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# Historical examples of entrepreneurial discovery

Revisiting the manufacturing history of Raufoss evolving between exploration and exploitation (Karlsen, A. 2019).

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## Introduction

Smart specialisation has been introduced as the basis for a policy framework for the EU's Innovation Policy and Cohesion Policy in 2011. Integral to this move, strategies for inducing smart specialisation have given public agents a key role. Entrepreneurial discovery processes are central in designing and implementing smart specialisation strategies (Foray, 2017). With regard to industrial change and agency, the concepts of smart specialisation and entrepreneurial discovery have much in common with the concept of 'path creation' (Garud and Karnøe, 2003; Simmie, 2012). The former concept is about discovery of new domains and transforming regional industries, while the latter concept focuses on 'development of new technologies and industries'. Both conceptualisations deal with collective entrepreneurial efforts for structural change in industry.

This chapter is inspired by the concepts of exploration and exploitation found in the study of organisation learning by March (1991). It aims to analyse local industrial development through phases of exploration and exploitation. How could the history of a Norwegian manufacturing town be explained by concepts such as smart specialisation and path creation? A case study will shed light on these concepts and their relevance for analysing regional development and renewal.

Empirically the chapter will tell a story of entrepreneurial discovery from a particular regional context: a local cluster originating from a company town. In the academic literature (see e.g. Steen and Karlsen, 2014), such a point of departure is regarded as a poor seedbed for entrepreneurial discoveries (Foray, 2017). The paper, however, recognises capabilities for diversifying arms production into a wide range of civilian manufacturing activities. Through demerger of a state-owned company, spinoff processes and inward investments, a quite high-tech manufacturing cluster emerged. The local industry is followed through four distinct phases of exploration or exploitation. The study recognises institutional tension between strategies of exploration leading to path creation on the one hand and strategies of exploitation implying path extension on the other hand. The story of industrial development confirms that entrepreneurial discovery may be driven by unique historical events in line with suggestions from the literature on path creation.

## Discussing the concepts of 'smart specialisation' and 'path creation'

For decades, scholars from various social sciences have discussed how to explain continuity and change in local and regional economies. Some of them have even made a distinction between radical change and continuous improvements and the role of learning in this regard. As a starting point for a historical study on industrial development, it is tempting to apply the two kinds of organisational learning introduced by March: 'exploration of new possibilities or exploitation of old certainties' (March, 1991:72). The first is about searching, discovering, experimenting and finding new solutions, while the latter is about refinement and efficiency in resource utilisation and work organisation. The allocation of search resources has implications for the consecutive adaptive processes. Exploitation relates to a shorter time horizon than exploration, which relates to a longer time horizon.

The conceptualisation above was developed for studies at an organisational level. For the study of industrial agglomeration on a local or regional level, we have to draw on further conceptualisations appropriate for these levels of investigation. In his study of the Danish wind power industry, Simmie (2012) applies the concepts of path dependence and path creation, which corresponds to the concepts of exploitation and exploration respectively. March (1991) finds that the choices between two contrasting ways of allocating resources for searching are made strategically at an organisational level. At a regional level, the strategy of exploration is reflected in the more recent policies of smart specialisation (Foray, 2014).

Foray (2014) gives historical examples of smart specialisation that emerge spontaneously. In today's world, where path dependence appears very strong in regions that would benefit the most from creating new industrial paths, a strategy led by public authorities seems to be required. This includes a process of identifying and realising new opportunities by integrating dispersed knowledge from many sources. Foray (2014) argues that the prioritisation should be based on knowledge integrated from the economic actors and knowledge institutions themselves. Smart specialisation strategy is a process of self-discovery which ends up in priorities of new domains within a smart specialisation policy. It appears as a staged process where the initial phase is expected to precede, go in parallel or even include processes of innovation. The strategy is not a process of self-discovery by itself, but it may support and even instigate or result in such a process.

I will argue that smart specialisation appears as a new policy strategy, but corresponding phenomena to entrepreneurial discovery processes are recognised and discussed elsewhere in the academic literature. There are some remarkable commonalities across the strands of literature on smart specialisation on the one hand and that of path creation on the other hand. Both strands of literature elaborate core processes of entrepreneurial discovery over time. As we will elaborate further below, they seem to focus on different stages of the change processes and may as such complement each other. As smart specialisation policy is assigning certain change agents strategic roles, based on analyses of the local context, it attempts to influence the processes of path creation as conceptualised on the basis of numerous empirical studies.

