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Theoretical and methodological advances in cluster research

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Abstract

Purpose – This paper aims to assess the dissemination of cluster ideas advanced in the "Competitive Advantage of Nations" and three subsequent national studies and the reasons for their substantial public policy impact in Norway.

Design/methodology/approach – The paper presents the theoretical and methodological novelties of each of the national studies, the inclusive study-organizing principle used and public policy impact.

Findings – The papers finds that the dissemination of cluster thinking and the development of a successful cluster-based industrial policy in Norway is largely a function of the nature and extent of the cluster research efforts that took place in Norway. The national cluster research projects mobilized all the key industrial and governmental actors in a very effective way, making studies with both rigor and relevance. Due to advanced and demanding policy makers, the studies also evolved in terms of the theoretical models and methodologies used.

Originality/value – The paper contributes by illuminating the direct and indirect impact of the "Competitive Advantage of Nations" on both academic endeavors and public policies in Norway and by explicating how studies that make it possible for academics and practitioners to work in tandem substantially affect public policy.

Keywords Cluster theory, Norway, Cluster policy

Paper type General review

Introduction: a cluster research agenda for Norway

In early 1990, the first author of this article, then professor at the Norwegian School of Economics, received a pre-publication issue of Michael Porter's "Competitive Advantage of Nations" for review from a Scandinavian publisher. The question was whether the book should be translated into a Scandinavian language, and then to be published for a larger audience. This was at a time when Porter's (1980) two famous books on strategy, "Competitive Strategy" and "Competitive Advantage" (Porter, 1985), were big hits both at business schools and in business. Companies were rapidly adapting five-forces analyses, and they all seemed to be mapping their value chains. After reading the rather lengthy book with detailed case studies of industrial clusters from 10 different countries, I concluded that "Competitive Advantage of Nations" would not have much appeal to a larger business audience, and the recommendation was not to publish. How wrong could I be in making such an assessment?

Following the publication of "Competitive Advantage of Nations" (1980), the cluster concept changed from being totally unknown to being an inherent part of the industrial and the political vocabulary in Norway. The opposition came from the traditional economics profession that dominated the Central Bank of Norway and the Ministry of Finance, advocating neutral industrial policy, taking no account

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of clusters and the positive knowledge externalities present. Today, the Norwegian Government, under changing political coalitions, has developed long-term industrial strategies, like Oil & Gas 21, Maritime 21, Oceans 21 and Bio Economy 21, and all of these policies seem to embrace the knowledge-based-cluster model (Reve and Sasson, 2012). In line with the Norwegian cluster projects recommendations (Reve and Jackobsen, 2001; Reve *et al.* 1992; Reve *et al.*, 2012), Norway has also developed regional cluster programs at three levels, arena for smaller and emerging local clusters, national centers of expertise (NCE) for the larger and more mature regional clusters and global centers of expertise (GCE) for the top global clusters, like offshore oil and gas and the maritime industries. These cluster programs are co-funded with the industry for 3, 5 and 10 years, respectively, giving tremendous network power to regional cluster initiatives. The Norwegian cluster approach to industrial policy has become an international success story, and it all started with "Competitive Advantage of Nations" (Porter, 1990) and "A Competitive Norway" (Reve *et al.*, 1992), a study of Norwegian industries.

We would argue that the policy success in Norway was largely a function of the cluster research efforts that took place in Norway. The national cluster research projects mobilized all the key industrial and governmental actors in a very effective way. The cluster research projects presented systematic research data in a new way as compared to previous studies of industrial sectors. The cluster model and the research findings were efficiently communicated to key business and government leaders at central and regional levels, and a completely new language for talking about industrial competitiveness was established. Rather than reverting to relative factor costs as a measure of industrial competitiveness, politicians and business leaders started to talk about making regions more attractive for international knowledge-based business, competent capital and international talents.

In the next three sections of this article, we will review the theoretical and methodological approaches taken in the three generations of empirical cluster research that has taken place in Norway during the past 25 years, their public policy impact and organization. The first cluster study (Reve *et al.*, 1992) largely followed the framework and methodology proposed in "Competitive Advantage of Nations" (Porter, 1990). The second cluster study (Reve and Jackobsen, 2001) advanced the conceptual model of clusters by adding three upgrading mechanisms, namely, innovation pressure, complementarity and knowledge dissemination, to understand the increased value creation of cluster industries due to innovation rent and reduced transaction costs. The third cluster study (Reve *et al.*, 2012) advanced our understanding of knowledge-based clusters by introducing the term global knowledge hubs for knowledge-intensive clusters with a global reach. More importantly, the study developed a new metric of seven dimensions for measuring cluster strength or cluster attractiveness, referred to as "the Emerald Model". In addition to the theoretical advancements, the most important contribution has been the advancement in data and research methodology, most pronounced in the third cluster study, combining business databases, national registers of companies and employees and surveys of cluster knowledge linkages. Norway was a perfect empirical setting for these methodological advances due to the availability of large, accurate databases for this type of research.

