creation of novelty? What are barriers to industry emergence? Why do new growth paths arise in some places and not in others? (How) does institutional context matter? And how do new technologies develop within complex and large-scale systems such as in the production, distribution and consumption of energy?

These are the kinds of questions that frame the choice of theoretical perspectives, methodological approaches and analytical frameworks employed and developed in this thesis. These questions are important - to researchers and policy makers alike - but also highly challenging to answer (Martin and Sunley 2006; Neffke, Henning, and Boschma 2011). A point of departure for this thesis is that new industries primarily develop by "*the fusion of a new technology with prior antecedent technologies*" (Feldman and Lendel 2010, 149) and through the efforts of knowledgeable and intentional actors. In other words: I will argue that new industries do not develop from scratch, nor do they arise by chance, although chance certainly plays a role. Processes of innovative recombination (Schumpeter 1934) or re-bundling of knowledge and other resources (Bathelt 2009) bring about innovations in technologies, markets, business models and supply chains that combine to form a new industry. Changes in institutional context is an integral aspect of this process, implying co-evolution between technological change, organizations, value chains, rules and norms, consumer preferences and so on. And as argued by geographers (in particular), these processes have distinct spatialities to them.

The remainder of this chapter proceeds as follows. I first present the positioning of this thesis within the economic geography literature stream. I then present some general perspectives on technological change and industry emergence, as well as life-cycle approaches. Subsequently, I trace the origins of the path dependence concept and outline key debates, before discussing its usage and role in economic geography. After this, the chapter moves on to discuss path creation processes and mechanisms, context and agency. This is followed by a brief outline of the literatures on socio-technical transitions and sociology of expectations, linkages to economic geography and the relevance of these perspectives to the thesis. The chapter ends with a summary.

3.1.1 The place of the thesis in the economic geography field

What has increasingly been addressed by economic geographers in recent years, in addition to the spatialities of various socio-economic processes, are their dynamics and temporalities (Bathelt, Feldman, and Kogler 2011). For instance, cluster research has moved from 'snapshot' analysis to more dynamic accounts of how clusters evolve over time, often through (stylized) 'life cycle' stages of

development (Menzel and Fornahl 2010; Fornahl, Hassink, and Menzel 2015; Trippl et al. 2015). Such more dynamic understandings of spatio-temporal processes of economic change have become increasingly commonplace following the (relatively) recent 'evolutionary turn' in economic geography (Coe 2011).

To explore path creation and industry emergence, this thesis employs theoretical frameworks and concepts that are particularly associated with what is now commonly seen as a distinct approach within the economic geography discipline, namely evolutionary economic geography (EEG) (cf. Boschma 2004; Boschma and Frenken 2006; Martin and Sunley 2006; Essletzbichler and Rigby 2007; Martin and Sunley 2007; Rigby 2007; Martin 2010; Martin and Sunley 2010; Asheim, Boschma, and Cooke 2011; Boschma and Frenken 2011). EEG, which takes much of its theoretical building blocks from evolutionary economics and which aims to provide explanation for dynamic processes of change across the economic landscape over time, has become highly influential within the economic geography literature in a relatively short period of time (Boschma and Frenken 2011; Coe 2011).

Within EEG there are a number of unsettled issues and debates, and this thesis questions some of EEGs theoretical underpinnings and provides both supplementary and alternative perspectives that are of relevance to the explanation of how new industrial development paths emerge. In particular this relates to four issues or topics: the notion of 'relatedness', agency, path creation mechanisms, and path interaction. On the other hand, and in acknowledging the value of EEG perspectives, the thesis aims to contribute to EEG theorizing by providing empirically based analysis that validate certain (recent) EEG informed explanations (or propositions) of how new industries emerge.

Having that said, I wish to stress that this is a thesis in *economic geography*, not EEG. Indeed, a reason why evolutionary perspectives have found such resonance in the discipline is arguably because EEG provides perspectives and ideas which fit with a long line of research topics within economic geography (Coe 2011). But in advocating a distinct *evolutionary* (or *institutional* or *relational* for that matter) take on economic geography, there is a risk of contributing to a weakening and fragmentation of the discipline (MacKinnon et al. 2009; Hassink, Klaerding, and Marques 2014). Barnes and Sheppard (2010, 193) lamented that "*economic geography has become increasingly fragmented into a series of intellectual solitudes that has created isolation, producing monologues rather than conversation, and raising the question of how knowledge production should proceed.*" I share Barnes and Sheppard's (2010) view that explanation and understanding benefits from a 'conversational attitude' and by developing pluralistic approaches.

Although the thesis relates in particular to EEG, the topics of the thesis are of relevance to the broader field of economic geography (e.g. knowledge spillovers, clusters, path dependence). Although not made explicit in the articles, my thinking around path creation is influenced by institutional and in particular relational (e.g. Bathelt and Glückler 2003; Coe et al. 2004; Yeung 2005; Bathelt 2006) approaches to economic geography, and these have (implicitly and explicitly) influenced my way of approaching the research objectives at hand. For instance, the analysis of knowledge spillovers in A1/Same Sea identified institutional barriers on the one hand, and understanding of actor-networks on the other.

Moreover, I consider it not only productive but also necessary to go beyond the fragmented (Patchell and Hayter 2013) but nonetheless somewhat narrow field of economic geography to improve explanations of path creation and industry emergence. In the articles, I draw on various strands of

literature that provide relevant theoretical tools for my analysis and (attempts at) explanation. These include ideas and perspectives from sociology, innovation studies, evolutionary economics, and entrepreneurship theory and business management. Due in particular to the nature of the empirical field and the aims of the thesis, I also draw on insights and analytical frameworks from the literatures on socio-technical (sustainability) transitions and on the sociology of expectations, the former having become the subject of a promising encounter with economic geography perspectives over the last few years (see section 3.5).

3.1.2 Innovation and technological change

New industries are intimately related to innovations and technological change. Evolutionary economists Freeman and Perez (1988) distinguish between four types of technological change that vary in significance, scale and scope. *Incremental innovations* are small-scale modifications of already existing products and processes. They result from hands-on learning processes, and although incremental innovations are easy to overlook (not least because they are frequent) they amount to significant changes and transformations over time. *Radical innovations* drastically change existing products and processes and may result in technological disruption at the level of firms (Christensen 1997) and creative destruction at the level of industries (Schumpeter 1976). However, according to Freeman and Perez (1988), it takes several radical innovations (coupled with incremental innovations) to create a *change of technology system*, whereby the development of new generic (or key enabling) technologies leads to change in multiple economic domains both in technological and organizational terms. Think, for instance, of the impact of modern communication technologies on practically all sectors of the economy (and society in general). It is important to note, as acknowledged by Freeman and Louçã (2001, 145), that "*the emergence, crystallization, and diffusion of new technology systems is a matter of decades, not just years.*" The most far-reaching form of technological change is a *change in techno-economic paradigm*, which encompasses clusters of incremental and radical innovations that lead to pervasive changes in the very way in which production and consumption of goods and services take place. To use the energy sector as an example, the introduction of first coal/steam power and later electricity are examples of new radical technologies that changed technology systems and had wider influences on practically all other economic sectors.

These perspectives on levels or significance of technological change are not by themselves helpful in terms of explaining why or how innovation takes place, the role of different types of actors, or how new industries (based on innovations) take shape. On the other hand, they are helpful in categorizing forms or levels of innovation as well as sectoral patterns of innovation (Castellacci 2008), and in explaining the relative stability – or path-dependence - of socio-economic structures and systems. Energy systems are archetypical examples of rigid and path dependent industries (Markard and Truffer 2006). The path dependence of energy systems is explained by the complex assemblage of various technologies, infrastructures, vested interests, consumer practices and so on, which is stabilized by self-reinforcing mechanisms such as sunk costs, economies of scale and network externalities arising from systemic relations between technologies, infrastructures, interdependent producers and users (Rip and Kemp 1998; Geels 2002; Lovio, Mickwitz, and Heiskanen 2011). New technologies may have feeble potential in such contexts. As Simmie (2012, 756) points out, "*new technologies often have to emerge into a complex landscape of historical path-dependent development which themselves may possibly provide significant barriers to that emergence.*" In other words, the potential and prospects of new technologies or technological solutions need to be related

to the socio-technical and institutional context in which they emerge. The next section (3.2) outlines the origins of the path dependence concept and its place in economic geography theorizing while section 3.3 discusses more recent 'open' perspectives on path evolution.

3.2 Path dependence – origins and debates

Over the last two decades the concept of path dependence has gained a prominent position in many social science disciplines (Arthur 1994; Pierson 2000; Boas 2007; Sydow, Schreyögg, and Koch 2009; Lovio, Mickwitz, and Heiskanen 2011) including economic geography (Scott 2006; Boschma and Frenken 2006; Martin and Sunley 2010). In short, path dependence has been used to explain the relative stability or persistence of development patterns of economic systems, industries, technologies, institutions and organizations. Perspectives on path evolution (incl. path dependence theory) have a prominent role in this thesis (notably in A2/Verdal, A3/Barriers and A4/Reconsidering). This is due to the important role that path dependence has attained in economic geography theorizing in general as well as its particular relevance to the empirical field.

Path dependence was initially conceptualized by evolutionary economists Paul David (1985) and Brian Arthur (1994). Their starting-point was a critique of neo-classical, equilibrium based micro-economic theory, which posits that market forces lead to the most technological efficient solutions prevailing in the long run, and that decisions are reversible and will be reversed if better technologies become available. The classical path dependence models challenged both of these assumptions (Simmie 2012), by showing how sub-optimal technologies prevail although 'better' alternatives are available.⁹ The formal models developed by David and Arthur are viewed as 'canonical' in the path dependence literature (Martin 2010). These models have three common features in terms of explaining path dependence (Henning, Stam, and Wenting 2013). First, accidental events have long-run effects on economic structures. Second, accidental events are reinforced by increasing returns¹⁰, leading to lock-in phenomenon. That is, once a series of steps has been taken in a certain direction, further steps in the same direction are more likely than steps in a different direction, even though better or more efficient alternatives are available (Martin and Sunley 2006). As argued by Mahoney (2005), once a certain technology has been chosen, 'going back' is not an option because of high costs associated with dismantling sunk costs and the need to 'de-learn' (for instance the QWERTY typewrite setup) and learn something new (such as the DVORAK typewrite setup). Third, locked-in patterns can be disrupted by external shocks. Path dependence processes are thus non-ergodic in the sense that current situations are dependent on previous events, but a situation cannot return to a previous state (David 2001). As noted by Martin and Sunley (2006), path dependence theorizing also concerns institutions, based on the observation that both formal and informal institutions (such as rules, routines, conventions, traditions, social arrangements) tend to change slowly and be self-reproducing over time (Boas 2007). In the social sciences, path dependence oriented research

⁹ One of the most oft cited (but also highly debated) examples of path dependence is the QWERTY keyboard layout for Latin script, which was developed for typewriters in the 1870s. The arrangement of the different letters of the alphabet was made so that frequently used letters were placed far from each other, thus reducing the problem of entangled type bars. The QWERTY has persistently remained on all sorts of devices for writing since it was first introduced, and is now the standard typewrite set up even on the latest electronic gadgets. Check your smartphone or tablet! The reason the QWERTY is so often invoked in path dependence circumstance is that it is dysfunctional and inefficient compared to other alternatives for keyboard setups (Becker 1998), such as the DVORAK configuration which was patented in the 1930s.

¹⁰ Arthur (1994) identified four major classes of increasing returns: scale economies, learning effects, adaptive expectations and network economies.

typically therefore traces a certain outcome backwards in time to identify critical junctures at which unexpected, random or small events set in motion a subsequent set of events.

The diffusion of the path dependence concept can be seen as part of a wider 'evolutionary turn' in the social sciences, evident also in geography with the rise of EEG (Coe 2011), in which metaphors, concepts and ways of thinking about change over time have been incorporated from evolutionary biology (Martin 2010).¹¹ Despite widespread application, there is however no common understanding of the path dependence concept (MacKinnon et al. 2009). Social science disciplines approach the path dependence concept somewhat differently, a result of what Benton and Craib (2011) refer to as 'regional ontologies' (regional here referring to disciplinary). To add to this complexity, path dependence is theoretically employed to explain issues at both macro, meso and micro levels (Vergne and Durand 2010), and on empirical matters (e.g. technologies, innovation, firms, societal institutions) that cut across disciplinary boundaries.

3.2.1 Economic geography and path dependence

Path dependence has become an important concept in economic geography (Martin 2010; Henning, Stam, and Wenting 2013), and is especially associated with the 'evolutionary turn' (Coe 2011) and the sub-discipline of EEG (Boschma and Frenken 2006; Boschma and Martin 2007; Strambach 2010). However, its analytical strength in accounting for the more or less stable development trajectories (of technologies, institutions, industries, regions) has been recognized by proponents also of institutional (Amin 1999), relational (Bathelt and Glückler 2003) and political economy (MacKinnon et al. 2009) approaches to economic geography. Scott (2006, 85), a leading economic geographer since the 1960s, explicitly called for "*an ontology of regional growth and development that is rooted in the idea of path dependent economic evolution.*"

The popularity of path dependence theory in economic geography can be explained by its seemingly good fit with empirical insights and theoretical explanations of why some places and regions fare well over time (in a socio-economic sense), whereas others seem helplessly lost in declining trajectories. Indeed, a crux of the argument from geographers is that path dependence and 'lock-in' are largely place-dependent processes, and therefore require geographical explanation (Grabher 1993; Martin 1999; Boschma 2004; Hassink 2005). That is, economic geography emphasizes the "*context-specific, locally contingent nature of self-reinforcing economic development, particularly the 'quasi-fixity' of geographical patterns of technological change, economic structures and institutional forms across the economic landscape*" (Martin and Sunley 2006, 398). Sources of (regional) path dependence thus include (the co-evolution of) natural resource bases, sunk costs, external economies of industrial specialization, technological 'lock-ins', economies of agglomeration, specific institutions and interregional linkages and interdependencies (Martin and Sunley 2006).

Over the last few years, however, various scholars have criticized the path dependence concept and the ways in which it has been employed in economic geography. For instance, Strambach (2010) notes that place-specific institutional endowments are used to explain both positive lock-in and continuous adaptability on the one hand, and negative lock-in and failure to escape previous success on the other. Leading EEG scholars Essletzbichler and Rigby (2007, 554) argue that evolutionary concepts such as path dependence, co-evolution and routines "*are deployed in an isolated, descriptive manner or they are grafted to poorly specified theoretical frameworks.*" In a similar vein,

¹¹ Evolutionary metaphors and concepts include notions of variation, selection, retention and heredity.

Martin (2010, 3) argues that *“despite their increasing invocation of the notion, economic geographers have directed little detailed critical attention to the assumptions, implications, and limitations of path dependence theory and its key idea of lock-in.”* An important issue underlying this questioning is that the canonical version of path dependence rests on ontological and epistemological underpinnings that may not be compatible with economic geography. In other words, employing a theoretical concept developed to explain technological path dependence to explaining regional economic development trajectories requires a considerable conceptual leap, not least because a regional or local economy is constituted by a (greater or smaller) variety of actors (i.e. unique socio-economic eco-systems which are part of wider networks of production, distribution and consumption) who do not act identically. In more practical terms, the ‘canonical’ model of path dependence emphasizes how actors over time become ‘locked in’ to particular institutional structures that inhibits innovation and change (Martin 2010). But if path dependence as conceptualized in the canonical model is a ‘common feature’ of technological, industrial or regional development, then how can change – which undeniably takes place even in fairly rigid ‘systems’ - be explained? How do new industries emerge, and how do actors free themselves from the chains of the past? I return to this discussion after a brief outline and discussion of windows of locational opportunity and life cycle perspectives.

3.2.2 Windows of locational opportunity and life cycle perspectives

Informed by the ‘canonical’ model of path dependence, proponents of EEG (Boschma and Frenken 2011) argue that innovations that are inherently part of industry emergence processes are associated with ‘windows of locational opportunity’ (WLO) in which the actual whereabouts of new industry formation is relatively open (Boschma and Frenken 2006; Boschma 2007; Menzel and Fornahl 2010; Ter Wal and Boschma 2011). The spatiality of industrial genesis will then depend on whether or not a set of generic conditions (e.g. infrastructure, human capital) is fulfilled (Storper and Walker 1989). The WLO approach suggests that new industries get locked into particular regions primarily because *“fundamentally novel innovations require different sets of skills, process technology, supplier and customer linkages and institutions, eroding the competitive advantages of existing regional production systems”* (Essletzbichler and Rigby 2007, 556). These perspectives have been developed within a life cycle perspective on technological and industrial change. The industry life cycle perspective developed from the discussion on product life cycles, which originated in the marketing literature (Klepper 1997). Consequently, the life cycle perspective has been used to explain how firms, technologies, networks, clusters and industries develop through distinct phases through their ‘lifetime’, and that this is a co-evolutionary process of technological change and market structure dynamics (Audretsch and Feldman 1996; Bergman 2008; Klepper and Malerba 2010; Menzel and Fornahl 2010).

These explanations of industry evolution have identified generic forms of path dependence in different industries (Martin and Sunley 2010). Neffke et al. (2011), for instance, distinguish between young and mature industries, and restrict their discussion of life cycle dynamics to three aspects (see Table 3): innovation intensity, type of innovation and mode of competition. A new industry will typically follow from the introduction of new products based on radical innovations. The development of immature technology results in high innovation intensity since there are many technological opportunities that may be explored. Large technological discontinuities are common in this stage because standards have not become fixed. Information about new innovations may arise from a plethora of different sources, implying that the entrants to the emerging industry should

benefit from Jacobs' externalities¹² and that a variety of knowledge sources are important for technological development. Furthermore, firms compete on product quality rather than price, meaning that they are less sensitive to factor-cost differentials between regions. A (second) period of experimentation follows, in which disruptions on the technological path become less likely. Fewer firms enter the industry at this stage, and industry shakeouts occur. In the third (mature) phase, production methods are further refined, significant innovations become rarer, output growth slows, and firm entry declines further (Klepper 1997). Mature industries are characterized by 'dominant designs', standardization of production, focus on efficiency gains and incremental (process) innovation, and the opportunity to exploit economies of scale and divisions of labour.

Table 3 Industry characteristics and life cycle developments. Source: Neffke et al. (2011)

| | <i>Life cycle stage of industry</i> | | |
|----------------------|-------------------------------------|---|---------|
| | Young | → | Mature |
| Innovation intensity | High | → | Low |
| Type of innovation | Product | → | Process |
| Mode of competition | Product | → | Price |

Geographers have taken up life cycle theory to address the question of whether types of agglomeration externalities¹³ that generate the highest benefit for local firms is determined by the industry life cycle stage. In a study of industry life cycles in Sweden, Neffke et al. (2011) found that young industries benefit from being located in diversified, high-cost locations, whereas mature industries benefit more from plants located in specialized, low-cost locations. These findings resonate with earlier findings (Audretsch and Feldman 1996) that clustered companies outperform non-clustered firms early in the industry life cycle, whereas non-clustered firms perform better in an industry's mature phase. As noted by Menzel and Fornahl (2010), one easily assumes that cluster life cycles follow the life cycle of their respective industry. This, however, is not the case, as numerous empirical studies have demonstrated. A well-known example is the growth of the Silicon Valley ICT/computer cluster, which happened at the same time as the computer cluster in Boston (Route 128) declined (Saxenian 1996). Cluster evolution, then, is "*prone to local peculiarities*" (Menzel and Fornahl 2010, 206). Moreover, as noted by Bresnahan, Gambardella, and Saxenian (2001, 835) more than a decade ago, there is empirical evidence to suggest that the "*factors that give rise to the start of a cluster can be very different from those that keep it going.*"

Despite some conceptual variety then, industry life-cycle approaches have a common schematic interpretation of industrial development and identify generic forms of path dependence in various industries (Martin and Sunley 2010). Trippi et al. (2015) find the life cycle approach problematic, in part because it suggests that all industries follow predetermined sequences through similar-type stages. However, some industries may never reach the growth stage, whereas others may evolve dynamically and renew themselves through a continuous introduction of innovations and/or development and exploitation of new market opportunities (Martin and Sunley 2010). Similarly, a critique of cluster life cycle perspectives is that they fail to explain how new clusters develop, and how clusters may shift orientation (towards) other industries (Menzel and Fornahl 2010). As I will

¹² Jacob's externalities refer to the positive effects of economic diversity (typically associated with urbanization) in terms of providing a variety of knowledge sources for innovation and consequent growth.

¹³ Agglomeration externalities refer to the benefits firms derive from being located geographically close to other actors. Three forms of externalities can be identified in the literature: Marshall-Arrow-Romer (MAR), emphasizing the benefits of industrial specialization; Jacobs', emphasizing economic diversity; and urbanization externalities, emphasizing the advantages of being located in large cities (Neffke et al. 2011).

discuss in the subsections that follow, a similar weakness in accounting for emergence and change is found in the 'canonical' path dependence literature.

3.3 Towards 'open' perspectives on path evolution

The preceding section presented the WLO perspective, which suggests that the geography of industry emergence is fairly open and largely a result of serendipity. Critics of this perspective argue that there will always be explanations as to why a particular technology (or technologies) forming the foundation for the development of a new industry developed towards maturity in one or several particular places instead or at the expense of others (Simmie and Martin 2010). Martin and Sunley (2006, 407) claim that "*(...) of itself, path dependence tells us little about how new paths come into being (...) the emergence is claimed to be serendipitous (...) it is largely silent on the issues of how and where (...) novelty comes from, or why one form of novelty gets selected over another.*" This line of questioning led to the development of a set of 'open' or 'hybrid' perspectives on path evolution, which combined insights from 'canonical' path dependence theory with a sociological perspective on path creation.

The sociological perspective on path creation is primarily associated with the work of Raghu Garud and Peter Karnøe (2001; 2003; 2010) who in a series of contributions have forwarded an alternative constructivist perspective (Sydow et al. 2012) on the development of new paths. In short, the sociological perspective emphasizes the intentional activities of reflexive agents and the collective endeavour that underlies path (co-)creation. Rather than seeing new paths being developed on the basis of 'historical accidents', Garud and Karnøe (2001) conceptualize path creation as a result of 'mindful deviation' by knowledgeable actors from existing paths. As such, the key agents of path creation are entrepreneurial firms who envision and create new opportunities, and various actors (such as regulators, R&D institutions) that provide complementary assets needed for a new path to develop and grow. Meyer and Schubert (2007, 41) assert that the "*agency of collectives of mindful actors is of major significance for explaining the social shaping of technological innovations.*"

As the path development process unfolds (see Figure 6), it "*results in a steady accumulation of artefacts, tools, practices, rules and knowledge that begin shaping actors in the domains of design, production, use, evaluation and regulation*" (Garud and Karnøe 2003, 296). The sociological path creation perspective thus acknowledges the key mechanisms underlying path dependence, such as cumulative advantages, dynamic learning effects and network externalities. The key difference lies in how the sociological path creation perspective emphasizes deliberation over chance, the distributed nature of agency and interactive nature of innovation processes, and disregards ideas regarding equilibrium and unescapable (in an endogenous sense) lock-in. Moreover, as argued also by Sydow, Lerch, and Staber (2010), the forces that create self-reinforcing mechanisms are not an aspect of institutions and structures in which actors are 'located' or 'embedded' but essentially an agentic phenomenon.

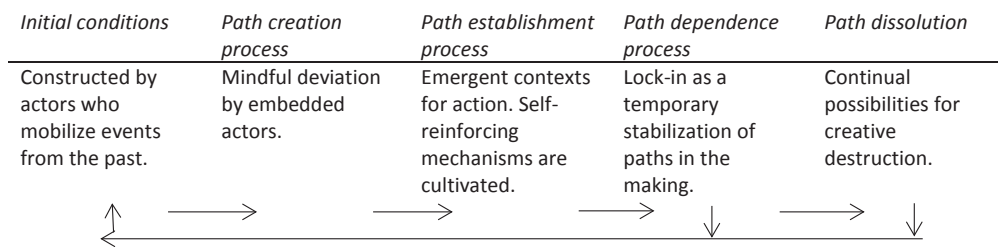


Figure 6 The sociology of path creation. Source: Simmie (2012), Garud and Karnøe (2001) and Garud, Kumaraswamy, and Karnøe (2010)¹⁴

In addition to stressing the relational dimension of agency, the path creation perspective of Garud and Gehman (2012) incorporates a distinct perspective on the temporality of agency, which further distinguishes it from the classic evolutionary perspective on path dependence. The crucial point is that agency is seen as inherently intertemporal in that agents simultaneously aspire for the future and make sense of the past whilst conceptualizing what is transpiring in the present. And because time elapses, the inter-temporal dimension of agency is always 'in-the-making'. This conceptualization of agency is key to the arguments I put forward in A4/Reconsidering, in which I suggest that the future orientation of innovating agents (and other 'systemic' actors involved in (interactive) innovation processes) and the role of expectations can provide deeper understandings of agency and the mechanisms underlying path creation processes (I return to this topic in section 3.5.2).

These ideas have influenced the launch of more 'open' perspectives on path evolution, which in a sense fuses ideas from the two path perspectives outlined above. These new takes on non-equilibrist path dependent evolution have in turn influenced a lively debate on various forms of path trajectories (see for instance Isaksen 2014). Taken together, these perspectives conceptualize the evolution of technologies, industries, and economies (on various spatial scales) as an ongoing battle between old and new, between stasis and change, implying that path dependence and path creation are continual inter-linked processes (Simmie 2012).

The key point in these perspectives is that path creation and path dependence are seen as different dimensions of ongoing development trajectories. Simmie's (2012, 753) point of departure for his development of a 'hybrid theory' on path evolution is an ambition to "*explain the processes by which agents may collectively contribute to the emergence of new technological pathways and overcome the barriers confronting them as a result of the evolution of historical forces that establish the path-dependent trajectories of contemporary technologies.*" Drawing on insights from historical sociology, political science and the socio-technical transitions literature, Simmie suggests a number of ways in which new pathways can emerge but argues that these typically take place in 'niches' outside of the dominant selection environment and 'technological paradigm' of established industries (see section 3.5).

In Martin's (2010) non-equilibrist 'open' perspective on path dependence, the generation of novelty is seen as a generic feature of ongoing path development (see also Martin and Sunley 2006; Martin

¹⁴ Direction of historical development of new pathway and iterative reflexive feedback loops are indicated by arrows (Simmie 2012).

and Sunley 2010). In this perspective, a new path then is seen as an outcome of a mix of intended or deliberate and accidental effects that result from the doings of various actors.