The literature on smart specialisation and that on path creation both explain structural change in the economy. Foray (2014) argues that entrepreneurial discovery allows the system to reorient and renew itself. Strategies of smart specialisation are, however, about deliberately developing new domains of opportunities or new specialisation in order to diversify the structure of a regional economy. Strategies of smart specialisation precede the innovation stage: application of general purpose technology has the potential to transform processes in a traditional sector and even generate many innovations. Relevant knowledge is found in science, but entrepreneurial and economic knowledge is just as relevant. As such, Foray goes beyond theories of technological development to also include regional institutions and scientists, in other words, the collective entrepreneur of the triple helix. The path-creation literature focuses more explicitly on the development of new technologies and new industries. Garud and Karnøe (2003) elaborate on the emergence of new technology paths, as they highlight deviations from existing trajectories. In the end, both strands of literature deal with diversification of the economy, which means some sort of exploration at a regional level.

In the literature of smart specialisation and that of path creation, reflexive actors take an entrepreneurial role. Both approaches emphasise the collaborative efforts of such actors across further domains. Strategies of smart specialisation should primarily be place-based. Smart specialisation strategy assigns policy-makers a role to help different stakeholders to discover a new and promising domain to develop. In order to build knowledge platforms in a region, it is necessary to exploit knowledge also from extra-regional sources such as universities and demanding customers. Garud and Karnøe (2001) argue that novel paths emerge as knowledgeable actors purposefully deviate from existing trajectories. These knowledgeable agents deliberately pursue certain courses of action. Key entrepreneurial firms discover and create new opportunities, whereas other actors, such as R&D institutions and other public bodies, interact with the firms and support them with complementary assets required to develop a new path.

Not just producers, but regulators, designers, users and evaluators co-create new industrial paths (Garud and Karnøe, 2003). The path-creation approach values the interaction with users of the technology. Agency has a distributed nature in both strands of literature emphasising the efforts of the many.

Path creation takes place as an accumulation of inputs (tools, artefacts, rules, practices and knowledge) that creates a momentum. An emerging path begins to enable and constrain the activities of the actors involved, who become embedded in the path they strive to form in real time. In a study of the emergence of wind turbines, Garud and Karnøe (2003) recognise a strategy of 'breakthrough' in the US industry as research-based attempts to create radical changes in technology. This strategy is contrasted with a more successful strategy of bricolage employed by Danish actors. The term bricolage explains how actors improvise and draw on many resources of relevance. Bricolage is the co-shaping of an emerging technological path in order to obtain modest but steady gains. These actors mobilise specific sets of events from the past in their endeavour to take new initiatives. Path creation is not a linear process. It is rather contingent on learning processes, where actors reflect explicitly upon past events and how they could be significant for entrepreneurial discovery. Both strands of literature emphasise learning processes, dialogues and local experimentation.

Different from the path-creation approach, the smart specialisation approach explicitly discusses the regional context. Foray (2017) finds that less advanced and transition regions have a special need for support of microsystems of innovation, as there are holes in their industrial ecosystem. Companies and specialised service and research institutions have to be mobilised to address the whole set of capabilities to develop novel domains. From the literature on industrial development of old industrial regions, we learn that such regions are inclined to different types of lock-in that restrain change and radical innovations (Grabher, 1992; Hassink, 2005). We find corresponding regional contexts in single-industry areas (Chapman, 2005) and company towns (Dale, 2002; Karlsen, 1999). The latter economies are typically dominated by one large firm surrounded by a limited number of smaller firms. As the smaller firms are more or less relying on transactions with the large one, the whole economy becomes dependent on a very limited number of external markets and external actors. Consequently, the local economy appears quite vulnerable. Even if these regions may prosper for long periods of time, such organisationally thin regions are considered to lack the heterogeneous composition of firms and institutions, and the innovative capacity, needed to initiate and develop new domains of activities (Isaksen and Trippl, 2017). Thin regions are typically trapped in path extension, characterised by incremental product innovations within existing industries and incremental process innovations along prevailing technological paths (Isaksen, 2015).

