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Barriers to path creation: The case of offshore wind power in Norway

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Abstract

Although economic geography has made considerable progress in explaining the emergence of new industrial development paths, a number of issues have yet to be sufficiently explored. The purpose of the article is to contribute to economic geography research on path creation by developing a conceptual framework that specifies key conditions and reinforcing mechanisms for path creation on the one hand, and barriers to the materialization of such conditions and mechanisms on the other hand. As such, the framework moves beyond firm-centric perspectives and argues that path creation needs to be understood as a collective endeavor incorporating both firm and non-firm actors. By implication, this necessitates an understanding of the broader contexts that shape path creation processes, including how the dynamics of an emerging path are affected by the dynamics of established paths. The authors employ this framework to analyze Norway's offshore wind power (OWP) industry. Their analysis reveals that an initial enabling context for OWP path creation turned into more constrained conditions. Similar to findings from a number of other studies, they identify branching between related sectors as a primary path creation mechanism. However, they find that this mechanism is vulnerable to shifting contextual conditions, which for various reasons resulted in the studied emerging path losing resources and legitimacy, thus implying potential negative path interdependence. The authors also identify barriers to path creation in the institutional environment, particularly in terms of lack of policy coherence in support for key resource formation processes that are pivotal for path creation processes to generate sustained momentum.

Key words: Path creation, Policy, Offshore wind power, Path interdependencies, Branching, Path dependence

In recent years, economic geographers have moved away from a constraining view of path dependence to explore how existing industries and regional economies evolve dynamically along more or less stable trajectories as well how new paths emerge (Martin and Sunley 2006; Martin 2010; Simmie 2012). An important idea regarding the latter, most prominently spelled out by proponents of evolutionary economic geography (EEG), is that new paths are latent in established paths, and are created through branching processes, whereby knowledge and other resources are transferred into new, technologically related sectors (Boschma and Frenken 2011). However, path creation, which in the present article refers specifically to new industrial development paths, is shaped by factors and processes that extend far beyond the firm dynamics of knowledge creation and diffusion emphasized in EEG (Garud and Karnøe 2003; Martin and Sunley 2010; Dawley 2014; Tanner 2014; Binz, Truffer, and Coenen 2016). Just as there are numerous sources of path dependence, there are multiple mechanisms for new path creation (Martin and Sunley 2006; Boschma et al. 2017), and many questions regarding the interplay of these constraining and enabling sources and forces have yet to be sufficiently explored (Martin and Sunley 2010; Simmie 2012). In other words, it is far from clear how (i.e., through what kinds of mechanisms) and when (i.e. under what conditions) new industrial paths are created (Binz, Truffer, and Coenen 2016).

In order to gain a better understanding of the broader processes, mechanisms and institutional contexts that shape path creation, empirical research, and theorizing must move beyond firm-centered accounts to include also the role of non-firm actors. As such, we make two important contributions. First, and expanding on the work of Martin (2010), Simmie (2012), and Binz, Truffer, and Coenen (2016), our framework explicitly outlines the conditions and reinforcing mechanisms that are necessary for path creation beyond early exploration and experimentation. These rely on key resource formation processes that generate and stimulate market development, knowledge generation, financial and human resource mobilization, and legitimacy (Binz, Truffer, and Coenen 2016). The critical aspect is that these mechanisms stimulate and feed on each other to create virtuous circles of development. However, few studies have explored the barriers to these self-reinforcing mechanisms.

Second, we contribute to understanding how path creation is potentially enabled or constrained by past trajectories, implying that these constitute part of the context in which new paths emerge (Martin 2010). As noted by Martin and Sunley (2010), there has been a dearth of research on how different paths are interconnected and the implications of change in one path for another, such as by spurring or hindering branching mechanisms, the latter being a topic that has not been addressed within this debate to date. Whereas it is well-established that branching is an important path -creation mechanism, we suggest that branching may also render emerging sectors vulnerable to the dynamics of established paths from which branching occurs. Connected to but beyond such firm dynamics, alternating activity levels in established paths may have both positive and negative effects on social legitimacy and policy support for new paths. Hence, in addressing the understudied topic of path interdependencies, our framework adds explanatory elements to how cross-sectoral dynamics may enable but also constrain reinforcing mechanisms associated with path creation.

We employ this framework to analyze the development of an offshore wind power (OWP) industry in Norway from the early 2000s to the end of 2013. In order to unravel the complexities of path-creation processes and mechanisms we employed a mixed-methods research design in which the emphasis was on the value of cotemporaneous qualitative approaches to understanding such multidimensional phenomena. This case and our methodological approach are well suited to illustrate the values of our analytical framework. In the mid- to late 2000s, OWP emerged as a potential new “industrial adventure” in Norway, and was specifically portrayed as a branching opportunity for the oil and gas (O&G) industry that was going through a downturn at the time. Our analysis reveals that an early enabling path creation phase was supplanted by a more constraining context wherein necessary reinforcement mechanisms associated with path development (Martin 2010) did not gain hold, and by 2013 considerable momentum was lost in the OWP path. Against this background, the main research question that guides our analysis is: What hindered path-creation processes in the Norwegian OWP sector?

In the next section, we discuss perspectives on path creation and develop our analytical framework. Thereafter, we describe our research design and data. This is followed by a section in which we introduce the empirical field and present an account of the initial enabling phase of the Norwegian OWP path. In the penultimate section, we analyze different barriers to this new industrial development path. Finally, we present our overall conclusions and discuss their wider implications.

Towards a Path-as-Process Perspective

The canonical version of path dependence theory stemming from evolutionary economics and the history of technology has been highly influential in economic geography due to its analytical value in accounting for the more or less stable development trajectories of technologies, institutions, industries, and regions (Martin and Sunley 2010). However, a critical discussion has come to the fore in recent years because canonical path dependence theory's emphasis on equilibrium and lock-in fails to provide explanatory power for changes in existing paths as well as for the emergence of new industrial development paths (Martin 2010). Recent contributions to the path debate in economic geography and elsewhere, such as Martin and Sunley's (2006) path-as-process perspective and Simmie's (2012) hybrid socio-technical theory of path creation, go beyond ideas of lock-in and equilibria to explore how path evolution is shaped by the interplay of stabilizing and change inducing mechanisms that are played out in specific spatio-historic contexts. Another middle-ground perspective is that of path plasticity (Strambach 2010), which suggests that paths are not coherent in themselves but are open to a range of possibilities (innovations) due to the elastic stretch of institutions and the interpretative flexibility of actors. In turn, both the above-mentioned and other contributions have spurred a lively debate on how path evolution involves a number of possible trajectories of change, such as Isaksen's (2014) distinction between processes of path renewal, reorientation, exhaustion, and creation.

The notion of path creation is arguably a somewhat fuzzy concept. Following Binz, Truffer, and Coenen (2016, 177), we define a new industrial development path as a set of functionally related firms and supportive actors and institutions that are established and legitimized beyond emergence, and are facing early stages of growth and developing new processes and products. In developing our framework, in the following subsections we review key arguments in the path evolution literature and discuss key conditions for and barriers to new industrial development trajectories, particularly those related to complex and path-dependent sectors.