Cluster studies 1.0: replication and contextualization

Following the publication of "Competitive Advantage of Nations", things started to happen very rapidly in Norway. Here is the start-up story as recalled by the first author of this article:

> One of the top executives in DNV (now DNV-GL, the world's largest ship classification agency based in Norway), called me and asked whether I and my research team at the Norwegian School of Economics could do an empirical study of Norway, similar to the 10 country studies of Competitive Advantage of Nations (Porter, 1990). He had talked to a top executive of Statoil, Norway's largest company, and they both wanted to subject Norwegian industries to the same type of analysis performed by 'Competitive Advantage of Nations'".

Again, I showed some reluctance, but being director of the research in strategy and management at the Foundation for Research in Economics and Business (SNF) at the Norwegian School of Economics, I accepted to take on the project, for a budget of $1 million, a large amount of money for research at that time. A total of 40 researchers and research assistants were involved in the project, in addition to about 100 MSc students doing case studies and course projects. A consortium of project sponsors were organized, consisting of Norwegian Technical and Industrial Research Council (NTNF), Norwegian Employers Federation (NHO), Norwegian Shipowners Association (NR), Norwegian Confederation of Trade Unions (LO), Norwegian Ministry of Trade and Industry, Norwegian Ministry of Oil and Energy as well as a group of 24 participating companies from key industries. All key actors were actively involved in steering groups and advisory panels, but the research group was completely free to publish any research findings. The result was a large empirical study of 15 Norwegian industries competing internationally, and the book, summarizing the 15 research reports, was titled "A Competitive Norway" ("Et konkurransedyktig Norge"), (Reve *et al.*, 1992).

The study introduced cluster strategic thinking to the Norwegian industrial policy makers and industrial leaders. In 1990, cluster thinking was virtually unknown in Norway. Firms had adapted strategic models, like the five-forces and the value chain, into their strategic processes. Similarly to the other Nordic cluster studies of the 1990s (Hernesniemi *et al.*, 1995; Pade, 1991; Solvell *et al.*, 1991), the study applied cluster and strategic thinking to local industries. Porter used some of the Danish cluster studies (Pade, 1991) in building the argument for the Competitive Advantage of Nations (Porter, 1990). Norway joined slightly later, but has been instrumental in cluster research and cluster development ever since. The Nordic studies contextualized cluster research. They complemented Porter's national perspective with a micro-perspective, highlighting firm-specific and cluster-specific factors. The studies helped bridging the gap between national competitiveness and firm competitiveness. The advantages of small nations clearly applied.

On the theoretical level, the first Norwegian cluster study remained true to Porter's model. It used the Diamond Model to analyze the competitiveness of 15 different Norwegian clusters, ranging from oil and gas, maritime and metals to tourism, fisheries and the forest industry. Similarly to Porter's study, its methodological perspective was largely qualitative and descriptive. It reported 50 firm case studies and 29 published cluster reports and described key factors which indicated the competitiveness of each cluster. In-depth studies of the various sectors of the maritime cluster were performed, and this was also the cluster where the studies later had the greatest policy impact.

The results of the cluster research were launched at one of the largest industrial meetings in Norway, the Annual Conference of the Norwegian Research Council, with more than 1,500 participants. It was subsequently presented at the Annual Conference of the Norwegian Employers Federation (NHO), with a similar turnout of business and political leaders. Some industries with strong cluster effects, such as the maritime cluster, embraced the findings, while other industries with weak cluster effects, such as the metal industry, argued against our findings. A heated debate followed in the business press.

Norway had during the 1980s developed a strong offshore oil and gas industry based on newly discovered oil and gas resources in the North Sea, and the Norwegian Government had followed a deliberate cluster policy to develop this industry, much without knowing how well the policy compared to the recommendations of the "Competitive Advantage of Nations". The study (which was immediately termed "The Norwegian Porter study" by the press) was broadly disseminated, and it almost immediately had policy impact. The study enhanced the legitimacy of the industrial policies implemented in the oil and gas industry. It also envisages an active role to the public sector in developing industrial clusters through industrial network building, choosing knowledge assets bases for further investment and encouraging firm cooperation.

Drivers and impacts

What were the key drivers behind these large-scale cluster research efforts and the cluster policy impact in Norway? First, there was a void in models for industrial policy at the time of the publication of "A Competitive Advantage of Nations". The state ownership and state subsidies approach of many European countries had failed, and the Margret Thatcher liberal market approaches to industrial development were never fully accepted in the Nordics. The Nordic countries had a tradition for combining the market economy with a relatively strong central government, similar to today's high growth parts of Asia, but, unlike Asia, adhering to strong democratic ideals. Such a political context seemed perfect for the cluster approach to industrial development. Other small nations with advanced industries, like Singapore, had similar rapid adaptation of the cluster approach.