Simmie (2012) explains, however, how reflexive agents create new paths within the context of path-dependent development influenced by the economic environment, technological paradigms, institutions and technological regimes. The basic idea of path creation is that new paths are latent in old paths, spin out from existing ones or even draw on further related industries as they combine existing resources in new ways (Martin, 2010). From this perspective, the legacies of the past are significant, not as constraints, but rather as resources that entrepreneurs and businesses may draw upon (Karlsen, 2011; Steen and Karlsen, 2014).

In light of the discussion above, it is reasonable to suggest that explorative strategies lead to path creation, while exploitative strategies imply path extension.

The following case study will investigate phases of exploration and phases of exploitation in the industrial history of Raufoss. It will form a basis for a further discussion of the concept ‘smart specialisation’ and the concept ‘path creation’, and their relevance for approaching regional development.

## The story of Raufoss manufacturing industry through four phases

The following empirical section takes a historical approach. The story does not follow the traditional distinction into phases given by the changes in formal organisation and ownership (demerger and privatisation). Each phase in this story is rather recognised by wider institutional capabilities in the region that underpin explorative strategies and exploitative strategies, respectively. The empirical section follows the regional industry through four distinct phases: (1) from an industrial district to a company town; (2) entrepreneurial discovery within the company; (3) cluster turning into path extension; and (4) facing a new technology landscape.

### *(1) From an industrial district to a company town (1850–1950)*

In the middle of the nineteenth century a sociologist characterised the Toten region, including the town of Raufoss (120 kilometres north of Oslo), as the most industrialised rural district of Norway (Sundt, 1867). He recognised craft-based industries specialised in wall clocks and sheath knifes having customers all over the country. The craftsmen and traders brought other products and knowledge home as input to innovation and the upgrading of existing industry in the district. A relatively advanced mechanical production emerged – an industry characterised by adaptability (Johnstad and Utter, 2015).

In the second half of the nineteenth century the Toten region turned, however, into a manufacturing region dominated by the Raufoss Ammunition Factory (RA), established in the town of Raufoss in 1896 (Wang, 1996). The central government established the state-owned company RA to strengthen domestic defence in a period of nation-building. The ammunition factory was located west of Lake Mjøsa for strategic reasons in a situation marked by tension between the two nations constituting the Swedish–Norwegian union. Modern industry and technology displaced the traditional ones. After the Second World War this defence industry was integrated into the strategies of NATO. RA experienced more or less continual growth, reaching the peak of 2,600 employees in 1980.

The state was not just an owner of the company, but also had responsibilities for the local community and the local economy. Production for the civilian market, as an additional activity to ammunition manufacturing, was put on the agenda of a commission in 1918. Additional production should work as a buffer and balance fluctuating demand from military activity over shifting periods of war and peace around the world. Therefore, central authorities and local management strove to keep the entire workforce employed. This endeavour was one example of the paternalism that characterised the RA organisation. The local factory and machinery were prepared for entrepreneurial discovery. The first example of additional production for the civilian market was the manufacturing of ball bearings in the 1920s. For the decades to come, the company tried to diversify into further activities within the company, particularly into civilian production. Initiatives to move into car fabrication were taken in 1923 and again in 1931, but these intiatives soon stalled (Wang, 1996). These initiatives may be considered as a sort of ‘smart specialisation strategy’ that was initiated by the central state rather than regional or local public actors, which recent literature proposes.

After the Second World War, RA became a state-owned but independent company that produced military-related articles. The Minister of Defence facilitated and coordinated industrial development in the region in close collaboration with local management (Wang, 1996). The working life relations were characterised by short distance of communication between managers and the shop floor, inclusiveness and democratic values. As such, social relations at Raufoss were the prototype of the Nordic model of close collaboration between social partners supported by a proactive state. This consent between employers and employees, the unions included, paved the way for growth in production of ammunition by rationalisation and enhanced efficiency. In this way, these social relations supported exploitation strategies.

