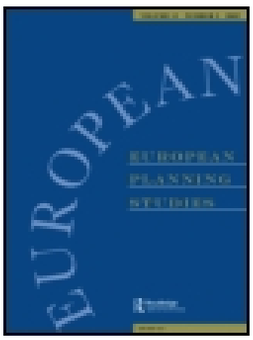

European Planning Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceps20

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**To cite this article:** Antje Klitkou , Marco Capasso & Teis Hansen (2021): Understanding conditions for path development after path exhaustion, European Planning Studies, DOI: 10.1080/09654313.2021.1875995

**To link to this article:** https://doi.org/10.1080/09654313.2021.1875995



Published online: 20 Jan 2021.

EUROPEAN PLANNING STUDIES
https://doi.org/10.1080/09654313.2021.1875995



# Understanding conditions for path development after path exhaustion

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**ABSTRACT**

This paper focuses on path development processes after a sudden path exhaustion. We analyse the decline, the closure and the attempts at the re-orientation of a forestry-based industry agglomeration in Southern Norway, located around the municipality of Hønefoss. In particular, this paper focuses on the Treklyngen holding company in Hønefoss. This paper explores how policy may be influenced by and built upon regional capabilities to support new path development in the aftermath of path exhaustion. It also shows how natural resources and institutional endowments could contribute to path development, under such difficult circumstances in a peripheral region.

**ARTICLE HISTORY**
Received 8 April 2020
Revised 5 January 2021
Accepted 6 January 2021

**KEYWORDS**
Path development; path exhaustion; peripheral regions; forestry-based industry

## 1. Introduction

This paper focuses on path development processes in a peripheral region after a sudden path exhaustion. The aim is to understand how path development processes can occur under such difficult circumstances, and how policy may build upon the existing regional capabilities. By analysing a case study from Norway, we analyse the attempts of path development in a peripheral rural region which for many years was highly specialized in pulp and paper production. The case is located in the Hønefoss municipality in Norway. For decades, economic activity in the Hønefoss district has been linked to the production of pulp and of print paper, in connection with the local availability of forest resources, but has recently experienced a dramatic decline, due to a global slow-down in print paper demand.

We employ the taxonomy of path development processes as defined by Grillitsch, Asheim, and Trippl (2018) and inspired among others by Isaksen and Trippl (2017) and Dawley et al. (2015), to describe the different policy options aimed at regional new path development. Natural resources and institutional endowments come specifically under focus, in our analysis, as regional capabilities which may survive path exhaustion in a peripheral region.

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In the next section, we describe the theoretical framework. In section 3 we sketch the historical background for the establishment of the district of Hønefoss, and the attempts made to create a new industrial cluster where firms exploit forest resources in novel ways. In section 4, we summarize the development of the four main industry development projects in the district of Hønefoss. Section 5 discusses the findings and concludes.

## 2. Theoretical framework

In this paper we are interested in understanding conditions for path development after path exhaustion in peripheral and organizationally thin regions. Consequently, we structure the theoretical framework as follows. First, we briefly explain the regional innovation systems approach with an emphasis on organizationally thin regional innovation systems. We zoom in on the theoretical concepts of regional capabilities and institutional endowments, used to frame types of regional resources beyond knowledge and skills. Additional theoretical references are given to address the specific role of natural resources and of policies in defining a region's potential. Then, we draw on the literature on regional path development processes and present previous insights on challenges and possibilities in organizationally thin RISs.

### *2.1 Regional innovation systems and regional capabilities*

A fundamental concept for understanding the existing and potential knowledge flows in a region is the 'regional innovation system' or 'RIS' (Cooke 1992; Cooke, Boekholt;, and Tödtling 2000; Cooke 2004; Asheim and Isaksen 1997; Asheim and Gertler 2005), which points at the set of relations determining the innovation patterns within a region. RISs include three core elements: a set of public and private actors (the organizational dimension of RIS), institutions influencing their behaviour, and networks linking those actors. In line with Lundvall (1992), we count as *organizations* in the innovation system not only those explicitly devoted at searching and exploring, such as R&D departments, technological institutes and universities, but also any actor in production, marketing and finance who can affect and contribute to learning as well as searching and exploring.

*Institutions* are the rules of the game that enable or constrain the actors' activities performed. Institutions can be both formal, such as regulations and policy initiatives, and informal, such as norms enforced by social conventions, values and attitudes. The institutional endowments of a region encompass 'all the rules, practices, routines, habits, traditions, customs and conventions associated with the regional supply of capital, land and labour and the regional market for goods and services' (Maskell and Malmberg 1999, 173). Institutions are often associated with stable patterns of behaviour, which sustains path dependent development processes. The institutional endowments can both spur and restrict 'the development of firms in a region, thereby exerting a strong – but never deterministic – influence on the future of the region' (Maskell and Malmberg 1999). More recently, scholars have highlighted that institutions can act as enablers for changing behaviour and hence lead to economic activity that break with existing paths (see Martin and Sunley 2006; Strambach 2010).

