‘Engineering’ the green transformation of the maritime industry in Western Norway

Svein Gunnar Sjøtun

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Abstract

This dissertation is empirically motivated by understanding the observed and ongoing green transformation of the maritime industry in Western Norway, a development that has had implications for both environmental protection, regional economic growth and job creation. Theoretically, the dissertation argues that the observed regional transformation processes should be analysed through an integration of three theoretical frameworks; 'Evolutionary Economic Geography' (EEG), 'Transition Studies' (TS) and 'Institutional Entrepreneurship Work' (IEW). As such, the dissertation argues that transformation is a complex phenomenon that requires co-evolution between several actors, technologies, policies and institutions, but also that these processes need to be embedded in evolving territorial contexts. Finally, these processes must be driven by purposeful actors aiming to change institutions to be more favourable for a green transformation. The dissertation approaches an integration between EEG, TS and IEW through engaging with three debates or 'areas of engagement' within these literatures. These include debates around how actors and agency affect institutional change processes, the role of territorial and multi-scalar dynamics, and the role of simultaneous and dynamically interacting dimensions of materiality, organization and discourse. Through these debates, the dissertation specifically argues for a new analytical framework which emphasises multi-actor institutional change (drawing on IEW), territoriality and multi-scalarity (drawing on EEG), and multi-dimensionality (drawing on TS), as well as the interplay between these elements.

The theoretical discussion is illustrated, empirically, by an extensive case study of the green transformation of the Western Norwegian maritime industry. The dissertation is based on four qualitatively oriented papers, each of which contributes to the overall problem framings that it has sought to tackle. These papers focus on the following issues; Paper #1) how engineers perform multi-scalar institution changing practices in addition to technologist practices during processes of transformation; Paper #2) how the material, organizational and discursive dimension around a specific multi-scalar demonstration project (the actor-networks around and the materiality of a 'performing project enacting agency') have led to change in public ferry procurement on regional and national level; Paper #3) how achieving 'directionality' in cluster policy must recognise that regional clusters are embedded in different 'trinity' (materiality-organisation-discourse), sector and territorial/multi-scalar dynamics; and Paper #4) how green

(regional) path creation processes should—drawing on EEG and 'Technological Innovation Systems' (TIS) literature—incorporate 'regional capabilities, multi-level dynamics, actors and agency, policy, guidance of the search, legitimation and market formation', as well as a future focus on 'narratives'.

The dissertation finds that several regionally embedded actors (industry actors, cluster staff, NGO representatives, public sector representatives and politicians) have engaged in institutional agency processes at and across spatial scales (together with actors on the national level). It also finds that territorial capabilities within the maritime industry in Western Norway (knowledge on power-electronics, energy-efficient engines and propeller systems, and the presence of risk taking companies), have enabled and embedded technological and commercial opportunities created by the global car industry, which has been vital for the observed green transformation. This has also been strengthened by a regional industrial cluster, which has been vital in maritime cleantech networking (between e.g. industrial actors and R&D) and in lobbying towards regional and national authorities. Finally, it finds that the green industrial transformation in the region is the result of a dynamic interplay between materiality (technological demonstration), organisation (lobbying and clustering) and discourse (framing of narratives). The dissertation adds to theory, particularly within EEG and TS, along the lines of the tree areas of engagement, but also in how these areas interact (e.g. how the material dimension can contain institutional agency). As such, I argue that the empirical findings have theoretical implications for transformation processes elsewhere.

Acknowledgments

This dissertation marks the end of four years of work, at times hard work, but most of the time it has been enjoyable and rewarding. Getting to thoroughly know the possibilities of how the maritime industry can contribute to sustainable development has been very interesting and inspirational. I feel privileged to have learned so much more about green industrial processes taking place in my own region, as well as, of course, being allowed to contribute to knowledge building around these processes myself.

However, there are a number of people who deserve my deepest gratitude with regard to this dissertation seeing the light of day. First, my heartfelt thanks to my main supervisor, Arnt Fløysand, working at the Mohn Centre for Innovation and Regional Development at the Western Norway University of Applied Sciences. He has done a tremendous job guiding me through these four years, both with regard to academic input and inspiration. Secondly, heartfelt thanks also to my co-supervisor Stig-Erik Jakobsen at the Mohn Centre, who has also been a huge support during this dissertation. You have both made me feel very included and helped me stay on course the whole way. Finally, a big thanks to Håvard Haarstad from Institute of Geography at the University of Bergen, who stepped into the role as a second co-supervisor when this was needed.

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Finally, a big thanks to my family and friends, who have been of tremendous help all the way. A special thanks to my parents, who have supported me throughout. Also, thank you Rian, for showing me that sometimes playing with cars on the floor is more important than writing about electrical ferries. And, of course, an extra praise to Denise, who has been so

patient and encouraging the whole way, in addition to helping out extra during stressful work periods.

Svein Gunnar Sjøtun

Bergen, October 2019

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Paper #2: Sjøtun, S.G. (2019) A ferry making waves: A demonstration project 'doing' institutional work in a greening maritime industry, *Norsk geografisk tidsskrift – Norwegian Journal of Geography* 73(1): 16-28. DOI: https://doi.org/10.1080/00291951.2018.1526208

Paper #3: Sjøtun, S.G. and Njøs, R. (2019) Green reorientation of clusters and the role of policy: 'the normative' and 'the neutral' route, *European Planning Studies* 27(12): 2411-2430. DOI: https://doi.org/10.1080/09654313.2019.1630370

Paper #4: Njøs, R., **Sjøtun, S.G.**, Jakobsen, S-E. and Fløysand, A. (in revision) Green path creation in regions: Towards an analytical framework, *Revised version submitted to Economic Geography (October 2019)*

1. Introduction to dissertation topic and research questions

1.1 Motivation for the dissertation and problem framing

The ongoing global green shift is the culmination of an ever-increasing societal focus on sustainable technological solutions and life-styles, since the issuing of the UN report 'Our Common Future' in 1987 (Brundtland et al., 1987). Today, there is little doubt that global warming is manmade, but as it is manmade we also have a choice in halting or mediating it. This dissertation has therefore come about due to a deep personal motivation for engaging with issues of environmental protection and sustainability. However, and more specifically, the dissertation is also the result of a curiosity of how regional industries in Western Norway, my home region, can contribute to sustainable regional development, where both environmental, economic and social concerns are taken into account. Thus, empirically, the dissertation has been motivated by investigating the *green shift in the maritime industry in Western Norway*, an industry which provides a very interesting case with regard to sustainable regional development. Now, barely a single day goes by without something being mentioned in the news about a new battery-powered ship being built or planned in the region (or elsewhere in Norway), or about maritime firms wanting to pursue projects connected to for example liquid natural gas (LNG) or hydrogen technology. Regional development connected to clean technology solutions for the maritime industry, or 'maritime cleantech', is therefore becoming an increasing part of everyday conversations, discourses, political attention and industrial practices, ironically in a region heavily embedded in the oil and gas industry (Gjelsvik and Aarstad, 2017).

Theoretically, the dissertation situates itself within '*evolutionary economic geography' (EEG)* (Boschma and Frenken, 2006, Martin and Sunley, 2006), in that it rejects the notion that any kind of innovation or economic, industrial or technological development can take place 'anywhere'. EEG urges us to study regional development processes as continuously being affected by evolutionary processes of 'variety, selection and inheritance' (Aldrich et al., 2008), or, in short, that the past affects present and future regional economic, industrial or technological development. As such, within EEG, regional industries are believed to reproduce themselves over time (Neffke et al., 2011), due to former choices and strategies and former industrial development trajectories, which initiate processes of increasing returns (Arthur, 1989). In short, these continuous, but also contingent, processes over time create various regional development 'paths', which increasingly narrow actors' (e.g. firms') choices or scope for action (Sydow et al., 2012). Subsequently, these paths become harder and harder to break

out of, potentially establishing strong regional 'path-dependence', and, possibly, organisational, industrial or technological 'lock-in' (David, 1985).

However, processes of *green* regional development add more complexity to the development processes. The reason for this complexity is related to the more comprehensive structural challenges for breaking away from carbon-based technologies, industries, infrastructures, institutions and lifestyles, which still dominate global economic development (Unruh, 2000). Therefore, in order to achieve '*green* regional industrial renewal' studies of '*socio-technical transitions'*, or '*transition studies' (TS)* (e.g. Bergek et al., 2008, Geels, 2002, Hoogma et al., 2002, Truffer and Coenen, 2012, Rip and Kemp, 1998, Foxon et al., 2005, Raven, 2005), have emerged as a research field in order to engage with these more complex challenges. The main argument within this field is that transitioning or transforming from unsustainable towards sustainable technologies, industries or lifestyles requires a complex and dynamic interplay, or co-evolution, between technologies, market demands, user practices, policies, cultural discourses and institutions, involving multiple actors on multiple levels (Geels et al., 2008). Therefore, while TS shares EEG's ontological focus on evolution, path-dependence and complexity (Markard et al., 2012, Sorrell, 2018), (green) change, unlike in EEG, is conceptualised as the outcome of a wider scope of actors, but also a wider scope of mechanisms, factors or processes. This 'expansion of focus' is related to a belief that in order to enable a green shift, there is a need to unravel and deconstruct a much deeper and structural 'lock in' than what is typically found in path-dependent regional industries.

Finally, however, both EEG (Martin and Sunley, 2012) and TS (Farla et al., 2012) represent structural or system-oriented frameworks. However, the dissertation also proposes, based on a research 'gap' on agency and practice within both EEG and TS, but also based on observed empirical observations with regard to proactive regional actors in the Western Norwegian maritime industry, to draw on what I term *'institutional entrepreneurship work' (IEW)*, including e.g. frameworks of 'institutional entrepreneurship' (IE) (DiMaggio, 1988, Garud et al., 2007, Levy and Scully, 2007, Maguire et al., 2004, Sotarauta and Pulkkinen, 2011, Battilana et al., 2009) and 'institutional work' (IW) (Monteiro and Nicolini, 2015, Fuenfschilling and Truffer, 2016, Lawrence and Dover, 2015, Lawrence et al., 2013). As a collective term in this dissertation, the IEW perspective focuses on how various actors 'from below' practice or perform institutional agency, that is, how they affect institutional change in green transformation processes—e.g. with regard to public procurement. It also holds that the

material dimension (drawing on IW) itself can play a role in these institutional change processes.

This dissertation therefore argues that the observed *green maritime industrial transformation* which has taken place in Western Norway, must, theoretically and analytically, be approached through an integration of EEG, TS and IEW. Based on theoretical debates within these frameworks, the dissertation focuses on three 'areas of engagement'. These relate to; 1) how to explain questions of 'intentional and institutional change' (agency) in green maritime industrial transformation processes (drawing particularly on IEW); 2) how green maritime industrial transformation processes are embedded in territorial contexts and affected by multi-scalar dynamics (drawing particularly on EEG); and 3) how green maritime industrial transformation must be seen as an outcome of dynamically interacting material, organisational and discursive processes (drawing particularly on TS).

The first area of engagement for the dissertation relates to the question of how to approach 'intentional change' in green regional industrial paths. Despite its theoretical and methodological 'mission' for explaining radical change, TS has tended to be biased towards structural explanations when engaging with green transformations, neglecting the role of agency (Farla et al., 2012, Genus and Coles, 2008, Markard et al., 2012, Binz et al., 2016, Smith et al., 2005, Musiolik et al., 2012) and social practices (Watson, 2012, Welch and Yates, 2018, Hoffman and Loeber, 2016, Hargreaves et al., 2013, Köhler et al., 2019). A structural bias is also existent in EEG, leading to questions around agency being high on the research agenda also here (Njøs, 2018, Boschma et al., 2017, Sotarauta et al., 2017, Dawley, 2014, Isaksen et al., 2019)—for example with regard to how purposeful actors can aid in a 'renewal' of paths trapped in negative path-dependence (Martin, 2010), or aid in the creation of new paths (Garud and Karnøe, 2010). A focus on 'agency' and 'practice' draws attention to the importance of actors and real-life processes or instances of purposeful agency, or, that spatial transformations must be 'practiced' or performed by actors with intentions, desire and capabilities for inducing change. Moreover, actors' agency and practices in transformation processes do not only have implications for industrial change per se, but also institutional change. The *relationship between agency and institutional change* has yet to be thoroughly explored in TS (Chlebna and Mattes, 2019, Fuenfschilling and Truffer, 2014, 2016) and EEG (Sotarauta and Pulkkinen, 2011, Grillitsch and Sotarauta, 2018). Actors representing both industry, the public sector and civil society can therefore for example act as 'institutional entrepreneurs' (Battilana et al., 2009, Woolthuis et al., 2013), capable of initiating and, ultimately, help bring about institutional

change (e.g. formal regulatory changes) of vital importance for transformation dynamics. Finally, 'institutional work' which 'describes the practices of individual and collective actors aimed at creating, maintaining, and disrupting institutions' (Lawrence et al., 2011: 52), brings an important practice perspective to how different actors perform institution changing practices—often, however, in less intentional ways. However, institutional work also brings attention to the role of materiality (Monteiro and Nicolini, 2015, Fuenfschilling and Truffer, 2016, Lawrence and Dover, 2015, Lawrence et al., 2013), or how material artefacts are capable of affecting particular 'story lines' or discourses (Geels et al., 2008, Lovell, 2008) in transformation processes.

The second area of engagement for the dissertation relates to the absence of geography in studies of transformation processes (Bridge et al., 2013, Coenen et al., 2012, Calvert et al., 2017, Kebir et al., 2017, Gailing et al., 2019, Capasso et al., 2019, Hansen and Coenen, 2015). This includes both a focus on territoriality, but also an increased need to focus on multi-scalar (rather than 'multi-level', as conceptualised in MLP) interaction (Bauer and Fuenfschilling, 2019, Binz and Truffer, 2017)[1]. As such, the dissertation incorporates insights from EEG in order to explain why green maritime industrial transformation has emerged precisely from within Western Norway. Still, while EEG itself is seen to provide insight for TS when it comes to regional or territorial dynamics, EEG is simultaneously seen to benefit from multi-scalar interaction or dynamics (Njøs, 2018). Finally, a multi-scalar focus brings attention to the fact that institutional, technological and industrial dynamics on different spatial levels have affected green maritime industrial transformation in Western Norway.

The final area of engagement for the dissertation relates to how a green regional maritime industrial transformation can be seen as the result of three dynamically interacting dimensions; a material, an organisational and a discursive dimension. While these dimensions and the relationship between them, to varying degrees, are explicitly and implicitly treated and approached within EEG, TS and IEW, often entailing a focus on one or two dimensions, this dissertation argues for a broader focus where the *simultaneousness* of the dimensions, and the attempt to analyse the dimensions *collectively*, is key to understand regional green maritime industrial transformation. In so doing, I draw inspiration from innovation studies and how industrial renewal, technological innovations and associated innovation practices should be conceptualised as the outcome of a dynamically interacting trinity of materiality, organisation

[1] However, the dissertation uses the terms multi-level and multi-scalar interchangeably, as e.g. multi-level has been used to cover multi-scalar interaction in Paper # 4.

and discourse (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019), but argue that particularly TS is well equipped to integrate all three dimensions. With regard to a material dimension, this encompasses industry structure (EEG), but also technology (TS), which so far has not been applied much in studies of green path creation. With regard to an organisational dimension, TS expands EEG's more limited actor scope (on, primarily, firms and entrepreneurs) in recognising several actor groups on multiple levels (albeit not 'scalar' levels) as drivers for transformation. Finally, with regard to a discursive dimension, which in TS e.g. is covered by emphasising that green regional industrial development is heavily affected by actors' 'visions and expectations' (Schot and Geels, 2008), I argue that EEG must incorporate normativity and directionality into its framework.

1.2 Research questions

The finished dissertation you now hold before you has evolved through 'natural abductive processes' of discovery and constant refinement, which I would assume also has characterised many other dissertation journeys. I started the PhD project by wanting to explain how the practices of engineers could be tied to the green shift in the maritime industry in Western Norway, due to a perceived importance of engineers for green innovation practices (cf. Jakobsen, 2011 for a description of the importance of engineers for innovation in the Norwegian maritime industry), and an interest in how studying their green innovation practices could add to a practice perspective within economic geography (Jones, 2014). Finally, these practices were conceived to be influenced by multi-scalar dynamics in social fields (Fløysand and Jakobsen, 2011) and a trinity of materiality, organisation and discourse (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019). Thus, engineers were believed to be important in greening processes per se, while simultaneously providing a good 'empirical opportunity' to analytically approach and operationalise a 'trinity' of materiality, organisation and discourse (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019). The focus was therefore more narrow and, theoretically, to a greater extent focused on EEG (Boschma and Frenken, 2006, Martin and Sunley, 2006) in a transformation context. While an emphasis on engineers in green transformation processes remains, I have gained a new theoretical and analytical conceptual vocabulary for 'talking about' the processes of greening or transformation, namely TS as a framework (e.g. Bergek et al., 2008, Geels, 2002, Hoogma et al., 2002, Truffer and Coenen, 2012, Rip and Kemp, 1998, Foxon et al., 2005, Raven, 2005). Moreover, I also expanded the transformation actor focus during the project, though, admittedly, the initial project description always contained a

preconception of other stakeholders and transformation processes being of importance too. This, combined with a focus on agency and practice, and how this could be tied to institutional change, has led me to include another theoretical framework in this project, IEW—which describes the ways different actors work to change institutions from below through e.g. 'institutional entrepreneurship' (DiMaggio, 1988, Garud et al., 2007, Levy and Scully, 2007, Maguire et al., 2004, Sotarauta and Pulkkinen, 2011, Battilana et al., 2009) or 'institutional work' (Monteiro and Nicolini, 2015, Fuenfschilling and Truffer, 2016, Lawrence and Dover, 2015, Lawrence et al., 2013). As such, the 'theoretical integration' and scope has departed somewhat from its initial idea, but the areas of engagement related to multi-actors and institutional change, territoriality and multi-scalarity and multi-dimensionality have remained a constant focus throughout the dissertation. A focus on engineers is also treated in a specific research question (SRQ2).

Based on the introductory discussion, the theoretical aim of this dissertation is related to contributing to each of the areas of engagement presented, but also, and equally importantly, how they relate to each other. These areas, and how they affect each other, have been the focus of the papers, although in different ways. That is, institutional agency is e.g. conceptualised as taking place across multiple scales, but should also, and simultaneously, be approached as a result of an interplay between materiality, organisation and discourse. This has eventually molded the final framing of the main research question in this dissertation, which seeks an answer of both theoretical and empirical character:

MRQ: What explains the green transformation in the Western Norwegian maritime industry, and how can it be theoretically framed?