### *(2) Entrepreneurial discovery within the company (1950–2000)*

From 1950 RA was given the role as a major supplier of ammunition to NATO. From 1960 RA prepared the production of rocket motors as an additional activity. As we will soon learn, this advanced manufacturing, still a core activity at Raufoss, spawned further projects and spinoffs directed towards the civilian market. In the 1950s the idea emerged to convert knowledge on material technology (particularly aluminium) into civilian production, an entrepreneurial discovery that had major implications for the industrial development to come. The idea materialised for the first time in the 1960s, when RA started producing articles for the construction industry, particularly extruded frames for doors and windows and façade sheets, for domestic office buildings and hotels. RA collaborated with national and international institutes in the construction industry. They were also into aluminium components for the oil and gas exploitation industry, such as heli-decks and pipe joints. Later and to a much greater extent, the idea of converting this knowledge of material technology to other uses was realised in manufacturing components for the automotive industry. In summary, many initiatives of entrepreneurial discovery took place and some failed. Other initiatives for developing a new domain showed success in the long run, but were typically realised decades after the first initiatives.

Conversion of knowledge for use in civilian production was evidently more successful when it came to the idea of producing aluminium profiles from the company's extruding press and rolling of aluminium sheets. The Swedish car company Volvo requested Norwegian firms to become suppliers to its automotive production, and in 1955 RA was mentioned as a relevant sub-supplier of car components. The company units enjoyed some autonomy and capability for developing new products demanded by the market, an activity that was encouraged by the top management. RA had allocated more resources to R&D activities, which were aligned to develop prototypes based on competence in material technology. In 1974 a new tool factory was ready, and the next year a new project department was created (Johnstad and Utter, 2015). The central authorities put pressure on companies in the domestic aluminium industry to connect thus far disconnected companies, in order to integrate a domestic value chain within aluminium. Soon the major metal producer (ÅSV) entered into formal collaboration with further processors of aluminium, such as the units at Raufoss, in order to prepare further downstream activities. In 1965 RA signed an agreement with Volvo to supply 500,000 bumpers in aluminium for their cars.

This contract was a milestone in the industrial history of the manufacturing town, as a first successful step in the direction of diversifying the local economy. First, manufacturing of car components turned out to become a fast-growing activity until the turn of the century. Second, the entrance into the automotive value chain implied a change in manufacturing culture. RA faced a demanding customer with regard to product dimensions and tolerance. The company strove to comply with quality and safety standards and requirements for cost-efficient, flexible and responsive production. The production demanded further competence building in material technology, but also new knowledge about up-to-date production processes. The car component division, in collaboration with research institute SINTEF, was also able to introduce new products, such as wheel suspension arms and steering wheel systems (columns). In the late 1970s, another Swedish car manufacturer, SAAB, became a customer of RA. In the 1980s the local manufacturers supplied various car components for a wider European market, and later also for a North American and an Asian market (Wang, 1996).

The company explored and implemented modern production processes and made investments in new machines and factories. RA relied on core competences in metallurgy, construction and tool making. The combination of competences in compression moulding and mass production of heat compression products provided capabilities for production of light metal components for the civilian market. The company prepared various products based on metal sheets, rods and profiles made at the works.

There are three examples of converting core competencies from arms production into new civilian products: (1) the manufacturing of cartridge shells in aluminium starting in the 1950s was the first step in developing various aluminium products. This production provided basic competence in alloys and processing for later production for the civilian market, first as bumpers (owned by German company Benteler since 2009), some decades later also as the wheel suspension arms for the automotive industry (owned by the Austrian company Neumann Aluminium since 2004). (2) Lessons learned from using brass in small arms ammunition were crucial for the development of break pipe fittings for utility vehicles. The unique fittings were easy to handle and ensured tight joints. In the hands of Kongsberg Automotive since 2004, brass material was increasingly substituted by composite materials, but far from completely. (3) As space rocket motors were partly made of composite materials, the activity provided material competence for LPG containers made of corresponding materials since 2000, in the hands of Hexagon Ragasco (Johnstad and Utter, 2015). These are examples of diversifications based on the entrepreneurial discovery made in-house at RA decades earlier. As diversification was at least partly directed towards the automotive sector, we could talk about a spontaneous smart specialisation.