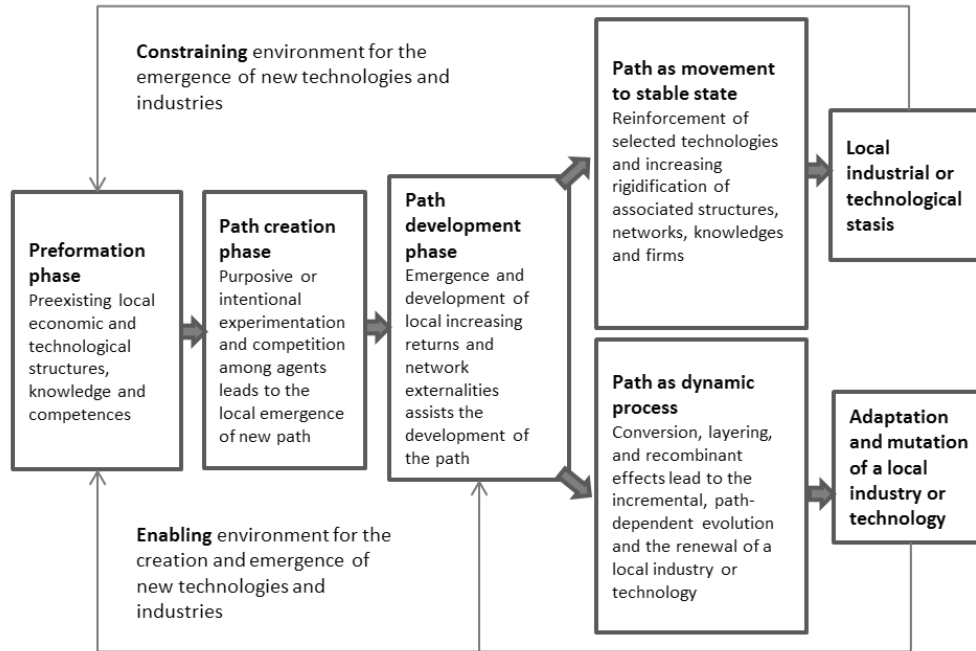


Figure 7 Towards an alternative model of local industrial evolution. Source: Martin (2010)

As Figure 7 illustrates, whether or not a path develops from a 'preformation phase' to a path creation phase with experimentation and competition will be contingent on the effects of the external environment (or context) which may be constraining or enabling. 'Contextual' factors also impact on movement to the third phase of path development based on increasing returns and externalities. From this 'point' a path may move to a fairly rigid state characterized by stasis, or it may continue to evolve dynamically without becoming 'rigidified'. Martin (2010) suggests that such path dynamics can be explained by layering (changes in composition of economic ecosystems), conversion (change and innovation) and recombination (meshing of new and old capabilities and competencies). This latter perspective is employed in A2/Verdal to analyse how the 'old path' of oil and gas related activities both enabled and constrained the formation of a new path in wind energy.

As argued by Dawley (2014), it is however not entirely clear what constitutes 'enabling' or 'constraining' environments, nor is the role of certain types of actors (e.g. policy makers) particularly well understood. This thesis, and especially A2/Verdal and A3/Barriers, seeks to unpack the broader contexts that shape path creation, how contextual conditions (i.e. market dynamics, framework conditions etc.) also change over time and how this in turn impacts on the dynamics of innovation and industry development. In the same articles, the role of other actors than firms (e.g. state agencies, quasi-public intermediaries) are integrated into analysis not only because such non-firm actors in important ways shape the conditions for path creation, but also because they are engaged in the co-creation of new paths (Garud and Karn e 2003; Simmie 2012; Dawley 2014; Simmie, Sternberg, and Carpenter 2014; Binz, Truffer, and Coenen 2015).

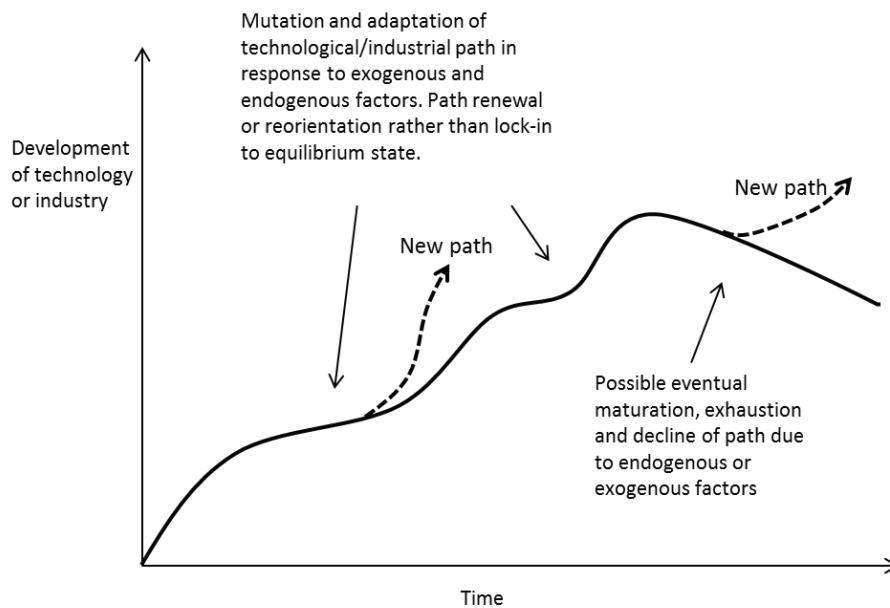


Figure 8 An 'open' model of path evolution. Adapted from Martin and Sunley (2010)

Figure 8 provides a schematic illustration of how a particular technology or industry path may develop over time, with the x-axis representing time and the y-axis representing a development process. With an open path evolution model, an industrial path develops as a result of mutations and adaptation that are responses to both exogenous and/or endogenous factors. Rather than being 'locked-in' to a predefined trajectory, a path may undergo series of renewal or reorientation processes driven by (incremental and radical innovation) as well as the exploration of new markets (Isaksen 2014). Furthermore, at all 'stages' of a path's evolution, a new path may 'branch off', contributing to new industry emergence. In reality, many of the 'elements' (firms, technologies, institutions, resources etc.) that constitute a 'path' will be enmeshed in other paths, as for instance with sectors having overlapping value chains. Whatever is endogenous or exogenous to a specific path, therefore, is largely an analytical matter. And in a territorial sense, the untangling of 'local' and 'extra-local' factors is of course not only a very tricky issue in an empirical sense but also artificial due to the profound and recursive mixing of exogenous and endogenous forces acting on regional (or local or national) economies (Martin and Sunley 2006).

It follows from the above discussion that path evolution processes are place-specific yet enmeshed in complex processes that are influenced by factors and forces on multiple scales and that path evolution in some place/region/country is linked to developments elsewhere. Another important yet largely overlooked aspect of path evolution is interaction *between* different industrial paths (co-)evolving in a given territorial setting, suggesting the possibility of what Martin and Sunley (2010, 79) refer to as 'path-interdependence'. Analysing path creation processes thus requires an understanding of (institutional, market, industry etc.) context, key mechanisms, and actors (both firms and non-firm

organizations) and their activities and strategies.¹⁵ These issues are discussed in some more depth in the sub-sections that follow.

3.4 Path creation: context, mechanisms and agency

A central idea in recent theorizing on the evolution of local, regional and national economies is captured in the notion of 'related variety' (Cainelli and Iacobucci 2012; Boschma and Frenken 2011; Boschma, Minondo, and Navarro 2012; Frenken, Van Oort, and Verburg 2007), which bridges the so-called 'localization and diversification debate'¹⁶ in economic geography and regional science. The crucial argument of the related variety perspective is that regional development relies on the ability to build on existing knowledge¹⁷ and competencies and (re)combine these with new knowledge and resources and diversify into new sectors and applications. This is obviously relevant to path creation dynamics, in the sense that new paths are related to previous paths in terms of the transfer of knowledge (Neffke, Henning, and Boschma 2011) or other resources (Hanson et al. 2015). From a policy perspective, a key issue is thus to identify and foster relevant 'branching opportunities' from existing to new sectors whereby particular knowledge assets can be reused (Asheim, Boschma, and Cooke 2011).

When new industries are established in particular regions or places then, this will often be related to the regional or local context and former trajectories of development (Martin and Sunley 2006). The idea of 'regional branching' (Boschma and Frenken 2011; Neffke, Henning, and Boschma 2011; Essletzbichler 2013; Bugge and Øiestad 2014) is thus a second key idea in evolutionary economic geography (EEG) theorizing on path creation. Branching occurs in two main ways: 1) a new path emerges from an established path; 2) a new path is formed through recombination of knowledge and resources from different sectors (Boschma and Frenken 2011). Through branching, organizational routines and other capabilities are 'passed on' from established to emerging industries.

The idea that the development of new sectors primarily occurs as 'branching processes' (Neffke, Henning, and Boschma 2011) is based on micro-level theoretical assumptions. Boschma and Frenken (2011) argue that the primary study unit of economic geography should be the firm, which they see as a carrier of specific routines on which firm compete. With this perspective, economic evolution is viewed as a selection process whereby those firms (and other entities) with the 'fittest' routines transmit their organizational capabilities over time by out-competing less fit competitors as well as through processes such as spin-offs and labour mobility. Since these are largely localized processes, the inheritance or replication of routines over time is primarily endogenous to specific regional or local economies. Four sub-mechanisms of regional branching have been identified (Boschma and Frenken 2011). First, regional branching can be a result of entrepreneurial activities such as spin-offs

¹⁵ At the same time, the myriad of possible linkages between various sectors and territories implies that pragmatic decisions need to be made in defining the spatial, sectoral and temporal boundaries of a given path creation process, and subsequently in analyzing particular path evolution processes.

¹⁶ The Marshall-Arrow-Romer (MAR) model emphasizes intra-industry knowledge spillovers (localization/specialization externalities), for instance by labor mobility. By contrary, Jacobs (1969) argued that the most important knowledge spillovers occur across industries. Firms operating in diverse industrial contexts are thus more fortunately exposed to a variety of knowledge sources, leading Jacobs to conclude that cities (urbanization economies) are the most prominent source of innovative activity.

¹⁷ In the contemporary globalized knowledge economy, knowledge is considered the most important resource and learning the key process (Lundvall and Johnson 1994). Globalization has resulted in a range of products becoming ubiquitous – available (almost) everywhere – making knowledge creation and the application of knowledge in innovation processes a fundamental cornerstone of competitiveness (Maskell and Malmberg 1999).

and start-ups. The second sub-mechanism is that of firm diversification, and associated development of new products and services (innovation), as well as organizational changes such as mergers and acquisitions. Third, new paths may form partly as a result of labor mobility between firms and sectors. Finally, social networking between agents is an important mechanism for knowledge diffusion between different (old and new) sectors. These are partially overlapping. For instance, the third mechanism (labor mobility) will often be an element in the second mechanism (firm diversification etc.).

Branching as key to the development of new industrial paths implies that regions are better off having related rather than unrelated variety in their portfolio of economic activities (MacKinnon 2011). Frenken, Van Oort, and Verburg (2007, 686), for instance, claim that “(a) region specializing in a particular composition of complementary sectors will experience higher growth rates than a region specializing in sectors that do not complement each other.” Additionally, a diversified economic structure may enhance the resilience of a region when confronted with disruptive factors (Martin 2012; Carlsson et al. 2014), for instance if resources can switch between different co-located technological trajectories (Bathelt 2001). The implication of this is furthermore that certain regions may be especially disadvantaged in terms of providing the breeding ground for innovation. Such regions include peripheral regions and single-industry regions (as forms the empirical context of the analysis in A2/Verdal), which are not rich in diversity and thus have more limited opportunities for reorientation, renewal and new path creation than more diversified regional economies (Hassink 2005; Martin 2012; Carlsson et al. 2014; Coenen, Moodysson, and Martin 2014).

Although a number of other path creation mechanisms have been identified (Martin and Sunley 2006), including indigenous path creation (where new innovations are developed on the basis of heterogeneous knowledge bases) and transplantation (which refers to the inward investment of firms from elsewhere), it is fair to say that the idea of branching as a mechanism for new path creation has gained most attention. However, this idea of regional branching as a primary mechanism of path creation has not been left uncontested. One such line of criticism relates to the (over)emphasis on firm routines and the limited influence of non-firm actors such as states, public agencies, intermediaries and R&D institutions (Dawley 2014; Tanner 2014; Dawley et al. 2015). National and regional state institutions, for instance, can play important roles in stimulating new paths or stifling established ones through a variety of policy instruments (Kivimaa and Kern 2016), but the role of these types of actors and policy activism has thus far received fairly limited attention in research on path creation (Dawley 2014). This is of course not to suggest that policy makers can simply establish industries based on new technologies by decree. But it is to suggest that policy can have strong impacts on for instance resource mobilization to novel paths.

Another critique of the regional branching thesis is that the emphasis on generic resources (mainly in the form of knowledge and skills) that are place-specific disregards the role of extra-local resources and knowledge linkages and thus risks fetishizing place. Binz, Truffer, and Coenen (2015) hypothesize that pre-existing capabilities, technological relatedness and other endogenous development factors will only spur new paths if integrated into a broader process of resource formation and alignment in the (global) innovation system developing around a new technology. A further 'complicating factor' is that (local/regional/national) economies are comprised of various sectors, which may or may not be interlinked through inputs and outputs, knowledge spillovers, shared labour pools or externalities such as infrastructure. There may thus be interdependence between different (established/emerging)

paths, depending on the structure and interaction between different segments of the economy (Martin and Sunley 2010). As argued by Martin and Sunley (2006) firms and non-firm actors in any given place or region (or country) are part of highly complex networks (businesses, markets, regulatory frameworks, institutions etc.) involving actors in other places/regions and at other scales¹⁸, and it is far from clear how this complex entanglement influences specific development trajectories.

Accounting for this complexity in contextual factors, mechanisms and agencies that impact on path creation necessitates perspectives that acknowledge technological, economic, institutional and social dimensions. One body of literature which provides such frameworks, which can be seen as complementary to economic geography theory (Coenen, Benneworth, and Truffer 2012; Truffer and Coenen 2012), and highly relevant to the empirical field that this thesis engages with, is the socio-technical transitions literature.

3.5 Socio-technical (sustainability) transitions

Deep structural changes in energy, transport, agro-food and other systems are needed in order to tackle the contemporary environmental problems of climate change, loss of biodiversity, resource depletion and pollution (Elzen, Geels, and Green 2004; Bridge 2008; Geels 2011; Cooke 2012). Such changes are often referred to as 'socio-technical transitions' because they imply and require changes in the configuration and dynamics of technologies, policies, infrastructure, cultural meanings, consumer practices and other ingredients in the heterogeneous elements that constitute complex systems.¹⁹ Because this literature focuses on empirical issues linked to environmental challenges, it is also often labelled the 'sustainability transitions' (ST) literature

The ST literature draws on evolutionary economics, economic sociology, institutional theory and different social constructivist accounts on technology, and argues that technology and institutions must be seen in parallel in studies of innovation and technological change (Truffer and Coenen 2012; Markard, Raven, and Truffer 2012). The ST literature eschews innovation as a technical fix, but rather emphasizes transformative systemic (structural) change as a co-evolutionary process between institutions, markets, user practices, technological trajectories and industrial dynamics (Geels, Hekkert, and Jacobsson 2008).

The ST literature, then, provides analytical frameworks for understanding the emergence of new technologies and industries, particularly within large-scale, highly path dependent, and complex systems such as those of the energy industries (Geels 2004; Markard, Raven, and Truffer 2012) which in my view complement economic geography perspectives. Insights from the ST literature are in particular drawn upon in A3/Barriers and in A4/Reconsidering. In addition, A4/Reconsidering engages closely with the sociology of expectations literature, which can be seen as a sibling of the ST literature stream. This thesis does not attempt to make theoretical contributions to the ST literature as such, nor does it employ ST frameworks as primary analytical strategies. Rather, by incorporating

¹⁸ This, of course, is a pivotal idea in global production (Coe et al. 2004) and innovation (Asheim et al. 2013) network approaches.

¹⁹ Recalling Freeman and Perez distinction of types of technological change (section 3.1.2), Geels (2007) argues that whilst incremental and radical innovation is primarily a research topic in business studies (e.g. Tushman and Anderson 1986; Christensen 1997), changes in techno-economic paradigms are the subject of research on long-waves (Freeman and Perez 1988). Changes at the (meso) system level are by contrast underexplored, they are "*complex (...) involving technological discontinuities and social, political, cultural, infrastructural and economic changes*" (Geels 2007, 1411-1412).

insights from the ST literature the aim is to contribute to theory development concerning path creation (and evolution) particularly with sectors such as energy in mind. These insights are in particular drawn from the approaches known as the multi-level perspective (MLP) and the technological innovation systems (TIS) approach, which will briefly be reviewed in the subsection that follows, where I also point out their relevance to the thesis.

3.5.1 The MLP and TIS approaches

The MLP is an analytic framework that is applied to studying historical processes of technological change by focusing on the interaction between emerging *niches* and existing socio-technical *regimes* in a broader *landscape* (Verbong and Geels 2007). MLP studies typically reconstruct historical processes of technological change within sectors, for instance from sail to steam on ships, or from fossil to non-fossil fuels (Geels 2005). According to Shove and Walker (2007, 764), “*the key idea is that change takes place through processes of co-evolution and mutual adaptation within and between the layers*”. The *landscape* (macro) level here refers to broader societal factors that cannot be directly influenced by regime actors, such as global commodity prices, changing consumer preferences or pressure arising from climate change concern. The key concept is however the socio-technical *regime* (meso level), which is an interrelated and stable structure made up of a heterogeneous network of actors, comprising established products and technologies, infrastructure, user practices, expectations, norms and regulations (Geels 2002; Smith, Stirling, and Berkhout 2005). The socio-technical regime concept extends (Rip and Kemp 1998; Geels 2004) Nelson and Winter's (1982) conceptualization of technological regimes²⁰ by adding various types of informal and formal rules that also serve to stabilize regimes. Proponents of the MLP also broadened the social networks that constitute regimes by way of arguing that many different types of actors are involved in reproducing, maintaining and transforming such systems, making transitions – the shift from one regime to another – complex and often long-term processes (Geels 2011). Not surprisingly, path dependence is a household concept also in the literature on socio-technical transitions (Geels 2010; Lovio, Mickwitz, and Heiskanen 2011; Markard, Raven, and Truffer 2012). Technological innovation requires ‘*niches*’, protected spaces for development ‘free’ from the constraints of market selection, performance standards and the infrastructural rigidities of established systems (Geels 2002; Smith and Raven 2012). This may be market niches, where actors have slightly different preferences selection criteria than buyers within the mainstream market, or technological niches where resources are provided by public subsidies or private strategic investments (Geels and Kemp 2007).²¹

The TIS approach is particularly geared towards studying the development, upscaling and implementation of new technologies as well as the institutional and organizational changes that have to run parallel with technology development (Hekkert et al. 2007; Bergek et al. 2008; Markard, Raven, and Truffer 2012). A TIS is defined as “*network(s) of agents interacting in a specific technology area under a particular institutional infrastructure for the purpose of generating, diffusing and utilizing technology*” (Carlsson and Stankiewicz 1991, 111). A basic premise of the TIS approach²² is

²⁰ Refers to shared cognitive routines or search heuristics that guide technological development within a community of engineers.

²¹ The MLP has been criticized for having key concepts (especially ‘regime’ and ‘landscape’) that are ambiguously delimited and operationalized (Smith, Voß, and Grin 2010; Lawhon and Murphy 2011). Other criticisms directed at the MLP is that it is “*too descriptive and structural*” (Smith, Stirling, and Berkhout 2005, 1492), and that its focus on the meso-context of regimes has come at the expense of agency (Raven et al. 2011; Farla et al. 2012).

²² A premise which the TIS shares with its siblings in the broader family of innovation systems approaches (national, regional, sectoral systems of innovation).

that economic performance of industries, regions or nations depends not only on business performance and technological development, but also on inter-organizational interaction straddling public and private sectors, knowledge creation and dissemination, and the build-up of infrastructure, institutions etc. (i.e. a *system*). This interaction is needed to convert ideas into products and processes that are commercially applicable, implying that the TIS framework draws attention to systemic innovation (Weber and Rohracher 2012). Similar to the MLP, this interaction is seen as being dependent on niches. Niches provide commercial opportunities and facilitate the development of different designs, value chain development and upscaling of production capacities (Geels, Hekkert, and Jacobsson 2008), and "*help building a constituency behind a new technology, and set in motion interactive learning processes and institutional adaptation (...) that are all-important for the wider diffusion and development of the new technology*" (Kemp, Schot, and Hoogma 1998, 184). Although new technologies may have many benefits (lower operational costs, less pollution etc.), they often struggle to develop beyond a nascent phase. Not only actors and markets but also institutions and networks can obstruct TIS formation (Jacobsson and Johnson 2000). Emerging TISs often face challenges which can be identified as system weaknesses. These challenges for technology development and diffusion can be identified by studying key processes or functions in an emerging TIS (Bergek et al. 2008; Hekkert et al. 2007). These functions include knowledge development and diffusion, influence on the direction of search, market formation, resource mobilization, legitimation, entrepreneurial experimentation and development of external economies (Bergek et al., 2008). Any weaknesses in these regards are seen as structural weaknesses or failures that may be addressed by e.g. policy makers.²³

In recent years, the ST literature in general and the MLP in particular has received growing interest from economic geographers (cf. Essletzbichler 2012; Simmie 2012; Truffer and Coenen 2012; Hansen and Coenen 2015). Coenen, Bennenworth, and Truffer (2012) argue that the ST literature has made significant contributions in providing analytical apparatus for understanding the complex and multi-dimensional shifts that are necessary in order to change current modes of production and consumption towards more sustainable ways of organizing economic activities, and that the ST literature has much to offer economic geography in these regards. It is basically in this sense that ST perspectives have informed this thesis. In short, the OWP industry constitutes a technological niche, and the further development and upscaling of this industry and the technologies that it embodies needs to be understood in relation to the wider energy system. As such, the established oil and gas and hydropower sectors can be seen as constituting two dominant regimes in the Norwegian energy system (Steen and Weaver 2015).

Geographers have on their part argued that ideas and insights from economic geography theory can enrich and improve ST frameworks. In particular, geographers have argued that more explicit spatial perspectives will contribute to better understanding of the diversity in transition processes, which follows from both variety in institutional conditions, networks, actor strategies and resources across space as well as how particular territorial configurations (TIS, niches, regimes) are embedded in multi-scalar and trans-local settings (cf. Coenen and Truffer 2012; Truffer and Coenen 2012; Binz, Truffer, and Coenen 2014; Murphy 2015). Examples of economic geography analysis which to larger

²³ The TIS approach has been criticized for not paying sufficient explicit attention to the context in which new technologies develop (Markard and Truffer 2008; Bergek et al. 2015). Other lines of critique include lack of consideration of spatial aspects, weaknesses and ambiguity in delineation of 'technological systems', and the role of policy and power relations (Markard, Hekkert, and Jacobsson 2015).

or less extent draw on a combination of economic geography and transition frameworks include Binz, Truffer and Coenen's (2014) study of global knowledge dynamics of membrane bioreactor technology, Martin and Coenen's (2014) study of the role of institutional context for the emergence of a biogas industry cluster in southern Sweden, Simmie's (2012) study of path creation in the Danish wind energy industry, and Dewald and Fromhold-Eisebith's (2015) study of the photovoltaic (technological) innovation system in Germany.

Whilst I am sympathetic with both the MLP and TIS approaches, I believe that some of the *a priori* assumptions underlying these frameworks are questionable. In particular, I find the view that established/mature firms (incumbents) are by definition static and defenders of status quo problematic. That is, in my view heterogeneity on the actor level is too often collapsed into a uniform mass of entities that are assumed to behave in certain predisposed ways. There is, as argued in section 3.5, not only considerable heterogeneity in capabilities among incumbents of the same industry, but also robust evidence to suggest that incumbents may contribute to transformational change.²⁴ This is not to say that incumbents with vested interests may not forcefully attempt to hinder new competing solutions (for example NRE technologies), but it is to suggest that also established firms (in established industries) may pursue radical innovation and contribute to the creation of new paths or industries. For instance, findings in this thesis clearly suggest that many of the actors involved in the OWP industry are firms that have diversified from other (established) sectors (see also Weaver and Steen 2013; Normann and Hanson 2015) thereby contributing to resource mobilisation and technological variety. This strategic reorientation of energy incumbents towards new (more sustainable) paths is of course a response to the transformational changes underway in the broader industrial sector in which they operate. The writing is on the wall – in green ink.

As such, an important argument within the ST literature (both MLP and TIS) is that actors involved in technology development not only anticipate future selection processes, but that the selection process is actively influenced by actors (Schot and Geels 2008). The perspective is quasi-evolutionary in that it argues that variation is not completely blind. Instead, future selection environments (for technologies) are anticipated and actively shaped by actors (Coenen, Raven, and Verbong 2010), which brings me to the sociology of expectations literature.

3.5.2 The sociology of expectations

As discussed in preceding sections, early phases of industries are characterized by high uncertainty regarding the development of technologies, markets, regulations and actors. According to Bakker et al. (2011, 153-154), a key characteristic of emerging technologies and socio-technical systems is that *“investment decisions (and other pre-selections) have to be taken in an early stage of development, when the new technologies are not yet prone to (...) trials of actual performance.”* With high levels of uncertainty, decisions are to some extent made on expectations rather than facts. A range of studies have shown how anticipations of the future are fundamental to understanding technological development (cf. Berkhout 2006; Borup et al. 2006; Truffer, Voß, and Konrad 2008; Pollock and Williams 2010; Bakker, Van Lente, and Meeus 2011).

Innovation and transition processes do not merely grow out of chance encounters between actors that chase their own strategies based on existing resources. Instead, these processes of change are,

²⁴ This has recently been acknowledged by scholars in the ST literature stream, e.g. Geels et al. (2016).

to some extent at least, strategically shaped by actors with a 'larger plan' or vision (Farla et al. 2012). Promises of new technology are an important element in niche emergence and development (Kemp, Schot, and Hoogma 1998; Borup et al. 2006; Geels and Raven 2006), and arguably therefore also in processes of path creation and industry emergence. Technological expectations are real-time representations of future technological situations and capabilities, and they are generative and performative in the sense that they guide activities, provide structure and legitimation, and attract interest and foster investments (Borup et al. 2006; van Lente 2012). These promises may then be translated into a shared or collective expectation capable of attuning different actors and resources towards a common goal.

However, the expectations that may be needed to attract resources and create momentum for a novel path may also pose considerable risk to that very same momentum, since expectations that are unfulfilled can damage the reputation of an entire technological field (Brown 2003). As explained by Ruef and Markard (2010, 317-318), expectations that fail to materialize can "*undermine the reputation of the new product or technology and of its developers. As a consequence, resource mobilisation becomes much more difficult and actors may even withdraw from the field.*" Whereas the impact of hypes (high expectations) has received considerable attention in the literature, the empirical studies on the consequences of disappointments (unfulfilled high expectations) is a neglected field (Ruef and Markard 2010).²⁵ However, as the preceding sub-sections have argued, and which the articles in this thesis demonstrate, 'failure' to develop new energy technologies is often a result of factors that have little to do with the technology per se, and more to do with framework conditions and (lack of) adequate policy instruments.

