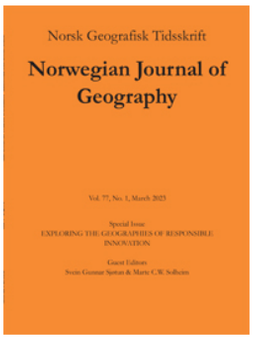

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Barriers to regional industrial development: An analysis of two specialised industrial regions in Norway

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ABSTRACT

The article aims to broaden the understanding of barriers to regional industrial development by focusing on the use and modification of the regional asset base. The authors employ Maskell & Malmberg's categorisation of assets and they regard asset modification through change agency as a vital part of regional industrial development. They aim both to complement Grabher's 'lock-in' approach and to provide a wider understanding of how barriers can be lowered through their empirical investigation of two specialised regions in Norway, Stavanger and Grenland. The authors address three research questions: What are historically created key regional assets in the two specialised regions? Do the assets function as support or barriers to green path development? If they are barriers, what are key agencies for lowering them? The findings demonstrate that the regional asset base functions both as support and as a barrier. To lower the barriers, both asset reuse and asset creation are deployed by actors in the region. The authors conclude that the article's two main contributions are that with regard to the regional asset base, a relevant framework can identify possible barriers to regional industrial development, and the finding that barriers can be lowered through asset modification.

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Introduction

Regional economies face the constant challenge of rebuilding their economic structures and counteracting old industrial activities to avoid stagnation (Asheim et al. 2019). In recent decades, globalisation, climate change, and other grand societal challenges have made regional industrial development even more intrusive (Tödtling & Trippl 2018). Furthermore, businesses are increasingly expected to respond to societal needs beyond the shareholders, and to involve also stakeholders and society as a whole, by taking responsibility for their activities and impact (von Schomberg 2019; Jarmai et al. 2020). Academic authors of responsible innovation (RI) literature have argued that RI requires more than the isolated actions of individual actors and should include the broader innovation system and its institutions (Stilgoe et al. 2013). Thapa et al. (2019) argue that the understanding of RI is compatible with regional innovation studies and that new insights could be gained by combining the two strands of literature. Furthermore, they argue that drivers and barriers to RI can be applied to regional innovation studies. In order to deal with these grand challenges in a responsible way, it is important to develop extensive knowledge of how regional industrial development occurs, as well as to identify the factors that function as support and barriers.

The economic geography literature claims that knowledge, competence, norms, and other regional assets accumulate and strengthen over time, creating self-reinforcing effects that lead to path dependency and possibly to 'lock-in' (Grabher 1993; Martin 2010). Stilgoe et al. (2013) emphasise how the same factors leading to lock-in and path dependency can create barriers to RI. In this article, we take a broader approach than lock-in on factors functioning as support and barriers to regional industrial development, as we conceptualise these factors as the regional asset base and the use

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of assets in a region. Drawing insights from literature on sustainability-oriented innovation, Jarmai (2020) finds that limited personnel and financial resources can cause internal barriers in companies' innovation practices and that a lack of knowledge, technology, or external actors can cause external barriers to innovation. Furthermore, technological and managerial capabilities, tangible and intangible assets, and knowledge and skills are mentioned as drivers of innovation, alongside the regulatory framework (Jarmai 2020). While Grabher (1993) focused on immaterial matters as barriers, Jarmai (2020) mentions both immaterial and material factors. From this, we see a need to expand the understanding of factors functioning as support and barriers to innovation beyond social linkages and close networks to include also material factors. Our conceptualisation allows for including both material and immaterial factors that can function as support or barriers to regional industrial development, and thus to include and supplement Grabher's factors in lock-in (Grabher 1993).

Jarmai (2020) states that when it comes to responsible innovation, all factors have the potential to act as either support or barriers to innovation, depending on the situation. The same applies to assets in the regional innovation system (RIS). The regional asset base develops over time, creates regional preconditions, and is often related to traditional ways of doing things, especially in strong old industrial regions categorised as thick and specialised RISs (Tödtling & Trippl 2005; Isaksen & Trippl 2016). Such regions are particularly vulnerable to industrial decline, as exogenous changes may be difficult to meet due to a specialised regional asset base that can be challenging to use for other purposes (Isaksen & Trippl 2016). Thus, the regional asset base can function both as support and barriers to regional industrial development, depending on the situation. Furthermore, Maskell & Malmberg (1999, 10) argue that regional assets are 'actively modified or reconstructed by the deliberate and purposeful action of individuals and groups within or outside the area'. In other words, regions have an historically developed asset base (MacKinnon et al. 2019) that can be modified through agency.

We aim to contribute to a wider understanding of barriers to regional industrial development by placing assets centre stage and asking the following overall theoretical research questions: How can regional assets function as support and barriers to regional industrial development? How can actors take steps if regional assets become a barrier and how can such barriers be lowered? To investigate these questions empirically, we conducted empirical investigations in the case regions of Stavanger and Grenland in Norway, both of which are characterised as organisationally thick and specialised RISs (Underthun et al. 2014; Deegan et al. 2021). In the Stavanger region, in the county of Rogaland, the industry structure is diversifying to become less dependent on oil and gas and to advance to other emerging industries (Stavanger kommune n.d.), while in the Grenland region, in the county of Telemark og Vestfold, there are aims to make the industry greener, given that industry in the county as a whole accounts for over 20% of Norway's industrial emissions (Vestfold og Telemark fylkeskommune n.d.). The following empirical research questions were addressed in the case studies:

1. What are historically created key regional assets in the two specialised regions?
2. Do the assets function as support or barriers to green path development?
3. If they are barriers, what are key agencies for lowering them?