However, as this research question obviously is too broad and does not describe the areas of engagement, several sub-questions are listed below. These are framed to build up 'substance' in the main question, by engaging with the three areas of engagement listed above. The first two SRQs therefore ask how institutional agency and practice in general (SQR1) and for engineers in particular (SRQ2) has played out, SRQ3 deals with question around spatial scale and multi-scalar dynamics, and SRQ4 is framed in order to capture the interplay between a material, organisational and discursive dimension:

SRQ1: How is institutional agency linked to green maritime industry transformation?

SRQ2: In what ways can maritime engineers be seen as drivers for green maritime industry transformation?

SRQ3: How has the green maritime industry transformation been affected by processes at various spatial scales?

SRQ4: What characterises the interplay between materiality, organisation and discourse in the green maritime industry transformation?

1.3 Short presentation of the main findings and the research papers

With regard to findings and contributions, these will be explained more in detail in Chapter 5. However, the main findings in the dissertation reveal that the 'Engineering' of the green transformation of the maritime industry in Western Norway is caused by something far more than engineers. They reveal that several regionally embedded actors (industry actors, cluster staff, NGO representatives, public sector representatives and politicians) have practiced institutional agency at and across spatial scales (together with actors on the national level). Moreover, it finds that territorial capabilities within the maritime industry in Western Norway (knowledge on power-electronics, energy-efficient engines and propeller systems, and the presence of risk taking companies), have enabled and embedded technological and commercial opportunities created by the global car industry. Thus, these capabilities have been vital for the observed green transformation in the region. Finally, green transformation has also been strengthened by a regional industrial maritime cleantech cluster. This cluster has been vital with regard to maritime cleantech networking (between e.g. industrial actors and R&D) and in lobbying towards regional and national authorities. Lastly, the dissertation finds that the green industrial transformation in the region has resulted from a dynamic interplay between materiality (technological demonstration), organisation (lobbying and clustering) and discourse (framing of narratives). The dissertation therefore adds to theory, particularly within EEG and TS, with regard to the areas of engagement (multi-actor institutional change, territoriality and multi-scalarity and multi-dimensionality). However, it also adds to theory as to how these areas *interact* (e.g. how the material dimension can contain institutional agency). I therefore argue that the empirical findings have theoretical implications for transformation processes elsewhere.

The dissertation is based on four qualitatively oriented papers, which in different ways have engaged with the SRQs. That is, all the papers deal with all the areas of engagement, but each paper illustrates the SRQs and the dynamics between them, more clearly than others. This is visualised in table 1 below. A thorough summary for each of the papers, as well as how their

main findings relate to the overall problem framing and theoretical and analytical framework of the dissertation, is found in Chapter 5. The analytical framework is visualised in Chapter 2.4 (Figure 1).

With regard to Paper #1, I find that the agency or practices of regionally embedded engineers have been of particular importance in green industrial transformation processes. Moreover, these practices have been more complex than previously assumed, as engineers have stepped into new roles as institutional change agents. I find that engineers participate in several social fields in which they perform practices of relevance for green maritime regional transformation; a global 'engineer discipline' field where they perform 'technologist' practices, a regional 'industry cluster' field where they perform cleantech practices (e.g. green technological practices and framing practices), and a national 'political' field where they perform lobbying practices. As such, ***Paper #1 is well suited to connect SRQ1/2 and SRQ3***.

With regard to Paper #2, I find that the regionally embedded demonstration project Ampere's technological demonstration (material demonstration), how the actor-network around it has used it in lobbying efforts and how it was instrumental in clustering (organisational dimension), and how the project was connected to framing activities (discursive dimension), has been vital for green institutional change (for public procurement) on the regional and national level**.** Demonstration projects as 'performing projects', e.g. 'a complex of discursive and organizational strategies of framing and lobbying deployed by the actor networks connected to it and its materiality' (p. 1) can therefore themselves perform institutional agency during green transformation. As such, ***Paper #2 is well suited to connect SRQ1 and SRQ4***.

With regard to Paper #3, where we draw on a theoretical integration of EEG and TS, we find that different trinity (TOD) dynamics of 'technology/materiality, organisation and discourse' characterise and influence different regional clusters' (a petroleum, a marine and a maritime cluster) strategies. We find that these dynamics have worked particularly well with regard to the green maritime cluster, NCE Maritime CleanTech, and thus argue, theoretically, that trinity dynamics must, together with territorial/multi-scale dynamics and different sector dynamics, be taken into account if the goal is directionality in cluster policy. This suggests that we must be sensitive to how different regions, but also industries in the same region, are capable of green transformation, and, importantly, that we must avoid 'best practice' cluster policy and promote policy mixes. As such, ***Paper #3 is well suited to connect SRQ3 and SRQ4***.

Finally, with regard to Paper #4, we integrate EEG and 'Technological Innovation Systems' (TIS) literature, and argue that EEG has overlooked the role of technology while TIS has overlooked territorial dynamics. Focusing on green path creation processes, we therefore argue for studying green path creation through a theory-informed (by EEG and TIS) analytical framework which emphasises 'regional capabilities, multi-level dynamics, actors and agency, policy, guidance of the search, legitimation and market formation'. We find, when analysing green path creation processes with regard to 'Maritime Battery Technology' (MBT) and 'Carbon Capture and Storage' (CCS), that while all the dimensions in the framework need to be present in order to explain green path creation, we believe—based on empirical observations in the MBT case—that a future focus on 'narratives' could be pursued in research on green path creation, e.g. that it potentially can be included as an analytical category here. This, we argue, explains the success of the development of a regional MBT industry (where positive narratives on 'environmental sustainability', 'regional sustainable growth' and 'job creation' coincide), and the failure of CCS (where similar narratives have not coincided). As the paper engages quite specifically with all the areas of engagement presented in this dissertation, I argue that ***Paper #4 is well suited to connect all the SRQs.***

Table 1: The papers on which the thesis is founded, their main findings and main SRQs answered

Paper	**Analytical focus**	**Areas of engagement / SRQs**			
		SRQ1	**SRQ2**	**SRQ3**	**SRQ4**
#1: Sjøtun, S.G. (invited to revise and resubmit) The Role of Engineers in the Greening of the South-Western Norwegian Maritime Industry: Practices, Agency and Social Fields, *Submitted to Geoforum (June 2019)*	Individual/group (focus on regionally embedded engineers)				
#2: Sjøtun, S.G. (2019) A ferry making waves: A demonstration project 'doing' institutional work in a greening maritime industry, *Norsk geografisk tidsskrift – Norwegian Journal of Geography* 73(1): 16-28. DOI: https://doi.org/10.1080/00291951.2018.1526208	Project/network (focus on one demonstration project)				
#3: Sjøtun, S.G. and Njøs, R. (2019) Green reorientation of clusters and the role of policy: 'the normative' and 'the neutral' route, *European Planning Studies* 27(12): 2411-2430. DOI: https://doi.org/10.1080/09654313.2019.1630370	Regional industry comparison (Regional clusters: subsea, marine, maritime)				

#4: Njøs, R., **Sjøtun, S.G.**, Jakobsen, S-E. and Fløysand, A. (in revision) Green path creation in regions: Towards an analytical framework, *Revised version submitted to Economic Geography (October 2019)*	Regional industry comparison (Focal technologies: Carbon Capture and Storage and Maritime Battery Technology)				

1.4 Structure of the dissertation

The rest of the dissertation is structured in the following way: First, in Chapter 2, I present the theoretical framework. I first present the key tenets of EEG, before presenting the research field that is TS. Then I present the common and specific challenges and contributions for these research fields, which are at the core of this dissertation; how to deal with notions of change (agency and practice), specifically the link between agency/practice and institutional change; how to understand spatial transformations (territorial and multi-scalar dynamics); and how to integrate materiality, organisation and discourse. Importantly, the dissertation sees these areas as intertwined, which is reflected in several of the papers. Arguing for a need for a greater focus on 'institutional entrepreneurship work' (IEW), I also here describe this framework[2], and how it is beneficial for this dissertation (Chapters 2.3.2 and 2.4). Then, in Chapter 3, I present the empirical context and study area, before I in Chapter 4 present the philosophy of science (critical realism), the methodology, methods and data used in this dissertation. In Chapter 5, I present the analytical and theoretical findings and contributions of this dissertation, and introduce some policy recommendations. Here, the papers in the dissertation are presented more in detail. The papers are, however, not presented in chronological order of publication/submission. This is done intentionally, in order to provide a more coherent story on how green maritime industrial transformation plays out at increasing levels of complexity, e.g. from the individual engineer level to the regional-industrial level. Finally, in Chapter 6, I present a concluding discussion, where I discuss some limitations of the dissertation and provide suggestions for further research. The full versions of the papers are included in the second part of the dissertation.

[2] Here conceptualised as a 'collective framework' for various institutional agency theories, e.g. 'institutional entrepreneurship' and 'institutional work'.

2. Theoretical framework

2.1 Evolutionary Economic Geography

The first research field, or discipline, on which this dissertation is based is that of 'evolutionary economic geography' (EEG) (Boschma and Frenken, 2006, Martin and Sunley, 2006). Hailing from 'evolutionary economics' (Nelson and Winter, 1982), which again has drawn on concepts from biology, EEG's core tenet is to understand regional economic, industrial or technological development processes as being continuously shaped by 'Darwinian'[3] evolutionary mechanisms of 'variety, selection and inheritance' (Aldrich et al., 2008), which over time cause regions to develop industrial or technological path-dependence (see Martin and Sunley, 2006). Within EEG, regional development can be conceptualised as a 'constant battle of expansion and reduction' in slowly evolving regions. This 'battle' is caused by constant processes of variety introduction through new firms (e.g. spin offs), which are subject to processes of market selection (Essletzbichler and Rigby, 2010). Here, the firms with the best inherited routines (Nelson and Winter, 1982) or capabilities (Teece et al., 1997) are most likely to survive and (re)form the basis for future regional industrial trajectories. In other words, which firms survive ultimately comes down to how the market conditions 'select' the firms with the best routines or capabilities. Therefore, EEG posits that present and future regional development (economic, industrial and/or technological) must be inherently understood as embedded in legacies of the past, and, moreover, since regional industries are subject to 'slowly working' evolutionary mechanisms, that industry structures have a tendency to reproduce themselves in regional contexts (Neffke et al., 2011). EEG is therefore somewhat optimistic with regard to 'predicting' future regional industrial trajectories, based on empirical observations of the past, but is simultaneously based on an evolutionary ontology which 'is fundamentally and persistently complex' (Castellacci, 2006: 867). As such, it is vital to bear in mind that the evolutionary ontology of EEG actually is one of inherent *un*predictability, as EEG 'builds on key notions of complexity, differentiation, structure, systems, openness, continuous change, and a high degree of uncertainty' (Njøs, 2018: 8)[4].

One possible scenario emerging from the homogenising evolutionary selection processes is an increasingly path-dependent development of a region, industry or technology (see Martin and Sunley, 2006). Path-dependence can be found on the firm and organisation

[3] Aldrich et al (2008) refers to this as 'Generalized Darwinism'
[4] Thus fundamentally differing from Krugman's (1991) notion of economic development finally reaching a 'final state', or 'equilibrium'

level (micro-level) through observed persistence of routines, but also on the industry or technology level, and the regional level (meso- and macro-levels). However, 'path dependence theory' has for the most part focused on the meso-level (the evolution of industries, innovation systems, clusters etc.), while the 'Generalised Darwinism' approach has focused on the micro-level (firm level). These approaches therefore make up two strands of EEG, but it is path-dependence theory that I focus upon in this dissertation (see Fløysand and Jakobsen, 2016 for a discussion of the difference between these). It can be described as (Martin and Sunley, 2006: 400):

> [t]he tendency for particular technological fields, themselves the outcome of temporally remote events, to become locked onto a trajectory, even though alternative (and possibly more efficient) technologies are available…[,the tendency] that the development of many phenomena is driven by a process of increasing returns, in which various externalities and learning mechanisms operate to produce positive feedback effects, thereby reinforcing existing development paths…[,and] the tendency for formal and informal institutions, social arrangements and cultural forms to be self-reproducing over time, in part through the very systems of socio-economic action they engender and serve to support and stabilize.

Path-dependence theory gained popularity in the 1980s and has since spread to many different disciplines with the social sciences—including EEG. Central to path-dependence theory is the idea that processes of 'dynamic increasing returns' (e.g. sunk costs, learning effects, co-ordinataion effects and self-organising) (Arthur, 1989) over time steer firms or industries down some industrial or technological 'paths' rather than others. These paths then become self-reinforcing, and will gradually narrow industrial actors' ability to 'break free from them' (Sydow et al., 2012). Eventually, according to theory, strong path-dependence will be established, leading to a possible 'technological lock-in' (David, 1985) for firms, organisations or industries. Such lock-in can be of a functional, cognitive or political nature (Grabher, 1993), and can therefore describe both processes where actors 'cannot' act otherwise (due to structural barriers) or 'will not' act otherwise (due to cognitive barriers). Path-dependence can also consist of institutional lock-in, or 'institutional hysteresis', where both formal and informal institutions follow potentially sub-optimal paths for firms or industries (North, 1990, Setterfield, 1993). The only way out of such a lock-in is for the path, or the industry in it, to be exposed to an 'external shock', such as a massive change in market demand or a depletion of input factors needed for production (David, 1985)—which then can form the basis for new industrial paths. Thus, path dependency theory recognises that development processes do not always follow 'optimal' trajectories, but can rather be trapped in trajectories or paths sub-optimal for innovation. The approach recognises, in other words, that observed innovations are not necessarily always the 'best innovations' or the results of intentional strategic choices, but can

indeed be sub-optimal (of which David's (1985) widely cited example of the persistence of the 'QWERTY' keyboard technology is a good example).

With specific regard to EEG, the theory of path dependence has been applied extensively in order to explain regional development dynamics (Martin and Sunley, 2006, Boschma and Martin, 2010). It has, moreover, been applied in adjacent disciplines and frameworks that both draw upon EEG and share its evolutionary origin. For example, EEG's association with 'innovation studies' (Fagerberg, 2005) is of critical importance, as it is 'innovation and knowledge' which is conceptualised to drive evolutionary economic development within EEG (Boschma and Martin, 2010). Innovation studies is a multi-faceted research field in which EEG is applied as a perspective. However, taking an innovation systems perspective, scholars emphasise the importance of the meso- and macro-level in innovation processes, as well as a view of innovation as an inherently relational, non-linear phenomenon and complex, emerging as the outcome of dynamic interactions between actors (Fløysand and Jakobsen, 2011, Fagerberg, 2005, Van de Ven et al., 1999). Thus, combining EEG and innovation studies, spatially embedded evolutionary innovation processes are expressed through 'regional innovation systems' (RIS) theory (Asheim and Gertler, 2005, Cooke, 1992). RIS theory posits that innovation processes are anchored to, or embedded in, (evolving) regional innovation systems, in which dynamic relationships between regional firms R&D organisations and public organisations affect regional actors' conditions for innovation. Thus, some regions are observed to be better at innovation than others, due to advantageous dynamics between different regional actors drawing on different territorial capabilities. In a similar vein, EEG has also contributed to 'cluster theory' (Maskell and Malmberg, 2007, Uyarra and Ramlogan, 2017, Fornahl and Hassink, 2017). Here, unlike Porterian understandings of clusters (Porter, 1998)—which draw on theories of 'agglomeration economies' (Marshall, 1920) and 'urbanisation economies' (Jacobs, 1970) which create 'externalities' or 'spillover effects' in close spatial proximity—clusters are often within EEG seen to evolve along path dependent lines, due to processes of specialisation and recirculation of knowledge (Njøs and Jakobsen, 2016).

As we have seen, complexity is at the core of evolutionary ontology, and therefore also EEG (Castellacci, 2006, Martin and Sunley, 2007). Empirically, however, complexity has primarily been conceived of something that explains 'neutral industrial development on the regional level'. Thus, EEG has been limited to, and academically not very interested in, approaching complex normative and societal 'grand challenges' (Asheim et al., 2016, Weber

and Rohracher, 2012), such as issues related to how one can plan for and develop sustainable industrial or technological paths. These challenges, moreover, are seen to need a wider and more complex interplay of actors and processes if they are to be handled properly. This realisation has become a central issue in the research field or 'transition studies', to which I now turn.

2.2 Transition studies

The second research field on which this dissertation is based, is that of 'socio-technical transitions', or 'transition studies' (TS) (e.g. Bergek et al., 2008, Geels, 2002, Hoogma et al., 2002, Truffer and Coenen, 2012, Rip and Kemp, 1998, Foxon et al., 2005, Raven, 2005). This research field was introduced as a response to mounting theoretical challenges connected to observations of successful and attempted 'green shifts', and has therefore increased in popularity the last decades. In short, TS aims to study how transitioning or transforming from an unsustainable towards a sustainable future, including both a shift in technologies and industries (Geels, 2002), environmental governance (Frantzeskaki and Kabisch, 2016), and lifestyles (Seyfang and Smith, 2007), demands a complex and dynamic interplay, or co-evolution, between technologies, market demands, user practices, policies, cultural discourses and institutions (Geels et al., 2008). Due to the complexity of transformations (Sorrell, 2018), this moreover involves the work of multiple actors in multiple networks on multiple levels (Geels et al., 2008). Green shifts or transformations are therefore, as indicated by the term 'socio-technical', not merely about industrial or technological change, but also social processes and cultural meaning and symbolic value attached to certain industries or technologies. This is something which does not necessarily change easily. Discussions around transformations can also encompass competing notions of 'what we should transform towards', which has given rise to debates concerning whether it is 'more green neoliberal growth' or 'de-growth' which is the more ethical alternative. Thus, studying transformations arguably makes for a much more hotly contested arena than that of 'mere' regional development per se, though TS, admittedly, so far has neglected to engage in serious discussions around alternatives to green capitalism (Feola, 2019).

Today, TS represents a research field that draws extensively on integration with other disciplines from social sciences gravitating around innovation research (science and technology studies, history of technology, evolutionary economics and innovation policy), as well as from

environmental studies and sustainability sciences (environmental assessment, integrated assessment, sustainability governance and environmental policy) (Loorbach et al., 2017, see also Markard et al., 2012 for a discussion). Its engagement with evolutionary theory also makes path-dependence a fundamental concept within TS. However, theoretically, analytically and empirically, TS is much more concerned with *co-evolution* (see Murmann, 2003, Schamp, 2010 for a discussion of the concept). As such, TS draws attention to the simultaneous importance of multiple co-evolving dimensions, multiple actors, stability and change, long-term processes, open-endedness and uncertainty, competing values and normative directionality (Köhler et al., 2019). Consequently, the 'mission' of TS is much more comprehensive than the tenets of the other sustainability sciences which preceded it. According to Köhler et al. (2019: 5):

> It is broader and more inter-disciplinary than many other sustainability approaches, such as industrial ecology, eco-innovation or environmental economics, which tend to focus on single dimensions or particular social groups, have a relatively short-term orientation, fail to acknowledge the systemic dimension, or are overly managerial and technocratic. Sustainability transitions research asks 'big picture' questions, which is probably one reason it has sparked such enthusiasm and creativity.