The institutional endowments are among the *regional capabilities*, that are 'localised capabilities' which determine the region's competitiveness and include assets such as infrastructure, knowledge and skills (Maskell and Malmberg 1999, 173; see also MacKinnon, Dawley, and Steen 2019). Regional capabilities are built and developed over time and are therefore hard to copy by other regions. They also include the *natural resources* available in the region, comprising both the region's own resources and the ones available through trade with other parts of the world. While a given natural resource may be available in many regions, industrial development centred on utilizing this resource may only be present in a smaller number of regions, thus providing opportunities for new path development. In the literature on economic development, there has often been a focus on the inhibiting effect of natural resource industries on development of more diverse forms of economic activity and economic growth in general (e.g. Sachs and Warner 2001). However, it has also been stressed that natural resource industries may drive the development of new upstream industries, which produce innovative inputs to the exploration, cultivation, extraction and transportation of natural resources (Andersen 2012). Similarly, the establishment of downstream manufacturing industries may also be stimulated by local availability of natural resources.

### 2.2. Regional path development

While the regional path development literature has recently started to consider pathways of decline (Blažek et al. 2019; Jolly and Hansen 2021) or exhaustion, defined as the innovation potential of local firms has been severely reduced, or innovations take place only along a restricted technology path (Trippl and Isaksen 2016), the main emphasis is on how positive path developments can occur in different ways. Here we follow the taxonomy developed by Isaksen and Trippl (2017), Isaksen, Tödtling;, and Trippl (2018) and Grillitsch, Asheim;, and Trippl (2018):

(1) *Path extension:* continuation of an existing path based on incremental innovation in existing industries on well-established technological trajectories;
(2) *Path upgrading:* a major change in an existing regional industrial path in the form of either (a) renewal (the infusion of new technological or organizational changes), (b) climbing GPNs (improved position in global production networks), or (c) niche development in mature industries, driven by integrating symbolic knowledge;
(3) *Path importation:* initiating an industry which is new to the region and unrelated to existing industries in the region, but not new to the world;
(4) *Path branching:* developing new regional industries by building on capabilities of existing industries;
(5) *Path diversification:* developing new regional industries by combining unrelated knowledge existing in the region; and
(6) *Path creation*: emergence and growth of an industry new to the world, often based on radically new technologies, scientific breakthroughs, new business models etc.

Path development may be constrained by the organizational and institutional structure of the RIS. Following Tödtling and Trippl (2005) and Isaksen and Trippl (2016), we distinguish between three types of RISs: organizationally thick and diversified RISs,

organizationally thick and specialized RISs, and organizationally thin RISs, which are often found in peripheral regions. Each type is associated to specific possibilities for path development and to specific needs for innovation policies.

Organizationally thick and diversified RISs host strong universities and other knowledge organizations, as well as a variety of industries and of innovation-supporting organizations. They have strong potential for path branching, path diversification and new path creation (Isaksen, Tödtling;, and Trippl 2018).

Organizationally thick and specialized RISs focus just on one or very few industries and the institutional set-up of the region is adapted to this. This strong specialization promotes incremental innovations in these industries, which support path extension and eventually path upgrading. Lock-in mechanisms lead to path dependencies, which can under certain circumstances, such as shrinking demand or rise of competition, lead to economic failure and a declining pathway.

Thirdly, organizationally thin RISs are characterized by a low variety of activities and they may require external sources of knowledge to ignite innovation processes in the region. Indeed, given that peripheral regions are typically characterized by low R&D activity, lack of critical mass in industrial specializations, thin institutional structures, and lower access to bank finance (Tödtling and Trippl 2005; Lee and Brown 2017), the literature highlights limitations in endogenous development of new paths.

*Path upgrading* into higher value-added activities is suggested to be the most likely type of path development process for peripheral regions (Barzotto et al. 2019), given constraints in locally available resources (Isaksen 2015). Whereas path upgrading can be achieved primarily based on local resources, the literature suggests that cases of *path diversification* are unlikely to be achieved without substantial inflows of resources from extra-regional sources (Reidolf and Graffenberger 2019). Firms may compensate for peripheral location by, e.g. establishing branch offices in central locations or collaborate frequently with extra-regional partners (Eder and Trippl 2019; Grillitsch and Nilsson 2015). Thus, entrepreneurs in both industry and policy spheres are not only leveraging regional assets, but also utilizing opportunities arising in the global production networks they are embedded in or in broader policy agendas (Dawley 2014). Consequently, path diversification processes in peripheral regions are vulnerable to changes in these domains (Dawley et al. 2015).

While studies of *path creation* processes in peripheral regions are few, Carvalho and Vale (2018) present an example of a success case of *path importation* where a biotech industry in a peripheral Portuguese region was established and consolidated despite the absence of industries with related knowledge in the region. In this case, the transposition by institutional entrepreneurs of institutional norms and practices onto the biotech industry due to institutional relatedness played a central role in the path development process. Similarly, Isaksen and Trippl (2017) and Nilsen (2017) highlight the essential role of inflows of exogenous resources connected to either investments by multinationals, establishment of branch plants or university research institutes for path emergence processes in peripheral regions.