The remainder of the article is organised as follows. The theoretical framework is presented in the next section, followed by clarification of the research design and an overview of the case regions. Thereafter, we discuss the empirical findings before presenting our conclusions regarding the article's theoretical and empirical contributions, as well as its policy implications.

Theoretical framework

Asset perspective on barriers to regional industrial development

This article seeks to contribute to a better understanding of barriers to regional industrial development. We conceptualise regional industrial development through the notion of path development. Many researchers have taken on the task of pinpointing factors and dynamics that enable or constrain regions' ability to change their paths (Martin 2010; Neffke et al. 2011; Dawley 2014; Boschma 2015; Grillitsch & Sotarauta 2020; Isaksen et al. 2021). Regional actors can contribute to multiple regional industrial paths, such as path extension, path upgrading, path diversification, path importation, and path creation (Martin & Sunley 2006; Hassink 2010; Isaksen & Trippl 2016; Grillitsch et al. 2018; Trippl et al. 2020).

The types of regions in focus in this article are characterised by their organisationally thick and specialised RISs. Such systems are characterised by one or a few dominating industries. Isaksen & Trippl (2016) argue that thick and specialised RISs, usually found in old

industrial regions, can be overspecialised in mature industries, which can have reinforcing effects that strengthen existing industries. Additionally, such regions are especially exposed to industrial decline (Isaksen & Trippl 2016). The literature offers insights into barriers to the development of thick and specialised RISs, such as being challenging to move beyond the existing path to new ones (Isaksen et al. 2018; Chen & Hassink 2020), and lack of regional leadership and prevalence of existing patterns (Fløysand et al. 2022), to mention a few. For a recent overview of barriers to regional industrial path development, see Kyllingstad (2021). Lastly, Hassink (2017) argues that within the evolutionary economic geography literature, the concepts of path dependency and lock-in are mentioned as the main barriers to industrial development.

Grabher (1993) first introduced the concept of lock-in to explain why the mature clusters in the Ruhr region in Germany faced a dramatic decline in the 1970s. The region, with its dominant industry of coal and iron mining, had until the 1960s been the motor of national economic development (Grabher 1993, 257). Grabher (1993, 260) called the phenomenon 'the rigid specialization trap' and made a distinction between three interrelated types of lock-in, which captured different facets of the challenges of close ties for industrial development. The first type of lock-in, *functional lock-in*, points to how close and stable ties between regional core firms and suppliers reduce boundary-spanning functions and undermine the ability to identify and absorb knowledge from external sources. The second type of lock-in is *cognitive lock-in*, which refers to how close ties over time create common norms and world views that can lead to the disregarding of information that does not align with existing norms. The third type of lock-in, *political lock-in*, occurs when close links between the dominating industry and both the political and administrative systems lead to reinforcement and support of the already strong industry. All types of lock-ins are, from Grabher's point of view (Grabher 1993), about the lack of new knowledge absorbed in a region's strong industries due to too close linkages and networks between intra-regional actors. The concept of lock-in is widely established, and the literature emphasises that lock-in situations can be barriers to regional industrial development (e.g. Tödtling & Trippl 2004; Hassink 2005; 2010; Hassink & Shin 2005; Hudson 2005; Blažek et al. 2020; Newey & Coenen 2022). Martin & Sunley (2006) emphasise that the degree of specialisation and institutional arrangements is relevant to whether lock-ins occur, as lock-in can be described as a condition where endogenous change ceases to evolve. Consequently, the common understanding of lock-in includes dense networks, fixed norms, and stable formal institutions.

Since the concept of de-locking was introduced, the de-locking of regional industry has been discussed by many authors (Martin & Sunley 2006; Martin 2014; Hassink 2017). Grabher (1993) suggested a loosening of closely tied networks to allow for new knowledge to penetrate the region. Both the understanding of the problem as having too close linkages and networks and the proposed solution of loosening the close networks have been repeated by several authors (Bathelt et al. 2004; Tödtling & Trippl 2005; Hassink 2010; Trippl et al. 2018).

Researchers have argued for additional insights into barriers to regional industrial development and to different types of RIS (Kyllingstad 2021). While lock-in situations due to close networks and linkages are seen as one type of barrier to regional industrial development, we suggest a complementary perspective. Grabher's approach is mainly concerned with immaterial factors (Grabher 1993), but in our framework we include material factors too. In line with Jarmai (2020), we argue that assets can function as both support and barriers to regional industrial development and that barriers to regional industrial development can be caused by the regional asset base. We adopt the following categorisations: natural assets (e.g. including land, oil wells, and climate), infrastructural and material assets (e.g. machines, financial resources and physical infrastructure), industrial assets (e.g. risk capital and organisational methods), human assets (e.g. competence and skills in the labour force), and institutional assets referring to formal and informal rules and to the institutional setting (MacKinnon et al. 2019; Maskell & Malmberg 1999). This categorisation allows us to capture both the material and immaterial assets. Furthermore, assets are developed over time and shaped by their surroundings, and they can be described as regional preconditions for further industrial development (MacKinnon et al. 2019). As regional assets are historically and geographically bound, they can also become self-reinforcing effects that create barriers to regional industrial development that extend beyond the negative effects of close networks, as explained by Grabher (1993). The regional asset base is often connected to the traditional way of doing things in regions' industries, especially in thick and specialised regions where one (or more) strong industry is strengthened by supportive institutional structures. To create new regional industrial paths or to reorient the established path, regional assets such as competence, technology, and rules and regulations need to be identified and

modified through the purposeful actions of individuals or groups (MacKinnon et al. 2019).