However, and specifically, TS consists of several sub-frameworks, each of which focuses on different aspects of transformation. The first, and most elaborated and applied one in the literature, is that of the 'multi-level perspective' (MLP) (e.g. Geels, 2002, Geels, 2014). The core idea of MLP is that transformations, whether successful or attempted, is the result of dynamic processes taking place within and between three conceptual levels; the niche level, the socio-technical regime level and the landscape level.

Starting at the top, both niches and regimes evolve in the context of an overarching 'landscape', which represents a 'set of heterogeneous factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, [and] environmental problems' (Geels, 2002: 1260). The landscape is seen as more stable conditions that do not change noteworthy over time, and which are beyond the control of both niche and regime actors. Therefore, the landscape makes up a macro-level that can exert influence on both regimes (meso-level) and niches (micro-level).

However, the most central of these three concepts is that of the 'socio-technical regime', or 'regime'. A regime is defined as all the 'scientific knowledges, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology' (Kemp et al., 2001: 272). Regimes thus often exhibit strong lock-in tendencies as a consequence of long path-dependent evolutionary processes (Coenen et al., 2015). These can prove very difficult to break out of, as

the presence of global locked-in carbon-based regimes within different sectors, which restrain the innovation and diffusion processes related to sustainable technologies (Unruh, 2000), testifies to. Thus, the key for enabling successful transformations is to overthrow observed and unsustainable incumbent regimes. One way of doing this is to build legitimacy and demand for new green technology in markets (Bergek et al., 2008). Another successful factor can be to invest in sustainable infrastructure (Kemp et al., 1998). However, these factors must also co-evolve with a change in institutions and policy and user practices, preferences and tastes. For example, Geels (2004) shows that the persistence of the 'car' as a mode of transport, is not merely due to its technological superiority, but also due to cultural discourses around the positive status of owning a car (making e.g. car owners convert to collective transport a challenge). Therefore, regime change is a daunting task, which is moreover coupled with the fact that barriers for transformations are not merely a technological or material exercise, but also requires massive cultural or cognitive change (Kemp et al., 1998, Smith et al., 2010, Haarstad and Wanvik, 2016).

Finally, however, regimes are constantly being challenged by processes happening at the 'niche' level, conceptualised as the arena where entrepreneurs and firms experiment with new ideas and technologies (Kemp et al., 1998, Raven, 2005). As such, a niche is conceptualised as a space which does not adhere to the normal rules and path-dependent dynamics of regimes. That being said, niches often need to be intentionally protected from the regime by the public sector, e.g. through subsidies or other incentive policies. Thus, through active 'strategic niche management' (SNM), another sub-perspective within TS (Kemp et al., 1998, Hoogma et al., 2002), it is believed that innovation and entrepreneurship processes in niches eventually can destabilise the incumbent regime, thereby causing niches to scale up and replace it. Still, as this heavily policy-inspired framework requires active state intervention, the emergence of new niches will be very dependent on the (political) context (Avdeitchikova and Coenen, 2015), or 'upon contingencies and processes beyond the unilateral control of niche actors' (Seyfang and Smith, 2007: 589, see also Berkhout et al., 2004). It is also in niches that we find demonstration projects (Fevolden et al., 2017, Hellsmark et al., 2016, Klitkou, 2016, Schot and Geels, 2008). Demonstration projects by themselves do not make up a coherent perspective within TS, but are together with actors important building blocks in niches. However, particular theoretical interest in and research on them have increased in recent years (Fevolden et al., 2017, Hellsmark et al., 2016, Klitkou, 2016). Here, unlike earlier writings on demonstration projects, which emphasised more the technological aspect and learning and

knowledge development related to testing of new technologies, TS also emphasises how demonstration projects can add to 'aligning new technology to institutional and organizational structures' (Hellsmark et al., 2016: 3). Demonstration projects can, as such, help in establishing visions and expectations (Schot and Geels, 2008) through building advocacy coalitions and increase public awareness around the technologies the demonstration projects aim to test (Fevolden et al., 2017).

Therefore, both 'niche', 'regime' and 'landscape' are integral parts of the SNM perspective (Hoogma et al., 2002), but also of the Transition Management (TM) perspective (Loorbach, 2010), another policy driven framework which studies how to govern and facilitate various activities (strategic, tactical and operational) on different levels in order to deal with 'societal challenges'. The last of the four main perspectives within TS is that of 'Technological Innovation Systems' (TIS) (Carlsson and Stankiewicz, 1991, Bergek et al., 2008). Within this perspective, the emergence of new sustainable technologies is contingent on the interplay between actors, networks and institutions. Unlike e.g. RIS theory, it is a focal technology, rather than the region, which is at the center of attention. Moreover, within TIS theory, development and diffusion of sustainable technological innovations is the result of a TIS' functions, i.e. development of formal knowledge, entrepreneurial experimentation, influence on the direction of search, market formation, resource mobilisation, legitimation and development of positive externalities (Bergek et al., 2008). It is the workings of these functions and the interplay between them that will enable sustainable technologies to develop and diffuse. While more aligned with innovation systems theory than e.g. the MLP perspective (which still, nevertheless, heavily emphasis innovation), TIS is already closely related to MLP, making further integration between them both logical and important (Markard and Truffer, 2008). Moreover, while TIS is explicitly applied in Paper #4, the dissertation as a whole should be read as following the MLP tradition.

2.3 Green regional industrial renewal: Institutional agency and practice, territorial and multi-scalar dynamics and multiple interacting dimensions

2.3.1 EEG and TS: A bias towards structure

As shown, EEG and TS share an evolutionary origin, in which path-dependence is a fundamental concept in both strands of literature (Truffer and Coenen, 2012, Boschma et al., 2017, Capasso et al., 2019). This has been part of the reason why an integration of EEG and TS

has gained increased scholarly attention during the last years (Boschma et al., 2017, Binz et al., 2016, Hassink et al., 2019, MacKinnon et al., 2019a). Path-dependence is shown to reproduce industrial structures within EEG (Neffke et al., 2011), or regimes within TS (Geels, 2002). Both strands of literature therefore share a 'bias' towards gradually evolving structures both explaining and being explained by industrial and technological development. This is also reflected in the literatures' focus on innovation systems, e.g. regional innovation systems (in EEG) and technological innovation systems (in TS).

Starting with EEG and its 'associated' perspectives or theories (RIS and cluster theory) working with explaining regional development, these share a systemic understanding of selection mechanisms and mechanisms of path dependence affecting future regional innovation and development dynamics. These mechanisms lead to retention or steering of 'fit' regional firm routines and knowledge, and regional industrial structures. However, as already implied, continuous change was always already at the core of evolutionary thinking (Castellacci, 2006). As such, even though lock-in and external shocks are real mechanisms, 'cessation of endogenous change is hardly a widespread phenomenon or tendency' (Martin and Sunley, 2006: 406). Thus, interest in how new paths are created or renewed endogenously, has become a central research agenda within EEG (Martin, 2010, Tödtling and Trippl, 2013, Cooke, 2012, Martin and Sunley, 2006, MacKinnon et al., 2019b). A presently dominating research agenda within EEG is for example to study how regional industries 'branch out' into other industries, due to the presence of regional 'related variety' (Frenken et al., 2007). Here, different forms of 'balanced proximity' (cognitive, organisational, social, institutional and geographical) (Boschma, 2005) enable regional industries to be related to each other—which, in turn, can form the basis of future industrial and technological regional paths or trajectories. Still, within EEG, change, conceptualised as new or renewed regional industrial paths or the survival of 'fit' regional firms, has primarily been explained through how evolutionary mechanisms, and structural and systemic contingencies condition action (Martin and Sunley, 2012, Uyarra, 2010). Thus, whether we talk about the selection of firm-routines by the market (Boschma and Frenken, 2009, Nelson and Winter, 1982), or regional industrial branching based on 'related variety' (Frenken et al., 2007)—which are seemingly 'read off' from statistics and observed industrial relatedness and distribution in regional spaces—this implies a downplaying of the agency of actors, since it does not specify how actors 'carry out' this branching.

TS also recognises evolutionary mechanisms and system structure as constraining human action in transformation processes (Farla et al., 2012, Markard et al., 2012, Truffer and

Coenen, 2012, Musiolik and Markard, 2011). Moreover, as TS indicates that transformation processes are much more complex than mere regional industrial development due to an increased amount of co-evolving factors, mechanisms or domains needed for successful transformations, socio-technical systems and regimes are also arguably even more entrenched than regional economic structures. Therefore, as argued by Farla et al. (2012: 991):

> a general feature [of TS] is that transitions towards sustainability are framed from a systems perspective. This is consistent with the general understanding of socio-technical transitions, which are conceptualized as major changes in technological, organizational and institutional terms for both production and consumption…Socio-technical transitions involve a broad range of actors and typically unfold over considerable time-spans (e.g. 25 years and above). In the course of such a transition (radically) new products, services, business models and organizations emerge, partly complementing, partly substituting existing ones.

However, while TS engages with studying very real path-dependent and locked-in structures and systems, which in turn act back on the transformations actors, its structure bias also seems partly the result of methodological 'choice' or attention. Thus, Farla et al (2012: 992, my emphasis) go on to argue that:

> [many writings within TS have] emphasized the *systemic and interrelated nature of innovation processes and socio-technical transitions at the macro or systems level.* These insights…have come at *the expense of a more actor-oriented and agency-sensitive analysis*. *The multi-level perspective…has been criticized for a weak conceptualization of agency issues* and not paying enough attention to conflicting interests and politics in transition process… *[N]iche based approaches have been challenged for putting too much emphasis on planned, well ordered and consensual management processes*…[and the] *technological innovation systems approach can benefit from a more explicit conceptualization of actor strategies and resources in…transformation processes*.

This is also echoed by Markard et al. (2012: 962):

> Although green innovation is one of the core drivers for fundamental shifts in industry structures, transition research has mostly focused on meso-level contexts, such as innovation systems and sociotechnical regimes. Therefore, the field might benefit from more in-depth studies on how system and regime structures are created and changed through the strategic interplay of different types of actors

As the quotes show, agency is often not made explicit within TS, for example in relation to actors' strategies, nor does it capture the more 'practice-oriented' actions that take place outside easily observable instances characterised by wide consensus. Moreover, as Genus and Coles (2008: 1439) argue; '[all] the result of applying evolutionary theories to innovation as systems in transition research has done is to play down the role of agency, and to emphasise more reactive and unreflective adaptive processes at work'. Thus, one can argue that one consequence of applying an evolutionary perspective in TS is that we risk only *describing* systems' structures rather than explaining how systems actually *change* (Bergek et al., 2008, Carlsson et al., 2002, Uyarra, 2010), which could be served by a stronger focus on agency. Finally, as shown in the

empirical analysis, a focus on precisely agency and practice in a transformation context is paramount if we are to explain the observed green transformation. An interest in agency and practice in this dissertation has thus originated in a research 'gap' on agency within both EEG and TS, but also—and importantly—through observed empirical observations which draws attention to proactive regional actors.

2.3.2 Institutional agency and practice in green transformation processes

As such, critiques towards a 'systemic-structural bias' are both valid and welcomed. And indeed, both EEG (Njøs, 2018, Boschma et al., 2017, Sotarauta et al., 2017, Dawley, 2014, Isaksen et al., 2019, Hassink et al., 2014, MacKinnon et al., 2009, Pike et al., 2009, Steen, 2016) and TS (Farla et al., 2012, Genus and Coles, 2008, Markard et al., 2012, Binz et al., 2016, Smith et al., 2005, Musiolik et al., 2012) actively recognise the challenge of this bias, and the need to engage more thoroughly and systematically with questions of agency. Following Emirbayer and Mische (1998), agency can be defined as (p. 970):

> the temporally constructed engagement by actors of different structural environments—the temporal relational contexts of action—which, through the interplay of habit, imagination, and judgment, both reproduces and transforms those structures in interactive response to the problems posed by changing historical situations.

In the light of this definition, actors are not mere components in systems or structures, but rather active 'factors' in constituting the systems or structures through their actions, or agency (cf. Giddens, 1984). While both EEG and TS should better specify the concept of agency, they have always emphasised the importance of actors on the micro-level. Thus, given their common roots in evolutionary theory with its associated focus on change, they are both compatible with a 'full' *theory* of agency.

Within EEG, the actor focus has for the most part been on regional firms. Here, a focus on evolving and heterogeneous 'firm routines' (Boschma and Frenken, 2009, Nelson and Winter, 1982) based on 'firm capabilities' (Penrose, 2009), has always drawn attention to the importance of the micro-level. However, within EEG this micro-level focus has nevertheless become 'aggregated' to a regional (meso) level in empirical analysis (Bathelt and Li, 2014), where it is regional structures and processes—and not the firm level—which become the actual units of analysis. This has, ironically, led to a downplaying of the original focus on firms within evolutionary economics (Nelson and Winter, 1982). Moreover, as RIS literature reminds us, it is not merely firms, but also R&D organisations and public organisations, and the dynamic interplay between them, that cause regional innovation (Asheim and Gertler,

2005, Cooke, 1992). However, with regard to how actors engage with change processes, interest in agency has increased within EEG the latter years (Njøs, 2018, Boschma et al., 2017, Sotarauta et al., 2017, Dawley, 2014, Isaksen et al., 2019). Returning to the notion of path creation and path renewal, for example, there is within EEG an increasing body of literature which focuses on how actors with purpose and intent can create new or renew existing industrial paths (Grillitsch and Hansen, 2018, Martin, 2010, Simmie, 2012, Trippl et al., 2019). Here, scholars have drawn inspiration from organisation and management studies, e.g. with regard to how actors can 'mindfully deviate' from the context or paths in which they are embedded (Garud and Karnøe, 2010, Garud and Karnøe, 2001, Sydow et al., 2012).

Moreover, within EEG there is a growing research agenda, which is also interested in how different types of agency conducted by different types of actors play out in spatial contexts (Isaksen et al., 2019). Recent writings within EEG have, for example, drawn attention to how regional agency processes consist of both Schumpeterian agency, institutional entrepreneurship and place leadership (Grillitsch and Sotarauta, 2018), or entrepreneurial and public policy agency (Holmen and Fosse, 2017). Such writings have emerged, in part, through a realisation that it is possible to strategically facilitate for regional industrial innovation (see for example Normann et al., 2013, Normann and Fosse, 2013), but also that e.g. 'place leaders' need to work proactively with several actors in several fields over multiple spatial scales (Sotarauta and Suvinen, 2019). This, in turn, requires other actors (e.g. regional leaders such as cluster facilitators) with other skills than economic actors (e.g. firms and entrepreneurs). As such, green industrial transformation would be better served by an understanding of different and similar types of agency being 'distributed' among several types of actors, but also—and very importantly—where individuals or social groups are capable of enacting all forms of agency (Grillitsch and Sotarauta, 2018, Paper #1).

The micro-level is also emphasised in TS, i.e. with regard to niche and regime actors, who also can belong to both levels (Berggren et al., 2015). Within TS, however, the micro-level is here seen to consist of several other actor groups than firms, as TS takes a multi-actor perspective (Geels et al., 2008). While several scholars rightly point out that the research field has not engaged thoroughly enough with agency (Farla et al., 2012, Genus and Coles, 2008, Markard et al., 2012, Binz et al., 2016, Smith et al., 2005, Musiolik et al., 2012), Fuenfschilling and Truffer (2016: 299) argue that:

> [W]e do not want to state that actors and their actions have so far entirely been neglected in empirical transition studies. Several aspects of embedded agency have been addressed in earlier research. […] More fundamentally, many of the theoretical approaches have reiterated

> constructivist notions of technology development or the idea of a dual structuration cycle à la Giddens … However, so far the different agency processes have not been analyzed regarding their potential to create, change or maintain core institutions of a regime.

Thus, more than an increased interest in how to approach questions of agency per se, a fundamental theoretical and empirical motivation for this dissertation (reflected in all the papers) is *how to connect agency to that of institutional change* with regard to the green industrial transformation in Western Norway. In studies within both EEG (see Coenen and López, 2010, Gertler, 2010, Rodríguez-Pose and Storper, 2006) and TS (Rohracher et al., 2009), institutions are often vaguely explained, assumed to exist *a priori* and treated as rather static constructs, though they are assumed to constantly being reproduced or altered over time through processes of layering (Thelen, 2004). Thus, when engaging with agency it is therefore interesting to ask: Can regional 'change agents' themselves create the very regulative, normative and cognitive institutions (see Scott, 1995) that will enable them to implement or uphold new transformation practices?

One way to engage with such questions is to draw upon the literature of 'institutional entrepreneurship' (IE) (DiMaggio, 1988, Garud et al., 2007, Levy and Scully, 2007, Maguire et al., 2004, Sotarauta and Pulkkinen, 2011, Battilana et al., 2009), which 'represents the activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones' (Maguire et al., 2004: 657). These activities can be conceptualised as different strategies of actors, such as framing (Callon, 1998, Hansen and Steen, 2015, Sotarauta and Pulkkinen, 2011) and lobbying (Woolthuis et al., 2013). Engaging with this theory can provide an increased understanding of the concept of 'embedded agency' (cf. Garud and Karnøe, 2003) as well as an increased understanding of 'institutions'. In short, IE views institutions—whether regulative, normative or cognitive (Scott, 1995)—as being created bottom-up by 'institutional entrepreneurs' (Sotarauta, 2017) who are themselves structurally embedded (Garud et al., 2007). These institutions will in turn enable (or constrain) further agency of both the actors that created or modified them, and the agency of other structurally embedded actors. Therefore, IE focuses strongly on agency and, as such, differs from neo-institutional theory—which assumes always already existing institutions (DiMaggio and Powell, 1983, North, 1990, see also Garud et al., 2007 for a review of institutional theory). In this way, IE provides *one understanding of embedded agency* and how it creates recursive feedback loops (Giddens, 1984) between actors-in-industries and institutional structures.