Apart from the observations that collective expectations develop more easily when actors are co-located (Coenen and Díaz López 2010), little attention has been devoted to the role of expectations and visions in economic geography.²⁶ Conversely, the sociology of expectations literature has not explicitly incorporated considerations of the spatial dimensions of expectations. In A4/Reconsidering I argue that expectations not only relate to how technologies and industries will evolve – and hence what opportunities are present or may arise - but importantly also where, when and how development processes will unfold. In other words, expectations have both spatial and temporal dimensions. When firms develop products and/or services, or decide to invest in a new factory or a power plant, they have more or less specific (anticipated) markets in mind with specific (anticipated) needs, demands and spatio-temporal characteristics. In the offshore wind power (OWP) sector, the market is constituted by a wide variety of projects that are developed in specific (maritime) territories that differ in depth, sea-bed conditions, wind conditions, distance to shore and so on. This, I suggest, has tangible effects on firm strategies and decision making, related to which activities and markets firms pursue, which innovations to develop, and how to organize and orchestrate these endeavors also in direct or indirect relation to other actors.

²⁵ This seems analogous to the situation in innovation studies literature, where success cases attract attention from researchers (along with investors, media, buyers etc.), whereas failed innovations are overlooked by researchers as well as most other actors (unless they are spectacular somehow). In a sense, this is natural because failed innovations are not easily noticeable.

²⁶ Tavassoli and Tsagdis (2014), however, argue that the generation of visions is a critical success factor for top-down cluster development.

3.6 Summary of chapter and reflections

This chapter has provided an outline and discussion of the theoretical foundation of the thesis, focusing on the notion of path dependence and perspectives on industry emergence and technological change as conceptualized in evolutionary economic geography (EEG), and complemented (in particular) by perspectives from the sustainability transitions literature.

Table 4 provides an overview of the theoretical frameworks and concepts employed in the articles, as well as territorial context (empirical frame of reference), illustrating that there is overlap and complementarity between the articles.

Table 4 Overview of territorial context and main theoretical frameworks/concepts employed in the articles (A1-A4)

| <i>Article</i> | <i>Open/non-constraining perspective on path evolution</i> | <i>Socio-technical transitions</i> | <i>Sociology of expectations</i> | <i>Regional (R) or national/sectoral (N) context</i> |
|------------------|--|------------------------------------|----------------------------------|--|
| A1/Same Sea | (x) | | | N |
| A2/Verdal | X | (x) | (x) | R |
| A3/Barriers | X | (x) | (x) | N |
| A4/Reconsidering | X | (x) | X | N |

Note: X implies key perspective/concept, (x) implies supplementary perspective/concept

The choice of theoretical approaches to draw upon in the articles also included considerations of perspectives *not to draw* on in accounting for industry emergence or path creation. Arguably, I could for instance have employed a life cycle approach. The shakeout of some of the Norwegian OWP firms could as such be explained by their inability to manage the production process, as explained by life cycle theory (section 3.2.2). That is, once technological designs become somewhat stabilized, focus shifts from product to process innovation and investments in capital intensive production methods. The fact that only one Norwegian foundation supplier has conducted production or fabrication in Norway, and exited offshore wind after an unsuccessful project (see A2/Verdal), may testify to such a hypothesis. The OWP industry, however, differs in its technological make up, implying that a life cycle perspective may be too high-level/abstract from industrial reality. That is, there is substantial variety in technological maturity across the value chain(s) constituting the OWP sector (EWEA 2013). For instance, designs for certain core components such as wind turbines (conventional 3-3.5 MW turbines), monopiles (foundations) and electricity cables are fairly mature. By contrast, immature technologies include large OWP turbines (10-20 MW), floating foundations and specialized vessels for more cost efficient installation and deployment. In a sense, this reflects how OWP is an immature industry receiving inputs from several mature industries. Thus, the approach taken here to focus more on these cross-sectorial aspects is appropriate.

A second option could have been to focus more on new firms, and employ entrepreneurship theory. Indeed, many literatures emphasize the role of new firms both for innovation in general and industry emergence. Processes of entrepreneurship fold out in specific contexts and must be analysed accordingly (Aldrich & Martinez 2001; Karlsen 2005). Entrepreneurial activity “*shapes the local environment through active learning and experimentation, the reinvestment of profits and expertise, the extension of relationships with universities and government laboratories, the building of local institutions such as industry networking associations and the subsequent pull of new actors to the*

region" (Feldman et al. 2005:130). However, because I was interested in the broader process of path creation – and because of the importance of various types of actors for such processes to unfold, I considered an entrepreneurship perspective to be too narrow, especially considering the nature of the OWP industry (capital intensive, long-term investments, high risks etc.) and substantial involvement of large firms (utilities, suppliers, construction firms) diversifying from other sectors.

On a final note, I did consider using a global production network (GPN) (cf. Coe et al. 2004; Coe, Dicken, and Hess 2008; MacKinnon 2011) approach in analysing the development of Norway's OWP industry. The GPN approach provides a multi-scalar analytical perspective which I consider to be highly fruitful in understanding the territorial development outcomes of economic activities. Taken together, the articles of this thesis illustrate that it is futile to see path creation as an endogenous process (in a territorial sense) driven by industry dynamics alone, points which are highly stressed in the GPN framework (see also Steen and Underthun 2011). Given the export-orientation of the Norwegian OWP industry, I could have focused on processes of strategic coupling (Coe, Dicken, and Hess 2008) between Norwegian industry and the strategic needs of lead firms in the OWP production network. However, the main reason why I did not opt for a GPN perspective in this thesis was that I did not really see the value of applying it to an emerging industry, as most empirical GPN research has been done on mature industries. In retrospect, and especially considering more recent theoretical developments (notably Yeung and Coe 2015) within this body of literature, I think there is much potential in bringing together GPN and path evolution perspectives.

4 Research design and methodological reflections

The following chapter describes the research design and process of the overall project and discusses strengths and weaknesses. I evaluate methods chosen for collecting and analysing data, and connect methodological issues to theoretical and analytical frameworks employed in the articles.

Methodological challenges and opportunities related to studying emerging industries contemporaneously are discussed quite extensively in A4/Reconsidering, and will therefore only be commented briefly upon here.

In studying the emerging offshore wind power (OWP) industry I have been influenced by what Yeung (2003) refers to as a process-based research strategy, in which complementary methods and techniques are employed to explore the micro-foundations of economic action as well as to reflexively generate theoretical insights. With this strategy, the specificities of a research strategy is driven by the research process itself, rather than some *a priori* epistemological position providing more or less stringent options in terms of methodological tools.

Some *a priori* assumptions and decision-making nonetheless guides a research process (Valentine 2001). When the research process began my ideas around both empirical and theoretical aspects were admittedly relatively vague. Therefore, when considering research strategy, my point of departure was not a particular theory that I aimed to confirm or challenge, but rather a set of empirical questions related to the OWP industry that I found intriguing and wanted to explore, coupled with a set of theoretical approaches that I considered promising in terms of providing answers. As such, my aim was to explore the empirical questions from various analytical perspectives, to identify actors and structures, to describe key processes and consequently provide explanations (Frankfort-Nachmias and Nachmias 2008) as to the how's and why's of the emergence and development of the Norwegian OWP path. The aim of this end product, then, is to contribute to economic geography theorizing on path creation. Theorizing here refers to both theory testing and theory development (George and Bennett 2005).

4.1 Researching path creation with a (primarily) qualitative approach

As argued in previous chapters, the emergence of new industries (or path creation) in many respects lacks explanation. Research on emerging industries is dominated by quantitative approaches (Beugelsdijk 2007; Feldman and Lendel 2010), as is research on knowledge spillovers (Desrochers and Leppälä 2011), regional branching and related variety (Boschma and Frenken 2011; Coe 2011; Boschma, Minondo, and Navarro 2012). Indeed, quantitative research strategies serve well to quantify particular distributions, to identify linkages or network patterns or to learn about the extent of knowledge spillover processes (Broekel and Boschma 2011). However, as argued in A1/Same Sea and A4/Reconsidering, studying an emerging industry, and especially a rapidly developing one such as OWP, cannot rely on statistical data alone because industrial classifications are simply missing. In the OWP sector, available statistical data are further complicated by aggregation of offshore and onshore wind industries, along with multi-industry firms operating across many sectors (Dawley 2014).

As such, qualitative approaches can complement quantitative research on path creation and industry emergence by shedding light on "*social and institutional processes that shape and operate within mechanisms of path creation*" (Dawley 2014, 108). As argued by Schoenberger (1991), "*the qualitative and inductive aspects may be highest in periods of great economic and social change that*

pose new challenges to the analytical categories and theoretical principles underlying much quantitative research." Compared to quantitative approaches, qualitative methods²⁷ are particularly potent when the aim is to understand the particularities and unique features of phenomenon and development processes. For instance, whereas quantitative approaches can shed light on the extent of (certain types of) knowledge spillovers, they are less helpful in capturing the contents and modes of such resource transfers (Beaudry and Schiffauerova 2009). In addition, and as argued in the theory chapter, I would argue that institutional, spatial and (inter-) sectoral context is highly important for understanding processes of industry emergence (Martin 2010; Dawley 2014), and capturing contextual factors with predefined categories and quantifiable measures can only provide shallow understandings of the environments in which actors are embedded and social processes unfold.

This thesis is therefore primarily based on a qualitative research approach. This has three main reasons. The first reason has to do with the nature of research questions that motivated this research. More specifically, this relates to exploration of issues such as actor strategies, interactions between different types of actors, the contents of knowledge spillovers and barriers to diversification. Second, studying an emerging industry in 'real-time' requires qualitative approaches not only because quantitative data is missing, but also because qualitative approaches can illuminate the agentic processes that are fundamental to path creation (see A4/Reconsidering for a more thorough discussion). The third reason for employing a primarily qualitative approach has to do with the aim of contributing to theory development. Whereas quantitative approaches have a strength in testing hypotheses derived from existing theory (Henning, Stam, and Wenting 2013), qualitative case-based approaches provide rich opportunity for theory development through a recursive cycling between empirical and theoretical understanding (Eisenhardt and Graebner 2007; Cresswell 2009; Kvale and Brinkmann 2009). As such, a characteristic of qualitative research that distinguishes it from quantitative research is that it to a larger extent involves development of ideas and concepts during data collection (Neuman 2007). This was certainly the case during this research project. For instance, one of the core topics discussed in A4/Reconsidering - the temporality of agency – first 'emerged' from analysis of some of the first primary data that was produced (see section 4.2) as part of this project. Subsequently, this led to theoretical 'exploration' and my discovery of the literature on the sociology of expectations.

Accordingly, the thesis follows a theoretically interpretative case study approach which explicitly highlights the importance of studying social processes in context, and which is aimed towards analytical generalization.

4.1.1 The case study approach

Following Gullberg (2013), I see the case study approach as a type of (primarily qualitative) research methodology as well as a product of the research process. A 'case' can be anything from a very concrete entity (e.g. a particular individual) to a less concrete entity such as a community or relationship. The important thing is to be able to define the case at hand using certain parameters such as time, territory or key characteristics. The 'ingredients' of the Norwegian OWP industry case are then all possible actors, activities and processes that are involved in OWP in one way or another

²⁷ That having said, rather than viewing quantitative and qualitative methods as polar opposites, I support the view of these as different ends of a continuum, with a 'mixed methods' approach residing in the middle (Cresswell 2009). Both quantitative and qualitative methods have strengths and weaknesses, and their application should follow from the particular aims of a research project rather than fixed epistemological positions.

(e.g. conducting research, lobbying, developing technology, fabricating products, supplying capital, developing legal and regulatory frameworks) in Norway (recognizing of course that actor-networks transcend territorial boundaries). The different articles focus on subsets of data within the Norwegian OWP case. A1/Same Sea and A4/Reconsidering both focus almost exclusively on firms. A2/Verdal is an embedded 'regional' case within the national context, and similarly to A3/Barriers (which is on the national level of analysis) explicitly covers other actors than firms.

This study can be categorized as a theoretically interpretative case study (Andersen 2005). That is, my motives for this particular project and its research aims are both empirical and theoretical (cf. section 1.1). I see the emerging Norwegian OWP industry as an example of a class or type of phenomenon²⁸, with an associated body of theoretical and empirical knowledge and understanding. This knowledge, which is necessary for theory development in the design phase of a case study (Yin 2014), includes, for instance, theories of industry emergence, technological innovation and systemic change in large-scale capital intensive sectors, and of the role of various types of policy instruments in supporting this type of industry formation. Generalizations based on qualitative research are not statistical or universal (Byrne 2009), but analytical and of relevance to theoretical claims (Yin 2003; Eisenhardt and Graebner 2007). The aim of case-based research is thus to achieve new (generalized) knowledge which is of relevance to a broader class of phenomenon, and which serves to develop both theoretical and empirical understandings. A main aim of the social sciences is of course to identify 'family resemblance': commonalities and similarities that create regularities across variety. Similarities and regularities can be considered at different levels of analysis. In this thesis, for example, generalization is based on firm type categories that include varied-but-similar type entities, defined and operationalized according to context and purpose, such as *specialized* OWP firms vs. *diversified* firms from other sectors in A1/Same Sea. Case study based generalization does not aim to achieve 'proof' status (as in, say, geometry), but rather to be based on sound and logical arguments (Yin 2012).

A key issue regarding analytical generalization relates to scope and questions such as how generally do findings apply?²⁹ Whilst large-N statistical analysis can extend to cases beyond the sampled population, case-based research is easily charged with critique that case selection is biased (i.e. that cases are idiosyncratic) (Goertz and Mahoney 2009). However, units of analysis in qualitative research are not representative (of a population), but rather illustrative or selective (Valentine 2001), and are chosen on the basis of existing theory that can shed light on findings. Conversely, new empirical insights can contribute to theory development through the development of new analytical concepts or nuancing existing ones, or through extending or modifying extant analytical approaches for instance by adding explanatory elements. In this thesis, examples of such contributions to theoretical development include the nuancing of the 'relatedness' concept in A1/Same Sea, the

²⁸ George and Bennet (2005, 17) define a case as "*an instance of class of events*", where 'class of events' refers to phenomenon of scientific interest, such as types of economic systems or kinds of personalities. Investigation of such phenomenon aims to develop theory or 'generic knowledge' regarding differences or similarities among instances (cases) within a class of events.

²⁹ Both the 'national' and the 'regional' case can be seen as exemplars of similar emerging OWP industries in other countries/regions, and add to theoretical understanding of (for instance) the role of different types of actors when new industries emerge. Thus, if seen as an example of 'an emerging renewable energy industry', generalizations could be made on the basis of comparing for instance policy instruments or the role of different types of firms in generating technological variety or building (different types of) supply chains.

discussion of path development in 'constrained' single-industry regions in A2/Verdal, and the reconsideration of agency and temporality in A4/Reconsidering.

Case study research emphasizes the rich and messy real-world context in which phenomenon occur (Eisenhardt and Graebner 2007) and typically covers relatively few study units (for example firms), but many variables or aspects of those units (Yin 2003). Another feature of case study research is that it often includes different types of units, such as different kinds of firms, network organizations and public actors, as well as relations between actors. Yin (2012) distinguishes between exploratory, descriptive and explanatory case studies. Similar to most case studies, this thesis includes elements of all these three types. As such, A1/Same Sea and A4/Reconsidering are (primarily) a mix of descriptive and exploratory, whilst A2/Verdal and A3/Barriers are a mix of descriptive and explanatory case studies. Finally, the ambition to provide in-depth understanding implies that case study analysis is often based on a broad set of data sources: documents, material artefacts, interviews, observations, but also survey-based and statistical data (Yin 2003; George and Bennett 2005; Yin 2012; Cresswell 2013).

4.1.2 Employing mixed methods

A study will be strengthened if various methods contribute with compatible and complementary findings and conclusions (Yeung 2003; Yin 2003; Cresswell 2013). This research project employs a mixed methods approach (Cresswell 2009) combining different types of interviews with document analysis, (participatory) observation and a survey. The empirical analyses are thus based on triangulation of both sources and methods. In practical terms, triangulation refers to the usage of different methods in one project, with the aim of maximizing the understanding of a research question by generating different types of data, and by employing different analytical strategies or perspectives. Triangulating, or “*establishing converging lines of evidence*” (Yin 2012, 13)³⁰, is a useful strategy for ensuring that findings are as robust or reliable (see section 4.3) as possible.

Triangulation can also refer to the use of different sources and informants (Valentine 1997). This connects to sampling strategies. With a qualitative approach, sampling involves considering how choice of cases or units may shed light on a set of key features (Neuman 2007). Given the limited size of the Norwegian OWP population (which was obvious at the onset of the project), I (in collaboration with others) attempted to cover a range of both specialized and diversified OWP firms as well as other actors. Sampling techniques included quota, purposive, snowball and deviant case strategies, with stratified purposive sampling (Cresswell 2013) as the principal method of deciding cases to include in the study.³¹ That is, I attempted to cover multiple actors within different 'categories' (e.g. specialized foundation developers or diversified cable producers) to allow for comparison across similar types of units within the broader case.

Many firms (and specific informants) were identified either through media or were recommended by other informants. In several cases, informants would suggest we talk to someone in another firm or organization with different experiences in the OWP industry, or even individuals with opposing views

³⁰ Or 'convergence validity' (Yeung 2003).

³¹ *Quota*: A preset number of cases in several predetermined categories to reflect diversity of population. *Purposive*: All cases that fit particular criteria. Cresswell (2013) distinguishes between random and stratified purposeful sampling, where the latter refers to choosing subgroups which in turn facilitates comparison across units within a case. *Snowball*: Use referrals from one case to obtain another, then another and so on. *Deviant case*: Cases that differ substantially from dominant pattern.

on certain topics (e.g. opportunity for technological development in the emerging sector). The project also involved doing interviews with managers in firms that were not directly involved in OWP, as well as other 'knowledgeable informants' (including for instance an NTNU professor on wind energy physics) who could contribute with more general insights and enhance our understanding of the industry and its context. A full list of all informants, time of interview and interviewers is provided in Appendix A.

4.2 The research process: data production and analysis

The main bulk of the empirical data was produced from September 2010 to December 2011. The research process unfolded in five main phases as illustrated in Table 5.

Table 5 The research process - five main (partly overlapping) empirical work phases

| <i>Approx. time period</i> | <i>Methods</i> | <i>Aims</i> |
|----------------------------|---|--|
| Jun – Aug 2010 | Desktop studies of media ³² , policy documents, industry reports, firm websites etc. Participation at industry/science conference. | Acquire a general understanding of the empirical field. |
| Sep – Dec 2010 | Semi-structured interviews (approx. 25). | Generate primary qualitative data. Highly exploratory, understand the Norwegian OWP industry development process from multiple angles. |
| Dec 2010 – Jan 2011 | Survey (online) | Generate primary quantitative data on firms involved in OWP. Exploratory and aimed at understanding e.g. market presence, strategic importance of OWP, collaboration with R&D. |
| Jan – Dec 2011 | Interviews (approx. 40), participation at numerous events nationally and regionally, document studies. | Generate primary qualitative data for more specific purposes than in preceding phases. Acquire additional knowledge of the empirical field and stay updated. |
| Jan 2012 – Mar 2014 | Interviews (approx. 10), (mainly regional) events and document studies. | Primarily follow-up and specific-purpose interviews + stay updated. |

In the initial phase (June – August 2010) I focused on acquiring general knowledge of the empirical field through desktop studies. This process of 'soaking and poking' (George and Bennett 2005) involved reading a broad range of documents (e.g. Government White Papers), reports (e.g. from industry associations) and academic literature, and browsing different company and organization websites in order to obtain an understanding of the history and status of the OWP industry both in Norway and internationally. As noted in section 1.2, very little research had been done on the emerging Norwegian OWP industry when this PhD project began in mid-2010. Volden et al.'s (2009) assessment of the potential for Norwegian offshore/maritime industry firms to serve the budding OWP market was helpful in terms of understanding the industrial prospects for Norwegian industry

³² Throughout the project, important media sources have been the weekly publication *Teknisk Ukeblad*, daily newspapers covering energy and maritime industries (e.g. *Aftenbladet* and *Dagens Næringsliv*) and the online media site *Offshorewind.biz*.

and which firms and other actors that would be relevant to focus in on. However, it said little about how and for what reasons firms approached the emerging sector, and the particularities of barriers that different actors were faced with in this regard.

In the second phase (autumn of 2010), a series of interviews (see section 4.2.1) were carried out within a relatively short time period. The interviews that were conducted in this largely explorative phase were semi-structured and broad in scope (see section 4.2.1). Document studies were conducted also in this phase, but primarily related to firms and other organizations in which also interviews were conducted. This was important both for interview preparation and for triangulation.

In the third phase, an online survey (see section 4.2.3) targeting the entire population of Norwegian firms involved in OWP was carried out to provide a broader understanding of the empirical field and to 'test' the validity and extent of certain findings from the first round of interviews and desktop analysis. As such, the survey may be seen as constituting the 'extensive' part of the research process vis-à-vis the 'intensive' part covered by interviews and other qualitative methods. The survey was anonymous, and was thus not used subsequently in sampling firms for interviews.

The fourth phase comprised a set of interviews that were conducted for more specific purposes. For instance, 10 semi-structured interviews were conducted in December 2011 with large O&G supplier firms that have diversified into OWP (or attempted to do so). These were strategically sampled to cover firms operating or targeting different parts of the OWP value chain. In these interviews, particular focus was on strategic motivations and barriers for diversification, contents of knowledge spillovers (especially with the analysis in A1/Same Sea in mind) and institutional context/framework conditions. A similar strategy was employed for the regional case study (A2/Verdal). Participation at various events and document studies were also important during this phase.

During the fifth phase of empirical research (2012-2014) a few interviews were conducted, mainly for follow-up purposes. Some time was also spent on document studies, primarily to stay updated on industry developments. In this phase, emphasis was on data analysis and preparation of journal articles.

The research process involved fieldwork studies in (mainly) three regions of Norway: 1) Mid-Norway (Trondheim and the Verdal region), 2) Oslo and 3) the west coast (Bergen and Stavanger). These three places/regions are host to the majority of Norwegian firms involved in the OWP industry (see also Normann and Hanson 2015), and constitute hubs in the Norwegian petro-maritime industries. However, there were also practical reasons why fieldwork was focused on these regions, such as time issues and fieldwork costs.

Not all of the data that was produced during the research process as described above is actively used in the thesis. The survey data, for instance, is primarily used to support main points and generalized findings from analysis of qualitative data (with the exception of A3/Barriers). One reason for what almost became a data overload problem (Lee and Fielding 2009) was that the empirical and analytical work was done in collaboration with others. For instance, Gard (main collaborator and co-author of A2/Same Sea and A3/Barriers) had a keen interest in the role of venture (or seed) capital (VC) firms for funding new technology-based start-up companies. I did not share this strong interest, but it nonetheless became part of the larger empirical project. However, although none of the articles in this thesis focus on VC firms (or the role of funding *per se*), interviews with VC actors provided valuable contextual understanding of the empirical field.

4.2.1 Interviews and (participatory) observation

Semi-structured interviews constitute the most important method used for generating primary data for this thesis, and were conducted to retrieve information and understand complex ongoing processes, rather than to measure theoretical variables (Lund 2002). As argued by Schoenberger (1991, 181), the evidence yielded by the corporate interview "*is the testimony of participants in complex, ongoing processes*" and the rationales underlying their activities. Conversation – or talk- is a primary medium through which (social) interaction and the sharing of information and generation of knowledge takes place (Silverman 2003). As argued by Clark (1998, 82) "*close dialogue is a means of understanding better the actual practice of decision making*" and other complex issues such as behaviour and motivation. Interviews moreover provide a way of obtaining a diversity of meaning, experiences and opinions found within a 'group' (e.g. of firms), but can also reveal similarities and consensus across several (types of) actors.

A major strength of interviewing is that it allows the researcher to discover issues that are of particular relevance to informants, and which may not be able to identify through observation or analysis of written accounts (Dunn 2005). This is especially the case with open or semi-structured interview, which provides some guidelines to ensure that a predefined set of topics are covered (thus allowing for comparison), whilst providing flexibility in sequencing and emphasis on various topics.³³ Semi-structured interviews allow informants to respond more freely about their activities, strategies, interests, expectations, historical backgrounds and relations to other actors. 'Other actors' here refers to suppliers, customers, competitors, R&D institutes, government agencies, industry associations and so on. As such, I find Yin's (2003, 89) characterization of interviews as "*guided conversations*" appropriate. Taken together, the use of semi-structured interviews allows for coherence in topics covered in 'guided conversations', while flexibility provides opportunity to open 'black boxes' (such as knowledge spillovers) by asking different types of questions and by probing into issues from various angles along the process of the interview.

Interviews commenced with a brief introduction of our aims and interests as well as intended data usage, and asking whether or not it was ok to use a recorder and clarify anonymity issues. We would then ask factual questions about the informant (brief background, current position, responsibilities etc.) and the organization (history, size, products/services, markets etc.) that the informant represented. The interviews would then normally proceed with an open ended question such as "*Your company is involved in offshore wind power, can you tell us how this came about?*" to let the informant explain and reflect using his/her own words and get the conversation going.

Some interviews were conducted via telephone. These were generally shorter, more structured in format and narrow in scope than face-to-face interviews, reflecting that they were conducted for more specific purposes with particular articles in mind. Another and more mundane reason why telephone interviews were generally shorter (than face-to-face) was that it is challenging to get *and* keep a conversation going over telephone, provided there has been no prior face-to-face meeting.

In addition to the interviews, a number of short 'fieldwork conversations' provided valuable information on various issues. Some of these 'fieldwork conversations' had a specific purpose and were conducted via telephone to various firm and non-firm actors, such as with the Maritime Energy

³³ By contrast, structured interviews may limit the opportunity to talk freely on the one hand, and also constrain elaboration on particularly important issues (for the informant) and discussion.

Test Centre in Rogaland County or advisors in the Research Council of Norway. However, most of the fieldwork conversations took place more or less serendipitously at various science/industry events.³⁴ For instance, industry seminars/events in both Oslo and Trondheim provided the opportunity to discuss the development of Norway's OWP sector with foreign firm managers and research scientists, who gave interesting 'outsiders' perspectives on the Norwegian OWP wind industry. Also presentations (and discussions that followed) by firm managers, researchers, government officials and others provided valuable insights on a diverse range of topics, such as the development of specific technologies, market outlook, supply chain development, policy frameworks and instruments, 'world energy outlook' and so on and so forth.

4.2.2 Preparation and analysis of qualitative data

All face-to face interviews were recorded, and most were transcribed.³⁵ Interviews conducted via telephone were not recorded, but notes were taken and a 'full text' written out immediately after the conversation. These transcripts were consequently sent via email to the informants who checked the transcripts and made necessary changes and adjustments. They would often also add something.

A characteristic of qualitative research is that the relationship between data collection and analysis is fluid and interactive (Yeung 2003; Lee and Fielding 2009). Data production often takes the form of an assemblage' of large volumes of data gathered from different sources, and this process provides a deepening understanding 'along the way'. Analysis, however, is mainly about both chronological and topical organization of data, implying that data material needs to be organized and structured. The main analysis strategy was what Kvale and Brinkmann (2009) refer to as 'theoretical reading', whereby data material is read with different theoretical lenses rather than organized in concordance with a strict set of rules or techniques.