From 1997–1999 the new CEO relied on external consultants and made risky acquisitions internationally. RA turned into quite an international company, with half of its activities abroad. The governing idea of the CEO was to turn the traditional manufacturer of car components into a provider of systems for the automotive industry. His strategies lacked local rooting. This was a break with the tradition of inclusive management and he entered into conflict with the employees and their union. In the wake of these actions, an economic crisis emerged. The local industrial activity was saved by the state and restructured. The return to locally recruited leadership appeared as a kind of a re-embedding and represented a continuation of the traditional industry culture at Raufoss. Lessons were learned by trial and error.

In the same period RA's division of forming technology, together with GM (Saab and Opel), had developed the aforementioned wheel suspension arms. Raufoss

Technology was to establish a new factory in Norway serving the European market and another factory in Canada serving the US market. In contrast to the former top manager, who wanted to sell this business out, the new CEO went all out for keeping this activity in-house. This turned out as a risky business and the investments failed as productions at GM halted. After a troublesome period searching for a new owner for Raufoss Technology, the company was acquired by the Austrian company Neumann Aluminium in 2004.

To cope with an economic crisis at the start of the century, the RA company was split into 11 manufacturing firms, and soon Raufoss Industrial Park consisting of 45 firms emerged. The paternalistic state ensured the new firms an economic foundation and handed the ownership over to companies with long-term interest in the respective industrial branches. The owners, typically German, Austrian and Swedish, allowed the local units a certain degree of autonomy as they recognised the local manufacturing culture and competencies. This entrepreneurial discovery with regard to new business ideas on industrial organisation was a further step into new path creation. More precisely, the new firms and ownerships represented some sort of layering by adding new structures to the existing ones characterised by the defence company.

The diversification took place by bricolage – local actors drew on events from the past and improvised by combining many resources. Government bodies, local industrial actors and R&D units have been co-shaping the emerging technological path based on some core competences, which have been refined in the following. The core competence of the R&D unit was material technology, which was cutting-edge, particularly with regard to stretch bending and forging of aluminium profiles. The competence included knowing who the key suppliers of various qualities of materials were. Tool production and process technology for automation made production efficient and provided the costumers with functional solutions.

The local R&D unit, demerged as Raufoss Technology & Industrial Management (RTIM) in 2002, was as good as bankrupt in 2003–2004. This crisis was solved by the support of the Arena cluster initiative,[1] project funding from the county council, and a patient bank. Soon RTIM was in the hands of various local and national stakeholders. SINTEF gradually increased their share of ownership, before the research unit became a subsidiary of SINTEF, renamed SINTEF Raufoss Manufacturing (SRM), and was subsequently further integrated in a national innovation system. In general, the R&D unit supported efficient serial production, particularly of high-quality car components. These innovation capabilities were stimulated by demanding customers, such as NATO, Volvo and GM, and the collaboration with research institutions at a national level, such as the Norwegian Defence Research Establishment (FFI), SINTEF and the Norwegian University of Science and Technology (NTNU).

### *(3) Cluster turning into path extension (2000–2015)*

As the attention of the demerged firms turned inwards, concentrating on their own core business, the regional industry appeared more fragmented than before (Johnstad and Utter, 2015). This industrial structure consequently faced a risk of losing projects diverging from ordinary activities. In this situation, the challenge was to develop cooperation across the regional firms in order to enhance innovation and competitive capabilities. Cluster creation strategies soon appeared as a turning point for local collaboration and for embedding the industry regionally. Based on experiences from the Arena project, the Raufoss manufacturing industry became a National Centre of Expertise (NCE)[2] in 2006. The success of the Raufoss manufacturing industry in obtaining status in succeeding cluster programmes rests on the efforts of key actors in local industry who have been proactive through stages of application and operation of the programmes. NCE Raufoss has launched a portfolio of research projects that involve the manufacturing industry as well as R&D institutions in order to support the innovative activities in regional industry.