Grabher's perspective highlights social linkages (Grabher 1993), which we argue is of immaterial quality. Furthermore, Grabher's observations in the Ruhr region can be interpreted from the asset perspective (Grabher 1993). The functional lock-in can be understood as an accumulation of knowledge and skills (human assets) in a select few firms with strong networks (infrastructural and material assets) consisting of fellow dominant firms. In the asset framework, the cognitive and political lock-ins can be understood as a strong shared culture (institutional asset) within industry itself and between industry and policymakers. However, we realise that Grabher's lock-in concepts are more dynamic than the classification of assets (Grabher 1993), which is why we do not claim that that our perspective is an alternative to Grabher's perspective. By broadening the perspective on barriers to regional industrial development to include assets, we provide a bigger lens through which to explore what factors (assets) can create barriers to and provide solutions (asset modification) for regional industrial development.

Asset modification and agency

Based on the argument that assets can become barriers to industrial development, we argue that asset modification is needed to lower such barriers and to contribute to industrial development. Asset modification is a cornerstone of regional industrial development (Chen 2021), as changes in a region's structure, development, and institutions are dependent on changes in the regional asset base. However, some assets are harder to modify than others, depending on the type of asset and whether it is an organisational-level or system-level asset. Most natural assets are given conditions that are hard to change, while industrial or human assets are more easily changed. Also, the exploitation of different types of assets is impacted differently by the legislative framework and policies. For example, in the Norwegian context, the exploitation of human assets is regulated by the Working Environment Act of 2005 (Lovdata 2022) and the Norwegian tripartite cooperation model (Arbeids- og inkluderingsdepartementet 2021). Following Isaksen et al. (2020), we make the distinction between organisational-level and system-level assets to emphasise how not all assets are tied to the same actors and that actors affect assets in different ways. For example, the Norwegian government is limited in controlling what technology local firms use, while firms might be limited in their exploitation of natural assets, as they (the firms) are often owned and controlled by the state. System-level actors, like governments, have the power to form legislative framework conditions and policies to which firm-level actors must adapt. This notion supports the argument that asset modification occurs on several levels. In this article, both organisational-level and system-level assets are included in the regional asset base. Thus asset modification is the key to understanding the development of new regional industrial paths (Isaksen et al. 2020; Trippl et al. 2020).

The lowering of barriers to regional industrial development through asset modification can occur in three ways, namely through asset reuse, asset creation, or asset destruction. Asset reuse is a process in which existing assets are redeployed or recombined for new purposes (Rypestøl et al. 2021). This can occur at the organisational level by, for example, using technologies for reasons other than their original purpose, or it can occur at the system level when new academic disciplines are introduced to a field (Kyllingstad et al. 2021). Asset creation entails the creation of entirely new assets to a region or firm through importation or internal development (Rypestøl et al. 2021). Asset destruction is the process of terminating assets that hamper future development, which can occur through the destruction of outdated technologies (Isaksen et al. 2020). This can also include the unlearning of routines in an organisation or the more drastic move of shutting down businesses or terminating support programmes.

However, assets do not change by themselves. The modification of assets to lower barriers to development requires purposeful actions by actors. The literature mentions several different types of agency. Grillitsch & Sotarauta (2020) identify change agency as the main driver of regional structural change, whereas Bækkelund (2021) argues that reproductive agency is necessary for path evolution. We distinguish between change agency and reproductive agency in this article, as the two types of agency present the intentions behind modifying assets either to produce change or to keep assets more or less unaltered in order to seek stability or avoid change. Furthermore, Isaksen et al. (2020) specify how change agency can be found on both the organisational and system levels and that asset modification processes on the two levels of agency need to be aligned to achieve the intended outcome. The agency performed by actors on the two different levels will impact assets differently in terms of both types and scale (Isaksen et al. 2020; Rypestøl et al. 2021). Additionally, there are three systemic levels – regional, national, and international – in which this perception also applies. Barriers to industrial development can be lowered if agency on the

organisational and system levels are aligned in modifying assets. For example, to build competence (i.e. the creation of human assets), change agency at the national level must grant funding for new educational programmes, whereas change agency at the regional level needs to establish arrangements for internships, and at the organisational level, educational institutions need to design and arrange their programme, as well as to recruit teachers and students. To develop physical infrastructure (i.e. infrastructural and material assets), change agency at the organisational level must specify its needs, and change agency at the regional level must promote this on behalf of the industry to the national level, where most funding and decision-making take place. However, the lowering of barriers can be prevented by reproductive agency, for example if it occurs at the national level with the power to overrule regional initiatives. Overall, several types of assets can create barriers to regional industrial development, and in such cases there would be a need for the creation of new assets, reuse of existing assets, and/or destruction of hampering assets to lower the barriers.

Context and research design

The empirical cases in this article strive to achieve a greener industry. Therefore, we investigate how assets can function as support or barriers to development processes, as well as how asset modification through change agency can lower any barriers. Both regions include thick and specialised RISs characterised by either one dominant industry or a few dominant industries. Isaksen & Trippl (2016) argue that thick and specialised RISs, usually found in old industrial regions, can be overspecialised in mature industries, which can have reinforcing effects that strengthen existing industries. Additionally, such regions are especially exposed to industrial decline (Isaksen & Trippl 2016). Regions heavily dependent on carbon-intensive sectors might especially struggle to ensure responsible and just transitions to greener industry, as fast downsizing of jobs in carbon-intensive sectors will affect some social groups more than others (Afewerki & Karlsen 2022).