Dawley et al. (2015) identified three types of policy interventions as important for path development processes in peripheral regions: construction of market opportunities, attraction of firms from outside the region, and proactive strengthening of the regional innovation system. Policymakers must here identify local firms that would be able to act

as gatekeepers for the external knowledge. They should also plan an expansion of the absorptive capacity of the region, so that the introduction of external knowledge could be followed by the knowledge diffusion throughout the region (Isaksen, Tödtling;, and Trippl 2018). Isaksen, Tödtling;, and Trippl (2018) distinguish between system-based policy and actor-based policy approaches, and their respective policy instruments. System-based approaches are derived from the understanding of the interaction in a regional innovation system, and include policy instruments, which facilitate such interactions, such as cluster policies, and policies for increased knowledge flows between universities and industry. Actor-based policy approaches address the capabilities of specific actors, providing firms with financial resources and advice, or strengthening R&D activities at universities and research institutes. Another distinction must be made between vertical and horizontal policy instruments. While vertical policy instruments target specific sectors or industries, horizontal policy instruments support growth-enhancing policies, particularly those that promote the entry of new firms and start-ups, the access to financing, and fast and cheap exit strategies, but not specific industries or sectors. It is suggested that a combination of vertical and horizontal policy instruments is needed to strengthen the regional capabilities of peripheral and organizationally thin regions (Isaksen, Tödtling;, and Trippl 2018).

Our research question is: what are the conditions for path development after path exhaustion in a peripheral and organizationally thin region? Two main sub-questions are: can an organizationally thin region capitalize on institutional endowment or natural resources, after path exhaustion? In this context, which challenges to path development could be effectively targeted by policies? In the following, we analyse path development processes and the policies adopted in the peripheral district of Hønefoss, afflicted by path exhaustion. Several approaches to path development have been pursued, with varying outcomes. We argue that a range of regional capabilities may be present in an organizationally thin region, even in the face of path exhaustion. Policy may leverage on those capabilities, but some options for path development still appear to be precluded.

## 3. Historical preamble: the establishment of Treklyngen

In 2012, the pulp and paper mill at Follum, near Hønefoss, was closed and sold for 60 million NOK by the pulp and paper company Norske Skog to the regional forest owner cooperative Viken Skog (Iversen 2012). Follum was sold to Viken Skog under the condition that the paper production had to be stopped and the equipment had to be dismounted. Viken Skog is a forest owner cooperative with about 11,000 forest owners, which means a very high degree of ownership fragmentation. The rationale behind the closure of Norske Skog was that the traditional market for newspaper print paper was diminished, which meant that forest owners had to find new possibilities for value creation.

In comparison with Finland and Sweden, which not only have much stronger and more diversified pulp and paper industries and larger forestry sectors, but have also come further in moving into new product areas (Hansen and Coenen 2017; Näyhä and Pesonen 2012), the Norwegian forestry sector was heavily hit by these changing market conditions. The development organization Treklyngen was intended to provide new possibilities for forest-based industry in the region around Hønefoss in South-Eastern Norway. Owned by Viken Skog, the explicit goal was to establish a forest

cluster with several firms exploiting forest resources, including residues and side-streams, in different ways; for instance, for the production of wood-based construction materials, of advanced biofuels, and of bio-chemicals and materials.

The inconsistent and unpredictable political framework conditions for forest-based value creation have contributed to the crisis of the forest-based industry in Norway. The 'red-green' government which governed Norway from 2005 to 2013 was criticized in respect to this, especially for three reasons: (1) the change of biodiesel taxes in 2009 was highly negative with regard to attracting risk capital for the green industry; (2) the payment of property taxes by Norske Skog in 2012 while the company had a clear deficit contributed to the difficult crisis; (3) over the years, wood chips guarantee instruments had been gradually reduced and at the same time low electricity prices were critical for wood-based bioenergy.

With the closure of Follum and another large pulp and paper plant in the region, Södra Cell in Tofte in 2013, it became difficult for the forest owners to find a market for their pulpwood: 2.6 million $m^3$ of pulpwood lost their domestic market. Treklyngen planned to exploit 3–5 million $m^3$ timber annually in the future – about half of today's national felling volume. These plans involved complementary businesses of different sizes, exploiting all parts of the raw material, including residues, for value creation at Follum.

*Job creation* was a main topic for Treklyngen since the start. With the closure of Norske Skog Follum, 365 jobs were lost. The closure of Follum was not the only event that contracted the labour market in the forest-based industry in Southern Norway: since 2006 almost 1.000 jobs were lost in related industries in the region, and the closure of Södra Cell in Tofte in 2013 endangered about 6,000 jobs in the forest-based industry (Anonym 2013a). These closures of such important actors in the forestry industry had negative implications for suppliers, service providers and the tax income of the involved region and municipalities. Consequently, Viken Skog developed as a vision for Treklyngen to create 1,000-2,000 new jobs (Mannsverk 2012).

What can be said about the institutional endowments in the region? The regional authorities have not possessed strong financial means to support job creation. They have supported the process by lobbying initiatives to national politicians and public authorities, and they have also financed the incubator Pan Innovation (Anonym 2015). Regional actors lobbied for improved framework conditions for forest industry and better possibilities for the transport of timber (Ødegård 2013). They demanded modernization of regulations and legislation and competitive framework conditions for Norwegian mainland industry (Gjerdbakken 2013).