Toten Aluminium Group (TotAl) was another network constellation of small firms that partly were spinoffs from RA (Karlsen, 2011). This group of SMEs outside the industrial park was particularly involved in processing of aluminium and other lightweight materials. The cluster programme Arena revitalised this network. The SMEs are partly suppliers to larger firms in the industrial park. The TotAl Group was an initiative to build a bridge to the industrial park and collaborate in upgrading the SMEs as suppliers. In 2016 the industrial cluster at and around Raufoss embraces more than 40 companies and more than 5,000 employees. In 2004 the industry re-established contact with the university college in the neighbouring town of Gjøvik. In 2016 this unit merged with NTNU in Trondheim. The merger appeared as a formal integration of a regional and a national innovation system.

SRM became the hub of the cluster network. As a key actor offering relevant competences for regional firms, SRM compensates for the shortages in R&D capabilities of the individual manufacturing firms at Raufoss. The R&D unit works as a common knowledge infrastructure for these firms. It maintains and develops material and manufacturing technology competence. The unit has test plants and workshops for prototypes and pilot production and offers competence on business management. The combination of research-based competence and experience-based competence provides a basis for a form of combined and complex innovation (Isaksen and Karlsen, 2012). The network constellations mentioned above imply further collaboration and integration in regional manufacturing industry. To put it simply, the glue was reinvented around 2005.

Evidently, the strategies of regional industry had turned from exploration to exploitation after the crisis in RA and the following restructuring at the turn of the century. The exploitation strategies were to a large degree based on previous discoveries and explorations. Core firms' attention and activities were directed towards the demands of customers in an international market characterised by tough competition. The production of car components appears as extensions of the assembly lines in Germany, Sweden and France. Customers demanded high-quality products and continuous cost reductions as well as reliable and responsive suppliers. As customers, a limited number of automotive companies had a captive relation to their suppliers. This kind of relation does not apply to the ammunition manufacturer, Nammo (the only core company that has its headquarters at Raufoss), operating with larger margins in the defence sector, but rather for manufacturers of car components operating with smaller margins in the automotive sector. We could thus talk about a layering process resulting in the co-existence of two contrasting types of relations between local suppliers and their foreign customers.

How do the cluster formation and innovation system, both regionally and nationally, work with regard to strategies of exploration or strategies of exploitation? The industry leaders find that their businesses have an advantage from their location in a local manufacturing cluster. By tradition, cluster firms share equipment and labs and they exchange knowledge, also enabled through mobility of personnel. They particularly appreciate participation in research projects initiated by the local R&D unit, SRM.

Cluster dynamics have been enhanced through participation in lasting R&D programmes. By the help of programmes and centres such as the Norwegian Centre of Expertise, SRM has launched several projects for enhancing competence in local manufacturing firms. At the turn of the century, 'lean production' received much attention. The manufacturer of bumpers trained operators as well as managers to improve both product quality and flow of materials and components (eliminating waste) and productivity in general. Since 2005 further companies took part in corresponding activities. Such incremental improvements appear in line with the exploitation type of strategy.

In the former RA there was both space and autonomy for developing new ideas. After restructuring, this space was lost within the slim organisations that demerged from RA. As such, they may have lost their capability to diversify. The R&D shortage of individual firms was partly compensated for by a common infrastructure found in the demerged R&D unit (now SRM) and related collaboration through cluster initiatives and other research programmes. The collaboration had more success in ensuring increased productivity among existing firms, and less success in new firm formation and creating spinoffs. Manufacturing firms report that they need to have high focus on daily operations. Their activities are directed towards improving the production process or incremental product innovations (interviews in manufacturing firms, 2017). The strategies of existing companies seem to underpin path extension. Cluster organisations have taken initiatives to facilitate entrepreneurship in the form of start-ups, but recognise shortages in new business formation and spinoffs in later years (interview with cluster organisations, 2018).

We could conclude that during recent decades few local actors have been exploring new domains that would potentially lead to new path creation. Programmes such as NCE seem rather to underpin path extension, which has been successful with regards to maintaining economic activity and employment in a demanding automotive sector characterised by intensive international competition.