The two regions analysed, Stavanger and Grenland, are located on the southern coast of Norway (Fig. 1). The oil and gas sector, which is dominant in Stavanger, has been through several crises, and both the sector and regional actors in the Stavanger region are on a mission to diversify into more industries, such as aquaculture and renewable energy. The metal and cement processing industry in Grenland is not currently experiencing a demand-side shortage, but the products and processes need to be more sustainable than they have been in the past in order to maintain and strengthen competitiveness. The two cases were chosen because of the efforts within them to transition regional industries. Stavanger is dedicated to diversifying the industry structure, whereas Grenland is working towards strengthening the existing industry structure with a greener and more sustainable focus. As the two case regions have different goals regarding regional industrial development, the study does not follow a matched pair design,

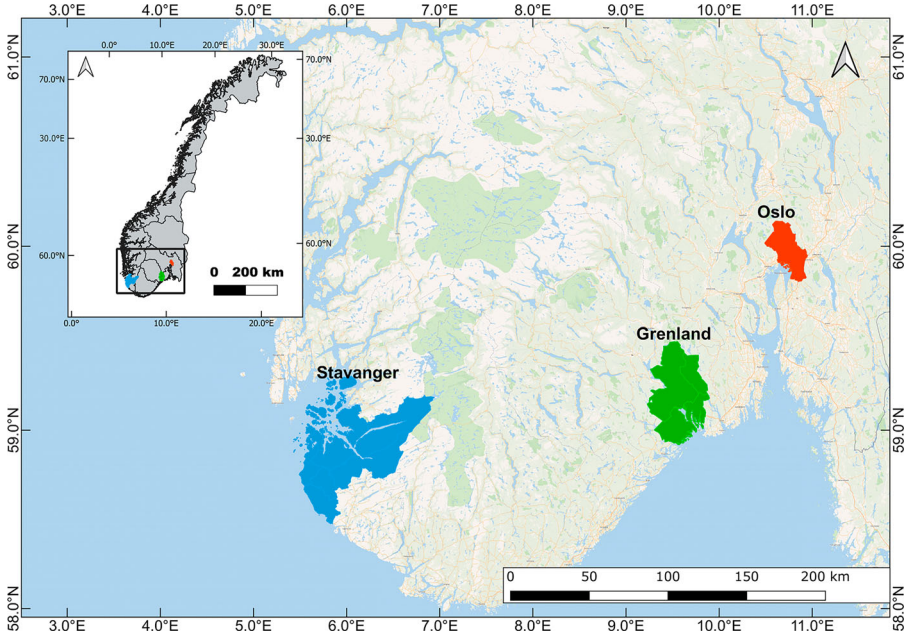

Fig. 1. Location of the Stavanger region and Grenland region in Norway

but rather draws on two parallel single cases (Sotarauta & Suvinen 2019).

The Stavanger region

The Stavanger region is located on the south-west coast of Norway and is known as the oil capital of Norway. In line with the housing and labour market regions formed by Gundersen et al. (2019), we define the Stavanger region as the economic region of the municipalities of Stavanger, Sandnes, Sola, Randaberg, Hå, Time, Klepp, Gjesdal, Strand, and Kvitsøy, all of which are in the county of Rogaland. In 2020, the region had a population of c.347,000; Stavanger, the largest municipality, had a population of 144,147, followed by Sandnes with 80,450 (Statistics Norway n.d.).

Over several decades, the region has increasingly become more specialised towards the oil and gas sector (Deegan et al. 2021). Big oil firms (e.g. Equinor), cluster organisations, and governmental bodies in the petroleum industry have their headquarters in Stavanger. While petroleum is the dominant industry, the region hosts other industries, such as aquaculture, agriculture, and tourism. Still, fluctuations in oil and gas prices have led to mass lay-offs several times, which have fostered growing concerns about the safety of jobs in the region and the need for a more diversified industry structure and labour market. As part of its strategy for industrial development, Stavanger Municipality specifies other industries (i.e. besides oil and gas), namely aquaculture, agriculture, and tourism, alongside renewable energy, as focus areas towards 2030 (Stavanger kommune n.d.). The aim of diversifying the region's industry structure is shared by Rogaland County as a whole and by Stavanger Chamber of Commerce in particular.

The Grenland region

One of the biggest manufacturing industry regions in Norway, measured by the number of jobs, is the Grenland region (Flatval et al. 2020) in south-eastern Norway. The Grenland region includes the municipalities of Porsgrunn, Skien, Bamble, Siljan, Nome, and Drangedal, all of which are currently in the county of Telemark og Vestfold (Gundersen et al. 2019). According to Statistics Norway (n.d.), the region had a population of about 118,500 in 2021. The largest municipality in terms of population is Skien, with c.55,000 people (Statistics Norway n.d.). Together, Skien and Porsgrunn, have the most workplaces in the region. The region possesses Norway's largest concentration of process industries, primarily petrochemicals, metal, and cement. The products and services produced in the region will be important in the future, but industrial activities in the county of Vestfold og Telemark as a whole already release over 20% of Norway's industrial emissions (Vestfold og Telemark fylkeskommune n.d.). Because of this, the Industrial Green Tech (IGT) cluster was established in 2018 to develop, test, and build new smart technology and efficient solutions for the industry and the circular economy.[1]

The overall vision in Grenland is for the region to become the world's first climate-positive industrial region. Furthermore, this vision is important for keeping companies in the region, as well as attracting new ones to ensure that there are workplaces in the future.