What we saw in Norway was growth in several industries, such as the maritime industry, with no particular resource endowment and little or no national market. How could such industries be so prosperous and so eager to innovate and change when there were no traditional comparative advantages to build on? The answers were found in the dynamic cluster structure of the maritime industry and its reliance on innovation, technology and new business models. In particular, there were strong regional clusters specializing in advanced shipbuilding, innovative maritime equipment, maritime IT and maritime commercial services, like finance, insurance and brokering. The maritime cluster was driven by risk-willing ship owners, entrepreneurs and family firm investors, creating some of the largest shipping companies in the world out of Oslo and Bergen. The term "the maritime cluster" was coined in the first Norwegian cluster study (Reve *et al.*, 1992), and it quickly became an integral part of the Norwegian industry and policy. The mobile nature of shipping firms made it necessary to harmonize shipping taxation, and new policy measures were implemented to stimulate the use of Norwegian officers on-board Norwegian ships. The Norwegian maritime cluster had its roots back to the

Vikings and to the Hanseatic trade of Northern Europe in the Middle ages, and it was transformed from sail, to steam, to diesel and lately to LNG and battery, as each new technology emerged. The market for shipping and maritime services was global, but the Norwegian maritime cluster remained competitive despite the intense cost competition from Asia. At the same time, other European nations without a maritime cluster policy lost out in the global competition.

The industrial knowledge of the maritime cluster seemed to reside in a combination of formal and tacit maritime knowledge. The maritime knowledge providers ranged from Norwegian seafarers and captains on-board Norwegian ships, to innovative ship builders and machine workshops along the coast, always coming up with new technological solutions, to risk-taking ship owners and investors, leading global actors in maritime finance, marine insurance, marine law, ship classification and ship brokering. Thus, it should not be a big surprise that the leading R&D centers for hydrodynamics and maritime technology are at the Norwegian University of Science and Technology (NTNU) and SINTEF-Marintek at Trondheim, Norway, and at DNV-GL, offering technological services worldwide. Today, we refer to this field as ocean space technology, combining the ocean sciences, engineering sciences and life sciences in finding new solutions for the new and emerging ocean industries, such as renewable ocean energy, ocean aquaculture and seabed mining. A new state-of-the-art ocean research lab, the Ocean Space Center, is currently being built at Trondheim, Norway. The research center is given top priority when it comes to government funding for research infrastructure.

When the offshore oil and gas industry came to the North Sea in the 1970s, Norwegian maritime industries were ready to transform into this new and promising energy industry. Unlike what happened in Mexico, West Africa and the Middle East, Norway was, in a very short time, able to develop a highly advanced offshore oil and gas supplier industry. The emerging Norwegian offshore oil and gas industry worked closely with international actors, developing the most advanced offshore oil and gas technology in the world, in rigs and supply vessels, in seismic and drilling technology, in subsea technology and in large integrated offshore production facilities, implementing some of the largest engineering projects in the world. The explanation could be no other than knowledge-based industrial clusters at work. The cluster policy followed by the Norwegian Government and Norwegian industries was not deliberately based on the recommendations of "Competitive Advantage of Nations" and the first Norwegian cluster study, but the cluster model created order in the policy void that existed in the early 1990s. The Norwegian Continental Shelf was opened up for international competition, both for operator oil companies and for international contractors and suppliers, while at the same time, Norwegian oil companies (including Statoil), contractors and suppliers were developed, often working closely with international companies. The knowledge linkages between the actors were many, and the Norwegian Government required the actors to invest heavily in education and R&D to build a sustainable industrial cluster. In addition, safety standards and the environmental requirements were set at very high levels, stimulating new technological solutions and good work practices.

At the time of the early 1990s, the Nordic countries had just experienced the first international banking crisis, and European governments searched for new ways to reregulate and make banks more solid after the liberalization of the financial markets.

The cluster approach was not a reversal to central planning and government interventions; it offered a bottom-up approach to industrial development, giving the government a more indirect role, providing good education, funding research and development, ensuring healthy and fair competition, offering early venture capital and providing more efficient arenas for innovation. The Nordic innovation eco-system (Asheim and Coenen, 2005) changed from a reliance on financial support to an emphasis on knowledge development (R&D) and knowledge dissemination, as evident in the cluster programs described above.