### *(4) Facing a new technology landscape – exploitation or exploration from 2015 onwards?*

Core companies at Raufoss have been involved in two centres of research-based innovation (SFI) succeeding each other. Four larger companies in Raufoss Industrial

Park took part in SFI Norman (2007–2014) in order to improve the competitive strength of the industry through long-term research and innovation in collaboration with SINTEF and NTNU. SFI Normann was consecutively followed by SFI Manufacturing (2015–2022) involving the same four manufacturing companies, university (NTNU) and R&D institution (SINTEF), and headed by the latter's subsidiary SRM. SFI Manufacturing is a multidisciplinary centre for research-based innovation (SFI) for competitive high-value manufacturing in Norway. It aims at providing sustainable innovations for automated manufacturing of multi-material products. Its vision is to demonstrate that sustainable and advanced manufacturing is possible in a high-cost country. SFI Manufacturing is organised in three research areas: (1) multi-material products and manufacturing processes; (2) robust and flexible automation; and (3) sustainable and innovative organisations. The focus on how to develop and manufacture multi-material products is particularly relevant for the producers of components for the automotive industry. This market requires the combination of strong and lightweight components (typically substituting steel components) in order to make cars more environmentally friendly.

Many of the activities within SFI manufacturing are, however, about introducing new general purpose technologies related to Industry 4.0. Core firms are adapting to a 'fourth industrial revolution', partly stimulated through their foreign ownership. Industry 4.0 is explained as a convergence between four increasingly powerful technological capabilities: robotics, 3D printing, artificial intelligence, and autonomous vehicles (Schwab, 2015). According to Kagermann et al. (2013), the future will see companies establishing global networks incorporating machinery, warehousing and production facilities in the shape of cyber-physical systems (CPS). Even if these scholars describe Industry 4.0 as a revolution that introduces disruptive technologies, the Raufoss companies have already approached and adapted to these new technologies, quite incrementally (interviews with management of local manufacturing firms, research institute and cluster organisations, 2017). As such, the new technologies have so far been used in exploitation strategies.

Basically, these general purpose technologies may be used for exploitation as well as for exploration. Both firms and knowledge institutions are preparing for these new technologies, introducing robots and additive manufacturing, etc. The vocational school, the vocational colleges, and the university are adjusting their curriculums in order to prepare their students for digitalisation and related new technologies in the industry of tomorrow. On behalf of the NCE, SRM applied for funding for a Norwegian Catapult Centre at Raufoss in 2017. The centre is, in 2018, ready to develop and demonstrate innovative production processes and general purpose technologies in mini factories, in collaboration with industry, research and educational institutions. This represents entrepreneurial discovery. The investments and efforts have potential for further exploration in the years ahead.

## Discussions

The approach of 'smart specialisation' and approach of 'path creation' are both emphasising collective efforts for industrial renewal. Smart specialisation is a place-based strategy where policy-makers have a key role. It includes a procedure for selecting adequate activities for developing the most promising domain. The path-creation approach recognises the selection process rather as an outcome of learning processes and mindful deviations taking place through time.

The industrial story of Raufoss through four phases shows that local and central actors over decades strove to diversify a local activity. Step by step, local industry was able to convert knowledge on material technology from ammunition production into knowledge on lightweight products for the civilian market and lastly for car components. On the way, the industry was involved in aluminium products for the construction industry for a short period, but this turned out to be a dead end. Diversification was a process of trial and error and tension over defining the most promising domain for local manufacturing activity. Together the local entrepreneurs drew on historical events, experiences and knowledge accumulated over decades, in various kinds of bricolage. The industrial trajectory has been contingent on the distributed agency and learning processes, which could not have been predicted. This open trajectory seems in line with scholars' explanation of path creation (Garud and Karnøe, 2003).

Cases of collaboration between the many actors in central government, local industry and R&D institutions both regionally and nationally on entrepreneurial discovery are partly in line with the ideas of smart specialisation policy (Foray, 2017). Through the industrial history of Raufoss, central policy-makers have led on as facilitators of local industrial development, but local industrial leaders have increasingly taken the initiative. These entrepreneurial discoveries were a precondition for the formation of an agglomeration of firms that soon developed into a dynamic cluster. They relied on a legacy of experiences in material technology and tool-making. The fact that three core companies started serving the automotive industry by serial production of components did not happen by accident. The specialisation of industry had been deepened particularly through decades of perfections of operations, collaboration and more generally through the co-evolution of industry, suppliers and knowledge institutions (Sæther et al., 2011). We can recognise some sort of continuity in expertise in material technology, across periods of crises and restructuring. In retrospect, the latter discontinuities typically receive too much attention as the major milestones in the industrial history of Raufoss.