## 4. Path development efforts

In the following, we highlight different path development efforts, as they have evolved over the last few years at Treklyngen. We focus on the development of four main industry development projects: biofuel for air transport, biofuel for road transport, biochar-pellets for power plants, and bio-carbon for the processing industry. Several other forest-based industry projects, such as the production of wooden construction materials and of bioenergy products, are not covered here. We describe the development of each pathway and discuss it in relation to the literature on path development in peripheral regions.

Our study bases upon a media analysis of Norwegian newspapers and magazines published since 2012, including ca. 800 articles and news messages; a document analysis of relevant policy documents and reports; and interviews with representatives from Treklyngen, and involved industry partners, and the national forest owner association.

### 4.1. Bio-jetfuel for air transport – collaboration with Avinor

In the Follum region, there have been two main industry development projects regarding biofuels for transport; this section describes the cooperation with Avinor for bio-jetfuel production. Avinor is a state-owned limited company under the Norwegian Ministry of Transport and Communications, responsible for the state airports and the air navigation service in Norway (Iversen 2013b).

In 2013 a consultancy report, commissioned by Avinor, was published, and showed good possibilities for production of bio-jetfuel in Norway, and in particular in five areas of Norway (Hansen 2013). Among the five areas, the most attractive was the region around Follum, mainly as a consequence of its short distance from the main Oslo airport (Iversen 2013b).

Avinor decided on an investment of 100 million Norwegian kroner to finance projects with the goal of producing bio-jetfuel in Norway; SIVA, a Norwegian state-owned enterprise which facilitates the development of new business in Norway, would also contribute with the same amount; Follum would be one of the central locations considered for the funded projects (Anonym 2013b).

The development leader at Treklyngen, Ole Petter Løbben, declared at the time that, even if the most difficult task had been finding a first player, it would be a priority to find more players; he also believed that Avinor, in addition to contributing money, it could help to connect to environments that have expertise in fuel technology (Kløvstad 2013). The difficulty of finding a first player was later confirmed both by Løbben himself (translated from Norwegian: 'For us this is a strong stimulus […] [Avinor] is a big and serious player who has a plan for what they want to do', Anonym 2013c) and by the board chairman of Viken Skog (translated from Norwegian: 'Getting the first player is always the most difficult part', Iversen 2013a). Soon after, Rolf Jarle Aaberg, CEO of Treklyngen, declared: 'We need a predictable demand through a predictable jetfuel market, with a predictable price. A model similar to European feed-in tariffs for renewable energy is what I envision for bioenergy in Norway' (Anonym 2014, translated from Norwegian).

Treklyngen then commissioned the Finnish firm Pöyry with a study about the profitability of a bio-jetfuel plant at Årbogen, near Follum; after the conclusion of the study, the Treklyngen development director Ole Petter Løbben declared: 'I have received yeses to all questions about whether such a facility can be placed here' (Iversen 2013b, translated from Norwegian).

At the same time, the international features of the sector still stayed in focus: Ragnhild Borchgrevink, administrative director of Viken Skog, stated that '[t]his is an international industry and that is where development takes place. It is very wise to connect with foreign 'competence environments' and investors' (Iversen 2013a, translated from Norwegian). Avinor's strategy was elaborated in connection with agreements on the demand side,

and especially with the jet-fuel supplier Air BP and the airlines Lufthansa Group, SAS and KLM (Endresen 2015).

The involvement of other strong actors was also considered necessary for technology development; Rolf Jarle Aaberg, CEO of Treklyngen, stated that '[h]ere, more technology development is needed. In collaboration with Avinor, we are working to strengthen the partnership with new players, in order to create a business foundation for production also at Follum' (Endresen 2015, translated from Norwegian); he also stated that bio-jetfuel production could perhaps start around the year 2020 (Bjørndal 2015).

In the spring of 2016, Avinor, Treklyngen, Elkem (a Norwegian leading producer of silicon-related materials owned by Chinese BlueStar) and Vardar (a regional energy company) began to work on the feasibility study 'Norwegian Wood' to investigate whether it was feasible to start an industrial production of charcoal and bio-jetfuel at Follum. Following the publication of the study, in February 2017, Avinor decided not to go ahead with the plans for the production of bio-jetfuel. 'With today's technology, we do not get those quantities of pyrolysis oil that we had hoped for. This makes it difficult to make aviation fuel out of wood logs', said Olav Mosvold Larsen from Avinor in a press release, adding that 'this project has been incredibly educational for us' (Iversen 2017). Follum was still considered by Avinor to be among the best locations for this type of production, and long-term plans would continue; commenting on the news, a local newspaper stated that 'impatience is good, but if we are to succeed with the revitalization of the wood industry in the region, we must endure setbacks. We must learn from them, take new path choices, grit our teeth and work harder' (Anonym 2017c).