Sources of Path Dependence and Path Creation

Whereas canonical path dependence theory explains novelties as arising from chance or serendipity, Garud and Karnøe's (2001) important contribution was to counter this perspective by arguing that new paths are launched by entrepreneurs and other actors who strategically and mindfully deviate from established paths. Consequently, this "provides a much wider range of possible cases of new path creation … both in terms of whether past trajectories are enabling or constraining and in terms of whether origins are intended and deliberate or accidental" (Martin and Sunley 2010, 79).

Whether contexts are enabling or constraining for path creation is contingent on a host of factors, such as variation in firm ecologies, absorptive capacities, innovativeness, entrepreneurial culture, asset availability, market opportunities, and institutional environments (Martin and Sunley 2010). In this sense, context should be seen as a relational phenomenon constituted by scales, locales, flows, and connections that transcend territorial boundaries (Murphy 2015). This understanding is reflected in Martin and Sunley's (2006) discussion of various sources of path dependence (i.e., constraints to path creation) in a territorial economy, which in addition to location-specific factors (e.g., natural resources, sunk costs of local assets and infrastructures, external economies of industrial specialization, institutions, economics of agglomeration) incorporate interregional linkages and interdependencies.

In his model of path dependent industrial evolution, Martin (2010) distinguishes between a first preformation phase constituted by the pre-existent economic and technological conditions, a second path creation phase with experimentation and competition by various actors leading to path emergence, and a third path development phase wherein increasing returns and network externalities assist path development. Thereafter, a path may continue to evolve dynamically or become rigidified and prone to lock-in. This will be contingent on whether the environment constrains or enables the emergence and development of new paths.

Different types of pressures or disruptions can lead to negative path dependence (Martin and Sunley 2006), as witnessed in numerous old industrial regions that fail to deviate from established paths (Hassink 2005), but such factors may also trigger the initiation of new paths. EEG has in particular focused on branching as a key mechanism of path creation. According to Boschma and Frenken (2011), branching occurs either by a new path growing out of an old path or as a result of a recombination of knowledge and resources from different established paths. The underpinning logic of branching is that firms move into industries that are based on similar resources and/or capabilities and are hence technologically related (Neffke, Henning, and Boschma 2011). In practical terms, branching occurs through firm diversification, labor mobility, social networking, and entrepreneurial activities (e.g., spin-offs, start-ups). Because many of these branching mechanisms play out locally, path creation tends to have a strong local bias.

However, the branching perspective has been contested. For example, Tanner (2014) argues that the mechanisms through which branching occurs are rather unclear, whereas Bugge and Øiestad (2014) question how different branching mechanisms result in knowledge transfer to new application domains, and how old and new knowledge sources are combined in this process. Binz, Truffer, and Coenen (2016) argue that the emphasis on territorially-specific generic resources (primarily technological knowledge) undermines the importance of translocal linkages and extralocal resource mobilization. Furthermore, the branching perspective has been criticized for focusing on firm and industry dynamics at the expense of other actors and contextual factors. These include universities and research institutions that may allocate resources to emerging technological fields or function as breeding grounds for entrepreneurial activities (Tanner 2014), and policy makers or public/quasi-state actors who may facilitate or hinder path creation mechanisms from being played out (Dawley 2014).

Institutional environments and policies that facilitate and support innovation and change are particularly important for highly regulated and relatively rigid sectors such as energy, as evidenced in the rapidly expanding literature on sustainability transitions (Murphy 2015). This is because new industrial development paths based on novel energy technologies "emerge into a complex landscape of historical path-dependent development which themselves may possibly provide significant barriers to that emergence" (Simmie 2012, 756), thus pointing to the importance of institutional change for both path creation and path renewal processes (Boschma and Frenken 2009). Based on this broader discussion, Boschma et al. (2017) suggest a four-fold typology of regional diversification. In this typology, diversification within or into an established sector (regime) is classified as replication or transplantation, depending on whether the diversification is related to the knowledge base of the region. The creation of new niches is termed exaptation or saltation, depending on the niches' relatedness to existing experience and knowledge in the region. For example, exaptation refers to a diversification trajectory on which a region creates niches in new sectors based on its existing knowledge, reflecting how institutions and resources that developed in an industry can be critical causes of and inputs to new industries, and thus creating "dependence between successive paths" (Martin and Sunley 2006, 427).

The development trajectories of industries in a given territorial setting are likely to influence each other to greater or lesser extent and may thus be path-interdependent (Martin and Sunley 2006). This relationship could be positive for the development of either some actors or the entire sector, for instance through knowledge spillovers, complementary input-output linkages or shared externalities. However, such interdependencies may also create barriers to new path creation, for example if there is competition over key resources such as finance, skilled labor, or political legitimacy. In other words, interdependencies should be seen as part of the path creation context and may have a direct influence on path creation processes.

Key Conditions and Barriers to Path Creation in the Energy System

There is general agreement that some form of disruption or triggering event is necessary for a new industrial development path to be initiated (Simmie 2012). As discussed in the preceding subsection, such triggering events for path creation most often involve a mix of chance and intentional agency (Martin and Sunley 2010). However, regardless of initiating factors, development beyond early path creation formation phases relies on self-reinforcing mechanisms that cumulatively stimulate entrepreneurial activities, innovation, and growth.

The socio-technical transitions literature (see Markard, Raven, and Truffer 2012 for an overview) is particularly informative in suggesting key conditions that must be met for new paths to emerge in capital-intensive and highly complex sectors such as energy (Simmie 2012; Murphy 2015). Conversely, these key conditions can be seen as critical for overcoming barriers to path creation. Three prominent problems confront new renewable energy (NRE) technologies (Geels, Hekkert, and Jacobsson 2008). First, NREs face cost disadvantages in the economic selection environment. Second, the development of NREs is fraught with uncertainties, which may prevent commitment from actors in terms of investing in, for example, innovation, commercialization, or production equipment. Third, and as suggested in the preceding subsection, path dependence due to sunk costs, economies of scale, and network externalities arising from systemic relations between technologies, infrastructures, institutions, and interdependent producers and users in existing energy systems is a key challenge that needs to be overcome. Within established industries, knowledge generation and innovation tends to be incremental and reinforce existing paths, and according to the sustainability transitions literature established actors will tend to attempt to preserve status quo. However, more recent contributions have started to question this assumption and have demonstrated that incumbent actors may initiate activities in new technological fields such as wind or solar energy (Steen and Weaver 2017). Reconnecting with the path-as-process perspective employed in this article, this suggests that also within highly path dependent sectors such as energy, new (sustainable) paths may be developed on the basis of knowledge, infrastructure and other resources from established (unsustainable) paths.