At the turn of the century, the second phase characterised by exploration was followed by a third phase of path extension – the strengthening of the exploitative dimension. Exploration is something beyond purely economic considerations, rather drawing on knowledge about developments in society and new technologies. It requires organisational capabilities that may have been lost due to restructuring of local industry. An institutional layering of an exploitative trajectory is due to integration in international value chains, foreign ownership, and responsive streamlining and refining of local activities. Capacity and capabilities for such exploration is hard to find within organisations tuned for daily operations. Industrial actors focused on exploitative strategies were thus not able to handle explorative strategies in addition. This exploitative strategy is contingent on the character of the particular industrial sector the suppliers are integrated into through the value chain. Suppliers' relation to a limited number of clients direct the attention towards enhancing quality of products and processes, and cutting costs. The domain of the industry is more or less taken for granted. This development appears as a successful path extension, at least in the short run.

In the fourth phase, local industry and knowledge institutions are facing technologies that scholars regard as disruptive. So far, the economic actors have had an incremental approach to the new technologies. The new technologies may substitute labour. This means less employment at least on the level of the single firm. Implementation of new technologies is necessary for firms to stay competitive. At the outset of the fourth phase it is hard to say whether the new technologies only will ensure successful path extension or even become a departure for developing a new domain. Only time will tell if the adoption of the technologies in educational and research programmes and a new catapult (Manufacturing Technology Centre) will result in new promising domains.

## Conclusions

Theoretical and policy lessons from this study are threefold:

1. According to the academic literature, the economies of organisationally thin regions are hard to diversify. This study shows, however, that entrepreneurial discoveries may take place even in a company town. Furthermore, a cornerstone company could have the capability for initiating entrepreneurial discoveries. The realisation of new domains is supported through industry's collaboration with research units, both at the local and the national level, and involvement in R&D programmes. The state evidently has a supportive role in diversifying the local economy.
2. Successive entrepreneurial discoveries taking place in a local manufacturing industry are not independent of each other. Rather, successive entrepreneurial discoveries take place as the latter ones draw on the former ones. In line with the path-creation approach, mindful deviations are based on learning processes taking place through time. Experiences from the past and knowledge accumulated over time appear as a vital heritage in developing a promising domain for an industrial future.
3. The study shows that strategies of exploration and strategies of exploitation are hard to combine at the same time. This is in line with studies of ambidexterity, that is, the ability of firms to maintain both their exploitative and their explorative capabilities at the same time (Tushman and O'Reilly, 1996; see also Nguyen and Mariussen, 2018, Chapter 10 in this volume). In this study, the two types of strategies follow each other sequentially, creating alternate periods of path creation and path extension.

If new technologies primarily are applied for substituting labour, job loss in the local labour market should be addressed by new entrepreneurial discoveries. A robust and dynamic industrial cluster should develop capabilities, allocate resources and ensure organisational autonomy also for explorative strategies. Existing organisations should also work as incubators for spinoff processes. Awareness of smart ambidexterity strategies, balancing exploration and exploitation, across the various types of regional actors, is a challenging, but still a reasonable advice for ensuring vital manufacturing industry in the short as well as the long run. The Raufoss case shows that alternatives to simultaneous strategies for exploration and exploitation in individual firms can be instituted by building a regional capacity for flexibly supporting both strategies over time. A project-oriented R&D organisation with high legitimacy and strong relations to strategic management in the local firms appears as a vital instrument in this regard. Whether this solution will be sufficiently responsive in a situation where the major firms have their strongest allegiances to their foreign owners remains to be seen.

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## Notes

[1] Arena is funded by Innovation Norway, SIVA and the Research Council of Norway, aiming to stimulate innovation and collaboration between firms, R&D and eductional milieus and public actors.

[2] The NCE programme is directed towards dynamic industry clusters that have established systematic collaboration and have potential for growth in national and international markets. Within their respective sectors and technology areas, the clusters are to have a national position.