The attempts made by Treklyngen to promote bio-jetfuel production in the region display many of the typical features of path development in peripheral regions. The national state appears as a prominent player, acting at the same time on the production side and on the demand side through state-controlled Avinor. Indeed, Avinor was the first actor to ask the question whether biofuel should be imported or not (a multiscale country–world question) and which would be the best regions for producing biofuel in Norway (a multiscale region-country question). Once Follum was identified as a possible production place, the Norwegian state scaled up the intervention through support from SIVA, a Norwegian state-owned enterprise, which plays a strong role in the implementation of cluster policies and has special responsibility for geographical areas with weak access to private capital.

While the path creation for bio-jetfuel production at Treklyngen failed because the technology was new to the world and not ready yet, we observe two types of policy interventions (construction of market opportunities, attraction of firms from outside the region) identified by Dawley et al. (2015), but both are functioning as horizontal instruments,as important for path development in peripheral regions, but to a lesser degree the proactive strengthening of the RIS. The existence of favourable regional capabilities, here underutilized forest resources, attracted large actors from outside the region (Avinor and Elkem). Something similar has has been shown in the case of the 'thin' region of Lister in Southern Norway, for the importance of natural resources, there of hydroelectric power, for path development (Isaksen 2015).

### 4.2. Biofuel for road transport – collaboration with St1

The changes in the wagering requirement for biofuels in connection to the state budget for 2016 contributed to positive expectations regarding the profitability of biofuels for road transport in Norway (Persson 2015). In the beginning of 2016, there was a discussion in the Norwegian media about the low sustainability of the biofuels, which were on the market at that time. Due to the new regulation, there was an increasing demand for biofuel, but this demand was not met by advanced biofuel (Anonym 2016b). Much of the biofuel was based on rest products from palm oil production.

At the same time, Treklyngen offered a solution for this bottleneck: production of advanced biofuel based on domestic forest resources which cannot be used by sawmills and paper production, such as treetops, low quality timber and sawdust. In June 2016, Brakar, the public transport service provider in the Buskerud region and the publicly owned national bus transport provider Nettbuss signed an agreement on fossil-free fuel in public busses. Biofuel from Treklyngen and/or Tofte is to be used for the buses. This created a market for biofuel in Buskerud County (Anonym 2016c). In August 2016, Finnish St1 and Treklyngen signed a letter of intent to build a bioethanol plant at Treklyngen, being in operation from 2021 and producing 50 million litres of bioethanol from 500,000 $m^3$ sawdust from sawmills and low-quality timber annually (Skjeseth 2016; Undheim 2016).

St1 has already established bioethanol plants in Finland and Sweden mainly based on the processing of food waste – and has more than 1,500 filling stations in Finland, Norway and Sweden. As a consequence, the Norwegian forest owner association, St1, Treklyngen and the political party Venstre demanded an increased wagering requirement for biofuels from 5.5 percent in 2016–7 percent in 2017 (Skjeseth 2016). This was accomplished in the negotiations for the 2017 state budget and strengthened Treklyngen's and St1's plans for producing advanced biofuel (Ødegård 2016). It seemed that St1 would probably not need external financial support for the planned biofuel plant (Bårdsgård 2016). The required investment was around 1 billion NOK and the company planned to make the final investment decision in 2018 (Anonym 2017a). St1 planned to produce Cellundix, bioethanol from spruce and pine, and to extract lignin from the wood which will be used to produce heat (Tronhus 2017). In addition to bioethanol and lignin, the company will extract fuel oils, chemicals and perhaps liquid biogas, which will allow better profitability (Bårdsgård 2017).

However, there are still two uncertainties related to the final decision to build the plant at Follum.

(1) There are still some technological uncertainties. While the company has experience with the production of bioethanol from food waste, a pilot plant which processed sawdust was first set up in Kajani in Finland in 2017 and the company had to learn from this pilot before the plant at Follum could be built (Lewis, Strand, and Bentzrød 2017). In 2018, the pilot plant was still experiencing technical problems related to the pre-treatment of the sawdust, which is necessary to get rid of the resin: this led to too much downtime at the pilot plant (Ødegård 2018). Thus, in 2019, the investment decision had still not been made.

(2) Investment decisions could also be hampered by unpredictable local property taxes on machines and equipment, which could mean about 0.5 million NOK per job at this plant, adding up to at least 10 million NOK (Thorgrimsen 2017). The CEO of Treklyngen, Rolf Jarle Aaberg, stressed that there are very good public support schemes for innovation and early start-ups. However, 'we must have a competitive tax regime; if not, we risk that the state contributes millions in the start-up phase to, for example, pilot plants, but that investors choose to place production abroad because they offer more favourable conditions' (Ødegård 2017). The joint lobbying by Treklyngen, the Norwegian forest owner association and the Federation of Norwegian Industries to abolish local taxes on machines and equipment was successful: in Autumn 2017 the government decided to abolish this tax (Blørstad 2017). It should be noted that this decision was not undisputed since municipalities lost income as a result.

We see this case as an attempt of 'Path importation': starting an industry (advanced biofuels) which is new to the region and unrelated to existing industries in the region, but not new to the world (existing already in Finland). However, this imported technology has some clear technological uncertainties.