Maybe it was a good thing that Norway was not included in the first round of national cluster studies of "Competitive Advantage of Nations" (Porter, 1990). The rivalry between the Nordic countries may have added to this. Norway wanted to do an even better cluster study than what was done in Sweden (Solvell *et al.*, 1991), Denmark (Pade, 1991) and Finland (Hernesniemi *et al.*, 1995). Furthermore, there were positive drivers related to data availability and openness by industry to this type of research. The Nordic economies are characterized by openness and trust that makes it easy to be a strategy researcher in these countries. There is also the issue of being a small economy, with short distances between the hierarchical levels. Researchers studying national cultures call it short power distance (Hofstede, 1984). Norwegians are used to cooperate, but they also know how to compete. This combination of cooperation and rivalry is a central characteristic of well-functioning clusters (Piore and Sabel, 1984). Being small also means sticking together, and most notable, this industrial culture is found along the West Coast of Norway, where some of the strongest industrial clusters are located. This is also where the cluster approach to industrial competitiveness was most deeply embodied in industrial practice. In the capital Oslo, however, it has always been much harder to involve companies in cluster initiatives and cluster action. We think this goes back to the diversity of industries in larger cities, in addition to the feeling of importance of being the capital with so many corporate headquarters and central national institutions.

Many economists and some politicians have been arguing strongly against "picking winners". No politicians or bureaucrats will be able to foresee which industries and which companies will be the future winners, thus they should refrain from active involvement in industrial development, concentrating on such issues as health, education and infrastructure, making sure there is macroeconomic stability and fair taxation. Cluster policy is not "picking winners". Cluster policy is one that strengthens the knowledge commons of industries that has already been able to develop cluster characteristics. Such clusters have positive knowledge externalities that need to be stimulated, in much the same way, as negative externalities have to be taxed or regulated when companies have negative effects on society, such as in industrial air and water pollution.

No clusters are better or more desirable than other clusters. What matters is whether cluster industries have high productivity and high innovation rates. Productivity measures capture the current economic efficiency of an industry, while innovation captures the future productivity and the industry's ability to adapt and transform. Cluster research shows that cluster industries have higher propensity to innovate and transform than non-cluster industries (Delgado *et al.*, 2010; 2014; Porter, 1998).

The cluster model provided a new language for industrial development policies, and it clarifies the roles of the various actors involved; central and local governments,

industrial associations and trade unions, universities and educational institutions, commercial actors at all levels of the value chain or value network, cluster organizations or institutions for collaboration. The model combines rather sophisticated economic models of agglomerations effects, market failure due to externalities and knowledge-based growth into simple models and graphic representations, Porter's famous Diamond Model, industry value chains or value networks (Stabell and Fjeldstad, 1998), cluster maps and bubble charts. It is not sufficient to present formal theory like what most economists do; theories have to be communicated in easily comprehensible forms, like what is typical in Michael Porter's writings. The terminology has been standardized, so it is easy to write and read cluster studies across industries and across nations. Large-scale educational efforts to disseminate cluster knowledge have been undertaken by the Microeconomics of Competitiveness (MOC) Network, organized by the Institute of Strategy and Competitiveness at Harvard Business School, and the reach of this network is now global.

Cluster studies 2.0: value creation and innovation

The above is merely the start of the Norwegian cluster studies and cluster public policy. Ten years after the publication of "A Competitive Norway" (Reve *et al.*, 1992), a new and more in-depth cluster study was published by the same first author, "A Value-Creating Norway" ("Et verdiskapende Norge") (Reve *et al.*, 2001). An elaborated theoretical model of knowledge linkages was developed, and systematic economic performance data were collected, drawing on total accounting information of 10,000 Norwegian companies over 10 years. In addition, a large survey, mapping cluster linkages, was administered to a large number of business companies in the industries studied. The budget for the empirical study was the double of the first study. The funding of the study was undertaken by a broader group of Norwegian ministries (industry and trade, oil and gas, fisheries, regional and local government), and Norwegian government agencies (including the Norwegian Research Council and the Regional Development Agency), as well as the two employers federations and several trade associations. In addition, a group of key private companies became sponsors of the second cluster project. A private foundation in the shipping industry came up with the initial funding, and then the other sponsors were added subsequently. The coalition public–private funding provided transparency and independence of any specific interest groups.

A central research team was set up at BI Norwegian Business School in Oslo, again involving about 40 researchers and research assistants, and initial research cooperation was established with Monitor Company to secure international research consistency. The "Value Creating Norway" study concentrated on six major industries: energy (offshore oil and gas and renewables), maritime, seafood, ICT, finance and retailing and trade. Again, dissemination of the findings was extensive, and the study was presented to key decision makers at industry and government levels, both centrally and regionally. In many ways, the cluster model became more deeply rooted at the regional level than at the central level, as the role of competitive industrial regions became more apparent. Cities with more diverse industries, like Oslo, were less concerned with developing strong clusters than more specialized industrial regions. Especially, the entrepreneurial West Coast of Norway embraced the cluster model and made it their own. Several industries and regions initiated annual cluster assessments to fine-tune regional industrial policy, and several research firms specializing in cluster analysis and