Research design

In line with the work of Yin (2013), the research design of the study on which this article is based followed a case study approach. Moreover, as mentioned in the section 'Context and research design', in this article we draw on Sotarauta & Suvinen (2019) by applying two parallel single cases, rather than a comparative case study of two regions or a matched-pair design, the reason being that our two case regions differ in industry structure and type of path development, as we focus on diversification in Stavanger and greening in Grenland. Drawing on insights from two different regions, we aim to provide a more thorough analysis, with two contexts and two sets of experiences related to regional industrial development.

Primary data were applied, as well as secondary data in the form of newspaper articles, company and municipality websites, and municipalities' strategic industrial plans. This was done to obtain relevant information about the regions and their ongoing development processes. Primary data were collected from in-depth semi-structured interviews. The use of semi-structured interviews is a well-known approach to gain insights into complex phenomena (Welch et al. 2011; Yin 2013), and the interviews enabled us to follow interesting leads with in-depth queries. In total, 30 interviews were conducted, 15 in each case region. The interviewees included company managers, cluster leaders, and municipal representatives, both administrative and political. Interviewing representatives of both the private and public sectors was important in order to gain a comprehensive understanding of how the regions worked with their respective regional industrial development processes, what were the central assets in the

[1]In 2022, the Industrial Green Tech (IGT) cluster was incorporated into the technology and industry cluster named Powered by Telemark.

Table 1. Overview of interviewees

	Stavanger		Grenland	
Time	Type of interviewees	Interviewee code	Type of interviewees	Interviewee code
September 2021	–		Company manager	G1
			Cluster representative	G2a
			Cluster representative	G2b
			Municipal representative	G3
October 2021	Cluster representative	S1	Company manager	G4
	Municipal representative	S2	County representative	G5
	Cluster representative	S3	Company manager	G6
	Chamber of Commerce representative	S4	Company manager	G7
	Cluster representative	S5	Company manager	G8
	Municipal representative	S6	Company manager	G9
	Cluster representative	S7	Municipal representative	G10
	Company manager	S8	Municipal representative	G11
	Cluster representative	S9	Company manager	G12
	Company project leader	S10	Company manager	G13
	Company manager	S11	Company manager	G14
	Company manager	S12	–	
	Company manager	S13		
November 2021	Company manager	S14	Company manager	G15
	Company manager	S15	–	

regions and who were important actors. Most interviews lasted c.60 minutes, in accordance with recommended qualitative research practice (Gioia et al. 2013), and they were recorded and transcribed with consent from the interviewees, except for five interviews, for which we relied on notes. Most of the interviews were done in person (21), but due to COVID-19 restrictions, some interviews were conducted electronically (9). The data were sorted manually, in line with relevant categories extracted from the theoretical framework, and they were analysed accordingly. An overview of the interviewees and the timeline of the interviews is shown in Table 1.

Findings and analysis

The Stavanger region

Key regional assets

For centuries, the Stavanger region has been influenced by the sea. In the 1800s, the region thrived on sailing vessels and herring fishing before the canning industry took over in the first half of the 20th century. Since then, infrastructural and material assets have been built at favourable places along the edges of the fjords and along the coastline, to support activity at sea. The knowledge of how to operate at sea has spread throughout generations and has become part of the human assets in the region. At the start of the 1960s, the oil and gas sector was established (Ministry of Petroleum and Energy 2021). Since then, the oil and gas sector has dominated the region, despite several crises. Thus, since the 1960s, the Stavanger region has built even more infrastructure and technology around offshore activity and the extraction of oil and gas. An overview of the assets mentioned by our interviewees is provide in Table 2. The assets mentioned in the categories of infrastructural and material assets, human assets, and institutional assets were emphasised most, and consequently we chose to focus on them as our key assets.

The geographical location of the region makes it well suited as a base for transportation between the Norwegian continental shelf and the mainland, and thus to

Table 2. Regional assets in Stavanger

Asset categorisation based on the work by Maskell & Malmberg (1999)	Empirical findings from Stavanger
Natural assets	Land for farming and grazing animals, landmarks and hiking trails, shoreline/fjord/sea/waves, proximity to the Norwegian continental shelf, wind, renewable energy
Infrastructural and material assets	Marine logistics, financial resources, test facilities, shared office buildings, innovation park, documents, machines and facilities close to the sea, advanced construction machines, close proximity to decision-makers (e.g. to the Ministry of Petroleum and Energy), access to renewable energy
Industrial assets	Industry-specific (especially oil & gas, and marine) technology), organisational structures
Human assets	Educated/skilled workforce, 'people and knowledge', 'fiery souls' (passionate individuals), industry-specific (offshore and marine) competence and technological competence
Institutional assets	'We can do this' attitude, proximity to decision-makers, networks/social linkages between national decision-makers (e.g. the Ministry of Petroleum and Energy) and regional decision-makers and industry, supportive institutional arrangements (e.g. Innovation Norway and the Research Council of Norway)

become a solid base for the development of a broad service and supplier industry. In addition to the infrastructural and material assets in the region, key assets are competence relating to offshore operations, the oil and gas market, and sector-specific legal arrangements, including the development and maintenance of technology over many years. The emergence of the oil and gas sector has been endorsed by national policies, such as those concerning taxation, as well as regional policies aimed at stimulating research institutes and educational institutions to support the oil and gas sector (Norwegian Petroleum 2023a; 2023b).