In this industry project, the national state again appears as a prominent player, by securing constructing market opportunities for advanced biofuels and through the abolishment of the unpredictable local property taxes on machinery and equipment, making investment decisions easier. However, these actions are not directly related to attempts to support path development in this region, but rather motivated by the need to change political framework conditions for new industry development in general (by abolishing taxes) and by the need to contribute to the decarbonization of Norwegian road transport. Thus, specific interventions to secure the attraction of extra-regional firms (cf. Dawley et al. 2015) are absent. In the absence of new endogenously created paths, the opportunities for path development in the periphery is to a considerable extent dependent on events which cannot be controlled by regional and national policymaking.

### 4.3. Biochar-pellets for power plants – collaboration with Arbaflame

In June 2014, Treklyngen and Arbaflame signed an agreement and plan for a production plant for a new type of biochar-pellet at Follum. Biochar-pellets are an environmentally friendly energy that can replace fossil coal and will be manufactured using unique Norwegian technology (Iversen 2014).

The Arbaflame plant was planned to have a yearly production capacity of 200,000 tons of biochar-pellets, exploiting 500,000 $m^3$ forest resources such as leaves, energy wood, sawdust and other less demanded fractions (Bjørndal 2015). The produced biochar-pellets were intended to be exported to Germany and the United Kingdom, and markets in Asia and the US were also envisioned (Bjørndal 2015). Actors in the forest-based value chain reacted very positively to the Arbaflame plans. Sawmills need the possibility to deliver sawdust to fibre-consuming industry because 50% of the timber ends as sawdust and this takes a lot of space (Havro 2014). In 2015, Treklyngen mainly worked on the Arba Follum industry project. This included pre-sales of the biochar-pellets and changes to the owner structure of Arba Follum AS (Iversen 2015). Treklyngen and Arba

Follum secured deliveries to a major power plant in Rotterdam. Arbaflame ran successful tests at Ontario Power Generation, which were considered as vital for pre-sales of Arbaflame's biochar (Heieren 2015). Arba Follum intended to build several plants for biochar in other parts of the world, such as in Canada, the US and the Baltic countries, and also to license the patented technology to other countries (Lie 2015). Costs for producing electricity with biochar are higher than with fossil coal. They have to be compensated with $CO_2$ taxes and incentives for biochar deployment, such as in the UK, the Netherlands, Belgium, France, Denmark and Japan (Lie 2015). At that time Arba Follum was only using the wet side-streams, such as sawdust, which means ca. 5-10% of the saw logs. Sawmills in the area around Treklyngen were to deliver around 15% of the required feedstock as sawdust. If they could find a good technical solution for 'bakhonet' (wood boards with bark on one side) they could cover 50% of the required feedstock (Berge 2015). In November 2015, Enova decided to support the Arba Follum project with 138 million NOK (Mannsverk 2015). Finally, in November 2016, after 13 months, the EFTA Surveillance Authority accepted this financial support (Iversen 2016). The next step was to achieve private co-financing.

At the end of 2018, Arbaflame received funding of around €19 million for a Horizon 2020 demonstration project together with partners in Norway, Belgium, and the Netherlands (Eriksen 2018). The goal of the project was to replace the coal in an existing coal-fired combined heat and power plant with thermally treated biomass produced on-site in Rotterdam. At that time, the plans for Arba Follum prevailed. However, Moelven, a large Scandinavian industrial group specialized in wood processing industries, planned to build a large plant for traditional pellets at Sokna, 20 km from Follum, and as a result the need to valorize sawdust in the region became less urgent, and access to sawdust more difficult and expensive (Iversen 2019). Arbaflame decided to build its full-scale plant at Grasmo, near Kongsvinger at the border with Sweden, where the company had had a pilot plant in operation for years. This plant will deliver 70,000 tons of biochar-pellets to Engie Energie for its CHP plant in Rotterdam. The plant will be ready in the summer of 2020. Already now, biochar-pellets from the pilot plant have been delivered to Engie. In the future, Arbaflame plans to build a larger plant at the harbour in Rotterdam, close to the CHP plant, and Treklyngen has left Arbaflame also on the owner side.

Two circumstances contributed to the negative outcome for Treklyngen:

(1) The main market for the biochar-pellets is not in Norway but in other countries, which deploy fossil coal for CHPs. The future plant will therefore not be located where the forest resources grow, but where the market is, and where the resources get shipped to.
(2) Private investments for the plant had to be attracted from foreign investors, such as Engie Energie, and the plant also required low prices for, and access to, sawdust. This was originally the main reason for locating the production at Follum, but with the competing pellets plant at Sokna this decision was no longer possible.

Again, the prospective path development gained institutional support, in particular through the financial support obtained from the government through Enova by a vertical policy instrument. However, policies did not seek to stimulate *regional* innovation system

building, and demand creation was beyond the scope of regional and national policies in the case of this specific emerging path and more a horizontal policy measure at international level. Consequently, while the available natural resources were important for the initiation of the preformation phase, they were by themselves insufficient to ensure the actual materialization of the path in Hønefoss, which instead developed in a location where previous demonstration activities had taken place. Following Isaksen and Trippl (2017), this highlights the importance of in-flows of knowledge and investments in order to embed the emerging path in the peripheral region.