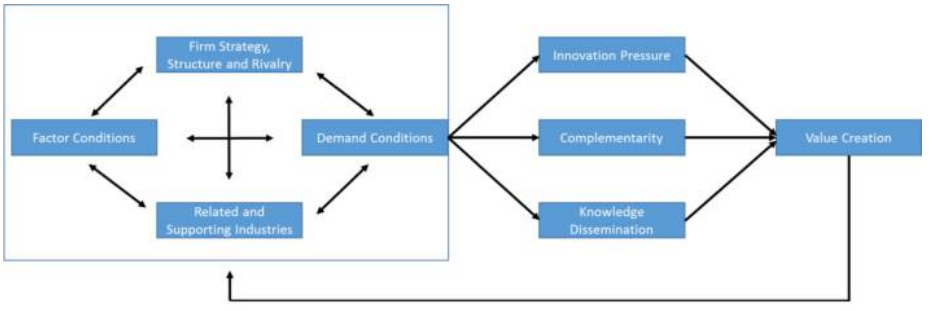
industrial development policies appeared. This included Menon Business Economics that was a direct spinoff from the "Value Creating Norway" project at BI Norwegian Business School.

"Value Creating Norway" directly extended cluster theory by clearly explicating the mechanisms linking micro-economic conditions, illuminated by the Diamond Model and value creation. Figure 1 depicts the model. Micro-economic factors define the competitiveness of an industrial environment as elaborated by Porter (1990) and discussed above. These factors determine the strength of the three pivotal upgrading mechanisms of innovation pressure, complementarity and knowledge dissemination, and hence also value creation (Reve *et al.*, 2001). The model applied for the second Norwegian cluster study (Reve *et al.*, 2001) added the cluster upgrading mechanisms in a more explicit way. New efforts were made to measure the knowledge externalities that took place between cluster actors, and innovation became a much more central variable in the cluster model.

In well-functioning clusters, firms experience pressure to innovate. This comes from three distinct processes: advanced customers demand innovative products and solutions; rich and open communication between customers and suppliers; and customers can choose between alternative suppliers (Reve *et al.*, 2001, p. 40). In less-functioning clusters, and areas with no cluster presence, firms will, all else equal, not be able to benefit from these processes, resulting in lower innovation rate and hence lower value creation.

Complementarity exists to the extent to which firms utilize resources which have value to more than one firm and their costs decrease with the number of users and the resources are not perfectly mobile (Reve *et al.*, 2001, p. 42). Size complementarity occurs when cluster size, the number of firms in a cluster, increases the likelihood of infrastructure investments (e.g. roads, laboratories, testing sites). Demand complementarity occurs when the demand for a firm's product or a service increases with the demand for another service or product by another firm in the cluster.

Knowledge dissemination is faster, more focused and relevant and is absorbing quicker in clusters (Jaffe *et al.*, 1993; Tellman *et al.*, 2004). Economic and social interactions between firms, institutions and individuals facilitate the exchange of information and knowledge (Saxenian, 1994). Clusters accelerate this process of knowledge externalities. Taken together, innovation pressure, complementarity and knowledge dissemination mediate between relationship between micro-economic



Source: Amended from Reve *et al.* (2001; p. 29)

Figure 1.
Clusters and value creation

factors and value creation. The effects are universal. However, clusters act as catalyzers. They bring about changes at a faster rate. The model also incorporates a self-reinforcing element. Value creation provides opportunities for further advancement of micro-economic factors, which further increase value creation.

These further specifications of the value creation process have direct implications for public policy. First, it directs attention of policy makers and firms to innovation as an important factor in the quest for competitive advantage and even more importantly its perseverance. Second, it specifies an active role for the public sector in affecting cluster growth. Policies that encourage competition stimulate cooperation and knowledge exchange coupled with the public sector role as a demanding customer and its investment in complementary resources (infrastructure, communication, laboratories) influence the functioning of the mechanisms describe above and hence value creation.

Further to the contribution in terms of model specification, the "Value Creating Norway" study is an integral part of the effort by the cluster community to further professionalize cluster research, through initiatives such as the Cluster Mapping Project. Methodologically, the study combines a remarkable number of interviews (500) encompassing six different clusters, a survey of leading firms in all clusters and firm accounting data. The use of the company register data (The Brønnøysund Register Centre) was instrumental to the methodological contribution for a number of reasons. First, it utilizes data on the population of firms operating in Norway. This allows the calculation, as opposed to estimation, of value creation. Second, the time-series of firm accounting allows for the observation of changes in value creation. Third, detailed information of firm activities allowed for fine-grained identification of clusters participants and especially those who bridge between multiple clusters. The latter required detailed knowledge of each industry.

The detailed operationalization of linkages between firms and institution is another important methodological advancement of this study. The survey sent to firms operating in all studied clusters focused on measuring the extent to which clusters are strong, with an emphasis on firm and institutions' local, national and international linkages to customers, suppliers, public institutions and related industries. Following the Nordic tradition, the study takes a micro-perspective and contextualizes linkages within each of the studied clusters.