Transcribed interviews as well as certain other texts such as particularly informative newspaper articles, were coded using the qualitative data analysis (QDA) software Atlas.ti (Lewins and Silver 2007). Using Atlas.ti allowed for both manual coding of different types of descriptive and analytical (thematic or theoretical codes) (Cope 2005)³⁶, well as automatic coding of specific terms or names (e.g. Dogger Bank, Statoil, Enova, Hywind, Innovation Norway). The intention with coding was not to count the number of times a certain word or concept appeared in a conversation (or text), but rather to allow for an easier organization of the data into higher order or abstracted analytical categories of relevance to theoretical perspectives. Once text material is coded, Atlas.ti allows for easy subtraction of passages of text related to particular issues, for instance 'UK', 'domestic market formation' or 'policy instruments'. More advanced features found in current QDA software, such as 'graphic

³⁴ I attended several industry/science events organized at both 'national' and 'regional' levels. Examples: Pareto Energikonferanse (Oslo, January 2011), Kystens Energi (Svolvær, February 2011), INTPOW Offshore wind supply chain conference (Oslo, March 2011), North Sea Offshore Wind Mission (Stiklestad, August 2011), NOWITECH seminar (Trondheim, September 2011), Windcluster Mid-Norway seminar – onshore (Trondheim, December 2011), NOWITECH/Windcluster Mid-Norway "Industry-meets-science" (Trondheim, September 2012 / Trondheim, February 2013 / Trondheim, June 2013 / Trondheim, October 2013).

³⁵ Transcription was to a large extent conducted by research assistants (master students at NTNU). I see this qualitative data material in text format as a window into human experience rather than an object of inquiry itself. The thesis thus follows a sociological (as opposed to a linguistic) tradition of analysis (Ryan and Bernard 2003).

³⁶ Examples of descriptive codes (or category labels): Names of firms or organizations, countries/regions/places, specific technologies (e.g. foundation structures). Examples of descriptive sub-themes: regions within countries, Government agencies/Ministries (under 'state'), floating foundations etc. Examples of analytical (thematic, theoretical) codes: innovation, knowledge, markets, framework conditions, policy, diversification. Examples of analytical sub-themes: innovation policy, energy policy, domestic/international market.

mappings' of findings and/or theory building (Weitzman 2003) were not utilized. As pointed out by Yin (2014, 134), using QDA will always involve considerable "*post-computer thinking and analysis*" on the researcher's part, reflecting how QDA can assist but not actually *do* analysis.

Organizing the data (coding) and analysis was conducted in an iterative manner, alternating between exploring the data and developing theoretical understanding. The starting points for these iterations were theoretical propositions based on extant literature (Yin 2014) that I was familiar with, reflecting how the coding process in a sense begins prior to data production (Cope 2005). In the analysis that resulted in A1/Same Sea, for instance, the key (abstract) concept of 'knowledge spillovers' was initially intended to cover technological knowledge as may be evidenced in key outputs or inputs (or patents), reflecting how knowledge spillovers are captured in studies of related variety (see section 3.3). The analysis, however, revealed that development and transfer of 'knowledge' into OWP relied on and also included various non-technological capabilities such as the ability to organize offshore construction projects. The analysis also revealed that such factors could also hinder knowledge spillovers. Such capabilities are not easily captured in quantifiable or aggregate data. Henceforth, 'knowledge spillovers' was operationalized (here referring to the process of specifying the extension of a concept) to include different types of knowledge (Lundvall 2006), such as competence, know-how and experience, which required detailed manual coding in order to (un)cover the many dimensions of knowledge that were part of the knowledge transfer process. This iteration between coding (analysis) and theory development also reflects how the development of more refined analytical codes requires a thorough understanding of the empirical field as well as the broader context in which the empirical material is situated (Cope 2005).

'Theoretical reading' (Kvale and Brinkmann 2009), or "*relying on theoretical propositions*" (Yin 2014, 136) and iterative analysis also led to exploration into alternative literature streams that could provide deeper understanding and more elaborate explanations of findings (which in turn played back on further theory development). For instance, my point of departure in this research project was the economic geography literature on path dependence and path creation, and exploration into the sustainability transitions literature came as a result of both increased empirical and theoretical understanding.

4.2.3 The online survey

Surveys are a convenient way of gaining insights on trends and processes. They are cost-effective, can cover a geographically dispersed population (such as firms in the OWP industry) and are highly flexible (McGuirk and O'Neill 2005). The online survey³⁷ conducted in phase three (December 2010 – January 2011) of the empirical research process (section 4.2) was targeted at a strategically sampled set of firms that constitute what Lund (2002) refers to as a 'rare population'. This rare population was comprised of all Norwegian firms deemed active in OWP. We used the membership lists of two large research centres (NOWITECH and NORCOWE), two membership organizations for firms in OWP (the 'Arena'³⁸ cluster initiatives Arena NOW and Windcluster Norway³⁹), the renewable energy industry network NORWEA, in addition to various reports, media coverage and own mapping. The identified firms were expected to meet one of the following criteria: OWP either as main activity,

³⁷ We used the online survey tool SelectSurvey.net

³⁸ The 'Arena' programme supports cluster projects in Norway and is jointly owned by Innovation Norway, SIVA and the Research Council of Norway.

³⁹ Previously Windcluster Mid-Norway, see A2/Verdal.

supplementary activity or future target area. Firms with OWP as future target area were primarily identified through media and fieldwork.

The survey (questionnaire) was explorative in nature, and our aim was to gain information about the different types of firms involved in this market (types of firms, age, size etc.), which value chain segments they operate in, which markets they are active in or oriented towards, resource allocation to OWP activities, involvement in research, use of different knowledge sources, views on framework conditions, support schemes and energy policy. The survey was pretested on a panel of three respondents (one from industry, one from a cluster organization, and one social science researcher).

The questionnaire basically comprised four categories of questions: First, descriptive or attribute questions on firm age, size, location(s) and so on. Second, attribute questions with yes/no (e.g. *has the firm developed a product or service specifically for OWP?*) or multiple possible answers (e.g. *in which markets is the firm active?*). Third, questions in which respondents were asked to assess the importance of various factors associated with their firm's activities in OWP (such as the value of different knowledge sources) or respond to different claims regarding for instance framework conditions. For the latter category we used a Likert scale of 1-6, including one or two of the option(s) "Do not know/ do not want to answer/ not relevant". Fourth, the questionnaire included some open ended questions, for instance: *"Do you have any ideas or thoughts on opportunities and/or barriers for offshore wind power in Norway (commercialization of technology and industrial development)?"*

The survey was distributed to 325 respondents with one reminder. After data cleansing we were left with 147 responses.⁴⁰ With a response rate of (45 %) we should ideally have undertaken a drop out analysis to check for possible systematic drop out explanations. However, we did not have access to any type of register data (or similar type data source) that could help us in this regard, reflecting lack of aggregate data for emerging industries (see also Volden et al. 2009). The distribution of different types of firms in our survey data set is, however, in line with other mappings of the Norwegian OWP industry. For instance, a mapping done by consultancy firm Multiconsult in 2011 assessed the Norwegian OWP firm population to be comprised of approximately 150-200 firms (see NVE 2012). Similar to our survey results, Multiconsult estimated the number of specialized OWP firms to be relatively low (approx. 20-25 firms). This estimate is supported by later surveys (Weaver and Steen 2013; Hanson et al. 2015).

An additional weakness of online surveys (and surveys in general) besides high drop-out rates, is that control opportunities are limited (Lund 2002). Even with personal email addresses (as opposed to e.g. postmaster@company.com) it is very difficult to assert that the right person has answered.⁴¹ Of the 147 respondents, 54% are general managers or CEOs, 19% have responsibilities associated with technology development, whereas 26% are responsible for business and market development. Given that these individuals have indeed completed the survey, the reliability of the survey data should be good. The survey data was analysed in SPSS and Excel. As noted in section 4.2, the survey data is mainly used to support generalized findings based on analysis of the qualitative material. The exception is A3/Barriers, in which survey results on questions related to state policy and frameworks

⁴⁰ Cleansing here refers to removal of duplicate and incomplete responses.

⁴¹ 'Right person' here refers to a firm employee with broad knowledge of the firm and its history, activities and strategies. In smaller firms this will typically be the CEO or General Manager. In larger firms, the 'right' respondent for our survey would be someone with both general knowledge of the firm and (as or even more importantly) knowledge of the firm's involvement in OWP.

in Norway (for doing OWP) as well as firm knowledge sourcing strategies are explicitly integrated into the analysis.

4.3 Trustworthiness, positionality and reflections

In combination, reliability, validity and reflexivity constitute the robustness or trustworthiness of research (Yeung 2003; Yin 2003; Kvale and Brinkmann 2009). Validity refers to whether the research methods and theoretical concepts and approaches are relevant given the nature of the research question. Given the aims of the study (section 1.2), the nature of the specific research questions posed, and the particularities of conducting research on an emerging industry (section 4.1), the choice of emphasizing qualitative methods was relatively straight-forward. The relevance of theoretical approaches and concepts is discussed in the theory section and in the articles and will not be dealt with here. The same applies to challenges in studying an emerging industry, which are discussed in A4/Reconsidering.

Reliability refers to the replicability of findings. The short history of the Norwegian OWP industry allows for a reconstruction of path creation processes over a short time span, which many of the informants had been part of in its entire length. They could therefore provide detailed first-hand accounts of key events and phases of development, which provides a strong methodological advantage to the primarily qualitative research design of the thesis (Binz, Truffer, and Coenen 2015). In sum, the various data sources used in this thesis largely give credence to generalized findings as discussed in the articles and in section 5.1. As such, the mixed-methods research approach, which included complementary methodological techniques, allowed for triangulation of findings. Other social science analysis of the Norwegian OWP industry and its development to date has been somewhat narrower in scope than this thesis. My interpretation of these other contributions is that they have arrived at fairly similar (and complementary) conclusions to the ones I (or we) have. Normann (2015), for instance, analyses the development of the Norwegian OWP sector from a policy perspective, and broadly describes a similar development process as we do in A3/Barriers, albeit providing considerable more detail to the policy dimension. The study by Njøs et al. (2013) on collaboration between industry and science actors in the scope of the NORCOWE OWP research centre arrives at similar conclusions as we do in A3/Barriers. That is, they find a mismatch or 'discrepancy' between the interests and time horizons of industry actors and R&D actors.

The researcher will always have an effect on the informant. It is therefore important to be aware of one's own identity and how this may affect interaction with informants. Awareness of the researcher effect "*is what academics describe as recognizing your positionality and being reflexive*" (Valentine 1997, 113). It is especially important to reflect over power relations between researcher and informants, depending on factors such as gender, age, and social status. More often than not, the social science researcher has a dominant position over informants. However, when informants are business managers, politicians or others with a certain 'elite position' the reverse is often true (Kvale and Brinkmann 2009). These types of informants control access to information as well as to other informants, and may attempt to influence the research process (Schoenberger 1991). My experience is that managers in large firms tend to be very professional in terms of communication (what they say (and not) and how they express themselves), and that statements (especially on sensitive issues) can be very general.

Being well-prepared and displaying understanding and knowledge of the context that firms (and other actors) operate in largely alleviates the potential challenge of informants controlling the interview. Demonstrating knowledge and understanding of the field generates trust and provides the foundation for conversation and reflections around multi-faceted issues that may also have strong normative aspects (climate change, resource depletion, pollution etc.). Understanding the empirical field and its context also enables the researcher to ask follow-up questions and to challenge informants in terms of providing concrete examples. My general experience from this research project was that we (reflecting that we were two researchers in most interviews) managed to create an open and 'trustful' atmosphere in the interview situations, yet with room for discussion and differing opinion.

Reflexivity refers to the ability to understand one owns (i.e. the researcher's) view on issues that may have an effect on the research process (from choice of topic, to sampling, to framing of research questions, interpretation etc.) and positionality, and to convey this to others. This is because the "*difficulty of assessing the reliability of qualitative research revolves around the nature of the research process it uses*" (Healey and Rawlinson 1993, 345), reflecting that social science researchers are both observers and participants in the research process (Frankfort-Nachmias and Nachmias 2008). Researchers interact with the socio-political environment, which influences both formal and informal decisions about (ongoing) research, and also implies that data must be understood as cultural products that reflect the aims and attitudes of those that have produced them. Aims and attitudes may also have an effect on interpretation of data. This means that interpretation requires caution and sensitivity to nuances and meaning, because there is always a danger that an informant and a researcher differ in their understanding of terms and concepts. The fact that we were two researchers (Gard and me, Asbjørn and me) analysing the same material, and drawing on additional sources of information (e.g. firm websites, reports), is as such a form of triangulation that enhances the credibility of interpretations.

Because researchers are part of the 'researched world' themselves, being clear about positionality is important. It also raises a set of ethical issues of how information is gained and used in analysis. Before initiating the interviews, I/we stressed that we were not seeking 'business secrets'. In many cases, informants would say something, and then add that "this is not something I want to be quoted on" reflecting in my opinion that we as researchers appeared trustworthy. Informants were informed that the information they provided could be anonymized. Some quotes in the articles can as such be traced directly to specific informants, whereas most cannot. Anonymity is thus provided by separating the identity of individuals from the information that they provide. We would also say that we were not advocates for the OWP industry, but rather that our research attempted to understand the opportunities and challenges associated with OWP industry development.

Studying real-time processes of industrial activity and technology development, especially within a highly contested sector such as energy, moreover led to many reflections on normative issues. My position is this: I am deeply concerned about the state of the planet, the effects of climate change, and the degradation of ecosystems and loss of biodiversity. I am – similarly to many other 'concerned citizens' in Norway - torn on Norwegian energy policy issues in between a position of continuation of O&G activities (but not seeing it as a viable business option in the long term, for both economic and environmental reasons) and a position in line with environmentalists who argue forcefully that we should abandon fossil fuels as soon as possible. Concerning OWP, I do question the development of

large scale OWP farms in Norway. That is, considering Norway's energy system (section 2.3.1), investing considerable public money into new electricity production capacity is not straightforward to justify. I guess my personal standpoint here is that we should focus more on using less energy, rather than producing more. But this is a complex issue, because at the same time, I have sympathy with the view that Norway can serve as a 'green battery' for Europe. And finally, as a citizen and academic interested in the economic future of my country, I do believe that OWP is *one* viable option for (future) value creation in Norwegian offshore and maritime industries.

Thus, insofar as OWP remains a targeted sector for the national energy strategy (ENERGI21 2014), I see my own somewhat normative position as compatible with an 'objective' research endeavour to illuminate barriers confronting such as quest. Put more simply: if developing an OWP industry is a goal of Norwegian policy then social science researchers can provide important knowledge about opportunities and challenges associated with that development. I firmly believe that social scientists should engage in and initiate public debate, which in a sense also serves to illuminate positionality. Based on the first round of interviews and the survey, Gard and I wrote an 'industry report' (Hansen and Steen 2011). Our motivation was mainly to share our results and 'give something back' to our informants and survey respondents, but we also hoped to inform the Norwegian policy debate on the development of renewable energy (technologies and industry) in general and OWP in particular. The report was distributed widely and gained some media attention.⁴² In later interviews and meetings with different actors of the industry we often met people who had seen or (even) read the report, which provided interesting ground for discussion and new questions and ideas. Similarly, I've (in collaboration often with others) written several newspaper commentaries and blogs on different topics related to the Norwegian energy system and industries⁴³, and sometimes also these were mentioned in interviews and spurred conversation.

4.4 Summary

This chapter has described the mixed- methods case based research design of the thesis. In addition to outlining the practical steps, the chapter as discussed the virtues, limitations and challenges with different methods. I have also discussed issues related to data analysis, trustworthiness and positionality. In short, the mainly qualitative approach chosen for this research project complements extant quantitative and aggregate research in economic geography on path creation and key issues of relevance to the thesis topic such as knowledge spillovers and relatedness.

⁴² As per early October 2014, the report had been downloaded almost 1900 times.

⁴³ Examples: Grønn omstilling (Green restructuring) in *Adresseavisen* 14.12.2010 (with A. Karlsen), Norsk industri og energi i det blå (Norwegian industry and energy in the blue) in *Dagens Næringsliv* 11.01.2011 (with G. H. Hansen), Så lenge det er vind, er det håp (As long as there's wind, there's hope) in *Bergens Tidende* 19.11.2012 (with G. H. Hansen).

5 Conclusions and outlook

This chapter summarizes main findings from the articles, spells out the main theoretical and empirical contributions of the thesis pertaining to understanding path creation processes, and discusses their wider implications. The chapter ends with a discussion of possible directions for future research.

5.1 Summary of main contributions and findings in the articles

Table 6 provides highly condensed summaries of main contributions and key findings in the four articles, illustrating how the articles engage with different topics of relevance to the path creation debate yet also overlap in many ways.

Table 6 Summary of main contributions and key findings in the articles

A1/Same Sea

- Questions the way relatedness is conceptualized and operationalized, particularly in quantitative work within EEG. Using a qualitative approach, the article sheds light on agency, contents and modes of knowledge spillovers (a key aspect of the relatedness theses), connecting with discussions on path creation mechanisms and path interaction. By employing a broad understanding of knowledge (i.e. beyond the 'technical' knowledge that tends to be captured using quantitative methods), the article additionally illuminates how knowledge spillover processes are affected by institutional differences between sectors.
- Both diversifying and entrepreneurial (specialized OWP) firms largely base their activities in OWP on 'proven technology' from offshore O&G. The article demonstrates similarities and differences between offshore O&G and OWP beyond technological relatedness. Barriers to knowledge spillovers primarily have to do with challenges in adapting to or coping with 1) differences in institutional contexts and 2) verifying solutions that are new to OWP.

A2/Verdal

- Analyses how a new local industrial development path (related to (offshore) wind energy) can be simultaneously enabled and constrained by an established path (O&G). Employs the concepts of layering, conversion and recombination to analyze (non-constraining) historical path evolution. Explores this topic in a single-industry town, i.e. a typical 'constrained' setting for new path creation.
- Identifies two major 'shocks' to the local industry and analyses their responses. Shock 1 resulted in vertical disintegration of the local cornerstone company and consequent diversification. These changes in the local economy are key to understanding the more proactive responses to shock 2. This response, the initiative to develop a wind energy cluster, initially focused on the offshore segment of wind energy. This however shifted towards onshore wind energy, and a rescaling of the cluster to the national scale took place. The article suggests that single-industry town lacks diversity for endogenous renewal as conceptualized in the non-constraining model of local industrial path evolution.

A3/Barriers

- Extending on a path-as-process perspective, the article develops a conceptual framework for analyzing the broader contexts that shape path creation. The framework specifies key conditions and reinforcing mechanisms for path creation on the one hand, and barriers to such conditions and mechanisms materializing on the other. Particular attention is paid to collective

agency and path-interdependencies. Employs this framework to analyse the broader path creation process of Norway's OWP industry.

- Identifies a largely enabling pre-formative and early path creation phase. However, reinforcing mechanisms failed to gain substantial momentum due to barriers that are analyzed along three themes: market and framework conditions, knowledge (co)generation and path-interdependencies. Suggests that 1) whether contexts are enabling or constraining is contingent on path creation mechanisms, 2) contexts change due to a mixture of institutional and economic factors, and 3) path interaction can be both positive and negative to new industrial development paths.

A4/Reconsidering

- Suggests that lack of explanation of how new industries emerge is (in part) due not only 1) to lack of attention to agency but that 2) agency needs to be reconceptualized as understood as intertemporal (simultaneously past- and future-oriented) and 3) that few coterminous studies of new industries have been conducted. Combines insights from the path creation debate in economic geography with perspectives from the socio-technical transitions and the sociology of expectations literatures to draw attention to the generative and performative role of expectations in path creation processes. Employs this framework for illustrative purposes on firms in the case of Norwegian OWP, and discusses methodological issues related to path creation research.

- Illustrates how both collective and individual expectations help explain actors' activities and strategies. Collective expectations relate to broader trends such as the shift from fossils to renewables. Individual expectations relate to particular technologies and application domains. Argues that in addition to being generative, expectations are inherently spatial as well as temporal. Findings indicate that seeing agency as intertemporal provides novel understandings to micro-level processes of key path creation mechanisms such as firm branching or diversification.

5.2 Overall contributions

The main aim of this thesis was to contribute to economic geography theorizing on path creation, here referring to the emergence of new industrial development paths. In attempting to do so, and as discussed in both the introductory chapter and in the theory chapter, the thesis employs and critically engages with theoretical frameworks and concepts that are particularly associated with evolutionary economic geography (EEG). As such, and by questioning some of EEG theoretical underpinnings and providing supplementary and alternative perspectives, the thesis contributes to theorizing both by way of theory testing and theory development (George and Bennett 2005). Overall, by employing a mixed-methods research design with emphasis on qualitative approaches, the thesis can be seen as complementing much of the quantitative work that has dominated economic geography research on industry emergence, knowledge spillovers and path creation.

In section 3.1.1, I pointed to four conceptual issues or topics related to path creation (or the question of how new industries emerge) that the thesis addresses: the concept of 'relatedness', agency, path creation mechanisms and path interaction. I consider these to be pivotal to enhancing our understandings of how (through what kinds of mechanisms) and when (under what conditions) new industrial paths are created (Binz, Truffer, and Coenen 2015). In exploring these four topics, the

thesis engaged with three main theoretical frameworks: open/non-constraining perspectives on path evolution, socio-technical transitions and the sociology of expectations literature (see section 3.6). Table 7 provides a simplified overview of the place and weight of these conceptual topics in the four articles, illustrating how the articles focus in on different aspects and are complementary.

Table 7 Overview of key theoretical topics covered in the articles

| <i>Article</i> | <i>Relatedness</i> | <i>Agency</i> | <i>Path creation mechanisms</i> | <i>Path interaction</i> |
|------------------|--------------------|---------------|---------------------------------|-------------------------|
| A1/Same Sea | X | X | (x) | X |
| A2/Verdal | (x) | X | X | X |
| A3/Barriers | (x) | (x) | X | X |
| A4/Reconsidering | (x) | X | (x) | (x) |

Note: X implies key topic, (x) implies topic primarily addressed implicitly

The topic of *relatedness* was in many ways the starting point of this entire thesis, and is most substantially dealt with in A1/Same Sea. It is however touched upon to larger or lesser extent in the other articles. Related variety (Frenken, Van Oort, and Verburg 2007; Boschma and Frenken 2011) and the broader notion of relatedness (Cooke 2012) has become an important topic in economic geography beyond the path creation debate. For instance, it is one of the cornerstones in the 'constructing regional advantage' approach (Asheim, Boschma, and Cooke 2011), and has more recently also become immersed in the debate on 'smart specialization' (Boschma 2013), the policy strategy for regional development being implemented across Europe (Foray 2014). As such, I find it important that these ideas are scrutinized both theoretically and empirically.

What I have argued in this thesis is that relatedness, or the way it has been operationalized, is largely a 'black box' concept. I suggest that a more qualitative understanding of its constituents (i.e. based on a broader understanding of knowledge than the knowledge dimensions that can be captured by SIC codes or patent data) illustrates the more multi-faceted ways in which industries are related (or not). This, broader understanding of relatedness in turn allows for more nuanced perspectives on how industries are related (and not), which in turn has implications for understanding (barriers to) knowledge spillover processes and identifying the important intersections at which knowledge and practices from different industries encounter each other. The methodological approach of covering a broad set of firms operating within the OWP and other (related) industries was pivotal to arriving at these insights. A1/Same Sea also suggests that as industries change, their (un)relatedness with other industries may change, which thus also connects with the topics of *path creation mechanisms* and *path interaction*.

As discussed in various chapters, as well as in the articles, a main aim of this thesis is to contribute to a better understanding of *agency* and the role of different firm and non-firm actors in path creation research. First, and on a general level, the thesis has illuminated multiple ways in which different forms of agency are crucial to new development paths. For example, whilst A1/Same Sea also explores the agency of knowledge spillovers by studying how different firms enter the OWP sector, A2/Verdal sheds light on the role that non-firm actors such as local industry support agencies can play in stimulating innovation and change. In their seminal article on path dependence and regional economic development, Martin and Sunley (2006, 404) somewhat (rhetorically) asked "*does path*

dependence need a theory of human agency?", and (more pointedly), *"how do agents create new paths?"* Although this thesis does not provide a theory of human agency *per se*, A4/Reconsidering suggests that understanding agency as primarily routine behaviour as suggested in EEG (e.g. Boschma and Frenken 2006) fails to grasp the intentionality and mindfulness that characterises agents involved in creating new paths (Garud, Kumaraswamy, and Karnøe 2010). By addressing the more fundamental question of what agency is, the thesis also goes beyond the call for attention to other types of actors than firms (and firm branching as a key path creation mechanism), as made by for instance Dawley (2014) and Tanner (2014).

Second, the findings in the thesis resonate with the idea that collective agency (Garud and Karnøe 2003) is necessary for new development paths to emerge, at least beyond the pre-formative and early path creation phases. More specifically, collective agency is needed for the reinforcing mechanisms (increasing returns, network externalities etc.) that assist growth along new development trajectories to gain hold (Martin 2010). Another insight to be drawn from the thesis is that by paying more attention to agency – how actors operate on the basis of both experiences and expectations – can further illuminate how and why particular branching mechanisms (Boschma and Frenken 2011) or other path creation mechanisms unfold as they do. The wider implication of this reconceptualization of agency is that it should also be taken into account when studying path evolution more generally. This could for instance provide better understandings of path renewal or reorientation processes, which similarly to path creation are based on (more or less) strategic attempts at innovation, new knowledge development and adaptation to new circumstances.

Regarding the topic of *path creation mechanisms*, the thesis has focused on the knowledge spillover mechanisms of firm diversification and (evolutionary) branching (Boschma and Frenken 2011). The primary reason for this is rather straightforward: out of the various sources of path creation identified by Martin and Sunley (2006), firm diversification dominates as a mechanism for the development of OWP as a new industrial development path in the Norwegian context. In this way, Norway differs from the OWP path creation in the UK where much effort has gone into attempts to attract key wind energy actors from abroad, notably turbine manufacturers (Dawley 2014). Referred to as 'transplantation' (Martin and Sunley 2006), the only case of this source of path creation in Norway is the one outlined in A2/Verdal with the attempt to attract General Electric to Verdal after its acquisition of the Norwegian wind turbine developer Scanwind. By employing the notions of layering, conversion and recombination (Martin and Sunley 2010), A2/Verdal furthermore provides 'theory testing' of how different types of path creation mechanisms unfold in non-constraining local industrial path evolution.

The topics of relatedness, agency and path creation mechanisms all relate intimately to the final topic addressed in this thesis, namely *path interaction*. As the different articles illustrate (in different ways), it is impossible to understand the dynamics of OWP path creation in Norway without taking account of how this path has developed in relation to other established industrial paths and the offshore O&G industry in particular. As such, the thesis provides new insights into how path interaction can be both positive (e.g. as a result of knowledge spillovers) and negative (e.g. if there is competition over resources), and that this will be contingent on a host of factors such as policies, framework conditions, market dynamics, firm level strategies and the specifics of path creation mechanisms. Moreover, the thesis underlines the importance of agency-sensitive research in order

to capture the multi-faceted ways in which linkages across paths result from strategic efforts by various types of actors.