That agency and structure are viewed as entities that reproduce each other is not novel (cf. Giddens, 1984). However, how we convincingly and empirically can link actors' strategies to 'immediate' regulative and 'slower' normative and cognitive institutional changes (see Scott, 1995), is something that deserves to be investigated further[5]. In this dissertation I therefore explicitly focus on specific empirical instances of *embedded actors' strategies which alter or create institutions*, instead of falling into 'one of the most common pitfalls of an institutional approach [which] is the constant temptation to want to 'read off' individual behaviour from…institutional structures' (Gertler, 2010: 5). Or, as argued by Bathelt and Glückler (2014: 14):

> macro-scale trends in economic and societal development should be based on, at least, some micro-scale evidence related to practices of economic action and the social relations through which these practices are channelled...[S]hifts in institutions are neither automatic nor frictionless processes.

Precisely due to such a clearer connection of agency and institutions, Bathelt and Glückler (2014) therefore argue that IE has—unlike e.g. institutional hysteresis (Setterfield, 1993) and incremental emergent institutional change (Thelen, 2004)—the power to solve the 'paradox of embedded agency' (Leca and Naccache, 2006, Powell and DiMaggio, 2012). Moreover, though sharing many similarities with 'mindful deviation' of actors as a driver for path creation (Garud and Karnøe, 2001), IE is more strategic with regard to purposely creating a new *institutional context* that will be beneficial to actors 'mindfully deviating' from below. The former approach indeed emphasises how new technological paths and institutions can emerge as a result of purposeful agency from embedded actors, but is more unclear on which specific strategies that actors need in order to intentionally attempt to change the *institutional structure* in which they are embedded. Finally, IE simultaneously highlights 'agency, interests, legitimacy, strategy, and power' (Sotarauta and Pulkkinen, 2011: 100), as well as issues around contestation and resistance (Levy and Scully, 2007).

There is nothing inherently spatial with IE. That being said, some writings have shown how we can begin engaging with IE through a spatial understanding (Bathelt and Glückler, 2012, Bathelt and Glückler, 2014, Sotarauta and Pulkkinen, 2011), by viewing it as a form of 'reflexive interaction in specific spatiotemporal contexts' (Bathelt and Glückler, 2014: 14).

[5] However, although IE arguably allows us to 'backtrack' certain policy regulations (regulative institutions) to the activities of certain institutional entrepreneurs, it is nevertheless speculative to claim that these activities allow for convincing empirical analyses of how *cognitive and normative* institutions change.

Interestingly, moreover, in a recent EEG contribution it is argued that there is a (Cortinovis et al., 2017: 1198):

> need to take a micro-perspective to see how local agents engage in collective action to mobilize knowledge, resources and public opinion to create new or adapt existing institutions…There is still little understanding of which institutional actors make a difference…and which regions are better capable of making the required institutional transformation.

Outside the application of similar frameworks to IE (i.e. path creation and path renewal), it is difficult to find any widespread explicit application of this theoretical approach in EEG. However, as argued by Capasso et al. (2019: 391):

> Whereas EEG has tended to focus on knowledge and firms, the current debate has placed particular attention on political and institutional contexts…hinting towards processes such as market formation and the role of institutional agency and policy-making

And, indeed, EEG scholars have now started to show more and more interest in IE and adjacent concepts (e.g. institutional navigation, institutional agency) (Dawley, 2014, Grillitsch and Sotarauta, 2018, Holmen and Fosse, 2017, Sotarauta and Suvinen, 2018).

TS can also undoubtedly benefit from engaging with IE, as it can bring novel insights in describing processes of co-evolution between actors, technology, institutions and policy. Geels (2014) has indeed included a slight focus on IE in recent works on MLP. In his attempt to establish a theory of 'bi-directional interactions' between firms-in-industries and external environments, he argues that the former 'not only adapt to institutional pressures, but also respond strategically to shape them' (p. 265). Moreover, Genus and Coles (2008) argue that MLP needs to address 'the making or unmaking of the various types of rules constraining or enabling actions…[which] has not been an explicit object of systematic study in MLP research' (p. 1442). These engagements can be seen as attempts to understand how 'various rules' (i.e. Scott's (1995) regulative, normative, cognitive and institutions) are made by actors—though, as Bathelt and Glückler (2013) remind us, rules are not necessarily synonymous with institutions. Furthermore, IE is implicitly emphasised in the TIS literature, e.g. with regard to how actors can build legitimacy for new technologies through institutional alignment, conformance and *creation* processes (Bergek et al., 2008), or with regard to how actors organise in networks in order to change institutional structures for specific technologies (Jacobsson and Lauber, 2006, Musiolik et al., 2012). It is, however, also explicitly mentioned as an avenue for further TIS research (Rohracher et al., 2009). Finally, when reviewing various strategies of actors within TS, Farla et al (2012) also argue for an increased engagement with IE, which significantly overlaps with their actor-oriented approach. They find that (p. 995):

> a commonality of the observed strategies is that they all reach out to the broader environment (or system) the actors are part of. In all cases, the actors tried to achieve more or less far reaching changes of existing structures or practices — or tried to prevent exactly such changes

This can be seen as an expression of IE, where actors use whatever resources at hand to purposely create or oppose institutional change. Finally, Smith and Raven (2012) provide a very interesting account of how empowered niche actors deploy discursive strategies, such as framing of sustainability issues, in order to change the institutional context (see also Fuenfschilling and Truffer, 2016). Yet, there is still room within the TS literature for a more explicit application of the IE framework, and adjacent institutional agency perspectives (Chlebna and Mattes, 2019, Fuenfschilling and Truffer, 2014, 2016). One such adjacent perspective relates to that of 'institutional work' (IW), which 'describes the practices of individual and collective actors aimed at creating, maintaining, and disrupting institutions' (Lawrence et al., 2011: 52). IW differs from IE in that it takes a clearer practice perspective, and is less inclined to see institutional change as the consequence of 'heroic individuals' (Fuenfschilling and Truffer, 2016). However, and equally importantly, it also brings attention to *the role of materiality* in institutional change processes (Monteiro and Nicolini, 2015, Fuenfschilling and Truffer, 2016, Lawrence and Dover, 2015, Lawrence et al., 2013).

2.3.3 Spatial dynamics in regional green transformation processes

As obviously indicated by the name, and which has already been presented in Chapter 2.1, EEG offers a theory of how spatial or territorial dynamics and capabilities affect regional industrial development. That being said, EEG is simultaneously a perspective in which, precisely, the regional level has taken centre stage (Bathelt and Li, 2014). This has, in turn, led to criticisms of EEG merely focusing on endogenous regional processes, or seeing the region as the 'container' and sole 'explanans' for regional industrial evolution (Njøs, 2018). Or, in other words, in 'emphasizing generic resources (mostly sector-specific knowledge and skills) originating and evolving predominantly from inside the region, EEG risks incorporating a kind of regional fetishism' (Binz et al., 2016: 173). This has led to several writings which claim that in order to fully understand how regional evolutionary processes unfold over time, we have to understand how focal regions simultaneously and dynamically affect and are affected by exogenous contexts, such as the macro scale (e.g. national/global policies and national/global technology development processes), and the micro scale (e.g. firms' and individuals' practices) (Njøs, 2018, Dawley et al., 2015, Matti et al., 2017). Therefore, a recent focus in EEG on multi-

level or multi-scalar dynamics has come high on the agenda (Njøs, 2018, Njøs et al., 2017, Binz et al., 2016, Trippl et al., 2017, Chlebna and Simmie, 2018, Miörner and Trippl, 2019 and MacKinnon et al., 2019b). While still founded in EEG, this understanding of multi-scalar interaction therefore draws inspiration from 'relational economic geography' (e.g. Bathelt and Glückler, 2003, Boggs and Rantisi, 2003, MacKinnon et al., 2009, Yeung, 2005), which emphasises the myriad of 'dynamic and heterogeneous relations among actors [which] are conceptualized as constituting the essential foundations of socio-spatial existence' (Hess, 2004: 178).

Increasingly, scholars have also sought to explain how TS can be tied to spatial explanations, theories and concepts (Bridge et al., 2013, Coenen et al., 2012, Calvert et al., 2017, Kebir et al., 2017, Gailing et al., 2019, Capasso et al., 2019, Hansen and Coenen, 2015). Within TS, and particularly with regard to MLP, an *implicit* notion of 'scale' (micro, meso and macro) has been treated through the conceptualisation of 'multiple levels' (niche, regime and landscape), though several scholars rightly have stressed that spatial scale should never be seen as synonymous with these different levels of increasing complexity (Coenen et al., 2012). As such, TS has so far engaged little with geography, and thus offers little explanation as to why transformation processes happen where they do. Thus, despite emphasising how focal technologies can span spatial levels in 'global innovation systems' (Binz and Truffer, 2017), the TIS framework still must engage more thoroughly with question of multi-scalarity (Coenen et al., 2012, Bauer and Fuenfschilling, 2019). That being said, in a comprehensive literature review on 'green growth' Capasso et al. (2019) note that, empirically, the national level has tended to be the most popular level of analysis[6]. Therefore, while not utilising explicit geographical theories and explanations, there is still a bias towards the nation scale or level as an important driver for transformation. However, in order to properly account for how heterogeneous transformation processes are playing out differently in different contexts (relating both to regional capacity to 'react' to national policies and implement measures, but also to how regions possess the right assets to develop e.g. green innovations and industries), Capasso et al. (2019) go on to argue that more studies on transformations in the future should focus more on the regional scale—and explicitly tie these studies to geographical theories and concepts. Indeed, this has yielded some work on 'regional green clustering' (McCauley and Stephens, 2012, Davies, 2013, Hatch et al., 2017, see also Cooke, 2015, Tvedt, 2019). However,

[6] While this review has been based on writings on 'green growth', which have not always been tied directly to TS, the authors still note that a bias towards the national level is synonymous with analytical 'preferences' within TS.

echoing equivalent critiques towards EEG, when engaging with geographies of transformation it is equally important to focus on the interaction between multiple spatial scales (Bauer and Fuenfschilling, 2019, Binz and Truffer, 2017, Capasso et al., 2019, Coenen et al., 2012, Hansen and Coenen, 2015), without sidelining these scales with the levels in e.g. MLP. As shown in all the papers, creating a maritime battery niche and changes in the established regime has involved processes and actors on different levels, ranging from the regional (engineers, firms, cluster) to the national (policy, public sector, NGOs) and global level (e.g. battery technology development)—though e.g. actor groups on the national level can be found on the regional level, and vice versa. Territorial (regional) specificities and capabilities, as well as interplay between scales, thus bring attention to the fact that e.g. a niche is not 'made' solely on the regional scale—but rather in relations 'at' and 'between' scales.

Drawing on the key arguments in the preceding discussion, the dissertation therefore argues for an increased focus of green transformation processes, and actors, as being regionally embedded. This embeddedness relates to both that of a territorial, network and socio-cultural embeddedness (Hess, 2004), e.g. a reading of space as being constituted by an interplay of material and social factors. It is therefore an industry that is 'ultimately' to be explained in this dissertation, but the dissertation also argues that studying green industrial transformation processes nevertheless must recognise the fundamental importance of both territorial (regional) dynamics and multi-*scalar* interaction, e.g. by acknowledging that 'niches, regimes and landscapes' can be found at, and 'between', all scales. This relates both to the need for EEG to be more multi-scalar, but also for TS to fundamentally acknowledge and incorporate scale due to its neglect of geography (which *at best* has been tied, implicitly, to the national scale). Therefore, the dissertation relates to two avenues of investigating green territorial transformation. This includes; 1) studying how green transformation processes are embedded in regional and evolving territory-specific institutions, networks and material structures; and 2) simultaneously seeing transformation processes as multi-scalar (Coenen et al., 2012, Truffer and Coenen, 2012, Hansen and Coenen, 2015).

2.3.4 Interacting dimensions in green transformation processes

As such, in order to properly understand green industry transformations, we should analyse how they in various ways relate to both a material dimension (existing industries and technologies), but also an organisational (network structures) and a discursive dimension (socio-cultural factors) (see Hess, 2004). These dimensions must align in order for transformations to be

successful. That being said, how materiality, organisation and discourse have been treated in EEG and TS, differs—at times vastly. Moreover, as will be returned to, how these dimensions dynamically interact with regard to processes of agency at, or 'crossing', different spatial scales is vital in this dissertation.

The material dimension – Within EEG, long historical evolutionary processes are seen to create and maintain very real material structures in regional territories, such as the emergence and retaining of 'fit' firms, industries and industry compositions, which often remain relatively unchanged over long periods of time (Neffke et al., 2011). However, while evolutionary processes can also be affected by material conditions such as natural resource bases (see Martin and Sunley, 2006), it is rather, as we have seen, believed that spatially proximate related industries (or material co-location)[7] will affect change or future regional path trajectories (Frenken et al., 2007). Within TS, however, 'materiality' is first and foremost conceptualised as 'technology and infrastructure'. With regard to technology, TS has for example repeatedly sought to understand how to develop, implement and scale up new and green technologies (e.g. Bergek et al., 2008, Schot and Geels, 2008). These technologies are often introduced and manifested in niches through material pilot or demonstration projects (Fevolden et al., 2017, Hellsmark et al., 2016, Klitkou, 2016). However, TS also emphasises the role of physical infrastructure (e.g. new electrical power lines and charging infrastructure for ships) and capital investments, which often change slowly due to issues of 'sunk costs' (Unruh, 2000, Geels, 2010). Moreover, remembering that TS seeks to integrate social and technical processes in the framework, TS scholars are primarily interested in how technologies relate to 'the renewal of a whole set of networked supply chains, patterns of use and consumption, infrastructures, regulations, etc.' (Smith et al., 2010: 439). However, a very important distinction between the perspectives relates to how they conceptualise the *role* of materiality in system change. That is, within EEG the analytical focus is not on materiality per se. Rather, regionally embedded and circulating knowledge or ideas are conceived of as the 'input factors in 'innovation systems'' (Staber, 2010: 227), whereas material innovations or technology are the *outcome* of the interplay in innovation systems. Within e.g. the TIS perspective, on the other hand, technological innovation is believed to have very real effects on system change, making it 'part of the system' (Markard and Truffer, 2008: 599), or an *input* factor in system change. In other

[7] Which must nevertheless also be cognitively, organizationally, socially and institutionally proximate (cf. Boschma, 2005)

words, TS is more prone to conceptualising materiality-as-technology as having 'causal' and system-wide effects, e.g. with regard to further (material) innovation.

The organisational dimension – Within EEG, the organisational dimension has for the most part been conceptualised as network interaction between *firm* actors on the regional level; in clusters (Maskell and Malmberg, 2007, Uyarra and Ramlogan, 2017, Fornahl and Hassink, 2017); in RISs (Asheim and Gertler, 2005, Cooke, 1992); and in cross-over innovation between related industries in regions (Frenken et al., 2007). That being said, it is important to underline that RIS literature precisely sees interaction between firms, R&D organisations and public organisations as they key interaction pattern which will yield regional innovation (Asheim and Gertler, 2005, Cooke, 1992). However, this interaction pattern still has a strong 'market orientation'. Within TS, the organisational dimension relates to both that of a 'multi-level' understanding and a wider 'scope' of actors that are considered important in transformation processes. That is, within TS, interactions of both cooperation and resistance between several actors in networks on the niche level and the regime level (which sometimes can include actors moving between these levels), and between these levels[8], affects transformation (Fischer and Newig, 2016). However, as the TIS framework reminds us, organisation can also have a more horizontal structure. Here, actors are rather organised around a focal technology, which, despite its lack of sensitivity to space (Coenen et al., 2012, Bauer and Fuenfschilling, 2019), also is conceptualised to span scales, e.g. through recent writing on 'global innovation systems' (Binz and Truffer, 2017). Moreover, TS sees dynamic interactions between *several* types of actors (e.g. firms, R&D organisations, public organisations, political departments, NGOs) and actor groups (e.g. civil society activists, engineers, economists, politicians, bureaucrats) in (new) networks as instrumental in bringing about this transformation (Geels et al., 2008). Thus, TS unlike EEG, also emphasises non-commercial actors 'around' the market as important for transformation processes. Thus, TS sees power, agendas, values and norms being distributed among a wider scope of actors than what is the case in EEG.

The discursive dimension – With regard to the discursive dimension, EEG's engagement with 'normativity and green directionality' has been rather absent. Rather, EEG has been more preoccupied with engaging with 'prominent discourses and practices, such as those that are related to the "master narrative" of competitiveness and the knowledge economy' (MacKinnon et al., 2009: 141). Still, in the later years there has been an increasing amount of writings which

[8] Though the 'landscape' is also important within e.g. MLP, but is considered more an abstract level on which there are no actors

are interested in how to integrate EEG with more normative questions and problem framings, e.g. with regard to directionality of regional innovation systems (see, e.g. Asheim et al., 2016, Trippl et al., 2019), how to steer regional economic paths towards *green* regional paths (e.g. Cooke, 2012, Dawley et al., 2015, Essletzbichler, 2012, Binz and Truffer, 2017, Grillitsch and Hansen, 2018, Trippl et al., 2019, Steen and Hansen, 2018, MacKinnon et al., 2019b), or indeed how to integrate technology, organisation and discourse into one analytical framework in studies of innovation and EEG (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019). TS, on the other hand, has from the very beginning fundamentally encompassed a discursive dimension with regard to directionality and normativity related to greening. This has been related to how e.g. actors-in-transformation promote *or* resist transformation. Arguing or fighting for or against change often takes place through deploying or framing narratives or 'visions and expectations' (Schot and Geels, 2008) about e.g. whether or not new technologies are environmentally, economically and/or socially sustainable. Moreover, however, discussions around transformations can also include more substantial debates of what we should transform towards. For example, some actors and scholars explicitly or implicitly argue towards 'more green neoliberal growth', while others again argue that 'de-growth' is a more ethical alternative and imperative in order to create a truly sustainable world (Feola, 2019). That being said, TS has, admittedly, so far not really engaged in serious discussions around alternatives to green capitalism, or seen other solutions than technological solutions as ways to a more sustainable future (Ibid.).

As shown in this chapter, an interacting relationship between materiality, organisation and discourse is more explicitly articulated within TS than in EEG, though there are exceptions to the latter framework (cf. Fløysand and Jakobsen, 2017, Jakobsen et al., 2019). However, the analytical value of TS is suffering from attempts to encompass or 'fit' too much into the framework (Sorrell, 2018, Farla et al., 2012). Therefore, both a more thorough theorisation of how these dimensions actually interact when integrating EEG, TS and IEW, and how we can approach them analytically has been approached in this dissertation (explicitly in Paper #2 and 3 and more implicitly in Paper #1 and 4). In addition, these dimensions must be linked to territorial and multi-scalar dynamics, as well as institutional agency processes—in the context of green industrial transformation.

2.4 Towards an analytical framework

Based on the preceding theoretical discussion in this chapter, table 2 shows how the theoretical frameworks this dissertation engages with relate to the areas of engagement, as well as the analytical contributions.