### 4.4. Bio-carbon for the processing industry – collaboration with Elkem

In April 2016, Elkem, Treklyngen, Avinor and the energy company Vardar established a collaboration to develop a new value chain for producing charcoal and bio-oil at Treklyngen. The envisioned 'Norwegian Wood' had the goal of exploiting whole timber (Anonym 2016a). The collaboration was supported by Innovation Norway and started with a feasibility study for an industrial pilot plant; it was planned that the plant would produce charcoal and bio-oil at Follum through pyrolysis. The decision was expected to be made in autumn 2016.

For Elkem this collaboration was motivated by the need for Norwegian biochar for the processing of silicon. This could replace expensive imports of foreign biochar or of fossil coal (Anonym 2016d). The Chinese owners of Elkem, Bluestar, demanded the deployment of sustainable biochar – all fossil energy should be replaced by sustainable sources. This demand is congruent with the political agenda of the Norwegian government – Klimakur 2020 – to reduce emissions of carbon dioxide in Norwegian industry (Økstad 2010). Elkem needs biochar to achieve reductions of $CO_2$ emissions (Venn 2016). The biochar can be imported, or it can be produced in Norway. The intention was to use the important side-stream of biochar production in the production of bio-jetfuel (Avinor) and of pyrolysis gas to produce heat and electricity (Vardar) (Venn 2016).

However, at the beginning of 2017, while Avinor's plans to produce bio-jetfuel were cancelled the collaboration between Elkem, Treklyngen and Vardar would continue, but the feasibility study showed that the production of biochar for Elkem should exploit the possibilities of using excess heat for other industrial production, thus achieving a kind of industrial symbiosis with neighbouring industry plants (Anonym 2017b). Elkem urged the Norwegian forest industry to become more focused on industrial value creation based on forest resources. The collaboration with Treklyngen has been an important step in the right direction, but it is not just technology that is an issue. The technical director of Elkem requested new business models to achieve more predictable business relations between forest owners and customers (Moe 2017).

In December 2018, Elkem group received 10 million NOK of funding to find a way to produce a 'greener' coal or 'bio-carbon'. The project was funded by Pilot-E, a funding scheme supporting the development from research to full-scale demonstration and based on a collaboration between the Research Council of Norway, Innovation Norway and ENOVA. Elkem collaborates with Treklyngen, other private actors and two large research organizations on the project, called Bio-CarMet, and aims to produce the bio-carbon at a new factory in Hønefoss. The bio-carbon would be used to produce silicon in Elkem's Norwegian smelters, replacing fossil coal with renewable coal (Iversen 2018).

While Elkem will develop further and test the technology, which is not Norwegian by origin, Treklyngen will investigate the raw material basis for the placement of a full-scale plant at Follum and will explore technical solutions, area requirements and energy needs. An investment decision is planned for 2021. In 2019, Elkem concluded that the company will need about 7% of all Norwegian annual forest extraction to produce sufficient bio-carbon (Ordenrud 2019). The construction of a test facility can start already in 2020, and Treklyngen is one of several alternative locations for this test facility.

In this case of path creation (new to the world), we can observe all three types of policy interventions defined by Dawley et al. (2015): construction of market opportunities, due to the need to replace fossil coal with bio-carbon, supported by the government (a horizontal policy measure) and by foreign industry owners; attraction of firms from outside the region around Hønefoss, but still not too far away (Southern Norway); and proactive strengthening of the regional innovation system, by financing pilot facilities in Norway (both a vertical and a horizontal policy measure). While it remains to be seen if this new path will completely materialize, a central outstanding question is again the performance of the technology. In this respect, the national research collaboration with leading actors in the Norwegian research system looks promising.

## 5. Discussion and conclusions

This paper aimed to improve our understanding of how policy may be influenced by and built on regional capabilities to support new path development in the aftermath of path exhaustion. The analysis covers three cases of attempted path creation and one attempt of path importation. Two of these attempts were unsuccessful, with the fate of the two other attempts (biofuel and bio-carbon) yet to be decided. Here, we first discuss how natural resources, the institutional endowments and policy have contributed to these path development processes. Subsequently, we discuss implications of the analysis for the literature on path development processes.

In all four path development efforts, we witnessed that the access to *natural resources*, in the case of Treklyngen access to timber, forestry residues and side-streams, is important for the path development processes. This brings forward a peculiar issue: the industries that can be created or implanted in the region would best be those industries that use the same natural resources as the previous existing industries. In other, less naturally endowed, regions suffering from path exhaustion, the influence of the disappearing industries on the new path could dwindle fast as, e.g. suppliers would suffer from the decay of the main industry. However, in our case the natural resources could easily remain the main inputs for the regional activities even after path creation or importation, since their suppliers can easily reactivate their production (through felling etc.). This naturally points the choice of new industries, for the region, towards other industries that use similar natural resources as the previous industries.

The *institutional endowments* in the region were important in getting the projects under way, but they were not strong enough to ensure a realization of the projects. Regional and local politicians focused on the creation of new jobs, and they lobbied national politicians and public authorities for better framework conditions regarding transport infrastructure, modernized regulations and legislations. These initiatives have been fulfilled to some extent by national policy. Of course, there is a balance: if

the institutional endowment would have been too strong, this could lead to some lock-in, and thus hamper the realization of radical projects.