Assets functioning as support and barriers in the Stavanger region

The ongoing development process in the Stavanger region mainly deals with diversifying the region through the development of other industries in addition to the oil and gas sector. This also involves more responsible innovation activities to develop greener industries compared with the oil and gas sector. The region's dependence on oil and gas has made it especially vulnerable to market fluctuations. A recent example was the financial and oil crisis in 2014, when the unemployment rate in the Stavanger region increased rapidly and reached a peak of 4.6% in 2016, 1.4 percentage points over the national average (Lima 2016). Many of our interviewees pointed to the 2014 crisis as a turning point for many actors in the region finally to taking action towards a green shift. Additionally, our interviewees claimed that since the oil and gas sector was profitable and offered Norway's highest average monthly salary of all industrial sectors, it was difficult to move away from such a sector: 'our problem is that we have an oil and gas sector that is willing to pay' (S8). In the aftermath of the 2014 crisis, firms started differentiating and pursuing other markets towards more sustainable options, as they realised profits from oil and gas production could be vulnerable and are not compatible with the worldview of a future with low emissions and renewable energy in accordance with the UN's Sustainable Development Goals (United Nations n.d.). According to one interviewee, 'the green shift has hit more seriously this time around. […] It is a shift here now that is much more fundamental than it has been previously' (S5).

In the Stavanger region, we observed several examples of assets functioning as support for green path development, whereby industries, especially maritime industries, reused infrastructural and material assets for new purposes to become less dependent on the oil and gas sector. Through our interviews, we identified a tendency for companies in the oil and gas service industry to shift away from the oil and gas market alone and to other offshore and maritime industries where they could use the infrastructure, technology, and competence they already possessed: 'we see that some of the green companies are locating here, and according to them they come here because of the competence' (S6).

However, strong and specialised competence in the oil and gas sector is not solely an advantage for the Stavanger region. Some interviewees identified challenges related to how high wages in the oil and gas sector exhausted the labour market of skilled workers with technological competence, leaving few competent workers for other, relatively smaller industries: 'It [the oil sector] is a sponge when it comes to competence' (S12). High wages are the result of a combination of several assets. The access to valuable natural assets (oil and gas), combined with the competence (human assets), technology (industrial assets) and machines and infrastructure (infrastructural and material assets) to extract and exploit the natural assets, as well as supportive institutional arrangements (institutional assets), have resulted in high profits for the sector. This has been beneficial to obtain and maintain the necessary competence in the firms and to develop the oil and gas sector.

High profits, materialised through high wages, affect access to human assets in the form of skilled workers. As a result, high wages create a barrier to the transference of skilled workers (i.e. human assets) from the oil and gas sector to other emerging industries, which in turn creates a barrier to further regional industrial development in the region. New emerging industries, such as aquaculture, especially lack the economic muscle to compete with companies in the highly profitable oil and gas sector. When the oil price is steady, the oil and gas sector has a 'vacuum effect' on the labour market by sweeping up the market of skilled workers (Deegan et al. 2021). When the oil price falls, as in 2014, people are laid off and skilled workers become available for other industries. Depending on the oil price, access to certain types of skilled workers is limited for industries outside the oil and gas sector and is thus a barrier to the development of those industries. As the growth of alternative industries is part of the diversification strategy of the region (Stavanger kommune n.d.), the high profits from the oil and gas sector materialised through high wages have also become a barrier to regional industrial development.

In the past, economic crises impacted the profitability of the oil and gas sector, which led to dismissals and the relocation of human assets. When the COVID-19 pandemic hit Norway in 2020, this could potentially have been a similar scenario. However, the Norwegian government formed a crisis package for the oil and gas sector to prevent dismissals and stimulate predictability for

the industry: 'Last year we had a combination of a pandemic and an oil price at twenty dollars [USD] a barrel, which was critical, and without that oil package from the government in June we would have seen mass dismissals in the industry' (S4). Given the challenge of high wages and competence being vacuumed by the oil and gas sector, dismissals from the oil and gas sector could potentially have led to the release of competence, which in turn could have become available to alternative industries in the region. Several interviewees expressed their opinion of what could stimulate further development, namely that the region needed lower oil prices and the subsequent release of competence from the sector for the newer industries to grow. In other words, the Norwegian government has prevented the potential scenario of reusing human assets by its actions to stabilise the labour market. The national government performed reproductive agency by doing so and thus prevented change. Even if sudden mass dismissals in a dominant industry might release human assets, it is not certain that alternative industries have appropriate jobs available at the same time. The region could risk losing valuable competence if alternative industries were unable to absorb the released assets.