Table 2: How EEG, TS and IEW relate to the areas of the engagement for the dissertation, and analytical contributions

	EEG	**TS**	**IEW**
Agency	Structure bias, firm actor	Structure bias, multi-actor	Agency focus, multi-actor
Spatial scale	Regional, multi-scalar	Neutral	Neutral
Analytical dimensions	Material (industry structure), organisational	Material (technology. infrastructure), organisational, discursive	Material (artefacts can have agency), organisational (cooperation, lobbying), discursive (framing)
Analytical contributions	Territoriality and multi-scalarity	Multi-dimensionality	Multi-actor, institutional agency

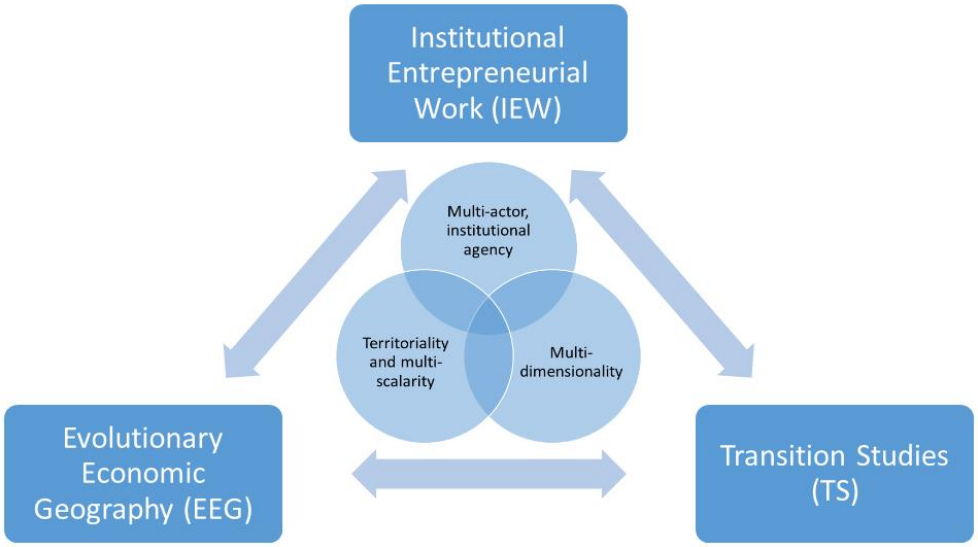
First, drawing on the multi-actor understanding in TS, a critique of the structure bias in both TS and EEG, and—of course—empirical observations, I argue that *multiple actors connected to institutional agency is vital to understand green regional transformation*. Moreover, institutional agency and practices are perceived to be distributed among various actors (e.g. industrial actors, cluster facilitators, public administrative staff, politicians and NGO representatives). Finally, connecting 'social agency' (located within the organisational and discursive dimension) to that of 'material agency', the dissertation focuses on the role of 'performing' demonstration projects (as 'constellations' of material and social agency) in bringing about institutional change of multiple scalar levels. In other words, institutional agency is usually conceived of as belonging to the realm of the social, where actors organise in networks for e.g. industrial cooperation and lobbying (organisational dimension). Here, they express or 'frame' opinions, concerns and beliefs (discursive dimension). Still, drawing on 'institutional work' (Monteiro and Nicolini, 2015, Fuenfschilling and Truffer, 2016, Lawrence

and Dover, 2015, Lawrence et al., 2013), the dissertation also *locates institutional agency to that of the material dimension* (Paper #2, and connecting SRQs1 and 4). Thus, IEW is implemented as a third pillar in my analytical framework.

Moreover, with regard to spatial scale and territorial dynamics, the dissertation draws on insights from EEG in order to analyse how transformation processes are embedded in evolving regional contexts (an argument presented in all papers, but a specific integration of EEG and TS takes place in Paper #3-4). However, as EEG itself has been criticised for its 'regional fetishism', I argue, based on recent contributions within EEG (Njøs, 2018, Njøs et al., 2017, Binz et al., 2016, Trippl et al., 2017, Chlebna and Simmie, 2018, Miörner and Trippl, 2019 and MacKinnon et al., 2019b)—as well as on the empirical investigation—that we must understand green industrial transformation as constituted through an interplay over *multiple spatial scales*. This relates to the 'territoriality and multi-scalarity' in the framework. However, and equally importantly, in *connecting multi-scalarity to institutional agency* it also sees this form of agency as being performed by different actors at different spatial levels, in transformation processes (showing e.g. that niche actors can be found at different spatial levels). However, agency can also be performed by actors *crossing over* several spatial scales, e.g. individuals operating in several, often overlapping, time-spatial 'social fields' (Grønhaug, 1978, Fløysand and Jakobsen, 2001, Fløysand and Lindkvist, 2001, Fløysand and Sjøholt, 2007), as shown in particular in Paper #1 (connecting SRQs 1/2 and 3). This perspective on institutional agency is also closely connected to *how multi-dimensionality plays out in territories and over multiple scales*, as shown in particular in Paper #3 (connecting SRQ3 and 4). Integrating a trinity of materiality, organisation and discourse, I draw in particular on TS as a framework, though there are contributions also within EEG integrating materiality, organisation and discourse (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019, Hassink et al., 2019, Steen, 2016). Here, actors are embedded in territorial, network and socio-cultural contexts (Hess, 2004), which—as social field methodology suggests—still can span multiple scales. 'Social fields' and the role of 'demonstration projects' as analytical entries into case studies will however be explained more in detail under 'methodology' (Chapter 4).

Based on preceding discussion, the analytical contributions, and how they relate to each other and position themselves with regard to the theoretical frameworks, are visualised in my analytical framework (figure 1).

Figure 1: The analytical framework for the dissertation



The dissertation draws upon critical realism as a philosophy of science in that it conceptualises multi-level or multi-scalar interaction, interactions between a material, organisational and discursive dimension, and the interplay between agency and structure dynamics in intentional institution change processes (institutional agency), as *necessary* conditions for green regional transformation. These are, however, *contingent* on actors' practices in different industrial and territorial contexts (see Sayer, 2000 for a dicussion of necessary and contingent conditions within critical realism). Critical realism, and how it has had implications for methodology, will be expanded upon in Chapter 4.1.

3. Empirical context and study area

3.1 Empirical context and study area

3.1.1 Empirical and background context

The green shift in the maritime industry has been lifted up as a very important theme or area of intervention, among Norwegian politicians, researchers and policy makers. This is reflected in several strategies, reports and plans which have been deployed the last years, most recently in *'Regjeringens handlingsplan for grønn skipsfart' [The Government's Action Plan for Green Shipping]* (Norwegian Ministry for Climate and Environment, 2019), and in the Norwegian Research Council's strategy for research, development and innovation, *'Maritim21. En helhetlig maritim strategi for forskning, utvikling og innovasjon' ['Maritime21. A comprehensive strategy for research, development and innovation']* (Norwegian Research Council, 2016). Moreover, a greening of the maritime industry is also emphasised as one of five key areas for Enova, the public institutional body for transformation processes in Norway. Green maritime industrial initiatives have also emerged. This has for example included a growth in new cluster projects within the 'Norwegian Innovation Clusters' (NIC) programme, which is financed by the Ministry of Trade, Industry and Fisheries, and the Ministry of Local Government and Modernisation, and managed by the public organisations Innovation Norway, the Norwegian Research Council and SIVA. The most prominent cluster project here with regard to cleantech development for the maritime industry, but also other ocean industries, has been 'NCE Maritime CleanTech' (NCE MCT) in Western Norway, which was established in 2011. Finally, maritime cleantech is being strengthened through the NOx fund, an industrial driven and managed fund where industry actors can apply for financial support.

Given Norway's important historical role as a maritime nation, both with regard to the shipping and ship building industries (Jakobsen, 2011), it is recognised that the maritime industry is an area of particular interest and potential in Norway, not only with regard to reaching the climate goals agreed upon in the UNFCCC Paris Climate Agreement, but also with regard to future economic growth and job creation. Two recent publications now show that the revenue generated from green technologies in the maritime industry tripled from 9 Billion NOK (ca. 0,9 Billion Euros) in 2014, to 28 Billion NOK (ca. 2,8 Billion Euros) in 2018 (Menon Economics, 2019b), and that ongoing electrification processes in Norway connected to industrial development have the potential of generating 210 Billion NOK (ca. 21 Billion Euros) in export revenue towards 2040 (Menon Economics, 2019a). The latter report estimates that significant economic development connected to electrification in Norway can occur within the

aviation sector, power and utility sector and maritime sector—though potential for economic growth through export is largest in the two latter sectors. The maritime industry therefore has the potential to contribute significantly to export revenue, due to observed innovation processes related to development and integration of maritime battery technology on ships (e.g. power-electronics processes and knowledge on energy-efficient engines and propeller systems), charging technology developing in the 'interface' between land and sea, as well as autonomous ship operations utilising battery technology. Due to Norway's reliance on hydroelectric power, which makes up close to 100% of all domestic electrical power produced, the electrification of Norway has the potential to truly represent a green socio-technological transformation.

3.1.2 Study area

A lot of the predicted growth will likely take place in Western Norway, the region which initiated the reorientation towards low- and zero-emission technologies in the Norwegian (and, indeed, the global) maritime industry, through e.g. various technology projects demonstrating fuel-cell and battery applications for ships, as well as various energy efficiency (e.g. fuel-saving) programmes among regional firms. However, the 'green industrial or technological shift', which has taken place in the maritime industry in Western Norway did not emerge from nothing. Thus, while the observed regional green maritime industrial transformation is also the result of technological, industrial and institutional development processes on both the global and national levels, a distinct regional maritime industry in Western Norway has developed over a long time, which, subsequently, has laid the foundation for the presently observed green transformation. The aim of this dissertation is therefore to understand the 'green maritime regional transformation' in *Western* Norway, or more precisely South-Western Norway, which gravitates around the maritime industry cluster in the region of Haugaland and Sunnhordland. It is from within region that the first efforts to pursue truly maritime low- and zero emission technologies, such as maritime battery technology (MBT) and maritime fuel-cell technologies, took place[9]. Due to these novel technological developments and applications in the regional maritime industry (henceforth 'industry' unless specified otherwise), this industry therefore provides a very interesting setting, or 'case', to study. This becomes even more relevant when, on a more general level, efforts to study processes of low/zero emission technological transformation in the industry have been surprisingly few (see, however, Holmen and Fosse, 2017), at least from a social science perspective (Steen, 2018). That being said, there is a

[9] Liquid Natural Gas (LNG) is not covered by this, though also this technology has been heavily pursued in this region, and elsewhere in Norway.

growing list of contributions here which e.g. focus on the national level (Bergek et al., 2018, Steen, 2018, Steen et al., 2019). However, as Steen (2018) reminds us, the absence of research on greening of the maritime industry has a lot to do with the fact that these changes are quite novel, and still very much ongoing. Still, while it is green maritime transformation processes in Western Norway that are to be explained, it is important to bear in mind that the observed transformation is not the sole result of endogenous regional processes (cf. the 'multi-scalar' argument), which has been reflected in the data collection (see Chapter 4.3).

3.1.3 The Western Norwegian Maritime industry

Norway, and in particular the region of Western Norway, has historically been strongly embedded in shipping and ship building industries (Jakobsen, 2011). This development has been caused by the presence of a long regional coastline with a myriad of inlets and islands, which has necessitated maritime transport for centuries, as well as a historical closeness to rich fishing waters (e.g. herring). The 'green maritime shift', which today can be observed both on regional and national levels, started within the counties of Hordaland (pop. 525.297) and Rogaland (pop. 476.852) (SSB, 2019)[10], more specifically in the maritime industry cluster located in the region of Haugaland and Sunnhordland. While the industry historically is much older, the present regional industrial and technological paths can be said to have originated from when fossil-based engines became the dominant technology in the industry around the beginning of the 20th century. A local entrepreneur then started a maritime engine firm which eventually became known as Wichmann (Bømlo Island). The 'Wichmann engine' was quickly established as the dominant technological standard in the region and later attracted inward investment by the Finnish corporation Wärtsilä, which bought the company in 1978, and which has remained heavily embedded in the region ever since. Engineers in Wichmann have also 'spun out' and created other regionally strong and globally esteemed firms, e.g. the propel and gear producer Servogear (1974-). Another regional key actor in the region is Kværner Stord (Stord Island), a wharf based on technology transfer from a herring factory. While this wharf originally produced steel-based passenger and transportation ships (around 1945 and onwards), it is today strongly embedded in the petroleum industry. In the 60s and early 70s it was world leading in the construction of super tankers, but was forced to go into new markets during the oil crisis in 1973. It was also around this time that the Norwegian state-run oil company Statoil,

[10] County Hordaland is together with another county (County Sogn og Fjordane) merging into the county of 'Vestland' in 2020

now Equinor, was founded (1972), due to the involvement of an active Norwegian state. Equinor alone has, furthermore, strongly affected regional-industrial development processes ever since, and laid the foundation for the Norwegian welfare state, as it appears today. Kværner Stord therefore started creating offshore installations (i.e. platforms) for the Norwegian petroleum industry, where it also up until recent times has been world leading (Grove and Heiret, 1996). Knowledge established within its engineering community belonging to its power and automation department (now bought up by Wärtsilä) has been vital for the electrification in the maritime industry. Other regional firms of importance include the wharfs Fjellstrand and Oma Baatbyggeri, which both possess world-leading competence in building aluminium ships for several markets. Finally, the region is also home to several visionary shipping companies, such as the offshore shipping companies Eidesvik, Solstad and Østensjø, and the ferry shipping company Norled.

Today, the maritime industry makes up the strongest industry in the region, and in 2010 more than 35% of total regional wages went to the industry, making it the highest percentage in Norway (SFN and SNU, 2010). In 2018 profits from the industry were around 4,9 Billion USD and the industry employed close to 17.000 workers (Maritime forum Haugalandet and Sunnhordland, 2019). However, while many regional maritime firms, e.g. shipping companies, wharfs and suppliers, make up a strong regional maritime value chain, the maritime industry is most strongly embedded in the regional (and national) petroleum industry. It can therefore best be conceptualised as a 'petro-maritime industry' (see also Holmen and Fosse, 2017) since regional maritime firms are involved in platform building or supplier activities connected to this. However, more importantly regional maritime firms are connected to value-chains centering around the construction of 'Platform Offshore Vessels' (POVs), which are highly specialised and advanced ships designed for delivering services for the oil industry and capable of carrying out demanding operations in rough seas.

3.1.4 Maritime cleantech: Regional responses to national and global challenges

In 1999 and, later, in 2008, the industry experienced stagnation due to the global downturn in oil prices. This, in turn, led to a realisation among some regional industrial actors that the industry needed to renew itself, should the oil prices fall again. Some of these actors therefore foresaw that there were economic opportunities for both firms and the industry as a whole to shift towards green maritime technologies, or 'maritime cleantech', in the region. Thus, in 2011, a network of regional firms applied to enrol in Norway's public program for industrial cluster

development. Today, this cluster, 'NCE Maritime CleanTech' (NCE MCT), is the main regional industrial network for developing and promoting maritime cleantech in the region. This cluster focuses, strategically, on 'establishing future-oriented, innovative and competitive solutions for the maritime industries which reduces environmental- and climate-hostile emissions to air and sea' (NCE Maritime CleanTech, 2018), and has been characterised by a strong 'project focus' in their work. Thus, several demonstration projects have emerged from this cluster network, including e.g. 'Folgefonn' (2011-) (a car ferry demonstrating battery technology, inductive charging and autonomous operations), and 'Urban Water Shuttle/Transport: Advanced and Modular' (UWS/TrAM) (2013-) (a concept for battery-driven maritime passenger transport in traffic-congested urban areas). Other demonstration projects, which have not been directly cluster-driven, include 'Ampere' (2011-2015) (the world's first fully-electric car ferry) and 'Viking Lady' (the world's first POV demonstrating fuel-cell technology (2009) and battery technology (2012) in demanding offshore operations). The cluster is currently working with several other maritime battery projects in the region, but are increasingly looking into developing hydrogen fuel-cell technology for cruise ships and other long-distance vessels. Regional firms are also in the race for constructing the world's first hydrogen driven car ferry, on mission from public authorities. These regional industrial and technological development processes have also attracted new players towards the maritime industry. This includes firms from the aluminium industry and from the 'power and utility' sector, which historically also have been important industries in the region. However, other new actors, such as maritime battery producers, e.g. Rolls Royce, who have already opened a factory, and Corvus, who recently opened their first factory for maritime batteries in Bergen, have also established themselves in the region. These actors are also moving fast towards other markets than maritime, e.g. by looking at the potential for electrification of marine salmon-farming plants. Moreover, in addition to 'hard technological innovation', there are also several cleantech efforts with regard to fuel-saving programmes, which e.g. the regional offshore shipping companies Eidesvik (Eidesvik Energy Efficiency Program), Solstad (Green Operations) and Østensjø (Mindset) are pioneering.

4. Methodology

This chapter describes the methodology and the process of choosing, refining and replacing theoretical and analytical constructs, or the consideration of choices that guide the 'dissertation journey'. The rest of this chapter will now go on to discuss the philosophy of science, critical realism, which has guided the choice of methodology in this dissertation. It then goes on to describe the methods applied, e.g. pros and cons of these, and the way the data collection and analysis process unfolded throughout the dissertation. While the application of suitable methods, e.g. tools, techniques and procedures that produce, organise and analyse data and knowledge on a phenomenon, is guided by what we study and the research questions we ask about it (Grønmo, 2007), these methods must always be founded in a methodology which reflects epistemological and ontological positioning (Edwards et al., 2014).

4.1 Critical realism as methodology

On an overarching level, this dissertation subscribes to a *critical realist* ontology, or rather epistemology. Critical realism suggests that real structures and mechanisms in the world precede our understanding of them, or that 'reality' is not simply reducible to that which we can observe in the world (Bhaskar, 2013, O'Mahoney and Vincent, 2014, Castellacci, 2006). Or, in the words of Sorrell (2018: 1268):

> […] critical realism combines an 'ontological realism' (the claim that phenomena exist independently of our knowledge of them) with 'epistemological relativism' (the claim that human knowledge is socially produced, historically transient and fallible) and 'judgemental rationalism' (the claim that there are rational grounds for preferring some theories and explanations over others).