In our findings, we see external sources of knowledge as in Isaksen and Trippl (connections with big national players), institutional relatedness as in Carvalho and Vale (which allows to use older political connections and lobbying capabilities for new sectors), state policy as in Dawley et al. 2015. Here in our case, the national state and organizations are external but not exogenous: institutional relatedness across sectors works in the sense that the regional actors are used to connect with national funding organizations which are not sector-specific, as well as municipal authorities which again are not sector-specific. Big players (also private) at the national level have both a financial and political strength but are also gateways for external knowledge.

*Horizontal policies* at the state level have been especially active in the field of R&D policy, as with the funding of two projects: Elkem, by the Research Council of Norway, Innovation Norway and Enova; and Arbaflame, by Enova. International R&D policy strengthened this capability even further in the case of Arbaflame (support by Horizon 2020). State policy has contributed to more supportive legal and regulatory framework conditions by changing tax regulations for machinery and equipment.

More *vertical policies* attempting to make the forest-based industry especially attractive to investments by firms from outside the region are much less visible in the four industry projects. An exception was the decision to increase the wagering requirements for biofuels to 7 percent in 2017. This contributed to improved market opportunities for advanced biofuels. The state has also supported transport infrastructure development in the forestry sector. The collaboration of Treklyngen, national authorities and regional authorities contributed to improved transport infrastructure, such as quays, railroads and roads, and further improvements are on the way. Transportation is especially important for such an industry, which is based on large volumes of natural resources.

We suggest that our analysis has at least four broader implications for the literature on path development processes. First, the analysis underscores the importance of various types of regional capabilities. Similarly to MacKinnon, Dawley, and Steen's (2019) emphasis on various regional assets as potentially influencing regional path development processes, our analysis highlights that availability of natural resources was a central impetus for all four path development processes. Thus, while the typology of path development processes emphasizes whether or not new industry paths rely on knowledge found in existing regional industries, the current analysis highlights that emerging industries may also be related to previous industries in other ways. Thus, in addition to institutional relatedness (Carvalho and Vale 2018), the analysis points to the importance of natural resource relatedness between old and new industries.

Second, the literature on path development processes in peripheral regions suggests that path extension and path upgrading are the most feasible types of path development processes (Barzotto et al. 2019; Isaksen et al. 2019). However, in situations of path exhaustion, such options are simply not feasible, thus, placing such regions in a difficult position. In the region analysed in the current paper, the four cases of path development and importation required the development of quite radical new technologies. In other words, the paths were not just 'new-to-the-region', in the sense that they already existed in many other places, but also 'new-to-the-world' in that they built on novel technologies that were still to be developed. This was even the case for the path importation

attempt, which was based on technologies currently under development in Finland. The cases highlight that there are certain challenges that come with these types of paths, which make them risky; in particular the lack of certainty concerning how well the technologies will function. While this is the case for all regions, it may be particularly difficult to successfully develop such paths in peripheral regions, which have only limited access to the core competencies around such technologies.

Third, the analysis contributes to the understanding of possibilities and limitations of regional policy to influence path development processes in peripheral regions. Political actions at the regional level strengthened the regional innovation system by financing the local incubator and supporting the municipality in stimulating local industrial development. However, the scope for regional policy to influence the developments of the paths was relatively limited, in particular given the focus on radical technologies and the lack of strong regional knowledge institutions, such as a university or technical research institute. Thus, the paths were crucially dependent on technological development and performance, but also demand creation in places, which were completely out of reach of regional policy (international demand for bio-jetfuel, biofuel or biochar). Consequently, if the international technology development or demand do not evolve as planned, the path development processes will not succeed, irrespective of the available capabilities in the region.

Regarding policy implications for peripheral regions, this suggests that path creation or importation based only on radical technologies serving mostly international markets constitutes a risky strategy. It might be advisable to also attempt to create less risky paths, aimed at serving regional or national markets. However, for less risky industry projects, competition between regions for industrial activity is more fierce. In the case of production of wooden construction materials, Hønefoss was unable to create as favourable conditions as other regions in Norway where this production is now localized (Klitkou et al. 2019). This highlights that there is no easy solution for peripheral regions experiencing path exhaustion.

Fourth, the analysis contributes to an emerging attention to negative path development processes (Blažek et al. 2019; Jolly and Hansen 2021) and failure in economic geography (Phelps, Atienza;, and Arias 2018), responding to the bias of researching success cases. Specifically, we focus on the aftermath of path exhaustion and emphasize some of the challenges that peripheral regions face in creating new paths. Arguably, attention to challenges and failures in path development processes constitute a central future research avenue that may also allow for providing better informed policy advice for 'normal' regions.

## Acknowledgments

We would like to thank Treklyngen for the cooperation. This work was supported by the Research Council of Norway under Grant number 244249/E50.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

We would like to thank Treklyngen for the cooperation. This work was supported by the Research Council of Norway under [grant number 244249/E50].

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