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Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge

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Abstract

The paper examines how firms in three regional clusters in Norway dominated by shipbuilding, mechanical engineering and electronics industry, respectively exploit *both* place-specific local resources as well as external, world-class knowledge to strengthen their competitiveness. From these case-studies we make four points: 1) Ideal-typical regional innovation systems, i.e. regional clusters 'surrounded' by supporting local organisations, is rather uncommon in Norway 2) External contacts, outside of the local industrial milieu, are crucial in innovation processes also in many SMEs. 3) Innovation processes may nevertheless be regarded as regional phenomena in regional clusters, as regional resources and collaborative networks often have decisive significance for firms' innovation activity. 4) Regional resources include in particular place-specific, contextual knowledge of both tacit and codified nature, that, in combination, is rather geographically immobile.

1. Introduction

Even in a globalising economy with its increased interdependency between firms in different nations, several authors simultaneously point to an increased importance of place-specific and often non-economic factors in creating competitive advantage and differences in regional economic growth rate. Thus, Porter argues that 'the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, motivations – that distant rivals cannot match' (Porter 1998: 78).

The crux of this regionalisation argument is that the regional (sub-national) level, and specific local and regional resources may still be important in firms' effort to obtain global competitiveness. Thus, a wide range of literature has emphasised regionalisation as at least part of the solution to understanding dynamic industrial development in some places as well as solving regional economic development dilemma stemming from the new competition in the globalised economy (Pike and Tomaney 1999).

The first part of the paper analyses the relevance of the regionalisation argument in interpreting firms' innovation activity in three regional clusters in Norway. To what extent do firms in the clusters rely on unique regional resources and local co-operation when innovating? Do the firms form regional innovation systems? The second part of the paper discusses what the results from the case studies mean for our theoretical understanding of regional innovation systems.

2. Innovation performance in three regional clusters

The analyses of the three regional clusters focus on how firms exploit the geographical scale and scope of knowledge infrastructure and innovation systems to strengthen their competitive advantage. Firms in different part of mechanical engineering dominate the three regional clusters. The clusters contain a few large scale enterprises (LSEs, with 250 employees or more), but are dominated by small and medium sized enterprises (SMEs) (Table 1). At Jæren, the firms studied all belong to the network organisation TESA (Technical Cooperation), which are the heart of the mechanical engineering sector in the area. In the other regions, we analyse innovation performance in a specific branch in the areas.

The branches constitute a regional specialisation. The regions are strongly overrepresented with jobs in relation to the national average within these branches. Thus, the location quotient varies between 10 in the electronics industry in Horten and 5 in the mechanical engineering industry at Jæren[1]. The three cases constitute regional clusters in the way Porter defines clusters as 'geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include,

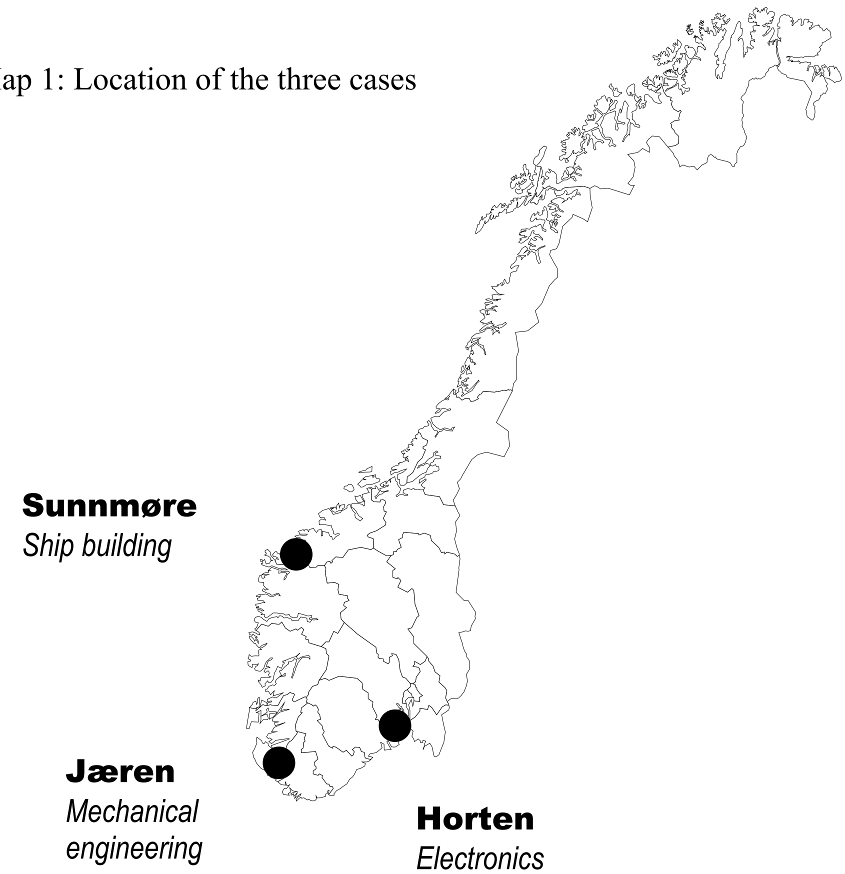
[1] The numbers refer to 1990 (Isaksen and Spilling 1996). The location quotient (LQ) is the share of jobs in the selected branches of industry in the regions in proportion to the branches' share of jobs in the country as a whole. Thus, the LQ of 10 for the electronics industry in Horten means that Horten has 10 times as many 'electronics' job as 'expected' from the number of jobs in the electronics industry in Norway as a whole.