A secondary aim of the thesis was to contribute with empirical knowledge about the Norwegian OWP industry. In combination, the various articles (as well as the preceding chapters) have explored the OWP industry and the question posed in the thesis title – *becoming the next adventure?* – from multiple angles and provided both general and more specific empirical knowledge of this industry. One 'type' of actor that deserves more attention than received in this thesis are the R&D institutions that form the core of the large state-funded OWP research centres. These R&D institutions comprise some of the largest groups of OWP researchers in Europe and are involved in multiple EU projects. Thus, it would be interesting to understand better how this research and development is absorbed by industry, how and if it results in commercialization (e.g. through spin-offs), and (more broadly) how Norwegian R&D contributes to knowledge development beyond the Norwegian OWP context.

In my view, the most important value of this empirical understanding is that it provides a basis for informing policy making. As I discuss in the methodology chapter (section 4.3), I think it is important that researchers engage in public debate and provide policy recommendations. Insofar as OWP is a target area in the national energy strategy (ENERGI21 2014), the policy implication that can be derived from this thesis is that Norway needs a more coherent mix of policies (Kivimaa and Kern 2016) in order to facilitate a stronger and more fertile potential for growth in the OWP sector. In practical terms, the state could provide funding for 2-3 large demonstration projects in which different products and services could be subject to trial and error in full-scale and real-life conditions. This could be valuable both for (new) value creation in Norway, as well as for potentially contributing to cost reductions in the global OWP industry. In terms of domestic value creation, it could be particularly valuable for nourishing collaboration, learning and joint expectations and visions (Klitkou et al. 2013; Heiskanen, Nissilä, and Lovio 2015) between actors in industry and science, and for qualifying Norwegian suppliers for international OWP markets. Reflecting the international nature of learning networks in the OWP industry (Wieczorek et al. 2015), as well as the importance of attracting relevant 'extra-local' resources (Binz, Truffer, and Coenen 2015), such demonstration projects should of course be open to actors from other countries. I do not see this as a 'picking winners' strategy, but rather as a strategic choice of a broad knowledge domain in which Norwegian industry is in the global forefront (Reve and Sasson 2012).

5.3 Directions for future research

Several theoretical and empirical topics that merit further attention in understanding path creation arise from this thesis. On a general note, I believe this thesis substantiates the need for engaged pluralism (Barnes and Sheppard 2010) and theoretical trading zones (Hassink, Klaerding, and Marques 2014) in economic geography, but also that economic geographers continue to look beyond the fringing borders of their discipline.

First, there is clearly a need for more research on path interaction or path-interdependencies. As suggested in this thesis, understanding the many ways in which paths can interact and/or be interdependent requires perspectives that go beyond studying firm-level dynamics. One important topic to understand better is how path interaction is mediated and shaped by institutional factors on multiple scales, resulting in part from how actors are embedded in networks that transcend both territorial and sectoral boundaries. I also think that the role of expectations can offer important

insights into path interaction, because it can provide insights into why and how actors opt for certain paths and not others. Conversely, it can help illuminate why actors detach from paths. Such research endeavours should incorporate the 'future making' also of non-firm actors, especially policy makers who have substantial power not only in their capacity to develop visions but also by creating instruments to arrive at future targets, such as diversifying economic structures, nurturing growth of certain sectors, or reducing greenhouse gas emissions.

Second, as stated in the introduction an important motivation for exploring the empirical topic of an emerging industry linked to renewable energy was to contribute to economic geography research on topics that relate to sustainability. Contributions to the 'geography of sustainability transitions literature' have focused on 'spatializing' transitions theory and/or theorizing space/place in transition perspectives (e.g. Coenen and Truffer 2012; Truffer and Coenen 2012). In my view, adding geography perspectives (place-/region-specific contexts, trans-local linkages, multi-scalarity etc.) certainly provide important insights into transition processes. That having said, I believe that some of the theoretical 'fundamentals' of transitions research should be treated with caution. For instance, and as argued in section 3.5.1 and elsewhere (Steen and Weaver 2015; Hanson et al. 2015), the tendency in transitions research to draw very clear boundaries between emerging and established sectors is problematic because it disregards overlaps in value chains and other actor networks. As such, transitions research typically posits the formation of new industries as arising from scratch. Given the monumental task of developing the necessary industrial capacity of shifting from fossils to renewables (factories for solar panels, wind turbines etc.), it is important to understand better how new industry formation can benefit from resource transfer from industries that are already established.

Third, and as I suggest in section 3.6, I think there is much potential in bringing together the debates on path creation/evolution with global production network (GPN) approaches (Coe et al. 2004; Yeung and Coe 2015). A GPN framework provides a way of disentangling the complexity of endogenous and exogenous factors that shape the evolution of industrial development pathways in particular territorial contexts. From a GPN perspective, regional assets and competencies can be seen as providing the basis for path creation. The value of a GPN approach in expanding our understanding of the emergence of new industrial development paths lays in its analytical focus on the processes whereby these territorial-specific assets are coupled or decoupled from the strategic needs of actors embedded in (production) networks that transcend territorial boundaries. Indeed, understanding the industrial dynamics of the Norwegian OWP case is futile without accounting for how Norwegian firms manage (or not) to enter international OWP markets. As such, the decoupling (MacKinnon 2011) of some Norwegian firms from the OWP was (as discussed in A3/Barriers) in part a result of challenges in accessing international OWP markets and supply chains. Even Denmark's success as a world leader in wind turbine manufacturing, which by coincidence is the empirical case informing the highly influential path creation perspective of Garud and Karnøe (2003), cannot be explained without acknowledging the importance of the success of Danish firms in markets elsewhere, especially the Californian "wind rush" in 1981-1985 (Hendry and Harborne 2011). On a more general note, drawing together the path evolution and GPN debates can provide better understandings of how path creation (or renewal, reorientation) results in differentiated levels and types of value creation, enhancement and capture across the economic landscape.

References part 1

- Amin, A. 1999. An Institutional Perspective on Regional Economic Development. *International Journal of Urban and Regional Research* 23:365-378.
- Andersen, S.S. 2005. *Case-studier og generalisering*. Bergen: Fagbokforlaget.
- Arthur, W.B. 1994. *Increasing returns and path dependence in the economy*. Ann Arbor: University of Michigan Press.
- Asheim, B.T.; R. Boschma; and P. Cooke. 2011. Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases. *Regional Studies* 45:893-905.
- Asheim, B.T.; M.M. Bugge; L. Coenen; and S. Herstad. 2013. What does evolutionary economic geography bring to the policy table? Reconceptualising regional innovation systems. CIRCLE Working Paper no. 2013/05.
- Audretsch, D.B. and M.P. Feldman. 1996. Innovative clusters and the industry life cycle. *Review of Industrial Organization* 11:253-273.
- Bakker, S.; H. Van Lente; and M. Meeus. 2011. Arenas of expectations for hydrogen technologies. *Technological Forecasting and Social Change* 78:152-162.
- Barnes, T.J. and E. Sheppard. 2010. 'Nothing includes everything': towards engaged pluralism in Anglophone economic geography. *Progress in Human Geography* 34:193-214.
- Bathelt, H. 2001. Regional competence and economic recovery: divergent growth paths in Boston's high technology economy. *Entrepreneurship & Regional Development* 13:287-314.
- . 2006. Geographies of production: growth regimes in spatial perspective 3 - toward a relational view of economic action and policy. *Progress in Human Geography* 30:223-236.
- . 2009. Re-bundling and the development of hollow clusters in the East German chemical industry. *European Urban and Regional Studies* 16:363-381.
- Bathelt, H.; M. Feldman; and D.F. Kogler. 2011. Territorial and relational dynamics in knowledge creation and innovation: an introduction. In *Beyond Territory*, ed. H. Bathelt; M. Feldman; and D.F. Kogler, 1-17. Abingdon: Routledge.
- Bathelt, H. and J. Glückler. 2003. Toward a relational economic geography. *Journal of Economic Geography* 3:117-144.
- Beaudry, C. and A. Schiffauerova. 2009. Who's right, Marshall or Jacobs? The localization versus urbanization debate. *Research Policy* 38:318-337.
- Becker, H.S. 1998. *Tricks of the trade. How to think about your research while you're doing it*. Chicago: The University of Chicago Press.
- Beise, M. and K. Rennings. 2005. Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations. *Ecological Economics* 52:5-17.
- Benton, T. and I. Craib. 2011. *Philosophy of Social Science. The Philosophical Foundations of Social Thought*. Hampshire: Palgrave Macmillan.
- Bergek, A.; M. Hekkert; S. Jacobsson; J. Markard; B. Sandén; and B. Truffer. 2015. Technological innovation systems in contexts: Conceptualizing contextual structures and interaction dynamics. *Environmental Innovation and Societal Transitions* 16:51-64.
- Bergek, A. and S. Jacobsson. 2011. Fremmer grønne sertifikater ny teknologi? In *Energirikdommens paradokser*, ed. J. Hanson; S. Kasa; and O. Wicken, 82-102. Oslo: Universitetsforlaget.
- Bergek, A.; S. Jacobsson; B. Carlsson; S. Lindmark; and A. Rickne. 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy* 37:407-429.
- Bergman, E.M. 2008. Cluster life-cycles: an emerging synthesis. In *Handbook of Research on Cluster Theory*, ed. C. Karlsson, 114-132. Cheltenham: Edward Elgar.
- Berkhout, F. 2006. Normative expectations in systems innovation. *Technology Analysis & Strategic Management* 18:299-311.
- Beugelsdijk, S. 2007. The Regional Environment and a Firm's Innovative Performance: A Plea for a Multilevel Interactionist Approach. *Economic Geography* 83:181-199.

- Bilgili, M.; A. Yasar; and E. Simsek. 2011. Offshore wind power development in Europe and its comparison with onshore counterpart. *Renewable and Sustainable Energy Reviews* 15:905-915.
- Binz, C.; B. Truffer; and L. Coenen. 2014. Why space matters in technological innovation systems— Mapping global knowledge dynamics of membrane bioreactor technology. *Research Policy* 43:138-155.
- . 2015. Path Creation as a Process of Resource Alignment and Anchoring: Industry Formation for On-Site Water Recycling in Beijing. *Economic Geography*:1-29.
- Blanco, M.I. 2009. The economics of wind energy. *Renewable and Sustainable Energy Reviews* 13:1372-1382.
- Boas, T.C. 2007. Conceptualizing Continuity and Change. *Journal of Theoretical Politics* 19:33-54.
- Borup, M.; B.D. Andersen; S. Jacobsson; and A. Midttun. 2008. Nordic energy innovation systems - Patterns of need integration and cooperation: Nordic Energy Research.
- Borup, M.; N. Brown; K. Konrad; and H. Van Lente. 2006. The sociology of expectations in science and technology. *Technology Analysis & Strategic Management* 18:285-298.
- Boschma, R. 2004. Competitiveness of Regions from an Evolutionary Perspective. *Regional Studies* 38:1001-1014.
- . 2007. Path creation, path dependence and regional development. In *Path Dependence and the Evolution of City Regional Economies*, ed. J. Simmie and J. Carpenter, 40-55. Oxford: Oxford Brookes University.
- . 2013. Constructing regional advantage and smart specialization: Comparison of two European policy concepts . *Papers in Evolutionary Economic Geography* 2013/22.
- Boschma, R. and K. Frenken. 2011. The emerging empirics of evolutionary economic geography. *Journal of Economic Geography* 11:295-307.
- Boschma, R. and K. Frenken. 2011. Technological relatedness and regional branching. In *Beyond Territory*, ed. H. Bathelt; M. Feldman; and D.F. Kogler, 64-81. Abingdon: Routledge.
- . 2011. Technological relatedness, related variety and economic geography. In *Handbook of Regional Innovation and Growth*, ed. P. Cooke; B.T. Asheim; R. Boschma; R. Martin; D. Schwartz; and F. Tödtling, 187-197. Cheltenham: Edward Elgar.
- Boschma, R. and R. Martin. 2007. Editorial: Constructing an evolutionary economic geography. *Journal of Economic Geography* 7:537-548.
- Boschma, R.; A. Minondo; and M. Navarro. 2012. Related variety and regional growth in Spain*. *Papers in Regional Science* 91:241-256.
- Boschma, R.A. and K. Frenken. 2006. Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography* 6:273-302.
- Bresnahan, T.; A. Gambardella; and A. Saxenian. 2001. 'Old Economy' Inputs for 'New Economy' Outcomes: Cluster Formation in the New Silicon Valleys. *Industrial and Corporate Change* 10:835-860.
- Breton, S.-P. and G. Moe. 2009. Status, plans and technologies for offshore wind turbines in Europe and North America. *Renewable Energy* 34:646-654.
- Bridge, G. 2008. Environmental economic geography: A sympathetic critique. *Geoforum* 39:76-81.
- Bridge, G.; S. Bouzarovski; M. Bradshaw; and N. Eyre. 2013. Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy* 53:331-340.
- Broekel, T. and R. Boschma. 2011. Aviation, Space or Aerospace? Exploring the Knowledge Networks of Two Industries in The Netherlands. *European Planning Studies* 19:1205-1227.
- Brown, J. 2011. UK Offshore Wind Market Study. INTPOW's 2nd Offshore Wind Supply Chain Conference, 22 March 2011, Oslo.
- Brown, N. 2003. Hope Against Hype - Accountability in Biopasts, Presents and Futures. *Science Studies* 16:3-21.
- Buen, J. 2006. Danish and Norwegian wind industry: The relationship between policy instruments, innovation and diffusion. *Energy Policy* 34:3887-3897.

- Bugge, M.M. and S. Øiestad. 2014. The Micro-foundations of Regional Branching—the Case of Digitization of Publishing. *European Planning Studies*:1-21.
- BVG Associates. 2009. Towards Round 3: Building the Offshore Wind Supply Chain: BVG Associates.
- Bürer, M.J. and R. Wüstenhagen. 2009. Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors. *Energy Policy* 37:4997-5006.
- Byrne, D. 2009. Case-Based Methods: Why We Need Them, What They Are; How to Do Them. In *The SAGE Handbook to Case-Based Methods*, ed. D. Byrne and C.C. Ragin, 1-13. Los Angeles: SAGE Publications.
- Cainelli, G. and D. Iacobucci. 2012. Agglomeration, Related Variety, and Vertical Integration. *Economic Geography* 88:255-277.
- Carlsson, B. and R. Stankiewicz. 1991. On the nature, function and composition of technological systems. *Journal of Evolutionary Economics* 1:93-118.
- Carlsson, E.; M. Steen; R. Sand; and S.K. Nilsen. 2014. Resilient peripheral regions? The long-term effects of ten Norwegian restructuring programmes. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography* 68:91-101.
- Castellacci, F. 2008. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Research Policy* 37:978-994.
- Chen, J. 2011. Development of offshore wind power in China. *Renewable and Sustainable Energy Reviews* 15:5013-5020.
- Christensen, C. 1997. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* Harvard: Harvard Business Review.
- Clark, G.L. 1998. Stylized Facts and Close Dialogue: Methodology in Economic Geography. *Annals of the Association of American Geographers* 88:73-87.
- Coe, N.M. 2011. Geographies of production I: An evolutionary revolution? *Progress in Human Geography* 35:81-91.
- Coe, N.M.; P. Dicken; and M. Hess. 2008. Global production networks: realizing the potential. *Journal of Economic Geography* 8:271-295.
- . 2008. Introduction: global production networks—debates and challenges. *Journal of Economic Geography* 8:267-269.
- Coe, N.M.; M. Hess; H.W.C. Yeung; P. Dicken; and J. Henderson. 2004. 'Globalizing' regional development: A global production networks perspective. *Transactions of the Institute of British Geographers* 29:468-484.
- Coenen, L.; P. Benneworth; and B. Truffer. 2012. Toward a spatial perspective on sustainability transitions. *Research Policy* 41:968-979.
- Coenen, L. and F.J. Díaz López. 2010. Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production* 18:1149-1160.
- Coenen, L.; T. Hansen; and J.V. Rekers. 2015. Innovation Policy for Grand Challenges. An Economic Geography Perspective. *Geography Compass* 9:483-496.
- Coenen, L.; J. Moodysson; and H. Martin. 2014. Path Renewal in Old Industrial Regions: Possibilities and Limitations for Regional Innovation Policy. *Regional Studies* 49:850-865.
- Coenen, L.; R. Raven; and G. Verbong. 2010. Local niche experimentation in energy transitions: A theoretical and empirical exploration of proximity advantages and disadvantages. *Technology in Society* 32:295-302.
- Coenen, L. and B. Truffer. 2012. Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. *European Planning Studies* 20:367-374.
- Cooke, P. 2010. Regional innovation systems: development opportunities from the 'green turn'. *Technology Analysis & Strategic Management* 22:831-844.

- . 2012. Relatedness, transversality and public policy in innovative regions. *European Planning Studies* 20:1889-1907.
- . 2012. Transversality and Transition: Green Innovation and New Regional Path Creation. *European Planning Studies* 20:817-834.
- Cope, M. 2005. Coding Qualitative Data. In *Qualitative Research Methods in Human Geography*, ed. I. Hay, 223-233. Oxford: Oxford University Press.
- Cresswell, J.W. 2009. *Research design: Qualitative, quantitative and mixed methods approaches*. Thousand Oaks, CA: Sage.
- Cresswell, J.W. 2013. *Qualitative Inquiry & Research Design*. Los Angeles: Sage.
- Cumbers, A. 2000. Globalization, local economic development and the branch plant region: The case of the Aberdeen oil complex. *Regional Studies* 34:371-382.
- Da, Z.; Z. Xiliang; H. Jiankun; and C. Qimin. 2011. Offshore wind energy development in China: Current status and future perspective. *Renewable and Sustainable Energy Reviews* 15:4673-4684.
- David, P.A. 1985. Clio and the economics of QWERTY. *American Economic Review* 75:332-337.
- . 2001. Path dependence, its critics and the quest for “historical economics”. In *Evolution and Path Dependence in Economic Ideas: Past and Present*, ed. P. Garrouste and S. Ioannides, 15–40. Cheltenham: Edward Elgar.
- Dawley, S. 2014. Creating New Paths? Offshore Wind, Policy Activism, and Peripheral Region Development. *Economic Geography* 90:91-112.
- Dawley, S.; D. MacKinnon; A. Cumbers; and A. Pike. 2015. Policy activism and regional path creation: the promotion of offshore wind in North East England and Scotland. *Cambridge Journal of Regions, Economy and Society* 8:257-272.
- Desrochers, P. and S. Leppälä. 2011. Opening up the ‘Jacobs Spillovers’ black box: local diversity, creativity and the processes underlying new combinations. *Journal of Economic Geography* 11:843-863.
- Dewald, U. and M. Fromhold-Eisebith. 2015. Trajectories of sustainability transitions in scale-transcending innovation systems: The case of photovoltaics. *Environmental Innovation and Societal Transitions* 17:110-125.
- Dewald, U. and B. Truffer. 2012. The Local Sources of Market Formation: Explaining Regional Growth Differentials in German Photovoltaic Markets. *European Planning Studies* 20:397-420.
- Dunn, K. 2005. Interviewing. In *Qualitative Research Methods in Human Geography*, ed. I. Hay, 79-105. Oxford: Oxford University Press.
- EC. 2010. Europe 2020. A strategy for smart, sustainable and inclusive growth. Brussels: European Commission.
- Eisenhardt, K.M. and M.E. Graebner. 2007. Theory Building from Cases: Opportunities and Challenges. *The Academy of Management Journal* 50:25-32.
- Elzen, B.; F. Geels; and K. Green. 2004. System Innovation and the Transition to Sustainability: Theory, Evidence and Policy. Cheltenham: Edward Elgar.
- ENERGI21. 2014. Strategi 2014. Oslo: Energi21.
- Engen, O.A. 2009. The Development of the Norwegian Petroleum Innovation System: A Historical Overview. In *Innovation, Path Dependency and Policy: The Norwegian case*, ed. B. Verspagen; J. Fagerberg; and D. Mowery, 179-207. Oxford: Oxford University Press.
- Essletzbichler, J. 2012. Renewable Energy Technology and Path Creation: A Multi-scalar Approach to Energy Transition in the UK. *European Planning Studies* 20:791-816.
- . 2013. Relatedness, Industrial Branching and Technological Cohesion in US Metropolitan Areas. *Regional Studies* 49:752-766.
- Essletzbichler, J. and D.L. Rigby. 2007. Exploring evolutionary economic geographies. *Journal of Economic Geography* 7:549-571.
- EURELECTRIC. 2011. Hydro in Europe: Powering Renewables. Brussels: Union of the Electricity Industry.
- EWEA. 2009. Oceans of Opportunity. Brussels: European Wind Energy Association.

- . 2011. The European offshore wind industry key trends and statistics 2010 Brussels: European Wind Energy Association.
- . 2011. Wind in our Sails. The coming of Europe's offshore wind energy industry. Brussels: European Wind Energy Association.
- . 2013. Deep water. The next step for offshore wind energy. Brussels: European Wind Energy Association.
- . 2014. The European offshore wind industry - key trends and statistics 2013. Brussels: European Wind Energy Association.
- Farla, J.; J. Markard; R. Raven; and L. Coenen. 2012. Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change* 79:991-998.
- Feldman, M.P. and I. Lendel. 2010. Under the Lens: The Geography of Optical Science as an Emerging Industry. *Economic Geography* 86:147-171.
- Firestone, J. and W. Kempton. 2007. Public opinion about large offshore wind power: Underlying factors. *Energy Policy* 35:1584-1598.
- Foray, D. 2014. From smart specialisation to smart specialisation policy. *European Journal of Innovation Management* 17:492-507.
- Fornahl, D.; R. Hassink; C. Klaerding; I. Mossig; and H. Schröder. 2012. From the Old Path of Shipbuilding onto the New Path of Offshore Wind Energy? The Case of Northern Germany. *European Planning Studies* 20:835-855.
- Fornahl, D.; R. Hassink; and M.-P. Menzel. 2015. Broadening Our Knowledge on Cluster Evolution. *European Planning Studies* 23:1921-1931.
- Frankfort-Nachmias, C. and D. Nachmias. 2008. *Research methods in the social sciences*. New York: Worth Publishers.
- Frederiksen, L. and A. Davies. 2008. Vanguards and ventures: Projects as vehicles for corporate entrepreneurship. *International Journal of Project Management* 26:487-496.
- Freeman, C. and F. Louçã. 2001. *As time goes by: from the industrial revolutions to the information revolution*. Oxford: Oxford University Press.
- Freeman, C. and C. Perez. 1988. Structural crises of adjustment, business cycles and investment behaviour. In *Technical Change and Economic Theory*, ed. G. Dosi; C. Freeman; R.R. Nelson; G. Silverberg; and L. Soete. London: Pinter.
- Frenken, K. and R.A. Boschma. 2007. A theoretical framework for evolutionary economic geography: industrial dynamics and urban growth as a branching process. *Journal of Economic Geography* 7:635-649.
- Frenken, K.; F. Van Oort; and T. Verburg. 2007. Related variety, unrelated variety and regional economic growth. *Regional Studies* 41:685-697.
- Garud, R. and J. Gehman. 2012. Metatheoretical perspectives on sustainability journeys: Evolutionary, relational and durational. *Research Policy* 41:980-995.
- Garud, R. and P. Karnøe. 2001. Path Creation as a Process of Mindful Deviation. In *Path Dependence and Creation*, ed. R. Garud and P. Karnøe, 1-38. London: Lawrence Erlbaum Associates.
- . 2003. Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. *Research Policy* 32:277-300.
- Garud, R.; A. Kumaraswamy; and P. Karnøe. 2010. Path Dependence or Path Creation? *Journal of Management Studies* 47:760-774.
- Geels, F. and R. Raven. 2006. Non-linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development (1973–2003). *Technology Analysis & Strategic Management* 18:375-392.
- Geels, F.W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy* 31:1257-1274.
- . 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy* 33:897-920.

- Geels, F.W. 2005. Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change* 72:681-696.
- Geels, F.W. 2007. Analysing the breakthrough of rock 'n' roll (1930–1970) Multi-regime interaction and reconfiguration in the multi-level perspective. *Technological Forecasting and Social Change* 74:1411-1431.
- . 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy* 39:495-510.
- . 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions* 1:24-40.
- Geels, F.W.; M.P. Hekkert; and S. Jacobsson. 2008. The dynamics of sustainable innovation journeys. *Technology Analysis & Strategic Management* 20:521-536.
- Geels, F.W. and R. Kemp. 2007. Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. *Technology in Society* 29:441-455.
- Geels, F.W.; F. Kern; G. Fuchs; N. Hinderer; G. Kungl; J. Mylan; M. Neukirch; and S. Wassermann. 2016. The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990–2014). *Research Policy* 45:896-913.
- George, A.L. and A. Bennett. 2005. *Case Studies and Theory Development in the Social Sciences*. Cambridge MA: MIT Press.
- Goertz, G. and J. Mahoney. 2009. Scope in Case Study Research. In *The SAGE Handbook of Case-Based Methods*, 307-317. Los Angeles: SAGE Publications.
- Grabher, G. 1993. The weakness of strong ties: the lock-in of regional development in the Ruhr area. In *The Embedded Firm: On the Socioeconomics of Industrial Networks*, ed. G. Grabher, 255-277. London: Routledge.
- Green, R. and N. Vasilakos. 2011. The economics of offshore wind. *Energy Policy* 39:496-502.
- Gullberg, A.T. 2013. The political feasibility of Norway as the 'green battery' of Europe. *Energy Policy* 57:615-623.
- Gustafsson, R.; M. Jääskeläinen; M. Maula; and J. Uotila. 2016. Emergence of Industries: A Review and Future Directions. *International Journal of Management Reviews* 18:28-50.
- GWEC. 2015. Global Wind Report. Annual Market Update 2014. Brussels: Global Wind Energy Council.
- Haggett, C. 2011. Understanding public responses to offshore wind power. *Energy Policy* 39:503-510.
- Hall, P.A. and D. Soskice. 2004. Varieties of Capitalism and Institutional Complementarities. In *Institutional Conflicts and Complementarities: Monetary Policy and Wage Bargaining Institutions in EMU*, ed. R. Franzese; P. Mooslechner; and M. Schürz, 43-76. Boston, MA: Springer US.
- Hall, R. 2011. UK Offshore wind supply chain and deployment. INTPOW's 2nd Offshore Wind Supply Chain Conference. 22 March 2011, Oslo.
- Hansen, G.H. 2013. New renewable energy and the Norwegian policy triangle. In *Norway: Nature, Industry and Society*, ed. G. Rusten; K. Potthoff; and L. Sangolt, 139-156. Bergen: Fagbokforlaget.
- Hansen, G.H. and M. Steen. 2011. Vindkraft til havs. Teknologi- og industriutvikling fra et norsk bedriftsperspektiv. CenSES report 2011/01, Trondheim: Centre for Sustainable Energy Studies.
- . 2015. Offshore oil and gas firms' involvement in offshore wind: Technological frames and undercurrents. *Environmental Innovation and Societal Transitions* 17:1-14.
- Hansen, T. and L. Coenen. 2015. The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions* 17:92-109.
- Hanson, J.; S. Kasa; and O. Wicken. 2011. Energirikdommens paradokser. Innovasjon som klimapolitikk og næringsutvikling. Oslo: Universitetsforlaget.