As such, critical realism provides a critique of social constructivism, by positing that reality is not merely a consequence of subjective thought, reasoning and reflection. Still, critical realism does not suggest that reality can be reduced to a set of observable universal laws and 'constant conjunctions' either, as is the core of positivist reasoning (Sayer, 2000, Sorrell, 2018). Specifically, critical realists argue that reality, and our conceptualisation of it, is made up of three stratified but interrelated levels; '[…] (i) the real (deep) level of structures and generative mechanisms; (ii) the actual level of events and states of affairs; (iii) the empirical level of observed phenomena, perceptions and impressions' (Castellacci, 2006: 861). The deepest layer is therefore that of the 'real', where we find deep generative mechanisms that potentially can cause events to unfold. Thereafter we find the 'actual' level, which consists of events generated by mechanisms on the real level under certain circumstances. Finally, we find the 'empirical'

level, which consists of events that we are able to observe directly (Castellacci, 2006, O'Mahoney and Vincent, 2014).

Following the tenets of critical realism, it should therefore be the goal of every researcher to uncover the 'real' level. However, it is argued that a full empirical description of reality is unattainable, and that our conceptualisation of reality will, at best, always be 'approximate' (Sayer, 2000). Simultaneously, as seen from above, critical realism rejects universal laws, and is open to approaching reality as an open, complex and ever-changing system, yet consisting of patterns and mechanisms that are realised—or realised differently—under certain conditions (Castellacci, 2006). Consequently, an ultimate research goal for any critical realist should be to uncover and differentiate between *necessary* and *contingent* conditions (Fløysand et al., 2013, Sayer, 2000), that is, which elements, mechanisms, processes or patterns that are 'causally' similar across research contexts or cases (necessary conditions), and which are dependent on context (contingent conditions). With regard to this dissertation and the papers of which it consists, I argue that one necessary condition for green transformation relates to that of 'the interplay between a material, organisational and discursive dimension' (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019). This interplay is concomitant with a central point within critical realism, namely how relevant physical *and* social entities are capable of producing generative, but contingent, mechanisms for events (Sorrell, 2018, Elder-Vass, 2010). However, *how* this interplay plays out, does not always lead to the same results, as the differing trinity dynamics[11] presented in Paper #3 shows. This, I argue, is due to contextual, or contingent, industrial conditions, which lead to differing dynamics for the different cluster strategies. Other assumed necessary conditions of great importance for this dissertation and green transformation processes, which have been revealed more clearly during the research, are those of multi-level or multi-scale dynamics (see also Njøs, 2018), and the interplay between agency and structure dynamics in intentional institution change processes (institutional agency). However, all of the necessary conditions (which play out in different ways in the papers) are contingent on the practices of actors. These practices are embedded in regional capabilities/territorial dynamics, where necessary and contingent conditions meet. Thus, while factors exogenous to Western Norway are important to explain green regional transformation, a vital point in this dissertation is that transformation is also driven by contingent regionally embedded practices, e.g. contextual conditions. In this way, the

[11] In the paper we approach materiality, organisation and discourse through focusing on technology-organisation-discourse or 'TOD' dynamics (Fløysand and Jakobsen, 2016), but in the 'kappa' I use 'trinity'.

dissertation looks at the region 'from within', rather than as a mere component in multi-scale dynamics (looking at the region 'from without'). As the above discussion suggests, some necessary conditions can be perceived as already existing, before research 'reveals' them. This is unproblematic with regard to methodological reasoning, as a critical realist methodology *always starts with theories* that describe or explain the empirical case or research context under study (Danermark et al., 2002, O'Mahoney and Vincent, 2014). Thus, and with regard to the dissertation, new theoretical discussions and debates around multi-dimensionality have guided a view on preconceived necessary conditions. To be clear, I am not suggesting that 'everything' can be a preconceived necessary condition, merely that theoretical discussions can guide us towards plausible explanations of existing necessary conditions—which then should be subject to empirical testing and refinement.

Thus, an important part in critical realism relates to that of 'abduction', which can generally be defined as a way to abstract observations into plausible causation sequences that 'gives rise to observed regularities in the pattern of events' (O'Mahoney and Vincent, 2014: 17). Abduction brings the world of the 'intransitive' (objects, materiality, real structures) into the world of the 'transitive' (theories, ideas), while simultaneously recognising that the transitive world acts back on our understanding of the intransitive world (Couper, 2015, Modell, 2009). Thus, abduction helps to construct a theory, which in turn allows for looking at empirical observations through new lenses, which again potentially can refine theory, and so on. As such, abduction is neither inductive nor deductive, but allows the researcher to continuously reflect on objects and variables and continuously to create better conceptual tools for 'talking about' these ('you know more about the empirically observable phenomenon when you have a better language about it'). However, as critical realism ultimately aims to uncover quite deep and complex processes, researchers often need to make a pragmatic choice through 'analytical resolution' (Danermark et al., 2002) or 'appreciative theorising' (Nelson, 1994), e.g. selecting and studying the relationships and causal processes the researcher *thinks matter the most*.

Referring to the theoretical discussion, and reflecting the evolutionary perspective, critical realists also emphasise openness, contingency and reproduction (Castellacci, 2006, Martin and Sunley, 2006). Moreover, within critical realism 'the future…is forged in the present, hammered out of the past inheritance by current innovation' (Archer, 1996: xxvi). This indicates that evolutionary processes create necessary conditions, e.g. 'set' structures or mechanisms (e.g. within the material and organisational dimension), which exist independently of our ability to observe them all. This both affects and is also contingent on e.g. the agency of

actors. Despite critical realism being new to innovation studies, though less so for social science in general, both EEG (Castellacci, 2006), TS (Sorrell, 2018) and IEW (Leca and Naccache, 2006) are compatible with critical realism on a general level (e.g. through the fact that EEG sees 'regions' as emergent entities, whereas TS sees 'niches, regimes and landscapes' as separate, but interacting, entities), though TS presents several questions that must be thoroughly handled in order for a critical realist philosophy science to be implemented. One of these questions relates, somewhat ironically, to the nature of interplay between the physical and the social world (Sorrell, 2018). In the dissertation such an interplay is addressed, specifically in relation to discussions around agency, and how materiality can 'contain' agency (Paper #2).

4.2 Qualitative research: Case studies, research design and strategy for data collection

While critical realism is open to applying quantitative methods in addition to qualitative methods (applying quantitative methods, however, is a point of contention among critical realist scholars) (Castellacci, 2006), my position is that of a qualitative researcher. Engaging in in-depth studies and uncovering contextual conditions is therefore important within a critical realist qualitative methodology or positioning (Roberts, 2014). Moreover, recalling that a critical realist informed project always starts with theory (Danermark et al., 2002, O'Mahoney and Vincent, 2014), conducting case studies should be based on former (and parallel) theoretical discussions or empirical insights of the context (Edwards et al., 2014, George and Bennett, 2005)[12]. Finally, and importantly, a qualitative position is also compatible with both EEG (Pike et al., 2016), TS (Geels, 2011) and IEW (Battilana et al., 2009). As already mentioned, and following the logic of critical realism, the research process has been a continuous and dynamic process of abduction (Danermark et al., 2002), as theoretical propositions and concepts and empirical observations have continuously affected each other during the whole research process, and also because there has been a gradual addition of both primary and secondary data throughout the research period. I have, as such, been 'in the field' on several occasions during the span of the dissertation—though the study is not an ethnography. Maintaining a regular presence in the field as a qualitative researcher is advantageous because it allows for detailed data, as well as continuous nuancing, refinement and corrections of previous observations (Kearns, 2000). However, it can also have drawbacks. For example, when being heavily

[12] Of which Holmen and Fosse (2017), Bergek et al (2018), Steen (2018) and Steen el al (2019) provide.

entangled in case contexts or 'the field', it is easy to become captured and captivated by it. When continuously meeting with informants through different events and gatherings (many informants took part in many of these), I felt it necessary to reflect upon my own role as a researcher. That is, was I able to gather and present objective data, or was this affected e.g. by my relatively frequent interaction and positive tone with actors in the regional maritime industry? Moreover, and with regard to the insider-outsider debate (see e.g. Smith, 1999), while I never became an 'insider to the industry', did the fact that I am an 'insider to the region' (e.g. feeling a personal sense of pride for what the maritime industry has achieved) affect the research? While I feel that the outcome of the fieldwork and the research process in general paints a 'real' picture of 'what really has been going on', it must nevertheless be recognised that qualitative studies can never be truly objective, and that the researcher's presence and pre-conceived subjective opinions will affect the result at some level (Creswell, 2017).

Moving towards a more concrete methodological approach, the dissertation can therefore be conceptualised as a 'qualitative case study' (George and Bennett, 2005) of the greening of the Western Norwegian maritime industry, in which several analytical approaches and methods have been applied. Thus, as is revealed in the papers, different levels and units of analysis have been at the centre of attention in each of the papers, such as engineers (individual/social group focus, Paper #1), a demonstration project and its associated actor-network (project/network focus, Paper #2), regional clusters (regional industry focus, Paper #3) and new regional industries based on new clean technologies (regional industry focus, Paper #4). While the overarching case is the green transformation of the Western Norwegian maritime industry, it is perhaps therefore best conceptualised as a stratified 'building block study' (George and Bennett, 2005), where each paper and analytical focus contributes to overall theory building by providing an aspect of an overarching pattern. Or, in other words, the findings in the papers become building blocks for the whole case study. However, and importantly, two of the papers (Paper #3 and 4) are 'comparative case studies' (George and Bennett, 2005). This, I argue, has been important with regard to teasing out exactly how the regional maritime industry cluster differs from other regional industrial clusters (Paper #3), or how a regional maritime battery industry differs from another 'potential' regional carbon capture and storage industry (Paper #4). Still, as the main objective has been to explain the greening of the *maritime* regional industry, the other clusters and technologies in the comparative papers are better conceptualised as comparative cases which aid in explaining the focal case through differentiation from it.

A constant goal with this dissertation has been to contribute to theory building, based on an empirical investigation guided by existing theoretical debates within EEG and TS—while simultaneously being explorative enough along the way, in order to take in new observations that can have implication for further theory building. Furthermore, while empirically interesting and motivating in itself, this case more importantly provides an interesting case for theory building in the light of the theoretical debates presented in Chapter 2. Thus, with regard to generalising from qualitative case studies, I argue that the findings in the dissertation provide for a *generalisation of theoretical propositions,* rather than empirical generalisation (Gobo, 2004). Therefore, the main purpose of the dissertation has been to contribute to a theoretical debate and framework which can explain something about green transformation in other contexts. The dissertation has therefore neither sought to construct universal laws about what will always happen elsewhere, nor make the study of this single case into a 'relative truth'. In the words of Sorrell (2018: 1268, my emphasis):

> From a critical realist perspective, the primary objective of social scientific research is not to predict or to interpret but to *explain*−in other words, to develop empirically supported theories and hypotheses about how, why and under what conditions particular phenomena occur

Thus, while the case was indeed always empirically interesting, my preconception of the observed and ongoing green industrial transformation in the Western Norwegian maritime industry suggested that this case was theoretically interesting in exemplifying a relatively fast transformation process. It also provided an interesting opportunity to study a transformation in progress. However, in order to conduct the case research, I—like any other researcher—had to make a reflected methodological choice on how to proceed. Viewing the case like a 'whole', containing different sub-cases, mechanisms, processes, and so on, still begged the question: Where do I start? How and what do I sample? Heavily inspired by social fields methodology (Grønhaug, 1978, Fløysand and Jakobsen, 2001, Fløysand and Lindkvist, 2001, Fløysand and Sjøholt, 2007), which was explicitly applied in Paper #1, I chose to start my analysis through a number of observed events (Grønhaug, 1978) embedded in the regional maritime industry; i.e. the 'occurrence of several demonstration projects'. Thus, these events became a starting point for exploring *how* these events came to be as a product of relations between actors in social fields, which potentially span several scales. This is also similar to Vayda's and Walters' (2011) methodology for analysing complex causal processes, where starting with an 'event' and then map out the 'the causal chains that lead to the events' (p. 2) is vital. However, how these events affected wider processes of greening was an equally important focus. A focus on four demonstration projects (Folgefonn, Urban Water Shuttle/TrAM, Ampere and Viking Lady, see

Chapter 3.1.4) as arenas or 'vehicles' for institutional work processes (Söderlund and Sydow, 2019) has therefore been guiding the research design. This has entailed an analytical focus on actors connected to demonstration projects (covering the organisational and discursive dimension, or 'social agency'), but also on the materiality of the demonstration projects themselves (covering the role of the material dimension for agency). This conceptualisation was directly applied in Paper #2, whereas Paper # 1, 3 and 4 were more concerned with analysing the interplay between materiality, organisation and discourse in general, linking it e.g. to *observed practices* among engineers (Paper #1) and as an *integration of EEG and TS* as theoretical frameworks (Paper #3 and 4). However, though a focus on demonstration projects as arenas for data gathering has been important, the research design has also been tailored to gather data from key stakeholders in the region (such as cluster staff and other actors with perceived key knowledge on maritime cleantech processes). Moreover, data has been gathered at maritime events, such as conferences, seminars, workshops and project meetings, which have focused around various maritime cleantech 'themes' rather than focusing on specific demonstration projects (except for the project meetings). Finally, during the dissertation I have also become connected to other research projects which have gathered data on the regional context—where exploring the greening of the maritime industry also has been a central topic. Thus, the original research design which set out to collect data from actors connected to specific research projects-as-events, in addition to key stakeholders and from maritime gatherings-as-events, has been accompanied by data collection also from other research projects. This, I argue, has strengthened the data collection and provided additional insights into green territorial dynamics.

4.3 Methods and data collection

Table 3: Methods and data sources used in the papers for the dissertation

Paper #, authors, year	**Title**	**Methods**	**Sources for data**[13]
Paper 1: Sjøtun (submitted to Geoforum, June 2019)	The Role of Engineers in the Greening Western Norwegian Maritime Industry: Agency, Social Fields and Practices	Case study; Semi-structured interviews, observation, desk research (document- and media-analysis)	• 39 interviews 2012-2013, 2016-2018 (Sjøtun, 35 interviews) • 18 instances of observation in various maritime seminars, conferences, workshops etc. 2015-2018 (Sjøtun)

[13] I have sorted all the interviews which I have conducted alone, but also the interviews I have conducted with other researchers, under 'Sjøtun'

			• Media analysis (Retriever web search (Atekst), 'Pocket' archive and online web searches (Sjøtun) • Government/NGO/industry strategy plans and reports (Sjøtun)
Paper 2: Sjøtun (2019)	A ferry making waves: A demonstration project 'doing' institutional work in a greening maritime industry	In-depth case study: Semi-structured interviews, desk research (document- and media-analysis)	• 21 interviews 2016-2017 (Sjøtun) • Media analysis; Retriever web search (Atekst), 'Pocket' archive and web searches (Sjøtun) • Government/NGO/industry strategy plans and reports (Sjøtun)
Paper 3: Sjøtun and Njøs (2019)	Green reorientation of clusters and the role of policy: 'the normative' and 'the neutral' route	Comparative case study: Semi structured interviews, observation, desk research (document- and media-analysis)	• 60 interviews 2011-2018 (Sjøtun, 28 interviews) • 18 instances of observation in various maritime seminars, conferences, workshops etc. 2015-2018 (Sjøtun) • Media analysis; Retriever web search (Atekst), 'Pocket' archive and web searches (Sjøtun/Njøs) • Government/NGO/industry strategy plans and reports (Sjøtun/Njøs), including analysis of cluster strategy documents and Norwegian cluster policy documents (Sjøtun/Njøs)
Paper 4: Njøs, Sjøtun, Jakobsen and Fløysand (revised version was submitted to Economic Geography, October 2019)	Green path creation in regions: Towards an analytical framework	Comparative case study: Semi structured interviews, observation, desk research (document- and media-analysis)	• 52 interviews 2012-2019 (Sjøtun, 32 interviews) • 18 instances of observation in various maritime seminars, conferences, workshops etc. (2015-2018) (Sjøtun) • Media analysis; Retriever web search (Atekst), 'Pocket' archive and web searches (Njøs/Sjøtun) • Government/NGO/industry strategy plans and reports (Njøs/Sjøtun)

My fieldwork and data collection for this dissertation was carried out between 2015 and 2018. Primary data was for the most part collected in Western Norway, but also in the Oslo Region[14].

[14] Several actors involved in public administration and regulation, maritime rule-making, and e.g. NGO lobbying for an environmental friendly maritime industry, were located here.

I have also used other interview data as well (see 'interviews' below). The methods and data sources applied in the dissertation are those of semi-structured interviews, observation and document studies, which now will be explained.

Interviews – Firstly, the papers in dissertation are based on data from, in total, 101 semi-structured interviews, of which I participated in 46. Interviews were conducted with industrial actors, public actors, politicians, environmental NGO actors, R&D organisation actors, industry development agency actors and maritime consultancy/regulation actors (see each individual paper for a detailed list), and were carried out in the period 2011-2019. Semi-structured interviews are typically used in qualitative studies (Dunn, 2000, Grønmo, 2007) and are considered appropriate to use because they can 'investigate complex behaviours and motivations…[and] collect a diversity of meaning, opinion, and experiences' (Dunn, 2000: 80). The interviews have been conducted by myself, together with other researchers, and by other researchers, as there have been adjacent and relevant research projects from which I have also drawn relevant interview data. However, the dissertation is also based on existing interview data (see table 3 for a full overview over the interview data used in each paper). The interviews were recorded and transcribed[15], and, during the interviews in which I conducted or took part, the interviews were accompanied by extensive note taking by myself. The interviews lasted for anything between 40 min. – 2 h. However, some of them were also conducted via phone due to limited means of constantly travelling to the field. The interview guide sought to map drivers, motivations and barriers for green maritime industry transformation and regional development, through collecting biographies (of the informants themselves, the firms or organisations they represented, the region they were embedded in and the demonstration project(s) which they were connected to), as well as data on technological, industrial, political and institutional development processes. However, since interviews used in this dissertation have also been conducted by other researchers, and have been collected in relation to other projects, the topics or guides for the interviews also differ. Still, I see this as a strength for the dissertation. First of all, I have conducted enough interviews myself to directly cover the questions and topics of relevance. However, both my participation in interviews conducted for other research projects and access to existing interview transcriptions, have added a lot to my understanding of regional development processes and how various stakeholders within key regional industries—including

[15] However, 5 interviews were not fully transcribed and 3 were not recorded, but transcribed based on extensive note taking

the maritime industry—public administration and R&D communities, view enabling factors for and barriers to greening of regional industries.