for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure' (Porter 1998: 78).

Table 2: Overview of the three regional clusters

	Horten	**Jæren**	**Sunnmøre**
Number of inhabitants in region	24.000	90.000	77.000
Branch of industry studied	Electronics	Mechanical engineering	Shipbuilding and suppliers
Number of firms in branch	25	13 (TESA members)	90
Number of employees	1.900	3.000	4.200
Firm structure	1-2 LSE, the rest SMEs	4 LSEs, 9 SMEs	A few LSEs, most SMEs
Location quotient (ca)	10	5	8
Number of firm interviews	11	9	7

Map 1: Location of the three cases



Shipbuilding at Sunnmøre – incremental innovations in a regional network

Sunnmøre constitutes the largest ship building area in Norway, and has been among the winner regions concerning ship building in Norway since the 1970, revealing job growth. The ship building industry at Sunnmøre covered 4.200 jobs in 1997, of which 1.600 were found in 14 shipyards, that concentrate on building different types of specialised ships. The remainder 2.600 jobs were spread on 80 equipment supplier firms and ship designers.

The competitiveness of the ship building industry at Sunnmøre is to a large degree based on the innovation capability in the cluster. Analytically, we may distinguish between four main (but inter-linked) ways in which mainly step-by-step improvements of existing products takes place in the area, i.e. 1) by local user-producer interaction, 2) as incremental innovations on the shop floor, 3) by local knowledge spill-over, and 4) by means of cooperation via local organisations. Regarding *local user-producer interaction*, a main driving force behind continual incremental improvements of products is to satisfy new demands and needs by customers and users. Thus, for equipment suppliers, local shipyards are important sources of innovation. Local shipping consultants, who design and construct new ships, also have an important role in mediating demands and specifications on products to yards and equipment suppliers. Ship yards have long-term cooperation with some ship owners, that often return to the yards to discuss new solutions and build new ships.

In the ship building industry, we may also distinguish between customers and users as sources of innovation. The 'end' customers are the shipping companies, while individual users are fishermen and seamen. Discussions with skippers, chief engineers and other crew members give important feedback on how the firms' – and competitors' – products work, as well as suggestions for improvements. Sunnmøre is an important fishing district, as well as an important shipping area, especially for ships serving the offshore activity in the North Sea and elsewhere. The contact with users occurs when fitters, service workers and product developers visit shipping companies or ships. However, a lot of contacts take place when people meet in their spare time, or meet on ferries and at airports, and then discuss how different products work, what to do better etc. The contact is facilitated by, for example, seamen and product developers being part of the same local culture and sharing some common knowledge and experience.

A second main way in which innovation occurs at Sunnmøre is as *incremental improvements on the shop floor*, relying on experience based competence by engineers and workers. This kind of innovation also reflects a common responsibility in the local community of developing the ship building industry and, consequently, the community. This attitude is seen in the drive, the enthusiasm and loyalty of the work force, i.e. when workers exert themselves to find better ways to do things, leading to frequent, smaller innovations. These are attitudes rooted in the way the ship building industry was established and developed in the area. The firms are mainly started by local entrepreneurs to supply a local market. The workers have to a small degree considered themselves as a proletariat, and the organised labour movement has traditionally attained only a weak foothold in this part of the country. Entrepreneurs, firm leaders and workers share the same attitudes with a dominance of the self employed life mode, stimulated by traditions of collective entrepreneurship through cooperatives (Wicken 1994).