Drawing on the technological innovation systems approach (e.g., Bergek et al. 2008), Binz, Truffer, and Coenen (2016) suggest that four key resources are necessary for path creation: knowledge, niche markets, financial investments, and legitimacy. Knowledge generation is a key aspect of new path creation, and, following Garud and Karnøe (2003), we consider the nature of actor involvement as particularly important in this regard. Garud and Karnøe (2003) suggest that path creation relies on collective action rather than individual efforts, and they distinguish between a bricolage mode of technology entrepreneurship and a breakthrough mode of technology entrepreneurship. Their analysis of the development of the Danish and US wind energy turbine industries showed substantial differences in how different actors (e.g., producers, users, evaluators, and regulators) became involved in the respective paths. In Denmark, hands-on involvement of heterogeneous firm actors and non-firm actors supported multiple reinforcing learning processes that fostered incremental innovation and a steady build-up of knowledge and relations through a bricolage approach based on available resources. In the US, actors were more hands-off and episodically involved, and the attempt to achieve a breakthrough development in terms of large and high capacity wind energy turbines failed.

A similar conceptual dichotomy to bricolage and breakthrough exists in the debate on innovation modes, which distinguishes between a DUI (doing, using, interacting) and an STI (science, technology, innovation) mode of innovation. DUI refers to experience-based learning processes typically associated with ongoing incremental innovation value-chain based interaction involving both firms and other actors, often in informal ways. STI learning processes to larger extent involve R&D (research and development) departments in firms, academic institutions and more formal top-down strategies (Berg Jensen et al. 2007), and tend to be more oriented towards radical (breakthrough) innovation. However, a limitation is that commercial application of radical innovations often depends on capabilities that are developed through user-producer interaction, practice, and hands-on experience (Herstad and Brekke 2012). Research suggests that DUI and STI modes of innovation ought to be seen as complimentary and thus reconciled in innovation strategies and policies (Berg Jensen et al. 2007; Herstad and Brekke 2012). However, there is no blueprint for this; the appropriate mix of DUI and STI would be contingent on factors such as technology in scope, capabilities needed for development, and market dynamics. Huenteler et al. (2016) suggest that in the wind energy industry, which is characterized by a complex-product architecture rather than mass production, interactive learning-by-using processes are key to innovation. This has the important implication that firms benefit from a local market.

Government incentives to stimulate market formation and knowledge generation have been crucial for speeding up development and deployment in leading NRE countries such as Germany and Denmark. These support policies are motivated and legitimized by a need for increased renewable energy production (to reduce greenhouse gas emissions), but also by a desire for green growth, enhanced energy security, and reduced import dependency. In early phases of development, policy-supported niche markets provide commercial opportunities for new technologies and facilitate the development of different designs, value chain development, and upscaling of production capacities protected from the constraints of selection mechanisms, performance standards, and infrastructural rigidities of established systems (Simmie 2012; Smith and Raven 2012). This stimulates the formation of key resources and contributes to reducing uncertainty and information asymmetry among actors involved in the cocreation of new technologies, markets, and institutions. Involvement in niches can also support the development of collective expectations, which is a largely overlooked aspect of the reinforcing mechanisms associated with path creation (Steen 2016). Expectations and visions not only describe potential future technologies but can also be generative by contributing to resources mobilization (Borup et al. 2006) and the creation of legitimacy whereby a new industry is aligned with regulative, normative, and cognitive institutions (Binz, Truffer, and Coenen 2016). However, expectations that are not met may result in loss of legitimacy and withdrawal of resources and commitment, with potentially highly detrimental effects on the momentum of a new technological field or sector (Borup et al. 2006).

Summary of Conceptual Framework

Our conceptual framework is based on key insights from the EEG and socio-technical transitions literature, and is employed in our analysis to explore the formation of four key resources (knowledge, market, resources, and legitimacy) that are crucial for generating the reinforcing mechanisms necessary for path development beyond an early emergence phase. The literature review presented above suggests that path creation mechanisms need to be seen in relation to context. Given that our empirical case is within the energy sector, we argue that key enabling/constraining contextual factors can be linked to three themes: market and framework conditions, knowledge generation and innovation dynamics, and path interdependencies. Because path creation is a result of various self-reinforcing mechanisms (i.e., it must be understood as contingent on collective agency), we pay particular attention to whether different private and public initiatives contribute to a coherent momentum, notably in the form of interactive knowledge generation and resource mobilization. Finally, and reflecting on the prominent role of branching as a path creation mechanism in EEG, our analysis explicitly addresses path interdependencies by analyzing how dynamics in established paths (e.g., from where branching originates) impacts positively or negatively on resource formation for the emerging path, which is in focus in this article.

Methodology and Data

This theoretically informed case study of the Norwegian OWP industry is based on both quantitative and qualitative methods, with emphasis on the latter. Triangulation of various methods and sources was done in order to provide a robust and comprehensive account of the OWP path in Norway. Transcribed data from seventy-five interviews form the core of our empirical material. Most of our informants were firms' CEOs (chief executive officers) and CFOs (chief financial officers), but we also interviewed a number of key personnel in cluster organizations, large OWP research centers, and public-private business development agencies (see Table 1). The limited size of the Norwegian OWP industry allowed us to maintain a good overview of actors, activities, and initiatives (both on firm and non-firm/multifirm levels) over the course of the period covered in our analysis. In-depth semistructured interviews provided information and viewpoints on firms/organizations' historic backgrounds, OWP activities and strategies, the role of networks and partnerships, motivations and perspectives on future opportunities, and innovation and R&D collaboration, as well as managerial perspectives on policy support, incentive schemes, and framework conditions.

Table 1

List of Interviewed Firms/Organizations

Firm/Organization Type	Firms
Diversified O&G sector firms (20 firms, 24 interviews)	AF Group, Aibel, CCB, Draca, Dr. Techn. Olav Olsen, Grieg Group, Ingenium, Inocean, Kongsberg Maritime, Kværner Jacket Technology, Kværner Piping Technology, Kværner Verdal, MasterMarine, Nexans, Odjell Drilling, Rosenberg, SmartMotor, Statoil, Troll (Goodtech), Vitec.
Specialized OW firms (11 firms, 14 interviews)	Inwind, Norwind, OWEC, Seatower, Siragrunnen Offshore, Sway, Vestavind Offshore, Vici Ventus Construction, Vici Ventus Technology, Windcarrier, WindSea,
Other firms/organizations (32 firms, 37 interviews)	Wind/renewable energy firms (9), utilities (4), multi-industry supply firms (4), seed/venture capital firms (8), support organizations/R&D (7)

The majority of these interviews were conducted in the period September 2010 to December 2011 (the last interview was conducted in 2014). Key informants in INTPOW and

Windcluster Norway were interviewed both early on and in the latter phases of the research process. Additionally, multiple attendances at various industry/science events in the period 2010–14 enabled us to stay updated also on topics such as research projects and policy discussions.

The events were organized at both national and regional levels. Presentations by (and discussions between) firm managers, researchers, and government officials at these events were important for our understanding of key resource formation processes and contextual issues. Our grasp of innovation activities and knowledge generation benefitted especially from our attendances at numerous science-meets-industry seminars that were jointly organized by a cluster organization and an OWP research network. These events also gave us the opportunity to engage in informal conversations with various stakeholders. Our analysis included archival event data (presentations and slides) and key energy policy documents. We also searched various media archives to identify, for example, firm start-ups, policy statements and debates, regulation changes, initiation of new R&D programs, and the awarding of contracts.