- Hanson, J.; M. Steen; T. Weaver; H. Normann; and G.H. Hansen. 2015. Complementarities and relatedness: implications for the interlinking between established and emerging paths. Presented at *International Sustainability Transitions Conference* 25-28 August 2015, Brighton, UK.
- Hassink, R. 2005. How to unlock regional economies from path dependency? From learning region to learning cluster. *European Planning Studies* 13:521-535.
- Hassink, R.; C. Klaerding; and P. Marques. 2014. Advancing Evolutionary Economic Geography by Engaged Pluralism. *Regional Studies* 48:1295-1307.
- Healey, M.J. and M.B. Rawlinson. 1993. Interviewing business owners and managers: a review of methods and techniques. *Geoforum* 24:339-355.
- Heidenreich, S. 2015. Sublime technology and object of fear: offshore wind scientists assessing publics. *Environment and Planning A* 47:1047-1062.
- Heiskanen, E.; H. Nissilä; and R. Lovio. 2015. Demonstration buildings as protected spaces for clean energy solutions – the case of solar building integration in Finland. *Journal of Cleaner Production* 109:347-356.
- Hekkert, M.P.; R.A.A. Suurs; S.O. Negro; S. Kuhlmann; and R.E.H.M. Smits. 2007. Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change* 74:413-432.
- Hendry, C. and P. Harborne. 2011. Changing the view of wind power development: More than "bricolage". *Research Policy* 40:778-789.
- Henning, M.; E. Stam; and R. Wenting. 2013. Path Dependence Research in Regional Economic Development: Cacophony or Knowledge Accumulation? *Regional Studies* 47:1348.
- Houghton, J. 2009. *Global Warming*. Cambridge: Cambridge University Press.
- Höök, M. and K. Aleklett. 2008. A decline rate study of Norwegian oil production. *Energy Policy* 36:4262-4271.
- IEA. 2014. *Key World Energy Statistics*. Paris: International Energy Agency.
- IMF. 2015. *How Large Are Global Energy Subsidies?* Washington D.C., International Monetary Fund.
- IPCC. 2014. *Fifth Assessment Synthesis Report. Summary for policymakers*. Geneva: Intergovernmental Panel on Climate Change.
- Isaksen, A. 2008. Høyt teknologisk industri: lokale klynger i nasjonale og globale nettverk. In *Innovasjoner i norske næringer - et geografisk perspektiv*, ed. A. Isaksen; A. Karlsen; and B. Sæther, 181-199. Bergen: Fagbokforlaget.
- Isaksen, A. 2014. Industrial development in thin regions: trapped in path extension? *Journal of Economic Geography* 15:585-600.
- Jacobs, J. 1969. *The Economy of Cities*. New York: Random House.
- Jacobsson, S. and A. Johnson. 2000. The diffusion of renewable energy technology: an analytical framework and key issues for research. *Energy Policy* 28:625-640.
- Jacobsson, S. and K. Karltorp. 2012. Formation of competences to realize the potential of offshore wind power in the European Union. *Energy Policy* 44:374-384.
- . 2013. Mechanisms blocking the dynamics of the European offshore wind energy innovation system – Challenges for policy intervention. *Energy Policy* 63:1182-1195.
- Jones, G. and G. Hollier. 1997. *Resources, Society & Environmental Management*. London: Paul Chapman.
- Karlsen, A. 2014. Negotiating industrial paths of offshore wind - a discourse analysis of an event. Paper presented at the *Association of American Geographers Conference*, April 8-12 2014, Tampa, USA.
- Karlstrøm, H. and M. Ryghaug. 2014. Public attitudes towards renewable energy technologies in Norway. The role of party preferences. *Energy Policy* 67:656-663.
- Kemp, R.; J. Schot; and R. Hoogma. 1998. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management* 10:175-198.

- Kern, F.; A. Smith; C. Shaw; R. Raven; and B. Verhees. 2014. From laggard to leader: Explaining offshore wind developments in the UK. *Energy Policy* 69:635-646.
- Kivimaa, P. and F. Kern. 2016. Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions. *Research Policy* 45:205-217.
- Klepper, S. 1997. Industry Life Cycles. *Industrial and Corporate Change* 6:145-182.
- Klepper, S. and F. Malerba. 2010. Demand, innovation and industrial dynamics: an introduction. *Industrial and Corporate Change* 19:1515-1520.
- Klitkou, A.; L. Coenen; P.D. Andersen; A. Fevolden; T. Hansen; A. Nikoleris; and D.S. Olsen. 2013. Role of demonstration projects in innovation: transition to sustainable energy and transport. Paper presented at 4th International Conference on Sustainability Transitions, June 19-21 2013, Zürich.
- Korsnes, M. 2014. China's offshore wind industry 2014. CenSES report 2014/01. Trondheim: Centre for Sustainable Energy Studies.
- Kristoffersen, B. and S. Young. 2010. Geographies of security and statehood in Norway's 'Battle of the North'. *Geoforum* 41:577-584.
- Kvale, S. and S. Brinkmann. 2009. *Interviews. Learning the Craft of Qualitative Research Interviewing*. Thousand Oaks: Sage.
- Ladenburg, J. 2010. Attitudes towards offshore wind farms--The role of beach visits on attitude and demographic and attitude relations. *Energy Policy* 38:1297-1304.
- Lawhon, M. and J.T. Murphy. 2011. Socio-technical regimes and sustainability transitions: Insights from political ecology. *Progress in Human Geography*.
- Lee, R., M. and N.G. Fielding. 2009. Tools for Qualitative Data Analysis. In *Handbook of Data Analysis*, ed. M. Hardy and A. Bryman, 529-546. Los Angeles: Sage.
- Lema, R.; A. Berger; H. Schmitz; and H. Song. 2011. Competition and Cooperation between Europe and China in the Wind Power Sector. *IDS Working Papers* 2011:1-45.
- Lewins, A. and C. Silver. 2007. *Using Software in Qualitative Research. A Step-by-Step Guide*. London: Sage.
- Lewis, J.I. and R.H. Wiser. 2007. Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms. *Energy Policy* 35:1844-1857.
- Lie, Ø. 2012. Fornybareksport øker CO2-utslipp. *Teknisk Ukeblad*, 18 October 2012.
- Lovio, R.; P. Mickwitz; and E. Heiskanen. 2011. Path dependence, path creation and creative destruction in the evolution of energy systems. In *Handbook of Research on Energy Entrepreneurship*, ed. R. Wüstenhagen and R. Wuebker, 274-301. Cheltenham: Edward Elgar.
- Lund, P.D. 2009. Effects of energy policies on industry expansion in renewable energy. *Renewable Energy* 34:53-64.
- Lund, T. 2002. Metodologiske prinsipper og referanserammer. In *Innføring i forskningsmetodologi*, ed. T. Lund, 79-123: Unipub.
- Lundvall, B.-ä. and B. Johnson. 1994. The Learning Economy. *Journal of Industry Studies* 1:23-42.
- Lundvall, B.-Å. 1992. *National systems of innovation: towards a theory of innovation and interactive learning* London: Pinter.
- . 2006. Knowledge Management in the Learning Economy. *DRUID Working Papers* 06-6.
- MacKinnon, D. 2011. Beyond strategic coupling: reassessing the firm-region nexus in global production networks. *Journal of Economic Geography* 12:227-245.
- MacKinnon, D.; A. Cumbers; A. Pike; K. Birch; and R. McMaster. 2009. Evolution in Economic Geography: Institutions, Political Economy, and Adaptation. *Economic Geography* 85:129-150.
- Markard, J.; M. Hekkert; and S. Jacobsson. 2015. The technological innovation systems framework: Response to six criticisms. *Environmental Innovation and Societal Transitions* 16:76-86.
- Markard, J. and R. Petersen. 2009. The offshore trend: Structural changes in the wind power sector. *Energy Policy* 37:3545-3556.
- Markard, J.; R. Raven; and B. Truffer. 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy* 41:955-967.

- Markard, J. and B. Truffer. 2006. Innovation processes in large technical systems: Market liberalization as a driver for radical change? *Research Policy* 35:609-625.
- . 2008. Technological innovation systems and the multi-level perspective: Towards an integrated framework. *Research Policy* 37:596-615.
- Martin, H. and L. Coenen. 2014. Institutional Context and Cluster Emergence: The Biogas Industry in Southern Sweden. *European Planning Studies*:1-19.
- Martin, R. 1999. The new 'geographical turn' in economics: some critical reflections. *Cambridge Journal of Economics* 23:65-91.
- . 2010. Roepke Lecture in Economic Geography—Rethinking Regional Path Dependence: Beyond Lock-in to Evolution. *Economic Geography* 86:1-27.
- . 2012. Regional economic resilience, hysteresis and recessionary shocks. *Journal of Economic Geography* 12:1-32.
- Martin, R. and P. Sunley. 2006. Path dependence and regional economic evolution. *Journal of Economic Geography* 6:395-437.
- . 2007. Complexity thinking and evolutionary economic geography. *Journal of Economic Geography* 7:573-601.
- Martin, R. and P. Sunley. 2010. The place of path dependence in an evolutionary perspective on the economic landscape. In *The Handbook of Evolutionary Economic Geography*, ed. R. Boschma and R. Martin, 62-92. Cheltenham: Edward Elgar.
- Maskell, P. and A. Malmberg. 1999. The Competitiveness of Firms and Regions. *European Urban and Regional Studies* 6:9-25.
- Mathews, J.A. 2013. The renewable energies technology surge: A new techno-economic paradigm in the making? *Futures* 46:10-22.
- McGuirk, P.M. and P. O'Neill. 2005. Using Questionnaires in Qualitative Human Geography. In *Qualitative Research Methods in Human Geography*, ed. I. Hay, 147-162. Oxford: Oxford University Press.
- Menzel, M.-P. and D. Fornahl. 2010. Cluster life cycles—dimensions and rationales of cluster evolution. *Industrial and Corporate Change* 19:205-238.
- Meyer, U. and C. Schubert. 2007. Integrating path dependency and path creation in a general understanding of path constitution. The role of agency and institutions in the stabilisation of technological innovations. *Science, Technology & Innovation Studies* 23-44.
- Murphy, J.T. 2015. Human geography and socio-technical transition studies: Promising intersections. *Environmental Innovation and Societal Transitions* 17:73-91.
- Neffke, F.; M. Henning; and R. Boschma. 2011. How Do Regions Diversify over Time? Industry Relatedness and the Development of New Growth Paths in Regions. *Economic Geography* 87:237-265.
- Neffke, F.; M. Henning; R. Boschma; K.-J. Lundquist; and L.-O. Olander. 2011. The Dynamics of Agglomeration Externalities along the Life Cycle of Industries. *Regional Studies* 45:49-65.
- Nelson, R.R. and S.G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
- Neuman, W.L. 2007. *Basics of Social Research. Qualitative and Quantitative Approaches*. Boston: Pearson Education.
- Njøs, R.; S.-E. Jakobsen; J.K. Fosse; and C. Engelsen. 2013. Challenges to Bridging Discrepant Knowledge Bases: A Case Study of the Norwegian Centre for Offshore Wind Energy. *European Planning Studies* 22:2389-2410.
- Normann, H. and J. Hanson. 2015. Exploiting global renewable energy growth. Opportunities and challenges for internationalisation in the Norwegian offshore wind and solar energy industries. CenSES report 01/2015. Oslo: Centre for Sustainable Energy Studies.
- Normann, H.E. 2015. The role of politics in sustainable transitions: The rise and decline of offshore wind in Norway. *Environmental Innovation and Societal Transitions* 15:180-193.

- NRK. 2013. Meiner staten og kommunane vil tape stort på grønne sertifikat. *Nrk.no*, 21 March 2013, <http://www.nrk.no/sognogfjordane/--vil-tape-pa-grone-sertifikat-1.10957973>. Accessed 21 March 2013.
- NVE. 2012. Havvind - Strategisk konsekvensutredning. Oslo: Norges vassdrags- og energidirektorat.
- OECD. 2009. Green Growth: Overcoming the Crisis and Beyond. Paris: The Organisation for Economic Co-Operation and Development.
- OED. 2013. Fakta 2013. Norsk petroleumsvirksomhet. Oslo: Olje- og Energidepartementet.
- — —. 2015. Fakta 2015. Energi- og vannressurser i Norge. Oslo: Olje- og Energidepartementet.
- Offshorewind.biz. 2011. Offshore Wind Growth Limited by Supply Chain (UK). *Offshorewind.biz*, November 3 2011. <http://www.offshorewind.biz/2011/11/03/offshore-wind-growth-limited-by-supply-chain-uk/>. Accessed November 7 2011.
- Patchell, J. and R. Hayter. 2013. Environmental and evolutionary economic geography: Time for EEG2? *Geografiska Annaler: Series B, Human Geography* 95:111-130.
- Pierson, P. 2000. Increasing Returns, Path Dependence, and the Study of Politics. *The American Political Science Review* 94:251-267.
- Pollock, N. and R. Williams. 2010. The business of expectations: How promissory organizations shape technology and innovation. *Social Studies of Science* 40:525-548.
- Porter, M.E. 1990. *The Competitive Advantage of Nations*. New York: Free Press.
- Portman, M.E.; J.A. Duff; J. Köppel; J. Reiser; and M.E. Higgins. 2009. Offshore wind energy development in the exclusive economic zone: Legal and policy supports and impediments in Germany and the US. *Energy Policy* 37:3596-3607.
- Qian, H.; Z.J. Acs; and R.R. Stough. 2013. Regional systems of entrepreneurship: the nexus of human capital, knowledge and new firm formation. *Journal of Economic Geography* 13:559-587.
- Raven, R.P.J.M.; G.P.J. Verbong; W.F. Schilpzand; and M.J. Witkamp. 2011. Translation mechanisms in socio-technical niches: a case study of Dutch river management. *Technology Analysis & Strategic Management* 23:1063-1078.
- Reve, T. and A. Sasson. 2012. *Et kunnskapsbasert Norge*. Oslo: Universitetsforlaget.
- Rigby, D.L. 2007. Evolution in Economic Geography? In *Politics and Practice in Economic Geography*, ed. A. Tickell; E. Sheppard; J. Peck; and T.J. Barnes, 176-186. Los Angeles: Sage.
- Rip, A. and R. Kemp. 1998. Technological change. In *Human Choice and Climate Change - Resources and Technology*, ed. S. Rayner and E.L. Malone. Columbus: Battelle Press.
- Rockstrom, J.; W. Steffen; K. Noone; A. Persson; F.S. Chapin; E.F. Lambin; T.M. Lenton; M. Scheffer; C. Folke; H.J. Schellnhuber; B. Nykvist; C.A. de Wit; T. Hughes; S. van der Leeuw; H. Rodhe; S. Sorlin; P.K. Snyder; R. Costanza; U. Svedin; M. Falkenmark; L. Karlberg; R.W. Corell; V.J. Fabry; J. Hansen; B. Walker; D. Liverman; K. Richardson; P. Crutzen; and J.A. Foley. 2009. A safe operating space for humanity. *Nature* 461:472-475.
- Ruef, A. and J. Markard. 2010. What happens after a hype? How changing expectations affected innovation activities in the case of stationary fuel cells. *Technology Analysis & Strategic Management* 22:317-338.
- Rusten, G. 2013. The hydropower industry: Technology, regulations and regional effects. In *Norway: Nature, Industry and Society*, ed. G. Rusten; K. Potthoff; and L. Sangolt, 99-116. Bergen: Fagbokforlaget.
- Ryan, G.W. and H.R. Bernard. 2003. Data Management and Analysis Methods. In *Collecting and Interpreting Qualitative Materials*, ed. N.K. Denzin and Y.S. Lincoln, 259-309. Thousand Oaks: Sage Publications.
- Saxenian, A. 1996. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge MA: Harvard University Press.
- Schoenberger, E. 1991. The Corporate Interview as a Research Method in Economic Geography. *The Professional Geographer* 43:180-189.
- Schot, J. and F. Geels. 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis and Strategic Management* 20:537-554.

- Schumpeter, J. 1934. *The theory of economic development*. Cambridge, MA: Harvard University Press.
- Schumpeter, J. 1976. *Capitalism, Socialism & Democracy*. London: Routledge.
- Scott, A.J. 2006. *Geography and economy*. Oxford, U.K.: Oxford University Press.
- Scottish Enterprise. 2011. *A Guide to Offshore Wind and Oil & Gas Capability*. Glasgow: Scottish Enterprise.
- Shove, E. and G. Walker. 2007. CAUTION! Transitions ahead: politics, practice, and sustainable transition management. *Environment and Planning A* 39:763-770.
- Silverman, D. 2003. Analyzing Talk and Text. In *Collecting and Interpreting Qualitative Materials*, ed. N.K. Denzin and Y.S. Lincoln. Thousand Oaks: Sage Publications.
- Simmie, J. 2012. Path Dependence and New Path Creation in Renewable Energy Technologies. *European Planning Studies* 20:729-731.
- Simmie, J. 2012. Path Dependence and New Technological Path Creation in the Danish Wind Power Industry. *European Planning Studies* 20:753-772.
- Simmie, J. and R. Martin. 2010. The economic resilience of regions: towards an evolutionary approach. *Cambridge Journal of Regions, Economy and Society* 3:27-43.
- Simmie, J.; R. Sternberg; and J. Carpenter. 2014. New technological path creation: evidence from the British and German wind energy industries. *Journal of Evolutionary Economics* 24:875-904.
- Smith, A. and R. Raven. 2012. What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy* 41:1025-1036.
- Smith, A.; A. Stirling; and F. Berkhout. 2005. The governance of sustainable socio-technical transitions. *Research Policy* 34:1491-1510.
- Smith, A.; J.-P. Voß; and J. Grin. 2010. Innovation studies and sustainable transitions: The allure of the multi-level perspective and its challenges. *Research Policy* 39:435-448.
- Snyder, B. and M.J. Kaiser. 2009. Ecological and economic cost-benefit analysis of offshore wind energy. *Renewable Energy* 34:1567-1578.
- Steen, M. and G.H. Hansen. 2014. Same Sea, Different Ponds: Cross-Sectorial Knowledge Spillovers in the North Sea. *European Planning Studies* 22:2030-2049.
- Steen, M. and A. Karlsen. 2014. Path creation in a single-industry town: The case of Verdal and Windcluster Mid-Norway. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography* 68:133-143.
- Steen, M. and A. Underthun. 2011. Upgrading the 'Petropolis' of the North? Resource peripheries, global production networks, and local access to the Snøhvit natural gas complex. *Norwegian Journal of Geography* 65:212-225.
- Steen, M. and T. Weaver. 2015. Exploring cross-sectorial dynamics and reconsidering niche-regime interactions. Paper presented at *International Sustainability Transitions Conference*, 25-28 August, Brighton.
- Storper, M. and R. Walker. 1989. *The Capitalist Imperative: Territory, Technology and Industrial Growth*. Oxford: Blackwell.
- Strambach, S. 2010. Path dependence and path plasticity: the co-evolution of institutions and innovation - the German customized business software industry. In *Handbook of Evolutionary Economic Geography*, ed. R. Boschma and R. Martin, 406-429. Cheltenham: Edward Elgar.
- Sydow, J.; F. Lerch; and U. Staber. 2010. Planning for Path Dependence? The Case of a Network in the Berlin-Brandenburg Optics Cluster. *Economic Geography* 86:173-195.
- Sydow, J.; G. Schreyögg; and J. Koch. 2009. Organizational Path Dependence: Opening the Black Box. *Academy of Management Review* 34:689-709.
- Sydow, J.; A. Windeler; G. Müller-Seitz; and K. Lange. 2012. Path Constitution Analysis: A Methodology for Understanding Path Dependence and Path Creation. *BuR - Business Research* 5:155-176.
- Sæther, B.; A. Isaksen; and A. Karlsen. 2011. Innovation by co-evolution in natural resource industries: The Norwegian experience. *Geoforum* 42:373-381.
- Söderholm, P. and M. Pettersson. 2011. Offshore wind power policy and planning in Sweden. *Energy Policy* 39:518-525.

- Tanner, A.N. 2014. Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions. *Economic Geography* 90:403-427.
- Tavassoli, S. and D. Tsagdis. 2014. Critical Success Factors and Cluster Evolution: A Case Study of the Linköping ICT Cluster Lifecycle. *Environment and Planning A* 46:1425-1444.
- Taylor, D. 2004. Wind Energy. In *Renewable Energy. Power for a Sustainable Future*, ed. G. Boyle, 243-296. Oxford: Oxford University Press.
- Ter Wal, A.L.J. and R. Boschma. 2011. Co-evolution of Firms, Industries and Networks in Space. *Regional Studies* 45:919-933.
- Toke, D. 2011. The UK offshore wind power programme: A sea-change in UK energy policy? *Energy Policy* 39:526-534.
- Tripl, M.; M. Grillitsch; A. Isaksen; and T. Sinozic. 2015. Perspectives on Cluster Evolution: Critical Review and Future Research Issues. *European Planning Studies*:1-17.
- Truffer, B. and L. Coenen. 2012. Environmental Innovation and Sustainability Transitions in Regional Studies. *Regional Studies* 46:1-21.
- Truffer, B.; J.P. Voß; and K. Konrad. 2008. Mapping expectations for system transformations: Lessons from Sustainability Foresight in German utility sectors. *Technological Forecasting and Social Change* 75:1360-1372.
- Tushman, M.L. and P. Anderson. 1986. Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly* 31:439-465.
- Underthun, A. 2013. The politics, rewards and paradoxes of the Norwegian "petroleum adventure". In *Norway: Nature, Industry and Society*, ed. G. Rusten; K. Potthoff; and L. Sangolt, 117-137. Bergen: Fagbokforlaget.
- Underthun, A.; S. Kasa; and M. Reitan. 2011. Scalar politics and strategic consolidation: The Norwegian Gas Forum's quest for embedding Norwegian gas resources in domestic space. *Norwegian Journal of Geography* 65:226-237.
- Valentine, G. 1997. Tell me about...: using interviews as a research methodology. In *Methods in Human Geography*, ed. R. Flowerdew and D. Martin, 110-126. Harlow: Longman.
- . 2001. At the drawing board: developing a research design. In *Qualitative Methodologies for Geographers*, ed. M. Limb and C. Dwyer. London: Arnold.
- van Lente, H. 2012. Navigating foresight in a sea of expectations: lessons from the sociology of expectations. *Technology Analysis & Strategic Management* 24:769-782.
- Vatne, E. 2008. Olje og gass: en ny næring i hurtig vekst. In *Innovasjoner i norske næringer - et geografisk perspektiv*, ed. A. Isaksen; A. Karlsen; and B. Sæther, 101-120. Bergen: Fagbokforlaget.
- Verbong, G. and F. Geels. 2007. The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy* 35:1025-1037.
- Vergne, J.-P. and R. Durand. 2010. The Missing Link Between the Theory and Empirics of Path Dependence: Conceptual Clarification, Testability Issue, and Methodological Implications. *Journal of Management Studies* 47:736-759.
- Verhees, B.; R. Raven; F. Kern; and A. Smith. 2015. The role of policy in shielding, nurturing and enabling offshore wind in The Netherlands (1973–2013). *Renewable and Sustainable Energy Reviews* 47:816-829.
- Volden, G.H.; H. Bull-Berg; F. Skjeret; H. Finne; and M. Hofmann. 2009. Vindkraft offshore og industrielle muligheter. *SINTEF report A12652*, Trondheim.
- Weaver, T. 2012. Financial appraisal of operational offshore wind energy projects. *Renewable and Sustainable Energy Reviews* 16:5110-5120.
- Weaver, T. and M. Steen. 2013. Utviklingstrekk i den norske energiindustrien. Censes report 01/2011. Trondheim: Centre for Sustainable Energy Studies.
- Weber, K.M. and H. Rohracher. 2012. Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. *Research Policy* 41:1037-1047.

- Weitzman, E.A. 2003. Software and Qualitative Research. In *Collecting and Interpreting Qualitative Materials*, ed. N.K. Denzin and Y.S. Lincoln, 310-339. Thousand Oaks: Sage Publications.
- Wieczorek, A.J.; M.P. Hekkert; L. Coenen; and R. Harmsen. 2015. Broadening the national focus in technological innovation system analysis: The case of offshore wind. *Environmental Innovation and Societal Transitions* 14:128-148.
- Wieczorek, A.J.; S.O. Negro; R. Harmsen; G.J. Heimeriks; L. Luo; and M.P. Hekkert. 2013. A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews* 26:294-306.
- Wiersma, F.; J. Grassin; A. Crockford; T. Winkel; A. Ritzen; and L. Folkerts. 2011. State of the Offshore Wind Industry in Northern Europe. Lessons Learnt in the First Decade: Ecofys.
- Wilhelmsson, D.; T. Malm; R. Thompson; J. Tchou; G. Sarantakos; N. McCormick; S. Luitjens; M. Gullström; J.K. Patterson Edwards; O. Amir; and A. Dubi. 2010. Greening Blue Energy: Identifying and managing biodiversity risks and opportunities for off shore renewable energy., 102. Gland: IUCN.
- Wiser, R.; Z. Yang; M. Hand; O. Hohmeyer; D. Infield; P.H. Jensen; V. Nikolaev; M. O'Malley; G. Sinden; and A. Zervos. 2011. Wind Energy. In *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*, ed. O. Edenhofer; R. Pichs-Madruga; Y. Sokona; K. Seyboth; P. Matschoss; S. Sadner; T. Zwickel; P. Eickemeier; G. Hansen; S. Schlömer; and C. von Stechow. Cambridge UK: Cambridge University Press.
- Wüstenhagen, R.; M. Wolsink; and M.J. Bürer. 2007. Social acceptance to renewable energy innovation: An introduction to the concept. *Energy Policy* 35:2683-2691.
- Yeung, H.W.-c. 2003. Practicing New Economic Geographies: A Methodological Examination. *Annals of the Association of American Geographers* 93:442-462.
- Yeung, H.W.-c. and N.M. Coe. 2015. Toward a Dynamic Theory of Global Production Networks. *Economic Geography* 91:29-58.
- Yeung, H.W.C. 2005. Rethinking relational economic geography. *Transactions of the Institute of British Geographers* 30:37-51.
- Yin, R.K. 2003. *Case Study Research. Design and Methods*. London: Sage.
- Yin, R.K. 2012. *Applications of Case Study Research*. Los Angeles: Sage.
- . 2014. *Case Study Research. Design and Methods*. Los Angeles: Sage.

PART 2

Is not included due to copyright

Is not included due to copyright

Is not included due to copyright

Reconsidering path creation in economic geography: aspects of agency, temporality and methods

Markus Steen

Abstract

The emergence of new industrial development paths is an important topic in economic geography. However, current perspectives emphasizing the constraining forces of historical trajectories on innovation and change have shortcomings in accounting for how and where new industries arise. This article argues that more attention needs to be paid to agency, and that agency must be seen as intertemporal in the sense that actors' activities and strategies are framed by combinations of experiences and expectations. As such, the article combines insights from economic geography, transitions studies and the sociology of expectations literature to expand extant theory on path creation. A brief analysis of the emerging Norwegian offshore wind power sector serves to illustrate how experience (the past) and different types of expectations (the future) have tangible effects on agency, and in effect on path creation processes. These insights have methodological implications, essentially favoring qualitative approaches over quantitative ones to understand formative phases in industrial development.