From a public policy impact, point of view, the second Norwegian cluster study did not have as much impact at the first study. The study, however, helped provide content to many of the initial cluster policy formulations, not only in high-tech global industries such as maritime and offshore oil and gas, but also in low-tech and labor-intensive industries as tourism and retailing. The study also provided a much higher focus on innovation than the previous studies, and the Norwegian industrial development agencies changed from providing easy financing to providing funds for innovation and entrepreneurship. The main government Agency for Regional and Industrial Development (SND) became Innovation Norway in 2003, and the Norwegian Research Council established a new Innovation Division, funding research and development interaction between business and academia, e.g. the BIA program, which is the largest innovation program of the Research Council. Ironically, the Deputy Minister of Trade and Industry at the time of reorganization of the industrial policy agencies was the former project coordinator of the first Norwegian cluster study, and the first director of

the Innovation Division of the Norwegian Research Council was former researcher of the second Norwegian cluster study.

Three government agencies, with Innovation Norway as the operator, jointly established the arena program for cluster development and later the NCE program for cluster advancement and cluster internationalization. The two Norwegian cluster programs were established with specific reference to the two Norwegian cluster studies, emphasizing the role of knowledge linkages in cluster development and cluster upgrading. External evaluations have given both programs high marks. More efforts also took place at the regional level, developing more cluster-based approaches to regional industrial development, and industrial development plans were established both at regional and local levels. Today, almost every Norwegian municipality and city has developed their own plans for industrial development, relying on more or less precise analysis of local and regional clusters. The tendency is to overstate the importance of clusters, not fully understanding the role of critical mass in cluster development.

Cluster studies 3.0: knowledge-based clusters

In 2012, twenty years after the publication of the first Norwegian cluster study, "A Competitive Norway" (1992), Torger Reve and Amir Sasson presented the third large national study of industrial clusters in Norway, "A Knowledge-Based Norway" ("Et kunnskapsbasert Norge") (Reve *et al.*, 2012). As for the two previous studies, a consortium of project sponsors was established, headed by Norwegian Ministry of Industry and Trade, Norwegian Employers Federation (NHO) and Norwegian Confederation of Trade Unions (LO). Although the project budget was much higher than for the previous study, full project funding was achieved by inviting in other key Norwegian ministries (oil and gas, fisheries and coast, knowledge and research and environmental affairs), Norwegian Research Council, Innovation Norway and other government agencies, as well as all the major industry associations representing cluster industries. Note that two new ministries became part of the project consortium, Ministry of Knowledge and Research and Ministry of Environmental Affairs. The first reflects the increased focus on a knowledge-based economy, while the latter reflects a greener economy.

Thirteen cluster industries were studied in depth, and as previously, special research reports were developed for each industry. Finally, the model and findings were published in a book (Reve and Sasson, 2012), presented at a large industry conference in the presence of HM Crown Prince Haakon, Minister of Industry and Trade, Minister of Oil and Energy and the Current Prime Minster (then leader of the main opposition party), as well as CEOs of the major international companies. In the year that followed, more than 200 presentations of the project and its findings were made to business and government audiences, and special seminars were held in the Norwegian Parliament for each of the political parties. The book ended with a knowledge-based policy agenda for Norway, and many of the recommendations for strengthening the knowledge commons have already been adapted (e.g. GCE).

The project is a continuation and an extension of theorization regarding the role of knowledge, clusters and competitiveness (Porter, 1998; Tellman *et al.*, 2004). For industries to be competitive and sustainable in a high-cost location like Norway, they have to compete globally, they have to be knowledge-based and they must be

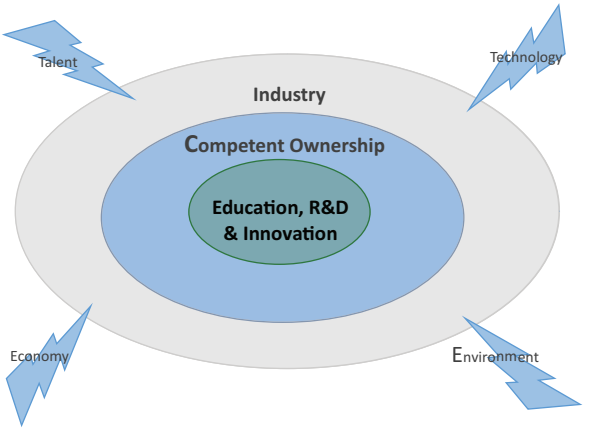
environmentally robust. Under such conditions, nations and regions strive to attract the best talent and the best firms. Knowledge-based industrial development occurs in global knowledge hubs (Figure 2) or superclusters characterized by a high concentration of innovative industrial actors interacting closely with advanced research institutions, venture capital firms and competent owners. Hence, firms, local authorities and national governments face the challenge of creating conditions under which knowledge-based industrial development can occur.