Building on document analysis and initial interviews, we conducted an online survey (between December 2010 and January 2011) of firms deemed active in the OWP sector. Our sample (325 firms) was drawn from two OWP cluster initiatives (Arena NOW and Windcluster Mid-Norway), the Norwegian NRE association (Norwea), and a petroleum supplier network (Navitas), which in 2009 extended its scope to include maritime renewables. The survey was completed by 147 firms (response rate = 45 percent), of which 94 firms reported having OWP activities, ranging from multiple sales in the market to concept studies. Our aims with the survey were to gain information about firm types, supply chain position(s), market orientation, networking, strategies for knowledge sourcing, strategic importance, and motivations and barriers associated with activities in OWP.

The Emergence of Offshore Wind Power

Northern European countries pioneered the development of OWP, with the world’s first OWP farm opened in Denmark in 1991. In the year 2000, the total installed OWP capacity in Europe was 36 MW. By 2005 this had reached 712 MW, and thereafter growth accelerated to the extent that more than 6500 MW was grid connected in Europe by the end of 2013 (EWEA 2014). Production capacity is set to surge towards 2020, particularly in the UK and Germany. This growth has been driven by policy goals to reduce greenhouse gas emissions, enhance energy security, and facilitate "green growth," and is supported by targeted and technology-specific subsidies linked to domestic energy production. The OWP industry is nonetheless associated with uncertainty and multiple challenges regarding technology, future costs and revenues, legal frameworks, time horizons, and designs for public support schemes (EWEA 2013). Continued public support of market formation and technological development is regarded as crucial to lowering costs to a level at which OWP can compete with more mature energy technologies (Jacobsson and Karltorp 2013).

Developing large-scale commercial OWP demands a complex value chain that incorporates a multitude of components and services (Lema et al. 2011). This high amount of subsystems and components and their interactions implies that OWP constitutes a complex-product technology wherein innovation processes depend to considerable extent on iterations and interactive learning-by-using processes (Huenteler et al. 2016). The OWP industry is largely based on engineering knowledge (Wieczorek et al. 2013), reflecting how this industry is a result of recombinations of (adapted) capabilities from various established industries such as onshore wind energy, maritime construction, and offshore O&G (Markard and Petersen 2009; Dawley 2014).

Despite vast potential for OWP (NVE 2012), Norway is the only North Sea country without a commercial OWP farm. Due to large hydropower resources, which in most years exceeds domestic onshore electricity demand, the utilization of other energy sources for electricity production has been marginal, and the drivers for developing NREs in Norway are relatively weak compared with other European countries (Hanson, Kasa, and Wicken 2011). However, OWP has been framed as an almost natural, new industrial opportunity, especially for Norway's large offshore O&G sector (Hansen and Steen 2015). Besides large state revenues (in 2010 approximately 25 percent of state income derived from direct taxes and state-owned assets in the O&G sector), O&G activities have given rise to a highly competent and internationalized offshore supplier industry (MPE 2012). O&G is a politically powerful sector in Norway and there is broad political agreement for continued O&G exploration and production. The framing of OWP as a branching opportunity for O&G sector firms must be seen in light of the trend in the European OWP market, which started around the end of 2008 and the beginning of 2009 with larger turbines being deployed in greater quantities in deeper waters located farther from shore, which in turn created the demand for specialized offshore capabilities and increased financial and industrial capacities (Markard and Petersen 2009; EWEA 2014). This branching out also reflected uncertain outlooks for the O&G sector, a topic that we elaborate upon in the empirical sections that follow. First, we present a condensed narrative of the largely enabling early path creation phase of OWP in Norway, before analyzing why some of this momentum was lost.

Preformation, Path Creation, and Early Path Development (2000–2011)

A few Norwegian supplier firms have been involved in the OWP industry since the early 1990s. More substantial activity levels were seen in the beginning of the 2000s, when O&G operators together with specialized suppliers conducted concept and feasibility studies of the use of OWP for energy supplies to offshore O&G installations. Specialized OWP supplier firms (start-ups and spin-offs) were established in this period, as were the first plans for an OWP farm in Norwegian waters. Around the year 2005, when market take-off in proximate European waters provided more substantial business opportunities, a number of larger firms (notably offshore O&G suppliers) entered OWP.

In 2007, a government-appointed Energy Council (Energirådet 2008) evaluated OWP as a potential industrial target area and concluded that Norwegian industry should have comparative advantages in developing and supplying products and services to this emerging market. The council's report also recommended that Norway should nurture a domestic market and aim to generate approximately 20 TWh from domestic OWP farms by 2020–25, and thereby support a new export-oriented industry for both power and technology. Utility companies seeking to expand their portfolio of productive assets responded, and by 2008, plans for a number of OWP farms were being made. In explaining and legitimizing these planned investments, the utility companies (primarily public owned) stressed the value of both clean energy and new market opportunities for the Norwegian supplier industry. Various incumbent and entrepreneurial firms became involved in feasibility and concept studies for these OWP projects, implying resource mobilization, and knowledge generation to the budding path.

Events both at home and abroad contributed to a surge in interest for OWP in 2009 and 2010. In 2009, Statoil deployed the world's first full-scale floating wind turbine (Hywind) with financial support from state agency Enova. In the same year, Norway's two major energy companies, Statoil (O&G) and Statkraft (power utility), became joint owners of the license to develop the large Sheringham Shoal OWP project in the UK, while specialized and diversified supplier firms were involved in developing Alpha Ventus, Germany's first OWP farm. In January 2010, Statoil and Statkraft, as part of the Forewind consortium, were granted the license to develop Dogger Bank, the largest zone in the UK's third OWP licensing round. Firms involved in OWP were generally optimistic about the opportunities in proximate European markets that were witnessing strong growth at the time, and some also explored OWP opportunities in China, Japan, the US, and elsewhere. One of our informants (CEO, specialized OWP supplier firm, 2010) stated "we are certain that this will be big!"

In our 2010–11 survey, seventy-seven of the ninety-four responding firms with activity in OWP had diversified from offshore O&G, which implied branching (Boschma and Frenken 2011) as a primary path creation mechanism. The seventeen specialized OWP firms (mainly suppliers) were generally small and young. Of the seventy-seven diversifiers, twenty-eight characterized OWP as a "supplement to main activity," while forty-one labeled OWP "a future target area," thus reflecting expectations that OWP would increase in importance. These firms comprised both OWP farm developers as well as a heterogeneous set of product and service suppliers along multiple segments of the complex OWP value chain (Lema et al. 2011), albeit with a notable dominance of firms involved in subsea equipment (e.g., foundations, cables) and installation services.