Innovation and learning is further stimulated by *knowledge spill-over* and technology transfer between local firms. The cluster contains a varied set of specialised firms, denoting that firms may find other firms to consult and/or buy specialised competence from. Knowledge spill-over takes place when firms cooperate in specific project, when firms obtain advice from neighbouring firms, in personal contacts between workers in different firms, and through job shifts. Experience based competence is transferred in informal circumstances outside working hours. Employees meet privately discussing good and bad experiences concerning the use of production equipment, how to solve specific problems and so on. Tacit, specific knowledge is more or less a common resource base in the ship building cluster, and firms obtain useful feedback and ideas, conditioned by their location at Sunnmøre.

The fourth main way in which innovation occurs is by means of *cooperation through local organisations*. Thus, a 'thick' institutional infrastructure of vocational schools, a technical college and the three associations, *The Mechanical Engineering Association in the district of Ulstein*, *Maritime Nordvest* and *Nordvest Forum*, stimulates local cooperation, competence building and some innovation activity in production methods. The Associations are established by and for local firms. *The Mechanical Engineerig Association* has for example four main tasks: vocational training, the promotion of local cooperation and common understanding (thus, firm leaders agree informally of not competing on wages in order to reduce local wage inflation), attract inward investments, and lobbying.

Although the example from Sunnmøre focuses on incremental innovations stimulated by local cooperation and knowledge spill-over, innovations nevertheless increasingly involve *the use of R&D-based knowledge*. Thus, several firms put more efforts into research and development, to go beyond the mere incremental innovation activities in order to fulfil customers' demand. Several larger firms have established R&D-departments to accomplish more basic product development, for example to obtain increasing speed and less weight on ships and the use of new materials.

This innovation activity often takes place in cooperation between the R&D-department and the engineering and market departments inside companies. Firms also cooperate with external R&D-institutes, most often with SINTEF in Trondheim, the largest technical research institute in Norway. Some firms also collaborate with similar institutes in other countries. The large and/or advanced firms at Sunnmøre have international customers, and must cooperate with the most competent R&D-milieus within their sector. Thus, firms are interacting with national and even international innovation systems.

Thus, firms make use of both local competence and global available R&D-competence. To be able to continue as a leading producer of advanced ship, the second largest shipyard in the region, Kværner Kleven, considers it to be of the utmost importance to be located in a maritime milieu and utilise the total available competence in this milieu. The milieu of relevance to the shipyards includes both the regional ship building cluster, with users, suppliers, and a competent work force, as well as access to the competence and cooperation with SINTEF and inside the

Kværner coporation. (At the time of the interviews the yard was owned by Kværner, now it has been bought back by local entrepreneurs, which could result in losing access to some competence inside Kværner).

Technological Cooperation at Jæren

Although much smaller than industrial districts in the Third Italy, one of the best examples of an industrial district type development in Norway is Jæren, located in the south-western part of Norway (cf. Map 1). Here an organisation called TESA was established by local industry in 1957, with the aim of supporting technological development among the member firms, which were small and medium-sized, export-oriented firms producing mainly farm-machinery. This has, among other things, resulted in the district today being the centre for industrial robot technology in Norway with a competence in industrial electronics/micro-electronics far above the general level in Norway.

In 1994 TESA had 13 member firms with more than 2.800 persons employed and a turnover of 2.2 billion NOK. The TESA firms have overall a very high export share with an average of 63%. However, in some of the firms a far larger share is exported; some firms had an export share of more than 90% in 1992 among them the two largest, ABB Flexible Automation (paintings robots) with 96% and Kverneland (farm-machinery) with 94%. According to the firms, without the inter-firm technological cooperation taking place within TESA, the development of this very strong competitive advantage would not have been possible.

The close, horizontal inter-firm cooperation and interacting learning processes, resulting in the development of core technologies, existing in this district, is rather unique in an international context. The technological cooperation was strongly dependent on the high level of internal resources and competence of the firms, and did not originally involve R&D-institutes in the regional capital of Stavanger. However, in later years, regional and national R&D-institutes have gradually become more in-volved in the R&D-work.