What makes an industry or an industrial location attractive for knowledge-based firms? The Emerald Model (Reve *et al.*, 2012) provides a framework for analysis of the attractiveness of localities. The surface of a hexagon, hence its name, provides room for maneuver for public authorities and a decision set for firms. It conceptualizes attractiveness as six-dimensional. Localities differ in their attractiveness in accordance with their abilities to attract advanced education institutions and departments, highly talented employees, advanced academic specialist and research and development projects, competent and willing investors and owners, the creation and implementation of environmental solutions and a diverse and sizeable group of related firms. *Cluster dynamics* moderates the effects of these dimensions on economic performance. Cluster dynamics is the degree to which related firms compose their internal and external relationships to constitute an inter-related group of firms and institutions as opposed to an augmentation of isolated firms and institutions merely sharing a certain geographical space.

To operationalize each of the dimensions of the Emerald Model, we needed data that encompass a wide range of issues including value creation, education, publications, innovations, ownership, knowledge dynamics and environmental impact. The Knowledge-Based Norway (Reve *et al.*, 2012) augments the Nordic tradition of case studies, interviews and a survey presented above by introducing mixed methods, longitudinal matched micro-level data and fine-grained cluster identification.

The study used a mixed-method methodology:

> It involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and



Source: Amended from Reve *et al.* (2012; p. 40)

Figure 2.
Global knowledge hub

> involve the integration of the data at one or more stages in the process of research (Creswell *et al.* 2003, p. 212).

We used the *concurrent triangulation* approach (Creswell, 2009; Creswell *et al.*, 2003). It implied that the two sources were compared to determine if there was convergence, differences or some other combination (Creswell, 2009). Inferences from each data source are often presented side-by-side to highlight the insights from the different sources (Creswell, 2009).

The qualitative side builds closely on the tradition developed in the "Competitive Norway" and "Value Creating Norway" projects. We sought to understand social reality by gaining rich descriptions of issues (Bryman and Bell, 2007), such as inter-firm interactions, competition, innovation and actors such as firms, governmental agencies and knowledge providers. For this purpose, we utilized two data-gathering methods: 300 interviews that yielded direct quotations from people about their experiences, opinions, feelings and knowledge (Patton, 2002), and 98 case studies which provided an in-depth understanding of contemporary issues (Ghauri and Grønhaug, 2005; Yin, 1989).

Similarly to contemporary cluster research (Delgado *et al.*, 2010, 2014), the Knowledge-Based Norway study was very data-intensive. We matched individuals' employment and education characteristics with the characteristics of their employers, including the latter's accounting statements, ownership information and innovative activities. In addition, we used data on students and education alternatives in Norway, academic staff, academic publications and patenting activity in Norway. The Knowledge-Based Norway study is unique in its utilization of micro-level data at the individual level. Many cluster studies take the cluster or the firm as the unit of data collection. We gathered data on *all* employees working for any firm located in Norway in the years 2000-2008 (about 13.5 million employees). This fine-grained level of data collection allowed us to examine some of the cluster mechanisms like employee mobility (Almeida and Kogut, 1999; Jaffe *et al.* 1993; Marshall, 1920). The database also provides a unique opportunity to examine the extent and pattern of employee mobility. It allowed the calculation of intra-cluster mobility as a proxy for knowledge linkages between cluster members and inter-cluster mobility as a proxy for knowledge linkages to related industries. We also matched firms with their innovation activities. The European Innovation Scoreboard (EIS) provides an annual benchmarking of national innovation performance levels across the European Union and internationally. We utilized data from both the EIS and from the annual R&D survey by Statistics Norway.

Cluster identification in the Knowledge-Based Norway study has its roots in the pioneering cluster mapping project and in the activity-based view (Porter, 1985; 1996) and the Nordic traditions of breaking clusters and industries to their value-adding activities (Reve *et al.*, 2001; Reve *et al.*, 2012; Stabell and Fjeldstad, 1998). Similar to the US cluster mapping project, we commenced with matching industrial classifications with each studied cluster allowing for overlap, e.g. an industry may be contribute to more than one cluster. Thereafter, through direct contact with firms or webpage examination, we assigned cluster membership for *each* firm in the resulting sample. For the identification of firms belonging to the oil and gas cluster, we individually examined 15,000 firms. Such a research approach requires detailed industry and business knowledge.