Both planned domestic OWP farms' and existing Norwegian firms' involvement in international markets bolstered awareness of the opportunities in OWP, especially within the O&G industry, which had a dismal outlook at the time. Low oil prices due to decreasing world energy demand caused by the international financial crisis (2008–2009) came on top of a decade of uncertainties regarding the future of O&G activities on the Norwegian continental shelf (NCS). Since the oil production peak on the NCS in the year 2000, no major new resource discoveries had been made, and the O&G path was framed as becoming exhausted. In a lively debate on the need for diversification in Norway's highly oil-dependent economy and the importance of both contributing to and developing new economic activity in NRE technologies, OWP appeared to be a highly relevant business opportunity in the renewable energy field for many actors in the O&G industry. Diversification from the established path was thus to a large extent based on expectations of continued decline in O&G, thus also reflecting how resource mobilization to a new path may be triggered by stagnation or crisis (Martin and Sunley 2006), and a promising future in OWP.

On the policy side, a number of policy measures were introduced to stimulate the development of renewable energy industries in 2009. The state supported the establishment of two cluster initiatives comprising various firms, both of which were explicitly aimed to develop OWP industry capabilities on the basis of experiences from the offshore O&G, maritime, and power sectors. The O&G market decline was an important catalyst for these cluster initiatives, which can be seen as regional expressions of green growth opportunity seeking. The Research Council of Norway established a substantial R&D scheme for renewable energy, and provided funding for two large Centres for Environment-friendly Energy Research (CEERs) on OWP. A regulatory framework for maritime renewable energy production was introduced in the same year, and provided the necessary legal framework for domestic OWP farms. When presenting the new Act, the Minister of Oil and Energy at the time (Terje Riis-Johansen) stated "offshore wind has the potential to become our next industrial adventure." Also in 2009, the Havsul project received the first license to develop a commercial OWP farm in Norway, and the public/private partnership organization INTPOW was established to promote internationalization of Norwegian renewable energy industries, with OWP as a target area.

Enabling Path Creation?

Thus far, we have suggested that the context for OWP path creation in Norway was largely enabling (Martin 2010) during the pre-formation and early path creation phases in the first decade of the 2000s. These early phases culminated in various public and private initiatives in 2009–2010 that contributed to substantial resource mobilization and a positive outlook on the prospects for OWP in Norway. It is important to note that a wide variety of large and small firms from the offshore O&G, maritime (construction, logistics, engineering), and utility sectors became involved in OWP. Both diversifying established firms and specialized start-ups largely built on formerly developed capabilities and adapted them to OWP. As such, the main path creation mechanism was diversification (Martin and Sunley 2006) or branching (Boschma and Frenken 2011), particularly from the offshore O&G sector, and thus constituted a case of exaptation (Boschma et al. 2017) in terms of the relationship between regimes and the emerging niche.

The interdependence between established and emerging paths was also evident in policy rationales for supporting OWP in Norway. This meant that reutilizing existing assets via recombinatory innovation to enable the build-up of an export-oriented supplier industry was the core idea underpinning state support for OWP, rather than ambitions of large-scale deployment of OWP turbines such as in Germany or the UK, and thus reflected Norway's limited need for a sustainable transformation (Geels, Hekkert, and Jacobsson 2008) of its electricity sector. Put differently, and recalling the somewhat dire outlooks of the offshore O&G industry, OWP was primarily legitimized as an industrial opportunity rather than an opportunity for domestic energy production. The state introduced regulatory frameworks, allocated substantial resources to R&D, and provided financial support for cluster development and internationalization. Although many of the key conditions for path creation (Binz, Truffer, and Coenen 2016) were thus seemingly in place, one element was missing, namely a financial incentive scheme that could support domestic niche market formation. This was the to be or not to be question for domestic OWP farm developers, but was also regarded as important for many supplier firms that were oriented towards the anticipated domestic OWP market. While the Norwegian government appeared to be supportive of OWP (Normann 2015), calls for tailored subsidies for OWP were put on hold while a joint Swedish-Norwegian support scheme for renewable energy production was being negotiated.

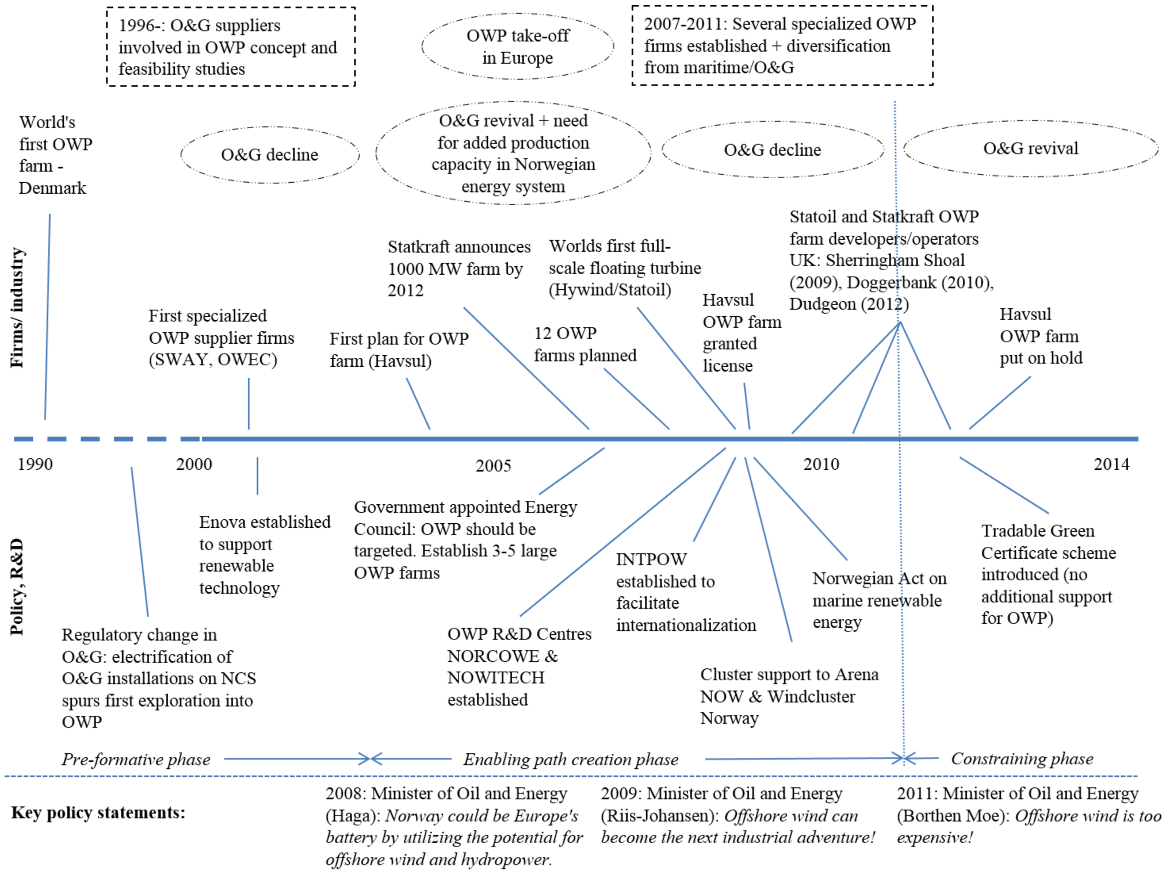

Figure 1. Timeline of phases and key events in the Norwegian offshore wind industry.