The Grenland region

Key regional assets

Grenland has hosted Norway's largest concentration of processing industries, dating back to the early 1900s (Hodne & Grytten 2002), when Norsk Hydro was established; Norsk Hydro later and became the leading company in the production of fertilizer, as well as aluminium and magnesium (Hydro 2023). Today, Norsk Hydro is no longer the same, as it has been split up into c.90 different companies. Many of these companies are still located in Grenland and are primarily in the petrochemicals, metals, and cement industries. Since Hydro's glory days, a strong infrastructure has developed in Grenland, which we understand as an infrastructural and material asset. The companies located in the region, are connected by a strong infrastructure, such as a pipeline that covers all of Herøya Industrial Park, in the city of Porsgrunn, access to the power grid, water, quays, and logistics. One company interviewee expressed that the Grenland industry had the advantage of being highly integrated. For example, Company X uses steam from Company Y in its factory, and Company Y uses fuel gas from Company Z in its processes. In other words, 'The industry has developed a functioning ecosystem' (G2b). This cooperation has in turn led to easy access to workers and the right competence (i.e. human assets). Throughout generations, people have worked in the same companies as their neighbours and family members, and they have gained knowledge of how many of the companies in the region operate, making it easy for them to help other companies during projects or if crises occur.

The local companies are in an industry that releases heavy gas emissions, and consequently the Grenland region has struggled for a long time with being 'dirty'. As mentioned in the Introduction and the section 'The Grenland Region', over 20% of Norway's gas emissions from the manufacturing industry (mainly process manufacturing) come from the county of Vestvold og Telemark as a whole (Vestfold og Telemark fylkeskommune n.d.). This had severe consequences for the region in the 1960s and 1970s, but since then efforts have been made to improved the situation. Frierfjorden, in Grenland, was once one of the world's most polluted fjords, and the main water channel was so polluted that an interviewee revealed that it was not possible to swim or fish in it: 'so the manufacturing industry definitely left its mark on the area' (G11). However, the industry has made changes to its processes and products over many years towards being more environmentally friendly, including having more responsible innovation activity (Enova 2021; Yara International 2021; Green Industry Cluster, Norway n.d.). A shift culture among workers (i.e. an institutional asset) has emerged over the century (i.e. since the 1920s) and is highlighted as one of the most important assets in the region. One of the latest initiatives came from the former cluster, Industrial Green Tech, which mobilised its members towards aiming to become the world's first climate-positive industrial region. Since the 1970s, the conditions have ameliorated, and several of the company interviewees argued that this problem had been on the industry's agenda for decades.

An overview of the empirical findings related to the different assets in Grenland is provided in Table 3. Overall, the regional asset base has a strong presence of infrastructural and material assets, human assets, and institutional assets, which are oriented towards the production of petrochemicals, cement, and metals, as highlighted by our interviewees. Therefore, in the next subsection, we choose to focus on these as key regional assets.

Assets functioning as support and barriers in Grenland

An examination of the central assets in Grenland and their potential to function as support or barriers to regional industrial development needs to be seen in light of the direction of the development process. According to the interviewees, stakeholders in Grenland

Table 3. Regional assets in Grenland

Asset categorisation based on Maskell & Malmberg (1999)	Empirical findings from Grenland
Natural assets	Water (cooling and fresh water), coastline, hydropower
Infrastructural and material assets	Logistics, a hub of infrastructure, docks, power lines, close proximity between companies, shared pipelines, a mature industrial area, roads
Industrial assets	Industry-specific technology (electrolyte, process industry, cement, energy), organisational methods, sharing of technologies, electrification
Human assets	Industry-specific competence (process industry), knowledge, skilled workers, cluster, good connections to local university and research institutes, knowledge sharing, process operators
Institutional assets	Shift culture, strong industrial environment, development processes in the region's DNA, politics, strong common industry initiative for change, population is used to a dominating industry, workforce is used to helping out at short notice, collaboration between private and public actors, supportive institutional arrangements (e.g. Innovation Norway and the Research Council of Norway)

have expressed they have no intention of changing its industry structure; rather, they want to strengthen it by becoming greener and reducing emissions.

Additionally, we identify many examples of assets functioning as support for the greening of the industry through asset reuse in Grenland. For example, many companies reuse part of their old production processes, especially industrial assets and infrastructural and material assets, while replacing fossil fues or dirty components, often natural assets, with greener and cleaner options. The cited examples are often based on common initiatives and projects set in motion by several industry actors, such as Herøya Industrial Park and the IGT cluster. Furthermore, the interviews revealed that the shift culture and strong unity between the industrial actors, understood as an institutional asset, have been important in initiating and developing green development projects in the region and thus can be interpreted as asset reuse.

Furthermore, there are examples of asset creation in Grenland, specifically through a project related to carbon capture and storage (CCS). Capturing and storing the large CO_2 emissions from the industry at Herøya Industrial Park is a vital part of the mission to become climate positive. The project involves the creation of a new facility where the capture and storage of carbon can take place. However, this will require much electrical power.

One important piece of the puzzle for Grenland and Herøya Industrial Park in the mission for the region to become the world's first climate-positive industrial region is an infrastructural and material asset, namely the power grid. This was mentioned in almost all our interviews, and we see it as a vital part of the regional industrial development process and as a barrier to greening. Many companies require increasingly more power to electrify their production processes. The expansion of the power grid (i.e. asset creation) is therefore an important issue. The upgrading of the power grid is controlled by Statnett, which is owned by the Norwegian state, and governed by the Ministry of Petroleum and Energy, and is the system operator responsible for development and operation of the power grid in Norway (Statnett n.d.). Being a public-owned organisation, Statnett is required to conduct internal processes that support and follow democratic principles, resulting in bureaucratic processes and long case-processing times. According to Statnett's priorities, Herøya Industrial Park will have its energy supply ready in 2030 at the earliest (Statnett 2021).

There is clearly a difference in the timeline for when the power capacity will be available and when it is needed. Statnett is part of projects related to the greening of the industry at Herøya Industrial Park, but it has prevented changes, at least in the short term. As the owner of the power grid, Statnett has total control over its use and management, which means that Statnett needs to consider all industrial and other needs for electrification, such as potential battery factories and data centres.