1 Introduction

Because new industries provide the ground for future economic growth they are of great interest to both researchers and policy makers (Feldman and Lendel 2010; Forbes and Kirsch 2011). Although there is consensus about the importance of new industries, the processes by which new industries emerge are not sufficiently explained by current theories, concepts, research strategies and empirical accounts in economic geography (Martin and Sunley 2006; Menzel, Henn, and Fornahl 2010). Evolutionary economic geography (EEG) has made important contributions to understanding path dependent evolution, notably by providing a theoretical basis for explaining how new industries emerge through re-combinations of knowledge and other resources from established industries (Frenken and Boschma 2007). A core idea underpinning EEG theorizing is that of path dependence; that the development trajectories of technologies, firms, industries, places and regions are conditioned (primarily in a constraining sense) by the historical processes that created them (Boschma and Frenken 2006; Martin and Sunley 2010). However, a conceptual debate concerning the relevancy of path dependence theory in accounting for change and renewal has emerged in recent years, informing the development of broader 'path-as-process' perspectives encompassing forces of both continuity and change (Martin 2010). Whilst this has paved the way for a much broader understanding of path creation, here referring to the emergence of new industrial development

paths (Martin 2010; Binz, Truffer, and Coenen 2015), it is fair to say that this debate is still in its infancy (Martin and Sunley 2010).

Against this background, the article departs from a recognition of three inter-related issues that could further develop our understanding of how new industries emerge in the economic landscape. First, insufficient attention has been paid to agency (Dawley 2014). EEG empirical research aims to explain new industry formation on the basis of firm level dynamics following variety in firm routines (Boschma and Frenken 2006). Despite this micro-level theoretical foundation, EEG accounts of new path creation tends to render social agency, motivation and strategy largely invisible. For instance, firm diversification has been identified as a key mechanism of path creation, but the strategies and motives underlying diversification into adjacent sectors are questions that few economic geographers have posed, let alone attempted to answer. Second, the temporal dimension of analysis in current perspectives disregards the future orientation which is fundamental to human agency (Emirbayer and Mische 1998), and particularly prevalent in innovation processes (Borup et al. 2006). Path creation relies on (collectives of) entrepreneurs, spin-offs, diversifying firms and other actors that more or less strategically recombine and transfer knowledge and resources from different sectors as they act on new and expected opportunities (Garud and Gehman 2012). The future, in this context, materializes as expectations and visions that shape and are shaped by strategy and planning, and are consequently acted (or not) upon (Borup et al. 2006). By implication, conceptualizations of agency and temporality should be reconsidered so as to provide more analytical strength in understanding actors, whilst the articulation of expectations should be seen as both resources that actors deploy in pursuit of interests (Berkhout 2006) as well as forming part of the socio-economic context (Martin and Sunley 2006) in which path creation processes unfold. Third, and reflecting the lack of attention to agency in research on path creation, coterminous studies of emerging industries are rare (Feldman and Lendel 2010). Novelty tends to be studied in hindsight, when (important) actors, phenomenon, processes, events, and (naturally) outcomes, may be identified more easily. Clearly, a challenge with emerging industries is that they do not fit with existing industrial classification schemes (e.g. SIC codes), making such data inappropriate for quantitative approaches. This article suggests that qualitative methods are needed to provide new insights into the complexity of ongoing path creation processes.

The aim of this article is thus to explore ways of extending economic geography theorizing on path creation, yet the ideas launched here have implications for understanding industrial development trajectories more broadly. To this avail, the article draws on insights from the literatures on socio-technical transitions and the sociology of expectations (SoE). The former provides analytical tools for

understanding technological shifts and the development of new technologies and industries, and has received growing attention from economic geographers (e.g. Simmie 2012; Truffer and Coenen 2012). The SoE literature, which focuses on the generative and performative role of expectations and visions in influencing innovation, strategy, resource mobilization to particular technologies and so on and so forth, has so far seen few encounters with economic geography. In this article I suggest that insights from the SoE literature stream can provide novel and valuable understandings of agency in path creation processes. That is, I argue that seeing agency as simultaneously past and future oriented helps disentangle the micro-level processes underlying processes of innovation and change, which are core to path creation and of relevance to path evolution more generally.

The article proceeds in three steps. The next section discusses current perspectives on path creation (in economic geography) and how these can be extended by drawing on ideas from the transition and SoE literatures. Thereafter, these ideas are employed mainly for illustrative purposes on a case study of the emerging offshore wind power (OWP) industry in Norway. Finally, I conclude and reflect on implications for path creation theorizing and research strategies.

2 Theorizing path creation

2.1 (Evolutionary) Economic geography and path creation

Recent theorizing in economic geography has focused on the evolutionary character of economic activities and how they relate to processes of socio-spatial development and change, giving rise to a distinct evolutionary economic geography (EEG) (Boschma and Frenken 2006; Essletzbichler and Rigby 2007; Martin 2010). In emphasizing evolution, EEG takes "*a critical stand towards static analysis*", and aims at explaining "*a current state of affairs from its history: 'the explanation to why something exists intimately rests on how it became what it is'*" (Boschma and Frenken 2006, 280). A key tenet of this work has been that development trajectories are subject to path dependent processes, meaning that any given outcome "*evolves as a consequence of the process' and system's own history*" (Martin and Sunley 2006, 399).

In EEG, explanations of path dependence are rooted in micro-level processes. Drawing on evolutionary economics (e.g. Nelson and Winter 1982) the key idea is that differences in firms' routines (how they tend to conduct various activities) explains variation in firm performance over time. Routines, which are seen as mechanisms of organizational control and (knowledge) resource coordination (Boschma and Frenken 2009), are necessary for decision-making processes and change only slowly, implying that they are a source of path dependence. In explaining changes in economic landscapes, EEG thus "*attempts to understand the spatial distribution of routines over time*"

(Boschma and Frenken 2006, 278). The focus on routines as a main way of explaining the behavior at the micro level stems from evolutionary economists' critique of mainstream (neoclassical) economic theory's premium rationale of 'maximizing profits'. In neoclassical economics, actors are taken to be careful in their deliberations and attempted foresights. Evolutionary economists argue that "*real actors, however, simply do not have the vast computational and cognitive power that are imputed to them by optimization-bases theories*" (Nelson and Winter 2002, 29). Actors are therefore not optimizers, but what Simon (1979) labelled 'satisficers', operating with a cognitive logic of bounded rationality (implying that decision-making processes are constrained by limited information and time), which provides theoretical underpinnings for path dependence as arising from the micro-level behavior of firms and other actors.

In evolutionary economics path dependence is conceptualized as having constraining effects on innovation and change (Martin and Sunley 2006). However, more recent conceptual work has argued that path dependent processes are not limited to continuity, but that they also generate change (Martin 2010). That is, through ongoing innovation and adaptation, which takes place even in rigid systems, path dependent processes may allow for knowledge development and resource transmission within and across sectors over time. A major contribution that EEG has made in this regard is to provide explanations for firm diversification into (new) activities that are technologically related to their existing activities and knowledge base (Neffke and Henning 2013). This same logic of 'evolutionary branching' whereby organizational routines diffuse applies to entrepreneurial spin-offs. As such, 'branching processes' (Boschma and Wenting 2007) are key path creation mechanisms (Martin and Sunley 2006; Cooke 2012). However, diversification is not only conditioned by the knowledge dimensions (commonality and proximity) of relatedness, but also by sunk costs and costs associated with adapting to new activities in new contexts. For instance, a production firm is likely to diversify into a new product market for which it has a relevant knowledge base *and* in which its existing manufacturing equipment may be reutilized. Whilst EEG emphasizes the technological dimension of relatedness, also other dimensions of relatedness, such as organizational setups (project economies, supply chains etc.) and institutional contexts, may facilitate (but also hamper) diversification processes (Steen and Hansen 2014; Tanner 2014).

EEG suggests that new industries emerge in windows of locational opportunity (Boschma and Frenken 2006). That is, the whereabouts of new industrial development paths is relatively open, provided a set of generic conditions (e.g. infrastructure, human capital) are fulfilled. The actual creation of a new path is however often attributed to 'historical accidents', which says little if anything about the origins of path creation. As argued by Martin (2010, 20), however, there is robust

empirical evidence that *"place-specific factors and conditions (...) are not simply "accidental" or random but are often the product of and reflect the economic, social, cultural, and institutional conditions inherited from the previous industrial and technological histories of a locality."* Such locality specific assets may form the basis for industrial renewal or the development of new industries (Klepper 2007), but they may also constrain innovation and new path creation because they are not easily adapted and applied to new circumstance (Maskell and Malmberg 2007). New paths may spring out of periods of crisis and creative destruction, but also from processes of adaptation and incremental change (MacKinnon 2011). In the latter cases, new paths evolve gradually from established paths through processes such as evolutionary branching (Frenken and Boschma 2007). However, 'old paths' may provide assets and resources relevant to different new paths. The particularities of new paths will thus be context specific (Martin 2010) and contingent on agency (Sydow et al. 2012; Dawley 2014). To understand why particular paths emerge instead of others therefore requires more attention to agency and how actors respond to changes in (but also influence their) the contexts in which they operate.

Garud and Karnøe (2001) pioneered the path creation debate and argued against the perspective that new industries initially arise by accident. Contrary to 'canonical path dependency', in which path dependence forces set in 'behind the back' of actors (Simmie 2012), Garud and Karnøe emphasize collective agency and knowledgeable actors who 'mindfully deviate' from extant paths and established routines to initiate processes that shape new social practices and technologies. This strategic agency is simultaneously past and future oriented (Garud and Gehman 2012). Whilst the strategic maneuvering of actors onto new paths has been incorporated into the more open perspectives on path evolution in economic geography (Martin 2010; Simmie 2012; Dawley 2014), the temporality of strategic agency has not been awarded much attention, at least not explicitly. Appreciating the importance of the future, which materializes in the form of expectations and visions (Borup et al. 2006), in shaping the evolution of the economic landscape may provide novel insights into how new industrial development paths emerge. That having said, this is not to suggest that 'chance' or 'accident' does not play a role in innovation and the evolution of technologies, firms and industries. As argued by Martin and Sunley (2010, 79), *"in most instances path creation will inevitably involve a complex admixture of deliberate agency and accidental and unintended emergence."* Thus, the effects of intended actions may be different than those envisaged, and chance events may have profound impacts.

To summarize thus far, explaining path creation requires attention to both context and agency. Regarding context, economic geography can benefit from drawing on insights from the socio-

technical transitions literature (see also Simmie 2012; Martin and Coenen 2014). This literature has developed a set of frameworks for analyzing the dynamics of technological and industrial development, particularly in constraining contexts. It is beyond the scope of this article to account for this literature in detail. In the following section I therefore briefly review core ideas in this literature relating to innovation and change before I focus in on the temporality of agency and the role of expectations in innovation and industrial development.

2.2 Socio-technical transitions

The socio-technical transitions literature provides various analytical frameworks for understanding the emergence of new technologies and industries, particularly within large-scale, highly path dependent, and complex systems such as those of the energy industries (Markard, Raven, and Truffer 2012; Truffer and Coenen 2012). A key concept is the 'regime', which encapsulates the complex assemblage of firms and other actors, technologies, infrastructures, regulations, institutions and practices that constitute established sectors and systems. A transition from an established 'socio-technical regime' (e.g. a fossil-fuel based energy system) to a new one (e.g. an energy system based on renewable energy technologies) happens as a result of an interplay of forces that are exogenous and/or endogenous to a (analytically defined) regime. Exogenous forces include changes on the macro-level, such as changing consumer trends or booms or busts in commodity prices, which serve to destabilize regimes and open up for new technological niches to emerge. Niches come into being as a result of agency and do not exist *a priori* as opportunities ready to be seized (Schot and Geels 2007). Although new technologies may be promising, they compete with both extant technologies and other new technologies and therefore often fail to survive past infancy. In short, the selection environment is strongly shaped by mature technologies and the economic practices, actors, institutions and investments linked to these. Promising technologies may increase their chance of survival if they attract resources through public subsidies or private strategic investments. This enables the formation of arenas for interactive learning processes and other self-reinforcing mechanisms that are necessary for development and maturation. Transition frameworks are quasi-evolutionary in that creation of variety is not seen as being completely blind. Instead, future selection environments (for technologies) are anticipated and actively shaped by actors (Coenen, Raven, and Verbong 2010). This brings me to the role of expectations in innovation and technology development, and, by implication, to the temporality of agency.

2.3 The temporality of agency and the role of expectations

Processes of entrepreneurship or diversification entails innovation, which in “*contemporary science and technology is an intensely future-oriented business*” (Borup et al. 2006, 285). A future orientation in behavior applies to individuals, groups, organizations, and even society as a whole, and is particularly prevalent in “*areas of science and technology, which are predicated on ideas of progress*” (van Lente 2012, 769). A range of studies have shown how expectations and visions about the future are fundamental to understanding technological development and industrial change (Ruef and Markard 2010; Bakker, van Lente, and Meeus 2012). Similar to Garud and Karnøe’s (2003) path creation approach, the sociology of expectations literature departs from the basic yet important premise that behavior is simultaneously oriented towards past, present and future circumstances (Emirbayer and Mische 1998). Agency is thus inter-temporal: ongoing processes of becoming connect the past -which constitutes the basis for ongoing action - with the future in the form of visions or expectations of how action may unfold. This inter-temporal orientation is moreover flexible, and changes with variation in the contexts that actors confront. According to Garud, Kumaraswamy, and Karnøe (2010, 767) actors mobilize parts of their past to support imagined futures, which are thus “*essential mechanisms that stimulate action.*”

In EEG a current state of affairs is explained by the events and circumstances that led to it – its history (Boschma and Frenken 2006). An intertemporal conceptualization of agency implies that attempts to explain innovation and change must also capture how actors’ activities and strategies are influenced and molded by their expectations of how the future could or should pan out. Martin and Sunley (2010) argue that contrary to accounts that emphasize serendipity in path creation, *ex ante* selection is a significant force in technological (and industrial) development. They (op cit., 82) connect this to micro-level processes when stating that “*new ventures are based on ‘business conceptions’ or the entrepreneur’s interpretation of the opportunity and the approach adopted to exploit it (...). Such intuitive conceptions characteristically mix past experience, memory, and current intentions and they have important framing effects on the new firm’s motivation and direction (...).*” However, they do not elaborate on the role of intentions, which, I would argue, are future oriented by their very nature, in shaping path creation processes. As pointed out by Garnsey, Lorenzoni, and Ferriani (2008), intentionality and choice in technological development distinguishes it clearly from biological evolution. Whilst *ex ante* selections may be constrained by routines, bounded rationality and limitations set by search heuristics, decisions to invest into new technologies and solutions are obviously informed by expectations of how futures (of markets, application domains, demands and needs) could or should pan out.

Expectations are important for path creation processes, therefore, because they are generative. That is, they contribute to attracting interest and fostering investments (resource mobilization), guiding and directing activities (steering technological development), providing structures and legitimation, the aligning of industrial actors and innovation networks, and to the build-up of hard and soft infrastructure (Borup et al. 2006). On the micro level, expectations influence the particular activities of engineers, scientists and other actors. Together these forces produce effects, which in extreme cases represent self-fulfilling prophecies (Borup et al. 2006; van Lente 2012). However, hyped expectations that are not fulfilled, for instance promises of new market formation supported by government subsidies, or technologies that do not 'deliver' as promised, may have a long-term detrimental effect on an entire technological field (Ruef and Markard 2010).

Expectations may be positive or negative, and often involve a mix of commercial, technological and societal aspects (van Lente 2012). Furthermore, expectations can be both collective and individual (Bakker 2014), implying that futures are contested rather than coherent. The framing of futures through strategic planning, foresight exercises and so on is done by many types of actors (not least by policy makers), but here I specifically focus on firms. Firms' decisions to invest in arising opportunities are based on experience combined with future expectations (Shane, Locke, and Collins 2003). However, when confronted with new opportunities, lessons learnt from the past may have limited relevance. Borup et al. (2006) argue that the generative nature of expectations is particularly important in initial stages of technological development, which are characterized by ambiguous roles, high levels of uncertainty, missing regulations, and so on. Because path creation is a result of collective rather than individual agency (Garud and Karnøe 2003) the development of some sense of collective expectation (of technological progress, market potential, regulations etc.) is important. Economic geographers have pointed out that the development of collective expectations benefits from geographical proximity (which facilitates closer interaction, learning processes etc.) (Coenen, Raven, and Verbong 2010). Such collective or shared expectations offer common understandings of potential risks and opportunities, and increase the possibility that a wider range of stakeholders are attracted to a new path. In this respect, an essential problem is that expectations are at their pinnacle during formative phases, and future realities are likely to differ from envisioned futures. These envisioned futures are contingent on vantage point (Borup et al. 2006), in the sense that the future looks different from a science lab than it does from the perspective of a 'common' consumer, or, I might add, from a large established corporation with vested interests vis-à-vis a small start-up firm struggling to attract resources, develop its products or services and establish itself in the market.

However, an issue that has not been advanced in this burgeoning debate is that expectations not only vary with vantage point, but that expectations themselves (often) have inherently spatial dimensions. In the energy sectors, for instance, this is evident in terms of expectations that certain countries and regions will lead the way in the 'green shift' by investing into renewable energy capacity and/or develop industries and technologies to cater to that demand. On the industry level, the 'green shift' will offer different opportunities and challenges for actors in established and emerging sectors, in part contingent on the spatial patterns industries. On the firm level, geographical market orientation is of course a key aspect of corporate strategy. We can for instance assume that there are firm specific expectations and motivations linked to particular market segments understood as *"sub-system structures that serve specific user segments and that are characterized by specific product forms and related actors, networks and institutions"* (Dewald and Truffer 2011, 286). In turn, these expectations should then have tangible impacts on the activities and strategies of firms (and other actors, e.g. R&D institutions, government), and, by extension, have imprints on the particularities, momentum, pace and direction of path creation processes.

2.4 An intertemporal perspective on path creation

In drawing together key insights from the preceding theoretical discussion, the point of departure is that innovation is the basis of new industrial development paths. Most innovations are incrementally developed within existing paths, where they lead to ongoing change and processes of renewal or reorientation (Isaksen 2014), but innovations may also spur the creation of new industrial development trajectories. However, in many circumstances, innovations compete with existing solutions in established industries (Truffer and Coenen 2012). This is particularly the case in large-scale, complex and relatively rigid sectors such as those constituting energy systems, in which new path creation hinges on processes of niche market formation and collective agency (Simmie 2012). Whilst a path-as-process perspective acknowledges forces of both continuity and change, a transition perspective adds value by providing conceptual tools for understanding the dynamics between established paths ('regimes') and new ones ('niches') and various macro level factors which alter selection pressures on extant paths and thus influence opportunities (and barriers) that confront actors. Whilst the case at hand (the emerging OWP industry in Norway) does not constitute a classic 'transitions case' (in the sense that OWP in Norway replaces an established energy technology), the more general insights provided by the transitions literatures are valuable for understanding how firms (and other actors) navigate in between established and emerging paths.

Of particular relevance to this article is the role of actors' expectations as an important generative mechanism in contributing to resource mobilization, experimentation, knowledge generation and so

on linked to new industrial paths. The discovery and recognition of new 'windows of opportunities' depends in large on previous experience (Shane, Locke, and Collins 2003), which helps actors in selecting among various potential new activities. It also contributes to explaining the diffusion of routines as a result of firm diversification into (emerging) sectors that are technologically related (Frenken and Boschma 2007). Whilst futures are always uncertain, this does not necessarily imply randomness and chance, but rather greater or lesser degrees of probability of certain scenarios playing out. In turn, expectations (individual/ collective, positive/ negative etc.) influence how firms and other actors navigate a new terrain, what strategies they employ, which activities they initiate, and how they (attempt to) mobilize and develop resources. It follows that firms (and other actors such as policy makers) must be understood as strategic entities, where strategy basically refers to the goals that actors aim to achieve, the activities they pursue in order to reach those goals, and the intangible and tangible resources they allocate to those ends (Farla et al. 2012).

3 Exploring agencies and strategies in the Norwegian offshore wind industry

Empirical studies in economic geography tend to study a specific development process and provide historical explanations for observations. This article suggests that this temporal perspective can be extended by including also the impact of expectations and future orientation on actor strategies and activities. Whilst outcomes naturally cannot be explained *ex ante*, firm activities and strategies based on expectations are at least in part accessible to researchers.

The guiding research questions for the brief and illustrative analysis that follows are *how are Norwegian offshore wind firms' strategies and activities linked to experience, current circumstance and expectations* and *how does expectations impact on path creation processes?* The empirical basis for the analysis is qualitative, with firm interviews as the principal research strategy component. As argued by Schoenberger (1991, 181), the evidence yielded by the corporate interview "*is the testimony of participants in complex, ongoing processes*" and the rationales underlying their activities. Semi-structured in-depth interviews with firm managers and other stakeholders (R&D, support organizations, finance providers etc.) were conducted in 63 different firms or organizations. Interviews were conducted in the period September 2010 to February 2014, with the main bulk in 2010 and 2011. The informants were mainly senior-level managers (CEOs/CFOs), but also included technical personnel and industry experts. In addition to interviews, the qualitative data comprises documents and participatory observation at various seminars and conferences organized by supporting member based organizations and/or research institutes.

3.1 *The emerging offshore wind industry and Norwegian involvement*

In the mid-2000s, the deployment of offshore wind power (OWP) turbines in Northern European waters 'took off'. OWP in Europe is expected to grow rapidly onwards and become a major new energy industry, with the UK as the largest market (EWEA 2014). Like other new renewable energy technologies, however, the OWP sector remains immature in terms of technology and regulations, and there is considerable uncertainty linked to future financing and policy support. Growth depends on state support in the form of market subsidies, research funding and so on (Wieczorek et al. 2013) until OWP can compete with more mature energy technologies. A key trend is that OWP farms are developed further from shore in deeper waters using larger, specialized turbines in greater quantities. Whilst the pioneers of OWP were actors with experience in onshore wind energy, the 'further, deeper, larger' trend created demand for the involvement and participation of incumbent firms (both producers and specialized product/service suppliers) from the maritime/offshore oil and gas (O&G) industries (Markard and Petersen 2009; Steen and Hansen 2014).

Many European countries have strong drivers for OWP in the form of CO² emission reductions in the energy sector, energy security issues, and new job creation. By contrast, Norway's national drivers for OWP are relatively weak, primarily due to a high share of renewables (hydropower) in its energy system. Nonetheless, a number (approx. 150-200) of Norwegian firms are (or have been) involved in this emerging industry to larger or lesser extent. The Norwegian OWP sector comprises a few (20-25) specialized OWP firms, energy majors Statoil (O&G) and Statkraft (utility), and a broad set of diversified supplier firms from the offshore O&G, maritime and power/utility sectors. Most of these firms are found in the deployment chain of the OWP industry (e.g. foundation structures, maritime logistics, installation) reflecting the knowledge base in the Norwegian petro-maritime industries. For both diversified and specialized firms, the move into the OWP niche is largely motivated by the opportunity that OPW offers for reutilizing historically developed capabilities and for supplementing core activities. However, also other and more intrinsic rationales (e.g. attraction of talent, exciting technology and business development) explains firms' diversification into OWP (Hansen and Steen 2015).

3.2 *Experiences, expectations and offshore wind power*

The case exemplar that follows aims to illustrate how the strategies and activities of firms that are involved in the emerging Norwegian OWP industry reflect both experience and expectations. The analysis reveals how some expectations are individual or firm specific, especially regarding the

development of particular technologies, market segments and value chain organization, whilst expectations linked to broader development trends to greater extent are collective.

3.1.1 Societal trends and industrial development paths

At the most general level, most firm managers that were interviewed share expectations regarding societal trends that will lead to a shift from today's carbon based energy system to a low-carbon system. On the one side, these collective expectations are linked to the depletion of O&G stocks ('peak oil'), particularly on the Norwegian Continental Shelf (NCS), which is the primary market for most of the Norwegian firms active in the OWP sector. On the other side, these expectations relate to the development, implementation and upscaling of renewable energy technologies. In that respect, there is a collective expectation that political support for those technologies are crucial for them to be able to replace hydrocarbons. As the CEO (interview, 2012) of a large O&G supply company put it, *"nobody doubts that the dirty industries will become less profitable because of taxes, whereas the clean industries will become more profitable because of technological development. The uncertainty lays in the subsidy policies."* These expectations regarding the development of established paths (O&G) and emerging paths (such as OWP), and the transition from current fossil-based energy systems to more sustainable solutions, have generative effects in that they influence firms to position for future market developments by initiating various forms of activities such as concept studies, piloting and vanguard projects.

Although oil production peaked in Norway around 2000, there are few signs of path destruction (Martin and Sunley 2006) in the near future, reflecting both the long term horizons of O&G investments as well as an anticipated gradual decline of activities on the NCS spanning multiple decades. Nonetheless, since the turn of the millennium there has been considerable uncertainty about overall activity and investment levels and the future opening of new exploration areas for O&G drilling. Although O&G production may remain high for decades, activity levels in many parts of the O&G value chain are expected to diminish, with varying effects for different segments of the industry. Thus, although the O&G industry path may be extended (Isaksen 2014), and possibly also become subject to (multiple) phases of renewal, certain technological paths within the industry may erode. Moreover, the O&G market is cyclical, and a 2008-2009 temporary 'bust' in the O&G industry led many firms towards pursuing OWP as a supplementary market (Hansen and Steen 2015), which at the time was pungent with expectations of substantial opportunities both domestically and internationally (Normann 2015). Industrial actors' strategies for embarking on a new path thus connect both with actual and perceived selection pressures on their core sector, as well as

opportunities arising in emerging sectors (such as OWP) into which they can diversify based on their accumulated knowledge and other resources.

Many of the interviewed firm managers have worked in the Norwegian O&G industry since its nascent phase in the 1970s. To large extent these managers have a shared expectation that the OWP sector will develop and mature through similar processes as did offshore O&G. In the early phase of the Norwegian O&G industry, capabilities from the Norwegian maritime industries were combined with O&G specific know-how from international oil companies and redeployed in the (then) new sector. As argued by the CEO of a large supply firm (interview, 2011), *"we have the knowledge and competence needed for offshore wind. It reminds me of the old ship yards (...) they struggled, but managed to adapt to the oil industry. In a few years I think the same will happen with offshore wind."* In analytical terms, managers' experience and understanding of previous rounds of industry emergence frame expectations about the future shaping of the OWP path. This same logic of developing OWP on the basis of Norway's industrial legacy in maritime and offshore industries also underlies Norwegian policy support for this industry (Hansen and Steen 2011), despite the lack of drivers for developing OWP farms domestically.