A Weakening Momentum for Offshore Wind Power (2011–2013)

Much of the momentum that had started building up for OWP in Norway was lost from 2011 onwards, and the context shifted from being largely enabling to being constraining. This is shown in Fig. 1, which indicates that both a revival in O&G and a lack of domestic market formation stalled key reinforcing mechanisms. In addition, and as we will elaborate in the following subsections, there was dissonance between innovation policy and firm innovation strategy, which was further amplified especially by the lack of domestic market formation processes. In sum, the reinforcing effects necessary for generating momentum for this new industrial development path failed to become cumulatively reinforcing (Martin 2010). In the following, we analyze barriers to the strengthening of key conditions for path development beyond the early path emergence phases along three themes: market and framework conditions, knowledge (co-)generation and innovation dynamics, and path interdependencies.

Market and Framework Conditions

After a decade of negotiations, the joint Swedish-Norwegian tradable green certificate (TGC) support scheme for investments in renewable energy production was introduced in January 2012. However, the TGC scheme is technology neutral and operates according to a least-cost principle, favoring more mature and less costly energy technologies (e.g., hydropower, onshore wind power) over less mature and more costly technologies such as OWP (Bergek and Jacobsson 2011). According to Normann (2015), the political coalition that supported a cost-efficient scheme was strong compared with the more fragmented and poorly organized advocates of a technology-specific scheme. In the absence of a technology-specific support scheme similar to those found in countries with a strong domestic OWP market formation (Kern et al. 2014), the anticipated OWP market failed to materialize in Norway. This resulted in a number of domestic OWP farm developers as well as suppliers that were involved in those domestic projects losing faith and withdrawing resources, thus reflecting how unmet expectations can have detrimental effects on path creation.

The CEO in one of the regional utility companies involved on the Havsul project, which was terminated in December 2012, claimed “the political signals that offshore wind power would become a target area were strong. That did not happen ... But that’s why there was considerable investment in research and technological development for offshore wind power” (BT 2012a). The termination of the Havsul project indirectly resulted in one of the two Norwegian OWP cluster initiatives shutting down, while the lack of domestic OWP market opportunities led the other cluster initiative to focus on onshore wind energy that would be supported by the TGC scheme.

As indicated by the above quote from the CEO, and as corroborated by our survey data (see Table 2), the largest obstacles to OWP path creation in Norway were shifting signals from the

Government concerning efforts to promote OWP and the lack of domestic opportunities to verify technologies. In general, informants in industry, support organizations, and R&D agreed that Norwegian policy for industrial development related to NRE had substantial shortcomings and lacked predictability and vision. Also, interviews with venture and seed capital firms and statements from larger financial actors (e.g., banks) at industry events indicated that uncertainty related to domestic energy policies and framework conditions throttled investments in NREs in the form of venture funding for new technology firms, in-house investments in large established companies, and investments in energy projects.

Table 2

Firms' Views on State Policies and Framework Conditions (Survey Completed January 2011)

Variables	Likert scale: 1 (strongly disagree) – 6 (strongly agree)				
	Mean	Median	Mode	SD	N (94)
Norwegian policy for new renewable energy is unpredictable	4.95	5	6	1.147	85
Funding for verification of new technology is lacking in Norway	4.70	5	5[a]	1.220	84
Lack of demonstration parks is a barrier for development of offshore wind technology in Norway	4.60	5	6	1.357	81
Norwegian energy policy is good industry policy	2.71	3	3	1.340	83

Note: Multiple modes exist, lowest value is shown

Many informants argued that one important way in which OWP farm developers and investors dealt with uncertainties (i.e., reduce risk) was to be conservative in their choice of technological solutions. Although many Norwegian firms approached the OWP industry with products and services that were proven in the maritime/offshore O&G industries, they were largely new to OWP. Verification of these solutions was thus seen as key to standing a chance of entering supply chains in international markets. Accordingly, a key argument for domestic OWP farms has been that it could allow Norwegian firms with broad maritime competence to think anew about both products and services, such as foundation solutions and logistics, which were (and remain) drivers of high costs in OWP (Lema et al. 2011). In this respect, an important argument from a range of firm and non-firm actors was that many solutions that are novel to OWP would require multiple changes and learning in and across the OWP supply chain in order to work.

Very few informants argued the case for large-scale domestic deployment of OWP, but most managers held the same opinion as expressed by a CEO in a large diversified O&G supply firm (interview, 2010), that "we don't need a big home market, but we need something ... We need to be able to demonstrate what we can, and to make mistakes at home." Opportunities for testing and verifying new solutions spanning different value chains segments could be provided by pilot or demonstration projects. In addition to supporting technology development itself, such niche markets could also facilitate collective learning and reduce uncertainties among both firm and non-firm stakeholders (Garud and Karnøe 2003). However, despite various attempts to launch OWP demonstration sites, only a few stand-alone installations, such as Statoil's Hywind project, materialized.

In the absence of domestic OWP projects, firms in the Norwegian OWP industry depended on access to international markets, but this posed a number of challenges. One barrier confronting many Norwegian firms was that their products or services did not match the needs or selection environments (Martin and Sunley 2010) of international OWP markets. Rather, many firms were focused on products and solutions for deep-sea (i.e. depths of 30+ meters) OWP farm projects, but these market segments developed more slowly than was expected when firms' explorations into OWP began. For instance, the manager of one of Norway's first specialized OWP supplier firms claimed "we were 10 years too early, we were too optimistic about the development of deep-sea offshore wind" (interview, 2014),

More generally, both specialized (OWP) and diversified Norwegian firms encountered institutional barriers in struggling to navigate demands, regulations, and supply chains in the growing OWP markets in Germany, the UK, and elsewhere. A manager in one of the Norwegian O&G diversifiers (interview, 2011) that was successful on winning contracts abroad claimed "this industry isn't established at all. State requirements, regulations ... the amount of uncertainty is unbelievable." Indeed, in 2013, the European Wind Energy Association (EWEA) argued that regulatory risk (e.g., unclear or conflicting political support) posed a greater challenge to OWP than availability of financing (EWEA 2013). Additionally, although EU regulations prohibited favorable treatment of domestic firms, many managers claimed that they were disadvantaged compared with local firms when competing for contracts on OWP projects abroad, due to informal local content requirements. This reflects how public investments into OWP in countries such as Germany and the UK are legitimized by both energy and industry policy arguments.