Although expansion of the power grid is on Statnett's agenda, representatives of companies in Grenland expressed that their companies did not feel that they were high on Statnett's priority list, which hampered the process of realising the region's vision: 'industrial development is hampered due to limited line capacity' (G8). The industry, as it seeks to perform change agency with its mission and initiatives to become part of the world's first climate-positive industrial region, does not receive any special privileges in the race for power lines. Even if it is not Statnett's intention to slow down the process of Grenland becoming greener, it is a consequence of the procedures Statnett needs to obey; thus, Statnett performs reproductive agency. While the companies in the region can take initiative towards green development processes at a firm level, they are limited by infrastructural and material assets controlled by a system-level actor. System-level agency is necessary to modify the infrastructure that is crucial for the firm-level actors. This exemplifies the need for alignment between

agency on different levels (Isaksen et al. 2020). Additionally, to achieve asset creation regarding the power gird, asset modification is also necessary in terms of the institutional assets concerning how and what Statnett can do.

Discussion

This article contributes to the literature on regional industrial development by extending the understanding of barriers to regional industrial development beyond the immaterial factors found in the lock-in concept originating from the work of Grabher (1993) to include also material factors conceptualised as the regional asset base. To investigate the relevance of this broader understanding, we asked the following questions: How can regional assets function as support and barriers to regional industrial development? and How can actors take steps if regional assets become barriers, and how can such barriers be lowered? Historically, regional asset bases were created to support the further development of key regional industries. While an asset base supports the already established and strong industries in a region, it can also function as a barrier to the transformation of regional industry, such as towards greener production processes and the establishment of new industries in a region. Such barriers can be lowered though asset modification, either in a fairly simple way through the reuse and recombination of historically created material and immaterial assets at the firm-level and regional-level assets, or in a more demanding way by creating new assets in firms and at the regional level, and possibly by destroying hampering assets.

The case regions of Stavanger and Grenland in Norway have been used as empirical settings to investigate three interlinked questions: (1) What are historically created key regional assets in the two specialised regions? (2) Do these assets function as support or barriers to green path development? and (3) If they are barriers, what are the key agencies for lowering them?

Regarding key regional assets, we see similar traits in both case regions, with a regional asset base specialised towards the respective regional industries, with infrastructural and material assets, human assets, and institutional assets as the most emphasised asset types in our data. In both regions, we see examples of assets functioning as support through asset modification, especially through the reuse of infrastructural and material assets. We also see examples of assets becoming barriers to industrial development in both regions.

The reuse of human assets in industries outside the oil and gas sector is a prominent challenge in Stavanger, as the oil and gas sector has swept up the labour market of skilled workers. This finding is in line with Jarmai's claim that limited access to competence and financial resources can be barriers to innovation, both inside and outside the firm (Jarmai 2020). In other words, this issue is not solely a firm problem but an overarching and systemic one that demands that actors at both levels perform change agency. To lower this barrier regarding high wages, change agency at the system level, such as the national and regional level, is needed to enable still further the reuse of human assets in the region. Companies within emerging industries can perform change agency at the firm level to boost the attractivity of their company. However, to make bigger changes, institutional changes by actors at the national and regional level will be required, such as through the wage determination system or policies targeting emerging industries.

The most prominent barriers in Grenland are the limitations in infrastructural and material assets, mainly related to the supply of much more electrical power and the lack of asset creation in that regard due to institutional assets. Similar to the Stavanger region, asset modification through change agency is also required at different geographical levels in the Grenland region to lower that barrier. Projects initiated by companies located in Grenland can be done through change agency at the regional level. Some of these projects, such as CCS projects, are regional, national, and international projects that require aligned change agency at multiple levels. When it comes to the issue of extending the power lines, this is a challenge that requires change agency at the system level in general, and more specifically at the national level, meaning governmental bodies such as the Ministry of Petroleum and Energy and Statnett. Asset modification, such as asset creation, is a potential solution in which new procedures and rules are created to suit the processing industry's needs better.

Conclusions

In resembling the work of Grabher (1993) and Martin & Sunley (2006), our study shows that assets that were previously strengths for the case regions have since become weaknesses. Additionally, our findings show that both immaterial and material factors impact regional industrial development. The asset perspective on barriers to regional industrial development presented in this article provides a useful framework for understanding barriers to industrial transformation and how such barriers can be lowered. Assets from the regional asset base in thick and specialised regions can function both as support and barriers to innovation and regional industrial development. Actors at the firm and system levels have

varying impacts on different assets and are limited in what assets they impact and how they impact them. As such, some assets functioning as barriers can be lowered through firm-level agency, while others need system-level agency to be lowered; in some cases, both levels of agency must be aligned. This is perhaps even more important when the assets functioning as barriers are natural resources, infrastructure, or institutional framework, as these types of assets are often governed by system-level actors.

In short, the asset perspective highlights additional conditions affecting a region's industry and in society in general rather than Grabher's lock-in approach as possible barriers (Grabher 1993). Connecting asset modification at firm and system levels, as well as change agency at different levels, such as regional, national, and international, provides a more dynamic point of view regarding how barriers can be lowered. Moreover, the asset perspective provides greater opportunities to connect barriers, lowering them to actions on different geographical levels. Consequently, this article is an important contribution to the understanding of barriers to regional industrial development.

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