In the absence of domestic market opportunities, the majority of both specialized and diversified firms have explored international market opportunities and the 'UK round 3' OWP licensing phase in particular. When the majority of our interviews were conducted (2010 and 2011) firm managers explained that they aimed for OWP projects being developed from 2013-2014 onwards. As expressed by the CEO (interview, 2010) of a specialized OWP firm, *"if Norwegian firms don't see that this is the time to strike (...) there's a window open between now and 2014, when huge things will start happening on the UK continental shelf."* The CEO (interview, 2011) of another specialized OWP firm stated that *"we aim for UK round 3, and believe that 50 % of all investments in offshore wind during the next 10 years will be in UK."* Several of the managers that were interviewed argued that future success in OWP both for individual firms and the Norwegian OWP industry as a whole would be largely dependent on the ability to enter the OWP market through this phase. This was linked to concerns that Norway's perceived comparative advantages in offshore activities would wither as more and more OWP farms were (and would be) built in the UK and elsewhere, with corresponding development of industrial capabilities and maritime experience. As argued by one CEO (interview, 2010), *"it is evident that they (Germany, UK, etc.) are building competencies, and they are already far ahead in terms of gaining practical experience. There is a real danger that Norwegian firms will never acquire the experience needed to get through the needle's eye next time around."* This quote reflects the importance of market formation as vital for the development of new industries (Markard, Raven,

and Truffer 2012), and, conversely, how lack of market access can lead to negatively framed expectations of industrial development (van Lente 2012).

3.1.2 *Technology development and application domains*

The products and services that both diversifying and specialized firms approach the OWP sector with are largely based on well-established knowledge and experience (Steen and Hansen 2014). On the one hand, firms' experience thus constrains their strategic choices, most evidently in terms of pursuing activities in OWP that are similar to their previous experience, for instance in the O&G industry. On the other hand, the very same historically developed assets and routines provide the platform for which to pursue new opportunities, which resonates well with EEG ideas of branching innovation (Neffke and Henning 2013). However, the specific strategic choices that firms make cannot be explained by accumulated assets and routines alone, implying that explaining a current state of affairs from history (Boschma and Frenken 2006) is insufficient.

One issue that came across strongly in the interviews was that expectations are linked to the development of specific technologies, supply chains and market segments with particular spatial, temporal, technical, physical and economic characteristics. For instance, the CFO (interview, 2011) of a diversifying firm supplying foundation structures explained that *"it's really very simple for us. Our markets are those projects that demand jacket foundations. The market is totally dominated by monopolies. Those projects that require jackets are in deeper waters using larger turbines. So we need to find those projects."* Diversifying firms thus (intend to) extend the utilization of their existing assets by moving into an emerging niche sector which they expect will develop along a trajectory where they anticipate demand for particular products or services such as jacket foundation structures. Reflecting individual expectations (Bakker 2014), these expectations linked to specific technological development paths naturally vary considerably between firms.

The CEO (interview, 2010) of an offshore installation company, which made a considerable investment into new vessels specifically designed for OWP, explained their choice of technological specifications on the vessels being the result of how the firm expects that the OWP industry will develop: *"We believe in bottom-fixed foundations developing first. Floaters will come later. The vessels we are building are for bottom-fixed foundations (...) the sites that have been decided on already, in the countries mentioned, are all requiring bottom-fixed solutions."* These targeted market segments (Dewald and Truffer 2011) 'fit' what firms (intend to) have to offer, and provides a business context and a set of demands that the firm believes it can manage and meet. These expectations

thus have tangible and generative effects (Borup et al. 2006) on ongoing path creation processes by drawing firm-level resources towards certain strategic investments and activities and not to others.

On a 'technological timeframe' firms thus assess their relative position vis-à-vis anticipated future market demand, an assessment which also involves considering how competition will develop both in the proximate and the more distant future. The manager (interview, 2012) in charge of OWP activities in a large maritime supplier firm specializing in delivering instrumentation systems on ships stated that *"we can do something of the same in the wind industry, and then offshore wind is the most similar (...) According to research reports, this kind of instrumentation will not be implemented before 2020-2025. We're trying to enter this market now whilst it's still developing. We won't be first, but neither will we be last."* Expectations also relate to the development and organization of supply chains in OWP. The CEO (interview, 2010) of a specialized OWP installation firm claimed that *"there are niches in which they will source services instead of developing in-house, and that is a position I think we'll see ourselves in soon, as sub-suppliers to a larger group of 'total suppliers', being specialized."* Thus, an important part of the strategic work of entering OWP involves developing partnerships with other firms, and also in this regard experience informs strategies for future activities. The manager (interview, 2012) of a technology supplier firm explained that *"we plan to enter together with offshore wind farm developers (...) It's the same thing we did in maritime, we allied with the ship owners."* In more general terms, the two last quotes reflect how innovation is linked to strategic adaptation of business models, given certain expectations of market demand and value chain development (Garnsey, Lorenzoni, and Ferriani 2008).

These considerations also impact on locational decision-making, for instance where firms should locate their manufacturing activities. The manager (interview, 2011) of a specialized OWP supplier firm explained that *"fabrication of our product will take place where the market is. In the UK this will be a demand from the customer. It will be totally unacceptable [for them] to subsidize a new industry and have all products and services imported. It's what's called a publicly known secret."* As such, the spatialities of expectations concern not only anticipated market demand and dynamics, but also institutional aspects.

On a final note, expectations that are not met can result in actors 'losing faith' and disconnecting from an emerging path (Ruef and Markard 2010), thereby withdrawing resources and weakening the momentum of reinforcing mechanisms necessary for new paths to develop (Martin 2010). Many Norwegian firms entered OWP in the period 2005 to 2010 with expectations that a domestic market would form. At the same time, exploration into OWP was based on actual as well as expectations of

continued decline in the offshore O&G industry. However, when a new technology neutral financial support scheme for renewable energy was introduced in 2012 it became clear that the anticipated domestic market would not materialize (Normann 2015). At the same time, the O&G industry was revitalized as a result of increasing global oil prices and several large resource discoveries on the NCS, with the result that many diversified actors reduced their involvement in OWP, whilst some abandoned the new sector altogether.

4 Concluding discussion and reflections

This article departed from a recognition of three inter-related issues that can advance our understanding of how new industries emerge in the economic landscape: more attention needs to be paid to agency, development processes can be better understood if studied in real-time and agency needs to be seen as simultaneously past and future oriented. In aiming to contribute to economic geography theorizing on path creation, I advanced the view that one potential way forward is to draw on insights from the literatures on socio-technical transitions and the sociology of expectations. Whilst the former provides analytical tools for understanding the relationship between established and emerging industries/technologies, the latter helps us see how agency in cotemporaneous processes of path creation is simultaneously shaped by expectations of the future. The ideas launched in this article were particularly connected to the debate on how new industrial development paths emerge, but should have relevance for path evolution processes more generally. To affirm this proposition, however, will require further empirical and conceptual work.

The brief analysis of the emerging Norwegian OWP industry supports a path-as-process perspective in the sense that forces of continuity and change were seen to be at work simultaneously. In this sense, the dynamics of the Norwegian OWP industry appear to imply a process of what can be referred to as "*path-dependent path creation*" (Martin and Sunley 2010, 82) in the sense that both diversifying and de novo firms that are active in this industry largely base their activities on experience from established offshore and maritime sectors. The analysis also illustrated how different actors' actions and strategies relate to and are shaped simultaneously by individual and collective expectations linked to both established and emerging industrial development paths. These expectations relate to different issues or dimensions, such as the development of technologies, supply chains and policies, and are framed according to both timescales (short- and long-term) and spatialities (e.g. in the form of particular (geographical) market formation processes). In short, expectations relate not only to how and when industries and technologies will or could evolve, but importantly also to why and where. The important point here is that these expectations result in actual investments and resource allocation towards more or less specific goals. This is evident both in

firms' innovation and product/service development strategies, as well as in the building of strategic linkages and partnerships for positioning for anticipated future opportunities.

Extending on the sociology of expectations literature, a takeaway from the analysis is that expectations have spatial dimension to them. Because of the very tangible effects expectations have on firm strategies and decision making they deserve closer attention in economic geography. This insight may be particularly relevant for understanding path creation in the context of capital-intensive, highly regulated, and relatively slowly changing industrial sectors. In energy sectors, for instance, investment decisions (e.g. new power plants) are often made for several decades, whilst government targets to reduce CO² emissions are set with specific long- and short-term deadlines. As such, another strand of literature worth pursuing here, especially regarding micro-level dynamics, is the literature on corporate foresight (Rohrbeck and Gemünden 2011). Whilst it was beyond the scope of this article to include the strategies, activities and expectations of other actors than firms (such as state bodies, R&D institutes or industry associations), these are obviously also part of the broader co-creation and 'future-making' processes (Karnøe and Garud 2012) that underly the emergence of new industrial development paths.

A few methodological reflections follow. Based on my reading of the EEG literature, the semi-structured interview guides that were used for this research project were meant to illuminate how firms' actions and strategies were conditioned by experience and historically developed capabilities (i.e. how 'history matters'). However, it only took a few interviews to realize that firms' involvement OWP was largely based on expectations of future growth. Our questions often triggered answers in the form of narratives whereby informants themselves connected past, present and future. This is important, because current explanations of path creation or industry emergence in economic geography are mainly based on rear-view-mirror approaches. When seen in hindsight, important actors, phenomenon and processes may be identified more easily. But while retrospective narratives may be coherent and 'sensible', they may also be over-rationalized and simplified, and important details about fragmentary events, failures, detours and mishaps may be suppressed, purposely omitted or simply forgotten. Accounts of the past tend to focus on causal factors that led to a certain sequence of events (i.e. providing the empirical basis for claims of path dependence), although many other alternative chains of events were likely along the way. This is in no way meant to discredit the value of historical analysis, but it is to suggest that placing oneself (as a researcher) in 'real-time' (Araujo and Harrison 2002) could help to avoid ex-post bias in explanation or retrospective meaning being imposed on events from knowledge of outcomes (Garnsey, Lorenzoni, and Ferriani 2008), and

enable more in-depth understanding of both successful and failed attempts at path creation (or path renewal/reorientation for that matter).

Researchers should therefore broaden the methodological and analytical scope to pay attention not only to origins and historical pathways, but also to how agency is informed by anticipated futures. In other words, this implies that analysis of innovation and industrial change should be based on a combination of retrospective, contemporary and (what may be referred to as) prospective data. Empirical insights of this nature, which require qualitative approaches such as interviews or participatory observation, can provide the basis for new theory development (Eisenhardt and Graebner 2007). Also other methods capturing expectations, plans and ambitions, such as foresight exercises or focus group workshops, should to larger extent be taken up by economic geographers. As argued by Schoenberger (1991, 181), the value of qualitative approaches "*may be highest in periods of great economic and social change that pose new challenges to the analytical categories and theoretical principles underlying much quantitative research.*"

'Futures' are invoked in all sorts of planning and strategic work, be it by civil society organizations, local authorities, large incumbents or entrepreneurs launching a new company. To some extent, strategies are only partially available to researchers, not least because there are limits to what informants will share. There is also a practical methodological challenge in contemporaneous studies of industry emergence because the window of opportunity may be short or unavailable in the given time frame (Forbes and Kirsch 2011). Researchers may simply not have the time to source funding, design research approaches and enter the field within the time frame. Historical perspectives are important, but researchers should attempt to place themselves in 'real time' even when considering data produced in the past so as to avoid constructing 'inevitable paths'.

References

- Araujo, L. and D. Harrison. 2002. Path Dependence, Agency and Technological Evolution. *Technology Analysis & Strategic Management* **14:5-19**.
- Bakker, S. 2014. Actor rationales in sustainability transitions – Interests and expectations regarding electric vehicle recharging. *Environmental Innovation and Societal Transitions* **13:60-74**.
- Bakker, S.; H. van Lente; and M.T.H. Meeus. 2012. Credible expectations — The US Department of Energy's Hydrogen Program as enactor and selector of hydrogen technologies. *Technological Forecasting and Social Change* **79:1059-1071**.
- Berkhout, F. 2006. Normative expectations in systems innovation. *Technology Analysis & Strategic Management* **18:299-311**.
- Binz, C.; B. Truffer; and L. Coenen. 2015. Path Creation as a Process of Resource Alignment and Anchoring: Industry Formation for On-Site Water Recycling in Beijing. *Economic Geography*:**1-29**.

- Borup, M.; N. Brown; K. Konrad; and H. Van Lente. 2006. The sociology of expectations in science and technology. *Technology Analysis & Strategic Management* **18:285-298**.
- Boschma, R. and K. Frenken. 2009. Some Notes on Institutions in Evolutionary Economic Geography. *Economic Geography* **85:151-158**.
- Boschma, R.A. and K. Frenken. 2006. Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography* **6:273-302**.
- Boschma, R.A. and R. Wenting. 2007. The spatial evolution of the British automobile industry: Does location matter? *Industrial and Corporate Change* **16:213-238**.
- Coenen, L.; R. Raven; and G. Verbong. 2010. Local niche experimentation in energy transitions: A theoretical and empirical exploration of proximity advantages and disadvantages. *Technology in Society* **32:295-302**.
- Cooke, P. 2012. Transversality and Transition: Green Innovation and New Regional Path Creation. *European Planning Studies* **20:817-834**.
- Dawley, S. 2014. Creating New Paths? Offshore Wind, Policy Activism, and Peripheral Region Development. *Economic Geography* **90:91-112**.
- Dewald, U. and B. Truffer. 2011. Market Formation in Technological Innovation Systems—Diffusion of Photovoltaic Applications in Germany. *Industry and Innovation* **18:285-300**.
- Eisenhardt, K.M. and M.E. Graebner. 2007. Theory Building from Cases: Opportunities and Challenges. *The Academy of Management Journal* **50:25-32**.
- Emirbayer, M. and A. Mische. 1998. What Is Agency? *American Journal of Sociology* **103:962-1023**.
- Essletzbichler, J. and D.L. Rigby. 2007. Exploring evolutionary economic geographies. *Journal of Economic Geography* **7:549-571**.
- EWEA. 2014. The European offshore wind industry - key trends and statistics 2013. Brussels: European Wind Energy Association.
- Farla, J.; J. Markard; R. Raven; and L. Coenen. 2012. Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change* **79:991-998**.
- Feldman, M.P. and I. Lendel. 2010. Under the Lens: The Geography of Optical Science as an Emerging Industry. *Economic Geography* **86:147-171**.
- Forbes, D.P. and D.A. Kirsch. 2011. The study of emerging industries: Recognizing and responding to some central problems. *Journal of Business Venturing* **26:589-602**.
- Frenken, K. and R.A. Boschma. 2007. A theoretical framework for evolutionary economic geography: industrial dynamics and urban growth as a branching process. *Journal of Economic Geography* **7:635-649**.
- Garnsey, E.; G. Lorenzoni; and S. Ferriani. 2008. Speciation through entrepreneurial spin-off: The Acorn-ARM story. *Research Policy* **37:210-224**.
- Garud, R. and J. Gehman. 2012. Metatheoretical perspectives on sustainability journeys: Evolutionary, relational and durational. *Research Policy* **41:980-995**.
- Garud, R. and P. Karnøe. 2001. Path Creation as a Process of Mindful Deviation. In *Path Dependence and Creation*, ed. R. Garud and P. Karnøe, 1-38. London: Lawrence Erlbaum Associates.
- . 2003. Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. *Research Policy* **32:277-300**.
- Garud, R.; A. Kumaraswamy; and P. Karnøe. 2010. Path Dependence or Path Creation? *Journal of Management Studies* **47:760-774**.
- Hansen, G.H. and M. Steen. 2011. Vindkraft til havs. Teknologi- og industriutvikling fra et norsk bedriftsperspektiv. *CenSES report* 01/2011. Trondheim: Centre for Sustainable Energy Studies.
- . 2015. Offshore oil and gas firms' involvement in offshore wind: Technological frames and undercurrents. *Environmental Innovation and Societal Transitions* **17:1-14**.

- Isaksen, A. 2014. Industrial development in thin regions: trapped in path extension? *Journal of Economic Geography* **15:585-600**.
- Karnøe, P. and R. Garud. 2012. Path Creation: Co-creation of Heterogeneous Resources in the Emergence of the Danish Wind Turbine Cluster. *European Planning Studies* **20:733-752**.
- Klepper, S. 2007. Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the U.S. Automobile Industry. *Management Science* **53:616-631**.
- MacKinnon, D. 2011. Beyond strategic coupling: reassessing the firm-region nexus in global production networks. *Journal of Economic Geography* **12:227-245**.
- Markard, J. and R. Petersen. 2009. The offshore trend: Structural changes in the wind power sector. *Energy Policy* **37:3545-3556**.
- Markard, J.; R. Raven; and B. Truffer. 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy* **41:955-967**.
- Martin, H. and L. Coenen. 2014. Institutional Context and Cluster Emergence: The Biogas Industry in Southern Sweden. *European Planning Studies*:**1-19**.
- Martin, R. 2010. Roepke Lecture in Economic Geography—Rethinking Regional Path Dependence: Beyond Lock-in to Evolution. *Economic Geography* **86:1-27**.
- Martin, R. and P. Sunley. 2006. Path dependence and regional economic evolution. *Journal of Economic Geography* **6:395-437**.
- Martin, R. and P. Sunley. 2010. The place of path dependence in an evolutionary perspective on the economic landscape. In *The Handbook of Evolutionary Economic Geography*, ed. R. Boschma and R. Martin, 62-92. Cheltenham: Edward Elgar.
- Maskell, P. and A. Malmberg. 2007. Myopia, knowledge development and cluster evolution. *Journal of Economic Geography* **7:603-618**.
- Menzel, M.-P.; S. Henn; and D. Fornahl. 2010. Emerging clusters: a conceptual overview. In *Emerging Clusters*, ed. D. Fornahl; S. Henn; and M.-P. Menzel, 1-13. Cheltenham: Edward Elgar.
- Neffke, F. and M. Henning. 2013. Skill relatedness and firm diversification. *Strategic Management Journal* **34:297-316**.
- Nelson, R.R. and S.G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
- . 2002. Evolutionary Theorizing in Economics. *The Journal of Economic Perspectives* **16:23-46**.
- Normann, H.E. 2015. The role of politics in sustainable transitions: The rise and decline of offshore wind in Norway. *Environmental Innovation and Societal Transitions* **15:180-193**.
- Rohrbeck, R. and H.G. Gemünden. 2011. Corporate foresight: Its three roles in enhancing the innovation capacity of a firm. *Technological Forecasting and Social Change* **78:231-243**.
- Ruef, A. and J. Markard. 2010. What happens after a hype? How changing expectations affected innovation activities in the case of stationary fuel cells. *Technology Analysis & Strategic Management* **22:317-338**.
- Schoenberger, E. 1991. The Corporate Interview as a Research Method in Economic Geography. *The Professional Geographer* **43:180-189**.
- Schot, J. and F. Geels. 2007. Niches in evolutionary theories of technical change. *Journal of Evolutionary Economics* **17:605-622**.
- Shane, S.; E.A. Locke; and C.J. Collins. 2003. Entrepreneurial motivation. *Human Resource Management Review* **13:257-279**.
- Simmie, J. 2012. Path Dependence and New Technological Path Creation in the Danish Wind Power Industry. *European Planning Studies* **20:753-772**.
- Simon, H.A. 1979. Rational Decision Making in Business Organizations. *The American Economic Review* **69:493-513**.
- Steen, M. and G.H. Hansen. 2014. Same Sea, Different Ponds: Cross-Sectorial Knowledge Spillovers in the North Sea. *European Planning Studies* **22:2030-2049**.

- Sydow, J.; A. Windeler; C. Schubert; and G. Möllering. 2012. Organizing R&D Consortia for Path Creation and Extension: The Case of Semiconductor Manufacturing Technologies. *Organization Studies* **33:907-936**.
- Tanner, A.N. 2014. Regional Branching Reconsidered: Emergence of the Fuel Cell Industry in European Regions. *Economic Geography* **90:403-427**.
- Truffer, B. and L. Coenen. 2012. Environmental Innovation and Sustainability Transitions in Regional Studies. *Regional Studies* **46:1-21**.
- van Lente, H. 2012. Navigating foresight in a sea of expectations: lessons from the sociology of expectations. *Technology Analysis & Strategic Management* **24:769-782**.
- Wieczorek, A.J.; S.O. Negro; R. Harmsen; G.J. Heimeriks; L. Luo; and M.P. Hekkert. 2013. A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews* **26:294-306**.

Appendix A List of interviewed firms

| <i>Firm</i> | <i>Type of firm: diversified (D), specialized offshore wind (S), other (O) + Main role in offshore wind / renewable energy</i> | <i>Position of informant(s) (number of informants)</i> | <i>Place, year</i> |
|---------------------------|--|--|--------------------|
| Troll Windpower | D Product supplier | CEO/founder (1) | Bergen, 2010* |
| OWEC Tower | S Product supplier | CEO/founder (1) | Bergen, 2010* |
| Norwind | S Service provider | CEO (1) | Bergen, 2010* |
| SWAY / SWAY Turbine | S Product supplier | CFO, Head of Human Resources, Senior Engineer (3) | Bergen, 2010* |
| Vestavind Offshore | S Wind farm developer/ operator | CEO (1) | Bergen, 2010* |
| Sarsia Seed | O Investor (seed/capital) | Partner (1) | Bergen, 2010* |
| Inwind | S Service provider | CFO (1) | Stavanger, 2010* |
| Innowind | O Product supplier | General manager (1) | Stavanger, 2010* |
| Vici Ventus | S Product supplier | General manager (1) | Stavanger, 2010* |
| Lyse Energi | O Investor (utility) | Production Director (1) | Stavanger, 2010* |
| Wave Energy | O Product supplier | General manager (1) | Stavanger, 2010* |
| Procom Venture | O Investor (seed capital) | Partner (1) | Stavanger, 2010* |
| AngleWind | O Product supplier | Business development manager (1) | Stavanger, 2010* |
| General Electric | O Product supplier | General Manager Wind (1) | Trondheim, 2010* |
| Energy Future Investments | O Investor (venture capital) | Investment partners (2) | Oslo, 2010* |
| Statkraft | O Investor (utility), wind farm developer | Vice President of Commercialization (1) | Oslo, 2010* |

| | | | | |
|--|---|---|---|---------------------|
| Statoil New Energy AS | D | Investor, wind farm developer, product supplier | Vice President, Wind Power (1) | Oslo, 2010* |
| Fred. Olsen Windcarrier | S | Service provider | Managing Director (1) | Oslo, 2010 |
| Havgul | O | Wind farm developer | Partners (2) | Oslo, 2010 |
| Energy Capital Management (Statoil subsidiary) | O | Investor (venture capital) | Partner (1) | Trondheim, 2010* |
| Proneo/Windcluster Mid-Norway | O | Support organization | Project managers (2) | Verdal, 2010** |
| Kværner Verdal ⁴⁴ | D | Product supplier | Local trade union leaders (3) | Verdal, 2010** |
| Cleantech Mid-Norway | O | Support organization | General manager (1) | Verdal, 2010** |
| Investinor | O | Investor (venture capital) | General Manager | Trondheim, 2010**** |
| Blaaster | O | Product supplier | CEO/Founder (1) | Trondheim 2010**** |
| Enova | O | State agency | Program Director New Technology (1) | Trondheim, 2010**** |
| NTNU | O | University | Professor in renewable energy (1) | Trondheim, 2011* |
| NOWITECH/NTNU | O | Research Centre/University | Director of Commercialization (1) | Trondheim, 2011* |
| Scatec | O | Investor (substantial shares in OWEC and Norwind) | Business developer, Head of communication (2) | Oslo, 2011* |
| Northzone | O | Investor (venture capital) | Partner/Founder (1) | Oslo, 2011* |
| MasterMarine | D | Service provider | CEO (1) | Oslo, 2011* |
| Kværner Verdal ¹ | D | Product supplier | Director of Business Development (1) | Verdal, 2011* |
| Siemens | O | Product supplier | Director of Wind Energy (1) | Svolvær, 2011 |
| Nordnorsk Havkraft | O | Investor (utility) | General Manager (1) | Svolvær, 2011 |
| Maintech | O | Service provider | General Manager, Principal Engineer (2) | Trondheim, 2011* |
| Chapdrive | O | Product supplier | Vice President (1) | Trondheim, 2011* |

⁴⁴ At the time of the interview, Kværner Verdal was named Aker Verdal.

| | | | | |
|---------------------------|---|---|---|------------------|
| SmartMotor | O | Product supplier | CEO (1) | Trondheim, 2011* |
| Statoil | D | Investor, wind farm developer, product supplier | Head of Renewable Energy Business Development (1) | Oslo, 2011* |
| Statkraft | O | Investor (utility), wind farm developer | Senior Vice President Onshore Wind Power (1) | Oslo, 2011* |
| WindSea | S | Product supplier | Managing Director (1) | Oslo, 2011* |
| Seatower | S | Product supplier | CEO (1) | Telephone, 2011 |
| AS Delprodukt | O | Product supplier | Director of Business Development (1) | Verdal, 2011*** |
| Vitec | D | Service provider | General Manager (1) | Verdal, 2011*** |
| Sarens Transrigg | O | Service provider | General Manager (1) | Verdal, 2011*** |
| Spenncon | O | Product supplier | R&D Director (1) | Verdal, 2011*** |
| Kværner Piping Technology | D | Product/service provider | CEO, Project manager, Manager of special products business area (3) | Verdal, 2011*** |
| NTE | O | Investor (utility) | Director of Energy Development (1) | Verdal, 2011*** |
| Ingenium | D | Service provider | Project Manager (1) | Oslo, 2011 |
| NORWEA | O | Support organization | CEO (1) | Oslo, 2011 |
| Inocean | D | Service provider | Senior Engineer (1) | Oslo, 2011 |
| Kværner Jacket Technology | D | Product supplier / engineering and design | Business Manager Offshore Wind (1) | Oslo, 2011 |
| INTPOW | O | Support organization | Regional Director (1) | Oslo, 2011 |
| Nexans | D | Product supplier | Head of Sales (1) | Telephone, 2011 |
| Draka | D | Product supplier | CEO (1) | Telephone, 2011 |
| Aibel | D | Product supplier | Development Manager and Vice President (1) | Telephone, 2011 |
| Dr.techn Olav Olsen | D | Product supplier / engineering and design | Business Development Manager (1) | Telephone, 2011 |
| AF Group | D | Service provider / investor | CEO Environment (1) | Telephone, 2011 |

| | | | | |
|---------------------------------|---|----------------------|----------------------------------|-----------------|
| CCB AS | D | Service provider | CEO (1) | Telephone, 2011 |
| Rosenberg | D | Product supplier | Marketing Director (1) | Telephone, 2011 |
| Grieg | D | Service provider | CEO (1) | Telephone, 2011 |
| Vici Ventus Construction | S | Product supplier | General Manager (1) | Telephone, 2011 |
| Odfjell Drilling | D | Service provider | Business Development Manager (1) | Telephone, 2011 |
| Vici Ventus Technology | S | Engineering & design | Technical Manager (1) | Telephone, 2011 |
| Proneo / Windcluster Mid-Norway | O | Support organization | Project Manager (1) | Verdal, 2012** |
| Kværner Verdal | D | Product supplier | Production foreman (1) | Verdal, 2012** |
| Blaaster | O | Product supplier | CEO/Founder (1) | Telephone, 2012 |
| Proneo | O | Support organization | Project Manager (1) | Verdal, 2012** |
| Siragrunnen | S | Wind farm developer | General Manager (1) | Trondheim, 2013 |
| SWAY | S | Product supplier | CEO/founder, CFO (2) | Telephone, 2014 |

With Gard Hopsdal Hansen (GHH) | **With GHH and Asbjørn Karlsen (AK) | *With AK | ****Only GHH*