Knowledge (Co-)Generation and Innovation Dynamics

The most substantial policy effort to nurture the Norwegian OWP industry was research funding. The two Centres for Environment-friendly Energy Research (CEERs) focusing on OWP (NOWITECH and NORCOWE) that were established in 2009 were comprised of a number of R&D institutions and industry partners, and were expected to foster cooperation, innovation, and commercialization of new technology (NFR 2009). Both of the OWP CEERs focused on deep-sea offshore wind (30+ meters), which fitted well with the capabilities and market ambitions of many Norwegian firms involved in OWP. However, both CEERs focused on precompetitive research, understood as research on areas without direct/present commercial applicability. The CEERs thus followed key logics of the STI innovation approach (Berg Jensen et al. 2007); they were led by R&D institutions and primarily aimed to achieve what Garud and Karnøe (2003) refer to as “breakthrough results.” However, since many firms pursuing OWP did so on the basis of existing capabilities, and had technology adaptation and verification as their primary concerns, they did not see precompetitive R&D as particularly relevant (see also Njøs et al. 2013). Firm innovation strategies were thus more in line with a DUI innovation approach (Berg Jensen et al. 2007) focusing on internal competence building and cooperation with other firms rather than with external R&D institutions (see Table 3).

Table 3

Overview of Knowledge Sourcing Strategies and Views on Innovation Support (Survey Completed January 2011)

Variables		Likert scale: 1 (to a very small extent) – 6 (to a very high extent)				
		Mean	Median	Mode	SD	N (94)
What are the main	Internal competence building	4.53	5	6	1.485	87

knowledge sources for developing OW technology?	Cooperation with other firms	4.40	5	5	1.448	83
	Cooperation with R&D institutions	3.70	4	5	1.837	82
		Likert scale: 1 (strongly disagree) – 6 (strongly agree)				
Support mechanisms and programs for cooperation between industry and R&D institutions are good		3.31	3	3	1.296	85
R&D institutions have a good understanding of challenges in the industry		3.10	3	3	1.298	85

While most firm informants considered the involvement of R&D institutions as beneficial to developing OWP technology in the long run, many also expressed that researchers have limited understanding or interest in industrial challenges, and are too focused on next-generation or breakthrough solutions. A manager in a specialized OWP firm (interview, 2010) claimed "it is good that the R&D institutions are entering this industry, but we don't have time or resources to participate in endless meetings ... so that they perhaps can help us optimize our products at some point in the future." Informants in universities and R&D institutes claimed that, for their part, too many firms, including firms involved in CEERs or other research projects, often did not allocate sufficient resources to capitalize on R&D involvement.

However, both industry and R&D representatives argued that more resources should be allocated to pilot projects, demonstration sites, and market stimulation. In interviews, at events, and in joint media statements, informants in both science and industry argued that this would provide a more fertile ground for reaping the potential commercial benefits of R&D. For instance, the research director of NORCOWE argued that their aim to stimulate innovation through close cooperation with industry "would be easier if we had activity in Norwegian waters" (BT 2012b). Our interpretation of this is that also R&D actors acknowledged the importance of interactive learning processes and the need for a mix of policy instruments to reconcile DUI-based and STI-based innovation.

Path interdependencies

To recapitulate, resource mobilization to the Norwegian OWP path was to considerable extent a result of diversification or branching (Boschma and Frenken 2011) from the offshore O&G industry. In particular, the declining O&G trend, which culminated with the financial crisis and its aftermath in 2008–2009, spurred O&G sector firm diversification into OWP. The O&G decline was also key to providing political legitimacy for OWP in Norway. However, it is fair to say that most diversifying firms were relatively cautious in terms of resource allocation to the emerging path. Accordingly, one informant (interview, 2011) in the support organization INTPOW said "many of the diversifying firms have not invested enough resources to succeed in what is quickly becoming a fiercely competitive market." Many of the informants from firms argued that this caution in resource mobilization was due to the considerable uncertainties associated with the OWP industry. However, this cautious attitude could also be seen as reflecting how involvement in OWP is a supplementary activity to most firms, and that offshore O&G is an industry characterized by cyclical business activity levels.

Already in 2010, many of our informants expressed that (re)increased activity levels in the Norwegian O&G sector would lead diversifying firms to abandon or reduce their involvement in OWP. According to one CEO (interview, 2010), the effect of a new major petroleum discovery in Norwegian waters would be that "most of the Norwegian companies currently involved in offshore wind, will turn right back to oil and gas … It pays a lot better, and we already know how to do it." Another informant (interview, 2010) rhetorically asked "You tell me … should we invest in the affluent oil business, or should we rather go for this underprivileged, risky new opportunity …? Tough choice!" This view was also asserted by a number of managers in O&G sector firms, who claimed they would find it difficult to invest time and resources in OWP in a situation with high demand in the petroleum industry.

In 2011, the O&G market was revitalized as a result of rising commodity prices and large O&G discoveries in Norwegian waters, including the largest oil field found in Norway for decades. This O&G path renewal alongside uncertainties in OWP framework conditions caused many firms (from O&G) to withdraw resources and reduce their involvement in OWP. Also the manager of INTPOW (interview, 2011) experienced that interest in OWP declined in 2011: "my impression is that after new oil was found, many of the firms that have offshore wind as a secondary activity have withdrawn resources." Although many Norwegian O&G firms continued to pursue OWP, O&G path renewal resulted in firms focusing on exploitative activities at the expense of explorative activities (e.g., in OWP). This tension between the exploitation of existing activities and exploration of new ones is a well-known managerial challenge (Tushman and O'Reilly 1996), especially when the prospects of explorative activities are highly uncertain. As such, had the framework conditions for OWP in Norway been more conducive, it is reasonable to expect that more firms would have invested more resources in the emerging path.

Another path interdependence dimension is that between the emerging OWP path and the established "electricity path." Whereas many utility companies with large hydropower assets were involved in attempts to develop OWP farms, many of the same actors alongside the large energy consumers in the energy-intensive industries did not support a technology-specific support scheme for NREs such as OWP. As such, there were both positive and negative path interdependencies between OWP and the established large energy sectors in Norway.

Constraining Path Creation

Recalling our definition of new industrial development paths as comprising a heterogeneous set of actors and institutions that are functionally related, and established and legitimized beyond early phases of exploration and experimentation, our analysis in this article has revealed that development of the Norwegian OWP path faced several more or less interlinked barriers. In sum, the Norwegian OWP path could be metaphorically described as a number of trails that failed to converge into a more robust development trajectory fueled by synergistic processes of cocreation (Garud and Karnøe 2003) and reinforcing effects (Martin 2010).

First, framework conditions were not sufficiently conducive to support market formation, which in turn impacted negatively on resource mobilization to the budding path. Because Norway's electricity system is almost entirely based on hydropower, important drivers for the development of new energy technologies and renewable energy sources are weak compared with other countries (Hanson, Kasa, and Wicken. 2011). In particular, the Norwegian OWP path suffered from lack of technology-specific incentive schemes that could facilitate domestic market formation. Thus, legitimizing the OWP path appears to have been challenged by what we may refer to as hydro lock-in. In other words, the technology neutrality of support schemes to support investments into renewable energy production capacity were adapted to the needs of mature energy technologies (such as hydropower) but failed to provide the necessary additional nurturing conditions for more immature technologies.