The majority of the informants who I interviewed have been engineers, e.g. individuals who possess an engineering education. Still, quite a few informants have not possessed a technical background, but are embedded in decision-making processes in firms, at the political level or in public administration. The informants were selected on the basis of their connection to and knowledge of the focal demonstration projects, and not merely as being embedded in the projects' supply chains. Some key informants, however, were selected despite not having a clear project connection, as they were believed to hold vital information about relevant topics on green maritime transformation, e.g. with regard to politics, public administration, technology etc. In addition, two interviews were not planned, but took place relatively 'spontaneously' at maritime events. I did get in touch with most of the informants of my sampling group, but there were a few informants (representing maritime firms) who did not have the time or the opportunity to be interviewed. Finally, most informants were identified prior to the fieldwork, but some were also identified due to other informants' recommendations. As such 'snowball sampling' (Morgan, 2008) was present to a small degree.

Observations – Secondly, three of the papers in this dissertation are based on observational data. This method for data collection is advantageous because it reveals the more informal interactions between actors, in that 'although an interview situation is still a social situation…it is a world apart from everyday life' (Evans, 1988: 203). However, lengthy and continuous immersion in the case or context under study can be difficult to attain. Therefore, as Kearns (2000) summarises, '[…] observation…involves strategically placing oneself in situations in which systematic understanding…are most likely to arise' (p. 196). Thus, from 2015-2018, I participated in 18 maritime conferences, seminars, workshops and project meetings, in which maritime cleantech was debated[16]. These events—which covered a wide spectrum of topics related to greening of the maritime industry, as well as that of e.g. digitalisation—were hosted by several actors; NCE Maritime CleanTech, ZERO, Maritime Bergen and Norwegian Electric Systems, Norsk klimastiftelse [Norwegian Climate Foundation], NOR Shipping, Friends of the Earth Norway and Western Norway University of Applied Sciences, and for the most part took place in the region. This allowed for confirmation

[16] I was not physically present during one of these events, which took part in Oslo, but I followed the stream online. Another event was a project meeting in relation to an external research project on the greening of maritime industry.

and reinterpretation of existing observations, but also access to additional information that was not necessarily revealed in the interviews. Moreover, observation as method also opens up the possibility of having 'informal conversations', which I had with actors at almost all the events. These conversations were most often recorded by hand as field notes, but rarely during the conversation (as I feared this would stop the 'flow' of the conversation). Finally, different presentations and debates also revealed opinions and strategies for a whole range of other regional firm actors (who were not interviewed) engaging in green transformation processes.

Documents – Finally, the dissertation is also based on secondary data authored by firms, organisations or public institutions (e.g. reports and strategy documents) or by newspapers or other media outlets (e.g. newspaper articles, magazine articles etc.). Secondary data was considered appropriate to use for all the papers in this dissertation because it provided a good insight in and description of contextual conditions, e.g. regional and industrial development and popular and political attitude towards maritime industrial and technological processes. In particular, secondary data can function as containers for discourses (Laclau and Mouffe, 2001), or as arenas where actors can circulate opinions or claims (e.g. framing) (Hansen and Steen, 2015, Callon, 1998) connected to e.g. 'green and sustainable' maritime technological solutions. While framing of narratives certainly can be articulated in interviews or through observation (and frequently does), they are of more interest as 'evidence' when circulated through document data, as they here can provide strong signals or 'power effects' (Foucault, 1980) for policy makers or the general public reading the newspapers.

With regard to data collection and to documents such as reports and strategy plans, I actively scouted the home pages of the organisations (NGOs, political and public institutions, and select firms) identified as important for green maritime industrial transformation, both regionally and nationally. However, when engaging with data collection from online media sources, I used Atekst (Retriever) to search for newspaper articles containing information on 'battery or electrical ferries'. The search interval was January 1st 2000 – May 16th 2017. This search was primarily intended for Paper #2, but ended up being used as a data source for all the papers. Moreover, I also performed supplementary media searches throughout the whole dissertation from select online newspapers and magazines on both the regional and national level. Many of these sources, together with other types of online data sources, were stored in the online archive software 'Pocket' (getpocket.com), from which it later could be easily retrieved when the coding and analysis started.

4.4 Data analysis

With regard to the interview data I produced myself, and common for all the papers, the analysis process started in the transcription phase. However, in terms of specific data analysis, the analysis process has been a bit different between the different papers. With regard to Paper #2, which was authored and published first, I e.g. used the software 'NVivo' to categorise interview data and document data. This was not done in the other papers. However, I also coded in word documents, e.g. by teasing out quotes that would be used to illustrate different processes. As part of analysing document data, primarily media data (e.g. online newspaper articles, web pages etc.), I also used Pocket, which allowed me to 'tag' and categorise media documents. This proved quite useful for handling a constantly growing number of media documents that I added to the archive, almost on a daily basis. With regard to Paper #3 and 4, the analysis was both based on former data analysis conducted by other researchers and undertaken together with other researchers that co-authored the papers.

With regard to reliability and validity[17], and as a general argument, the data collected and utilised in this dissertation point back on the SRQs. I argue that this has been ensured by different processes. First, with regard to the reliability of the research (e.g. transparency with regard to how data has been collected, analysed and presented), this is sometimes difficult to prove in qualitative case studies. Yet, following George and Bennett (2005) I have provided a detailed account on how 'data was created and collected' (in Section 4.3), which they argue is the most important rule to follow with regard to data collection in case studies (p. 106). This, I argue, has ensured reliability. Second, as seen, the dissertation is based on several types of qualitative data sources, which according to e.g. Yin (2009) can aid in increasing validity (e.g. the accuracy and truthfulness of data and findings) in case studies. For example, during events which I observed, I took notes during presentations and public debates which were then used to cross-examine observations and findings from the document and interview data. Claims and information in interviews were also (re)analysed in light of similar claims and information in the document data. Finally, for Paper #1-3, identifiable quotes which were desired to be used in the publication, were also sent back to the informants for approval. While this was done in order to allow informants to approve their quotes due to ethical concerns, it simultaneously worked as a verification with regard to whether or not the quotes were 'valid'. Furthermore, for

[17] Some authors suggest using concepts like 'credibility, consistency, transferability and trustworthiness' rather than 'reliability' and 'validity', as the latter two come from the quantitative tradition (Golafshani, 2003, Lincoln and Guba, 1985). Still, as there is no established practice to use the former four concepts within qualitative research (Thagaard, 2013), I choose to use 'reliability' and 'validity'.

Paper #3 and 4, increased validity was ensured due to several authors discussing the empirical findings. Finally, my empirical observations were found to be consistent with former (Holmen and Fosse, 2017) and parallel (e.g. Bergek et al., 2018, Steen, 2018, Steen et al., 2019) research related to my case and context. These factors, I argue, have allowed for a 'thick description' of the case and context, which has increased the internal validity of the data and findings in the dissertation. Moreover, qualitative case studies which engage with in-depth research of complex causal mechanisms and variables, and the relationship between these, are also considered useful in aiding of the construction of conceptual validity (George and Bennett, 2005). This is also consistent with critical realism, where data and theory have continuously affected each other through 'abduction'.

5. Contributions

This chapter discusses the general empirical findings, and the theoretical and methodological contributions of the four papers in the dissertation. The papers have all gone through blind review process. Two have been published and two are in process (see details below). However, before discussing the general contributions of all the papers, the relationship between them, and how they link up to the SRQs, I provide a summary of each paper and discuss their specific contributions.

5.1 Paper 1: The Role of Engineers in the Greening of the South-Western Norwegian Maritime Industry: Practices, Agency and Social Fields

The first paper to be presented in this dissertation, of which I am the sole author, has been invited to be 'revised and resubmitted' to *Geoforum*[18]. It focuses on the role of regionally embedded maritime engineers in processes of green maritime industry transformation. Analytically, it studies the practices of these engineers, thus focusing on *individuals/social groups*. It finds that engineers participate in three 'social fields' (Grønhaug, 1978, Fløysand and Jakobsen, 2001, Fløysand and Lindkvist, 2001, Fløysand and Sjøholt, 2007), in which they perform practices of relevance for green maritime regional transformation; a global 'engineer discipline' field where they perform 'technologist' practices, a regional 'industry cluster' field where they perform cleantech practices (e.g. green technological practices and framing practices), and a national 'political' field where they perform lobbying practices. The empirical analysis therefore finds that engineers, naturally, perform practices related to e.g. technological innovation and production, both based on existing regional knowledge and competence, but also on global technological development trends (e.g. battery development driven by the global car industry). Moreover, the analysis also finds that several engineers simultaneously have performed green technological practices in the region, but also discursive practices of framing new maritime clean technologies as e.g. 'environmentally friendly' and 'cost-saving'. Finally, several of these engineers have conducted lobbying activities towards regional and national politicians and public organisations. Thus, the discursive practices of framing and lobbying indicate that engineers, in addition to technologist practices for the industry, also have participated in 'institutional agency' activities on different scalar levels.

This paper contributes to TS theory in three ways. First, it takes an agency perspective and addresses a 'practice gap' in the literature (Watson, 2012, Welch and Yates, 2018, Hoffman

[18] It was first submitted in June 2019

and Loeber, 2016, Hargreaves et al., 2013, Köhler et al., 2019), by operationalising an analysis of practices through a social field methodology. Moreover, when applied in a transformation context, the paper also has implications for a renewal of social field methodology as well. That is, the paper shows that engineers do not merely participate in 'incumbent or cemented fields', but are also aiding in creating new fields, as well as moving into existing fields that are new for the engineers (e.g. the political). As the engineers here perform both entrepreneurial and technological practices, and institution changing practices, the paper also links up to the theory of 'institutional work'—which emphasises a practice perspective (Lawrence et al., 2011). Secondly, applying a social field methodology addresses the 'spatial gap' within TS literature, in that it shows how engineers participate in overlapping fields that are either located to a specific spatial scale, or which span several scales. Finally, the paper nuances the TS perspective on 'multiple actors', by rather showing how individuals in one actor group actually can perform several different types of practices, or agency (see also Grillitsch and Sotarauta, 2018).

5.2 Paper 2: A ferry making waves: A demonstration project 'doing' institutional work in a greening maritime industry

The second paper, of which I am also the sole author, has been published in *Norwegian Journal of Geography* (2019)[19]. It focuses on the role of a demonstration project, the fully-electric battery ferry 'Ampere', and how this project has aided in institutional change within the publicly controlled ferry sector, in addition to green industrial and technological change processes in the maritime industry in Western Norway. It focuses on a *project or network 'level'*. Specifically, the paper argues that the very materialisation of Ampere proved to policy makers that maritime battery technology was mature, in turn causing public ferry procurement policy to demand 'low- and zero-emission technologies whenever technologically possible', first on the national level and thereafter on the regional level. However, different actors both from Western Norway (e.g. firms and cluster staff), where Ampere was 'conceived' and built, but also on the national level (e.g. firms, NGOs and the public agency that initiated the development contract leading to Ampere) simultaneously aligned themselves around the project and drew upon it e.g. in lobbying and framing processes. Here, and elsewhere, they deployed or framed advantageous narratives with regard to how the demonstration project aided in 'saving the environment', but also—and probably more importantly—how the ferry's battery

[19] This paper is part of the special issue 'Green restructuring, innovation, and transitions in Norwegian industry: The role of economic geography', edited by Markus Steen and Rune Njøs.

technology aided in significant 'savings of fuel-costs', making maritime battery technology also 'good business'. This was also confirmed by Ampere's material or technological demonstration. As such, the paper argues that Ampere must be seen as a 'performing project', conceptualised as 'a complex of discursive and organizational strategies of framing and lobbying deployed by the actor networks connected to it and its materiality' (p. 1), where the interaction of material, organisational and discursive agency has led to institutional change.

This paper contributes to TS theory by showing how demonstration projects or 'niche innovations' can have significant and rapid impacts, also with regard to regime change (exemplified, in this paper, primarily through institutional change in public procurement policies and practices). It does so by conceptualising demonstration projects as simultaneous interplays of materiality, organisation and discourse. While several TS scholars already argue for such conceptualisations (Fevolden et al., 2017, Hellsmark et al., 2016, Klitkou, 2016), e.g. how demonstration projects can aid in establishing visions and expectations (Schot and Geels, 2008), and how they aid in building advocacy coalitions and public awareness around new technologies (Fevolden et al., 2017), the paper contributes to TS literature by emphasising how the '*material agency* of demonstration projects' aid in 'aligning new technology to institutional and organizational structures' (Hellsmark et al., 2016: 3). It does so by drawing on the literature of 'institutional work' and its conceptualisation of material agency (Monteiro and Nicolini, 2015, Fuenfschilling and Truffer, 2016, Lawrence and Dover, 2015, Lawrence et al., 2013), and introduces the concept of a 'performing project'. Moreover, the paper also contributes to TS literature by articulating how demonstration projects work as anchors or reference points for narratives that can aid in transformation processes.

5.3 Paper 3: Green reorientation of clusters and the role of policy: 'the normative' and 'the neutral' route

The third paper, co-authored with Rune Njøs (second author), has been published in *European Planning Studies* (2019)[20]. This paper argues that there is a need for 'green directionality' in cluster policy and theory in order to stimulate to green reorientation in industry clusters, and focuses on *regional industries*, here represented through cluster networks. In so doing, the paper draws on insights from EEG and TS and further draws upon an analytical framework which studies the interplay of 'technology, organisation and discourse' (TOD) dynamics (Fløysand

[20] This paper is part of the special issue 'Expanding the field of Responsible Research and Innovation — From responsible research to responsible innovation', edited by Stig-Erik Jakobsen, Arnt Fløysand and John Overton.

and Jakobsen, 2017). Based on this, the paper compares the strategies for greening in three industrial clusters in Western Norway through the lens of the TOD framework. This includes a petroleum cluster (GCE Subsea[21]), a marine cluster (NCE Seafood Innovation) and a maritime cluster (NCE Maritime CleanTech). The paper finds that these clusters' strategies differ due to differing TOD dynamics, thus leading to two routes for cluster reorientation; a 'normal' (GCE Subsea) and a 'normative' route (NCE Seafood Innovation and NCE Maritime CleanTech). Thus, in order to introduce more directionality into cluster policy and theory, these differing TOD dynamics in different clusters must be taken into account. However, more than situating attempts at greening in a territorial context, through a cluster policy perspective, the paper shows that 'uniform territorial contexts' do not alone lead to transformation. Rather, since the different regional industries are influenced by different sector dynamics and territorial/multi-scale dynamics, successful green cluster policy initiatives are not by themselves enough for green cluster reorientation or green regional (e.g. cluster) transformation, to occur. Thus, the paper also argues for the role of a 'policy mix' approach (Flanagan et al., 2011) e.g. in the instances of observed 'normative' routes.

This paper contributes to literature on cluster policy and cluster theory through an integration of EEG and TS, as it engages with recent challenges in innovation policy concerning 'directionality' of policy (e.g. Pyka, 2017, Schlaile et al., 2017). Specifically, it argues for understanding the basis for green cluster reorientation as an integration of a technological (material), organisational and discursive dimension through a 'TOD perspective', as conceptualised by Fløysand and Jakobsen (2017). In so doing, the paper simultaneously reaffirms the role of geography for cluster policy and theory, which EEG has engaged with for some time now (e.g. Fornahl and Hassink, 2017, Martin and Sunley, 2006). However, it also draws on TS in order to make a case for discourse and normativity in cluster policy/theory, as well as an inclusion of more actors on multiple levels as (potentially) important for green cluster reorientation. Finally, the 'success case' in the paper, e.g. NCE Maritime CleanTech, moreover shows that with regard to cluster policy 'understandings of 'envisioning and agency must be incorporated in order to include the normative/discursive dimension of industrial change' (p. 15).

[21] This cluster has now changed its name to 'GCE Ocean Technology', but at the time of writing the paper it was called 'GCE Subsea'

5.4 Paper 4: Green path creation in regions: Towards an analytical framework

The fourth, and final, paper, authored by Rune Njøs, myself (second author), Stig-Erik Jakobsen and Arnt Fløysand, is currently in revision in *Economic Geography* (revised version was submitted in October 2019). Like Paper #3, this paper also integrates EEG and TS—here, specifically, the TIS framework—though the focus of this paper is on *green industrial path creation* processes in Western Norway. The general theoretical argument of the paper is that EEG has overlooked, in particular, the role of technology in green path creation processes, while TIS has overlooked territorial dynamics. Specifically, the paper therefore argues that green path creation must be approached through a theory-informed analytical framework which integrates 'regional capabilities, multi-level dynamics, actors and agency, policy, guidance of the search, legitimation and market formation'. Empirically, the analytical framework is applied in a comparison of two emerging green technologies, Carbon Capture and Storage (CCS) and Maritime Battery Technology (MBT), and how these relate to regional path creation processes in Western Norway. It finds that MBT can be conceptualised as a new industry path with functionally related firms, supportive actors and institutions (Binz et al., 2016), caused by a favourable interplay between the factors in the theory-informed analytical framework, but also—and importantly— due to empirically observed aligning *narratives* around 'sustainable regional development' (where 'environmental sustainability', 'regional sustainable growth' and 'job creation' coincide). CCS, on the other hand, is still in a preformation phase, even though it 'contains' all the functions. Thus, we believe—based on empirical observations in the MBT case—that also 'narratives' have explanatory power, which could have future implications for applying this as another analytical category in studies of green path creation. However, more research with regard to this is needed.

As such, this paper departs from EEG theory, but argues that additional insight from TIS can lead to a richer conceptualisation of green regional path creation. Specifically, it contributes to a reading of green path creation as being infused by both technological development processes and territorial capabilities, though it argues for the fundamental importance as seeing these factors as intertwined. Still, based on the observed and positive effect narratives connected to sustainable regional development have had on the creation of a regional MBT industrial path, we argue that the role of discourse must be more thoroughly connected to green path creation processes.

5.5 Synthesising the findings – Overall contributions to the problem framing of the dissertation

The four papers in this dissertation contribute theoretically to the problem framings raised by the SRQs in the dissertation, while there also are some methodological contributions. In so doing, they implicitly (Paper #1-2) and explicitly (Paper #3-4) integrate the theoretical frameworks of EEG and TS, as well as that of IEW (the 'glue' tying all the papers together).