The policy impact of the third Norwegian cluster study is a bit early to assess, but one or two early program innovations should be mentioned. Less than one year after the publication of "The Knowledge-Based Norway" study (Reve *et al.*, 2012), the Norwegian Government added a third-level cluster program, GCE, which is directly taken from the policy chapter of the book. Currently, three NCE have been granted GCE status, all of which are clusters in maritime and offshore technology, funded for 10 new years. A proposal to concentrate R&D resources with the major industrial clusters has also been implemented, placing new centers of research-based innovations with the newly established GCEs. A more radical proposal for new tax incentives for continuing education of employees at the business level has so far not been implemented. New strategic cluster initiatives are under way at the industrial level both at strong cluster industries, such as the seafood industry and the finance industry, and at weak cluster industries, such as the biotech industry and the tourist industry. Several political parties have adapted new policy formulations in their party programs, recommending knowledge-based cluster policies, but it is too early to see the practical policy results.

Discussion

Rather than becoming another country ridden by the natural resource curse, Norway during one or two decades put the resource rents obtained into a Government Sovereignty Fund (NBIM), currently the largest sovereignty fund in the world (with net market value approaching $1,000 billions), which is about two times Norway's gross national product (GDP). The Norwegian Sovereignty Fund can only invest in listed shared and bonds in *international* financial markets, and the government can only use the annual gains (estimated to 4 per cent p.a.) for budget purposes.

The policy followed by the Norwegian Government for developing the new offshore oil and gas sector was to allow international competition at all levels of the offshore oil industry, investing heavily in education, technology and R&D, and building critical cluster mass. Today, Norway has one of the most competitive offshore oil and gas supply industry in the world, rivaling Houston as a global offshore oil and gas hub.

The economic and industrial success of Norway is the result of rich endowments of natural resources, e.g. hydropower and offshore oil and gas, combined with sound macroeconomic policies avoiding the natural resource curse. It is, however, also the story of sound industrial policies, emphasizing knowledge and competence development, and implementing deliberate cluster policies for the main international industries. Norwegian cluster policies, as have been discussed above, have focused on building sound knowledge commons behind the key industrial clusters, and each industry has developed industrial strategies implementing cluster policies. Rather than giving the government the lead role in industrial development, a triple-helix approach has been applied, actively involving the private sector, the investors, the academia and civil society in building the knowledge-based industrial platform for the future. Norway has one of the highest cost levels in the world, but many Norwegian industries remain competitive in international markets based on advanced technology and effective business models.

Currently, the strongest cluster is put to a critical test, as the Norwegian offshore oil and gas industry is adapting to a scenario of permanently lower oil prices. Our hypothesis is that the energy and ocean-based industries are able to transform themselves through innovation and adaptation, much like what happened during previous crises, e.g. when the maritime industry collapsed in the 1970s. Thus, we are facing a critical test of the innovation and transition capacity of the Norwegian knowledge-based clusters.

Conclusions

In this article, we have analyzed and discussed the large global impact of the "Competitive Advantage of Nations" study published by Michael Porter in 1990. Norway is probably one of the countries where the impact of Competitive Advantage of Nations has been the most profound. The reasons for that, we have argued, is the stream of national cluster research projects undertaken in Norway over the past 25 years. In this article, we have discussed the theoretical and methodological advances made during three generations of cluster research in Norway. The high-cost economy and the large data availability in Norway facilitated systematic and detailed studies of knowledge-based clusters.

We also argued that small nations like in the Nordics provided ideal socio-political contexts for cluster policy formulation and cluster policy implementation. Initially, the cluster ideas were met by considerable opposition from traditional economists, but today there is wide acceptance for cluster models and the importance of knowledge externalities among policy makers and politicians, and even by many economists. Industrial leaders have always found the concepts of clusters appealing because it captures the business reality they know better than traditional models of industry.

Why did the cluster approach succeed so well in Norway? We think the organization of the national cluster research projects provides much of the explanation. All key stakeholders participated in the studies. There were no key sponsors claiming that the study was theirs; the research was a joint product. Both the employers and the employees were, in good Nordic tradition, represented, by including both the employer federation (NHO) and the trade unions (LO). All key ministries were involved in the project, although not the Ministry of Finance, which stood for more economic orthodoxy. The Norwegian Research Council and the Regional and Industrial Development Agencies played key roles in all three projects. So did the trade associations representing key cluster industries. Subsequently, the same triple-helix actors were mobilized at the regional and local levels, resulting in numerous cluster projects and cluster initiatives.

The three cluster projects took place at the two major business schools, and the main researchers established themselves as senior experts in the field of strategy and industrial competitiveness, also working internationally. A systematic communication strategy was developed, not only for communicating research results at the end, but also for rooting the cluster model and the research approach among key decision makers throughout the entire research period. The stakeholders were actively involved at all levels of the project. The researchers gave concrete policy recommendation, and the government and the various industries adapted many of these recommendations. This is not to say that all Norwegian industrial policies are knowledge-based cluster policies, but the influence has been substantial throughout the past 25 years much thanks to the publication of "Competitive Advantage of Nations" and the subsequent national studies.

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