Second, unconducive framework conditions also appear to have impacted negatively on processes of knowledge generation and innovation dynamics. Public policy support for knowledge generation (for OWP) was primarily to STI-based research activities that did not match the more DUI-oriented innovation strategies that characterized firm initiatives towards OWP. The latter reflects that most firms approached the OWP market with experience and capabilities developed in other sectors rather than with entirely new solutions. This is not to discredit the key role of R&D for knowledge generation, which may be particularly important for reducing costs in the OWP industry. However, the lack of bridging mechanisms between R&D and industry knowledge generation (i.e., demonstration projects or other niche markets (Smith and Raven 2012)) led to knowledge generation largely taking place within the confines of science and industry respectively. As such, bricolage-type interaction and collective learning-by-using, that are key in the wind energy industry (Huenteler et al. 2016), and also pivotal in the co-creation of technology and institutions (Garud and Karnøe 2003), had barren conditions.

The third theme under which we have addressed barriers to key path creation mechanisms is that of path interdependencies (Martin and Sunley 2010). When the O&G market had an upturn in 2011, much of the momentum for the main mechanism for OWP path creation—firm branching—was lost. The dynamics of the established O&G path thus initially contributed to an enabling context for OWP, and then later to a more constraining context in which many actors reduced their involvement and (re)focused on their more traditional exploitative activities. The industry dimension of resource mobilization to the budding path, as well as legitimacy in the sense of OWP providing a new growth opportunity, thus proved vulnerable to organizational path dependence, implicating a negative dependence between the established path and the emerging path (Martin and Sunley 2006). Also, both a positive interaction and a negative interaction were observed between the established energy sector and the emerging OWP sector.

Conclusions

This article contributes to recent economic geography theorizing on path creation by shedding light on the broader processes and enabling and constraining factors that shape the emergence of new industrial development paths. Departing from a path-as-process approach to understanding path evolution (Martin and Sunley 2010), our theoretical framework expands on recent contributions (e.g., Dawley 2014; Tanner 2014; Binz, Truffer, and Coenen 2016) that have called for more attention to the complex interaction between diverse agencies, mechanisms, and contextual conditions in understanding path creation processes. Against this background, we developed a framework that explicitly seeks to unpack the particularities of reinforcing mechanisms that are crucial to new paths that are developing beyond the early phases of exploration and experimentation (Martin 2010), as well as potential barriers to such forces that are gaining momentum. In connecting to Binz, Truffer and Coenen's (2016) notion of key resource formation processes underlying path creation, and in engaging critically with the branching mechanism for path creation, our framework highlights the importance of analyzing the dynamics between established and emerging industrial paths.

Due to the immense variation in both path creation conditions and outcomes, we agree with Martin and Sunley (2006, 428) that "no single model of path creation has universal applicability." We nonetheless believe that our framework complements extant perspectives by providing for broader and more nuanced perspectives on path creation, particularly compared with frameworks that focusing more or less entirely on technological relatedness and firm branching (e.g., Boschma and Frenken 2011). We believe these insights are of particular value when analyzing the prospects for new paths that emerge in a context of highly path-dependent established sectors (e.g., energy, transport), but should also be of broader relevance to economic geography research on new industries.

The value of our framework is demonstrated in our analysis of the emerging phases of the Norwegian offshore wind power (OWP) industry. Despite an initially enabling context in early path creation phases, the necessary reinforcing mechanisms and more importantly their co-evolution over time to generate virtuous circles of development did not gain hold. In addressing our research question—What hindered path creation processes in the Norwegian

OWP sector?—our analysis has revealed a number of barriers to this new industrial development path. Key resource (knowledge generation, resource mobilization, market, legitimacy) formation processes suffered from uncertainties in framework conditions and dissonance between firm innovation strategies and policy support for knowledge generation, and were prone to negative path interdependence with the dynamics of established paths.

The results of our analysis suggest there is a need for detailed interrogation of the coevolutionary aspects of path creation (Garud and Karnøe 2003), particularly with regards to knowledge generation (Binz, Truffer, and Coenen 2016). Our analysis revealed a discrepancy between policy instruments to nurture knowledge generation and firm innovation strategies, thus reflecting different innovation modes (Berg Jensen et al. 2007) with differing aims and time horizons. The effects of this discrepancy were that knowledge generation processes did not benefit from potential synergies between industry and science. The literature on path creation within the energy sectors emphasizes the importance of collective agency (Garud and Karnøe 2003; Simmie 2012), but it is not entirely clear why some path creation processes benefit more from or even rely on domestic innovation system configurations and market opportunities, while other new sectors emerge through international networks (for an example of the latter, see Binz, Truffer, and Coenen. 2012). Our analysis supports Huenteler et al.'s (2016) argument that local learning processes are particularly important in a complex-product sector such as OWP, which to large extent is based on learning-by-using processes that characterize DUI innovation modes (Berg Jensen et al. 2007).

Moreover, our findings have led us to conclude that whether contexts are enabling or constraining (Martin 2010) is contingent not only on institutional contexts and intrapath dynamics but also on the specificities of path creation mechanisms and interpath dynamics. Especially the potentially negative dimensions of path interrelatedness have been largely overlooked in the path evolution literature (Martin and Sunley 2010). A general lesson to be drawn from this article is that when firm diversification is an important path creation mechanism, reinforcing effects (increasing returns, network externalities) that assist new path development may be vulnerable to extension or renewal processes (Isaksen 2014) in established paths that have strong political support, especially if the new paths are associated with considerable uncertainty. Future work should seek to unpack more clearly how changing dynamics in established paths can impact on the reinforcing mechanisms associated with new path development. We assume that this will be contingent on various factors, such as sectoral maturity, levels of uncertainty, and prospects of value creation in different markets, thus implicating a need for detailed empirical research in different contexts.

Contexts, understood as relational phenomenon conditioning agency (Murphy 2015), change over time due to a complex mix of institutional and economic factors. In addition to substantiating the need for dynamic perspectives on path evolution, this suggests that more attention should be paid to how contextual change impacts on agency (e.g., firm strategies, policy making). Although our analysis has been conducted at the industry level, we hypothesize that whether contexts are enabling or constraining is contingent on the type of actor. In developing capital demanding technology or accessing international markets in a context of multidimensional uncertainty, small entrepreneurial technology firms obviously differ from large incumbents diversifying from another industry. While our analysis has only superficially illuminated how different actors' strategies and activities are influenced by the networks, markets, value chains, policy frameworks, and broader institutional environments in which they are embedded and formed, we see this as a key area for further research. As illustrated in this article, the role of non-firm actors (e.g., R&D institutions, government bodies, intermediaries) must be taken into account in order to understand more fully how, when, and where new industrial development paths emerge or do not emerge (Dawley 2014; Tanner 2014). The implication of the above insights is that policy support must be attuned to the particularities of specific path creation processes and the mechanisms underlying them, in turn implying that there is no one-size-fits-all approach in facilitating and nurturing key conditions for the emergence of new industrial development paths.

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