Multi-actor, institutional agency – The first theoretical contribution shared by all the papers relates to the first area of engagement; how agency and practice is connected to institutional change in green industrial transformation processes. Here, I am therefore answering SRQs 1 and 2. The papers find, on a general level, that regionally embedded industrial actors (e.g. engineers), cluster facilitators, public administrative staff, politicians and NGO representatives (and actors on the national level), all have worked proactively to induce a greening of the industry. In so doing, they have performed institutional agency, e.g. through framing and lobbying activities. This relates to engineers (Paper #1), actors connected to a demonstration project (and the material project itself) (Paper #2) and cluster staff (Paper #3). While I also find that proactive Schumpeterian or entrepreneurial agency processes have been important in the Western Norwegian maritime industry, it is rather the focus on institutional agency processes which is of main importance for the dissertation. This has been captured by the IEW framework. In opposition to popular opinion that it is merely top-down regulations (or 'sticks') which drive the green shift in the maritime industry, regional maritime actors have therefore shown that perceived benefits (or 'carrots') are to be gained if the industry takes the first step. Moreover, several different firms within the wharf, supplier and shipping segments in the maritime value chains have worked proactively. This is highly surprising, especially when considering that the global maritime industry, especially within the shipping segment, is characterised as quite conservative with regard to new technologies (Rehmatulla et al., 2017). Moreover, as the oil companies in Norway pay the fuel costs (Bergek et al., 2018, own investigation), there is really no incentives for offshore shipping companies to start pursuing greener technologies. Yet, this is precisely what has happened in Western Norway. Thus, despite the Norwegian maritime industry being quite innovative (Menon Economics, 2015), the step to go from more incremental (fossil-based) innovations to more 'disruptive' (low- and zero-emission) innovations, has been somewhat surprising in the region.

With regard to the papers, Paper #1 shows that different forms of agency are not 'mutually exclusive' for actors, as it shows how engineers in green transformation contexts

simultaneously can contribute significantly to both technological- *and institution-changing practices*. As the empirical investigation shows that engineers have stepped into new roles as institutional change agents, I argue that engineers can be more complex than previously assumed during green transformation. The paper moreover shows that institutional agency can take place at and over *multiple spatial scales*, e.g. that the practices of engineers are embedded in different social fields on different spatial scales. This also creates a multi-scalar dynamic where regionally embedded engineers perform different practices which can be located so to speak, to different scalar levels; they participate in a global 'engineer discipline' field where they conduct 'technologist' practices, a regional 'industry cluster' field where they perform technological-industrial cleantech practices, but also framing practices (related to regional sustainable development), and a national 'political field' where they conduct lobbying. As such, in addition to their 'normal' engineering practices, the paper adds to theory by showing that regionally embedded engineers have conducted/conduct institutional agency practices, both on the regional and national level. Still, the paper shows that the regional 'industry cluster' field has been particularly important, e.g. with regard to integrating globally-driven battery technology with regional technological-industrial communities with knowledge on power-electronics, energy-efficient engines and propeller systems. Therefore, Paper #1 is well suited to *connect SRQ1/2 and SRQ3*. Moreover, Paper #2 contributes to theory by conceptualising a demonstration project as a performing project with 'material agency', in addition to being a gravity point around which social agency revolves. This paper therefore explicitly integrates the *material dimension (in addition to the organisation and social dimension) and agency*. Therefore, Paper #2 is well suited to *connect SRQ1 and SRQ4.* Finally, as shown in all papers (but particularly Paper #2-4), cluster staff lobbying on behalf of its industry members, has also been vital. This, I argue, is one of the success criteria for why the maritime cluster has been so successful in their attempts at greening, compared to the petroleum and marine cluster. Summing up, while the SRQs also ask how we can connect questions of agency and practice to the empirical context of the dissertation, I argue that the four papers add to *theory building*, by showing the importance of different actors enacting different forms of purposeful institutional agency (IEW perspective). The papers therefore contribute to debates within EEG and TS concerned with more thorough research on institutional agency.

Territoriality and multi-scalarity – The second theoretical contribution relates to the second area of engagement, i.e. questions around territorial dynamics in green maritime industry transformation processes, as well as multi-scalar interaction. Here, I am therefore

answering SRQ3. With regard to this point, the papers find, on a general level, that territorial capabilities within the regional maritime industry, such as technological-industrial knowledge on power-electronics, energy-efficient engines and propeller systems, as well as the presence of risk taking companies (particularly shipping companies), have been vital for the observed green transformation. Moreover, the establishment of a regional industrial cluster has been vital in strengthening regional cooperation around maritime cleantech development, R&D, and in conducting lobbying activities towards politicians and public administration on regional and national levels. Finally, the regional industry has seized technological opportunities created by the global car industry, e.g. with regard to maritime battery technology. Moreover, the empirical findings illustrate that greening processes in the maritime industry affect processes in other industries, and thus have several implications for wider regional industrial development processes, or regional restructuring. For example, it is the *maritime* industry that has attracted battery producers to the region (see, in particular, Paper #4), and thus has been driving the electrification processes that we now see in other regional industries in Western Norway, such as the petroleum and marine industry. I therefore argue that the maritime sector is of particular importance beyond the thematic of the dissertation, in that it can tell us something about wider regional development processes, or how evolution in the maritime sector can co-evolve with other regional industrial sectors. This relates both to how the maritime industry is creating new supply chains (by attracting e.g. battery producers and becoming more integrated with the power and utility sector and material technology firms) and how they engage with societal 'missions'—e.g. questions of greening and normative regional development (see Paper #3). Finally, problem solving related to electrical charging of ships, e.g. working with charging infrastructure at the interface between land and sea, has also led to several innovations for the supplier industry. In fact, the potential for technological innovation is particularly high here, as pressure to charge car ferries fast within the ferry sector is very high (in order for the ferries to keep existing time tables). This pressure has led to several innovative technological solutions, which should be seen in conjunction with the new maritime battery path that has been established (Paper #4).

All the papers emphasise (although in slightly different ways) the importance of integrating regional territorial capabilities and multi-scalar interaction in processes of green transformation, by implicitly (Paper #1-2) and explicitly (Paper #3-4) drawing on an integration of EEG and TS. As already shown, Paper #1 shows how institutional agency and territorial/multi-scale dynamics have interacted, linked to the multi-scalar practices of

regionally embedded engineers. However, with regard to integrating territorial/multi-scale dynamics with multi-dimensionality, I argue that Paper #3 in particular shows how different regional industries are characterised by different constellations of a trinity of materiality, organisation and discourse, and different territorial/multi-scale dynamics. These have had different implications for green transformation processes. Therefore, Paper #3 is well suited to *connect SRQ3 and SRQ4.* In addition, Paper #2 also argues for a multi-scalar understanding, by emphasising how Ampere as a performing project has affected and been affected by institutional processes at the national level. However, it also argues that the region where Ampere was conceived and built should be seen as an explanatory factor of the demonstration project, though the project itself has also aided in stimulating to regional cluster cooperation. Finally, Paper #4 argues, that green path creation connected to maritime battery technology must be explained e.g. by territorial capabilities (as presented above), but also how aligned 'discourses and narratives' on sustainable development have created a favourable condition for green industrial path creation in the region. As such, all the papers contribute theoretically to how territorial capabilities/dynamics and multi-scalar dynamics (relating to EEG) can be integrated with green transformation processes (relating to TS).

Multi-dimensionality **–** The final theoretical contribution the papers make relates to the third area of engagement for the dissertation, i.e. the interplay between materiality, organisation and discourse. Here, I am therefore answering SRQ4. However, even though all these dimensions, and the dynamic interaction between them, are found in all the papers, they are conceptualised or operationalised somewhat differently there. Analytically, the interplay between materiality, organisation and discourse is an explicit focus of Paper #2 and 3. Thus, as already shown, in Paper #2 the dimensions are manifested in a concrete, yet 'performing', demonstration project. Moreover, as this paper shows, the role of 'material agency' becomes just as important as that of social agency. In Paper #3 the trinity is manifested in an interplay of 'technology, organisation and discourse', and how this interplay has affected the cluster strategies and development processes in three regional clusters. Moreover, as shown, dimensions are linked to different agency and practices, where engineers see what is technologically/materially possible (Paper #1), but also that new networks and political work coupled with framing narratives about new green innovations and technologies are needed (Paper #1 and 3). This is, moreover, tied to territorial and multi-scalar dynamics. Finally, Paper #4 also provides an argument for a 'trinity' of an interacting material, organisational and discursive dimensions, through an integration of EEG and TIS into an theory-informed

analytical framework, which emphasises the simultaneous workings of 'regional capabilities, multi-level dynamics, actors and agency, policy, guidance of the search, legitimation and market formation' in green regional path creation processes. Here, EEG should particularly recognise the role of technological specificities (from TIS), and TIS should increasingly recognise the role of regional capabilities (from EEG). However, the paper argues—based on empirical observations in the MBT case—that studying 'narratives' could have future implications and explanatory power as an analytical category in studies of green path creation. Paper #4 therefore also empahsises an interplay of materiality, organisation and discourse, as well as (institutional) agency and territoriality/multi-scalarity (*in this way capturing the 'essence' of the dissertation and all the SRQs*). As such, a dynamic interplay between materiality (technological demonstration), organisation (lobbying and clustering/networking) and discourse (framing of narratives) is central in explaining the observed green transformation, and the different papers have in different ways operationalised this interacting 'trinity of materiality, organisation and discourse' (Fløysand and Jakobsen, 2017, Jakobsen et al., 2019)which has been a fundamental mission of this dissertation.

Although the dissertation has not sought to expand on methodology with regard to the RQs, I still argue that the dissertation also provides some *methodological insights*. With regard to Paper #1, for example, applying a social field methodology is in itself novel within TS, despite recent engagement with field theory (Hoffman and Loeber, 2016), or transformation contexts (Normann et al., 2016). However, the paper also shows that in transformation contexts, social field methodology can itself, potentially, be renewed. That is, while social field theory has empahsised 'set' relations, norms, values etc. (Grønhaug, 1978, Fløysand and Jakobsen, 2001, Fløysand and Lindkvist, 2001, Fløysand and Sjøholt, 2007), i.e. 'structure', Paper #1 also shows that during transformation processes the agency and practices of actors (e.g. engineers) can stimulate the creation of new networks, 'renew' fields with new meaning content, or lead actors to go into fields which are 'new to them'.

Studying an emerging and ongoing green transformation is studying a phenomenon that is changing over time. With regard to critical realism-based research, a methodological implication is that in order to uncover the 'real', one should study a phenomenon over time e.g. through 'retroduction' (Castellacci, 2006). This can help in teasing out which processes or mechanisms are necessary and which are contingent. In this dissertation I operated with a preconception that necessary conditions for green transformation were those of an interplay between materiality, organisation and discourse. However, based on the various papers, I argue

that multi-level and multi-scalar dynamics, as well as intentional institutional change processes, such as various forms of institutional agency that connect agency (bottom-up) and structure (top-down) dynamics, can also be perceived as necessary conditions for green transformation to occur. However, how these necessary conditions play out is contingent on practice in different territorial contexts. These practices can be e.g. either economic, technological or institutional, but will be embedded in territorial capabilities.

Policy development and policy recommendations – With regard to policy development and policy recommendations, the papers in this dissertation, particularly Paper #3 and 4, show that policy and regulations can aid in shaping green maritime industrial transformation. However, in line with criticisms of a 'one size fits all' approach to cluster policy (Uyarra and Ramlogan, 2017), Paper #3 shows that applying cluster policies (e.g. stimulating to increased networking etc.) in itself is not enough if the desired outcome is greening of industrial clusters—due to the different clusters' various trinity dynamics. Rather, one should recognise that a 'policy mix' is needed. Paper #4 also argues for a 'policy mix' and that policies advantageous for green industrial path creation should follow a 'bricolage policy strategy'. Thus, more than e.g. stimulating cluster policy, successful greening of the maritime industry also requires policies connected to public procurement and financing demonstration projects—which, like especially Paper #2 shows, have proven very important for stimulating to concrete technological innovation in the Western Norwegian maritime industry. How, exactly, these should be put together to provide an 'optimal route' in green transformation processes in the maritime industry remains an empirical question beyond the scope of this dissertation. That being said, the existence and application of a 'mix of policies' should not be seen purely as 'preexisting factors'. Indeed, the dissertation finds—connected to the theoretical contributions of the dissertation—that actors and demonstration projects have significantly contributed to altering public policy, in particular with regard to public procurement in the ferry sector. Moreover, the empirical investigation shows that green transformations can be governed quite directly through such public procurement. Thus, more than public procurement having a direct environmental effect in that it reduces emissions, the investigation has also shown that it is good innovation policy (Uyarra et al., 2019). The lesson from Ampere shows, for example, that setting 'technology neutral' demands will allow for industries to come up with the best solutions to societal problems (e.g. environmental challenges), while simultaneously ensuring that firms and industries remain economically competitive. Finally, and reflecting the above discussion on regional industrial co-evolutionary dynamics, future green regional policies (related to

development, innovation etc.) should take into account that the maritime industry seems to have a positive, and growing, influence on green transformation in other regional industries, particularly when it comes to battery development. Thus, future policies should aim to strengthen co-evolutionary dynamics, e.g. through stimulating to more crossover innovation between industries or industrial clusters. This can e.g. relate to stimulating to more cooperation between the regional maritime industry and the power and utility sector and material technology firms (e.g. aluminium producers), which the maritime industry has already established several interesting collaboration projects with.

6. Concluding discussion and directions for future research

This dissertation has contributed empirically to our understanding of the greening of the maritime industry in Western Norway, but has also contributed to theory development along several lines within EEG, TS and IEW. It has engaged with three areas of engagement debated within these frameworks; how to explain questions of intentional institutional change (agency and practice) in green maritime industrial transformation processes (drawing particularly on IEW); 2) how green maritime industrial transformation processes are embedded in territorial contexts and affected by multi-scalar dynamics (drawing particularly on EEG); and 3) how green maritime industrial transformation must be seen as an outcome of dynamically interacting material, organisational and discursive processes (drawing particularly on TS). Moreover, it has specifically argued for a new analytical framework, integrating EEG, TS and IEW, which emphasises *multi-actors and institutional change, territoriality and multi-scalarity, and multi-dimensionality—and the interplay between these elements.* Thus, while several scholars within both EEG and TS, or scholars already working on bridging these frameworks (e.g. Boschma et al., 2017), have dealt with the abovementioned 'areas of engagements' in isolation or as affecting each other, I still argue that a theoretical novelty with this dissertation is to see them as more thoroughly connected or integrated through an emphasis on institutional agency. Including an IEW perspective has therefore been of key importance. Moreover, empirically, the dissertation is engaging with studying an industry that so far has escaped academic attention in social sciences when it comes to processes of green transformation—though, as shown, there are a few exceptions with regard to the national level (e.g. Bergek et al., 2018, Steen, 2018, Steen et al., 2019). At the same time, studying the green transformation of the maritime industry in Western Norway provides for a very interesting case to study with regard to integrating multi-actors and institutional agency, territoriality and multi-scalarity and multi-dimensionality, and, thus, theory building with regard to this.

There are some limitations with the dissertation. However, this is natural due to the sheer complexity of what it takes to understand and map out a complete green maritime regional transformation, affected by a myriad of social and material processes also at the national and international level. For example, ownership of the new charging infrastructure, which at present differ from county to county (see Almestad and Pettersen, 2019), standardisation of charging technology, and the 'rule regime' within the Norwegian maritime sector (in order to use the new battery technology in Norwegian waters, a new rule framework had to be made), are all important issues. These themes were touched upon in the interviews, but have not been

explicitly addressed in the papers. A final point, relating to future studies of green transformation in the maritime sector, is to make comparisons with other similar cases or contexts (of which there are, however, not too many at the moment, hence the motivation for studying this particular context).

Although the dissertation has sought to understand and explain green maritime industrial transformation in Western Norway, I argue that the empirical findings also have wider implications for the expanding Norwegian 'electricity regime'. This overarching regime has historically included the Norwegian energy system which is based more or less completely on renewable hydroelectric power, but which is increasingly focused on further expansion into offshore wind and solar energy, as well as grid upgrading. This development is taking place partly in order to cater to increased demand for electricity in the Norwegian transport sector, e.g. the car fleet (directly as energy source) and ship fleet (directly as energy source, but also as an input factor in clean hydrogen production). Moreover, both of these transport sectors in Norway are global spearheads with regard to electrification (see e.g. Fagerberg et al., 2016 for a description of the diffusion of electrical cars in Norway). Thus, future research on the green transformation of the maritime industry should look into how e.g. the electrification of the maritime sector (batteries and charging technology) interact with other transport sectors, but also for example the housing sector (e.g. new remote off-grid storage solutions) and the building sector. It must also focus more on how clean technologies interact with each other, e.g. how maritime battery technology can be complementary to maritime hydrogen technology (Steen et al., 2019). Another important point with regard to future studies seeking to merge EEG and TS relates to focusing on 'natural endowments or physical resources' as an important factor for green growth (Capasso et al., 2019), e.g. related to *clean* electricity- and hydrogen production (which Western Norway can exploit due to a fully hydroelectric power regime). These resources and associated technologies can give certain regions comparative advantages if coupled with the rights skills and knowledge that can exploit them. Moreover, clean electricity and hydrogen do not merely provide the foundation for the greening of a whole range of industries and transport systems (demand side), but also show high promise as export products (Menon Economics, 2019a). As such, electrification provides the basis for future regional green growth in a range of regional industries, but can also directly and indirectly (by being 'converted' to clean hydrogen) create new global export industries.

As such, the green transformation in the Western Norwegian maritime industry can potentially have vast implications for other regional, industrial and technological development

processes. This makes it an interesting and important case beyond the case itself. Still, as shown in this dissertation, the green and ongoing transformation must be read as a true example of sustainable regional industrial development, capable of solving 'grand challenges' or 'wicked problems' *and* sustain economic development in the regional maritime industry (which potentially can have quite positive implications for other regional industries in the years to come). Regional actors have seized opportunities presented by global technological development processes and successfully integrated them with regional and industrial competence and knowledge. In so doing, engineers, in alliance with other actors, have come up with and promoted technological solutions that have heavy implications for regional economic growth and development. Of course, industry actors have not done this for 'idealistic' reasons. Rather, regionally visionary firms and individuals (including several engineers) perceived that national and supra-national regulations (e.g. in IMO) demanding greener technologies would come into being, and thus sought to position the region for this change. This, *combined* with strong identified regional capabilities with regard to power and automation processes and risk-taking shipping companies, has been important. Specifically, these regional capabilities have been very compatible with maritime battery integration or application processes, as well as with that of fuel-cell technologies. As such, both willingness from firms (in particular shipping companies) to take risks, and technological territorial pre-conditions, combined with new and green public procurement demands and other top-down regulations—which still have been lobbied for 'bottom-up' by regional actors—have provided the basis for e.g. the emergence of a regional maritime cleantech cluster focusing on network building, lobbying and demonstration projects (see also Holmen and Fosse, 2017). The materialisation of demonstration projects coupled with processes of green clustering have thus shown concrete examples of innovations that simultaneously can contribute to saving the environment *and* simultaneously providing both new green work places and economic growth opportunities for the regional maritime industry. Overall, this explains why the green maritime regional transformation which has been at the core of the dissertation, is taking place in this region and not elsewhere.

7. References

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