As part of the work to promote the member firms' competitive advantage, TESA took active part in the establishment of JÆRTEK (Jæren's technology centre) in 1987. The aim of JÆRTEK is to offer training to prepare workers and pupils in technical schools for the advanced industrial work of tomorrow, and to secure the competence basis for a continued, rapid technological development. To achieve this, the first complete computer-integrated manufacturing (CIM) equipment in Norway was installed in JÆRTEK.

The most well-known firm at Jæren is ABB Flexible Automation, which was bought by ABB in the late 1980s. Today the firm supplies around 70% of the European market for painting robots to the car industry, and has also been upgraded to become a "supplying unit" in the ABB corporation, which has resulted in production capacity for painting robots being transferred to Jæren from Germany.

The reason for the success story of ABB Flexible Automation has partly to do with the informal, tacit knowledge and social qualifications of the work force (i.e.

Marshall's 'industrial atmosphere'), and partly to do with localised learning based on 'sticky' contextual knowledge. This refers to 'disembodied' knowledge which are not embodied in machinery, but are the result of positive externalities of innovation. Such knowledge is often constituted by a combination of place-specific experience based, tacit knowledge and competence, artisan skills and R&D-based knowledge. These factors were recognised by ABB as being extremely important for the competitive advantage of the Jæren plant, and which, due to their 'stickyness', could only be exploited by being present in the region.

Today, the focus on technological cooperation has been somewhat reduced, and the focus on organisational, managerial and strategic issues has increased. The decreasing focus on local cooperation within TESA to promote technological innovations is primarily a result of the two parallel development trends of globalisation and corporasation that has taken place the last ten years. This development has resulted in many of the firms 'growing out' of the district, when it comes to technological development. In addition, the mechanical engineering firms at Jæren have more limited innovation cooperation with national R&D-institutes, as these often do not have the kind of competence the firms need with respect to product innovations. In this situation, most of the manufacturing firms at Jæren apply two strategies to find relevant R&D-based competence. The first is to use foreign innovation systems, preferentially specialised R&D-institutes and universities in Sweden and Germany, which both have a large manufacturing industry. The second strategy is to utilise R&D-departments inside the corporations (if the firms are part of a large international corporation) or research in cooperation with foreign, strategic partners.

The TESA office is now located in the new science park in Stavanger, in the proximity of Rogaland Research and Stavanger Regional College. This will strengthen the close relation to both research institutes, other centres of competence, local public authorities and educational institutions. Thus, TESA will also have a potential important role to play in the future in promoting the industrial renewal necessary to upgrade some of the more traditional firms in, for example, the farm-machinery industry to higher value-added production. This is especially the case with respect to the question of the future role in this upgrading process of local knowledge and localised learning processes in the context of globalisation and corporasation. The basis for continuous use of the local production system as a strategy of increasing the innovativeness and competitiveness of the firms located in this area must be said to be good against the background of the high technological competence represented by the TESA-firms, and the role of TESA as a network based development coalition with long-term cooperation between workers, managers and different actors at the regional level (Asheim and Pedersen 1999).

The electronics industry in Horten – commercialisation of 'national' research

The electronics industry in Horten comprises about 1.900 jobs and 25 firms, thus constituting one of the largest electronics cluster in Norway. The motive power in the local electronics industry is the large system houses and OEM-suppliers (Original Equipment Manufacturers). The system houses have their own, highly advanced products, often produced in small batches, which are sold to final customers on national and international markets. Currently, Horten has nine system houses with nearly 1.000 employees. The OEM-suppliers have their own products as well, but these are components used by (mostly international) system houses. Horten has three OEM-suppliers employing nearly 450 people. In addition, the electronics cluster in Horten includes about 13 subcontractors with 500 jobs, that serve system houses and OEM-suppliers in Horten, and in other parts of Norway and Scandinavia.

The systems houses and OEM-suppliers are very *product innovative*. Many firms in Horten develop patented products, systems and solutions new to their niches on the world market, and the firms generally have relatively high R&D-costs. The firms' innovation activity mainly takes place in cooperation with national (and international) technological R&D-institutes. Large, mainly national, customers, also form part of the innovation system in acting as early and demanding customers through testing prototypes, giving feedback and making claims on products. Other advanced firms and suppliers complement the firms' internal competence in innovation projects. In addition, much of the innovative activity and learning takes place inside the firms, which have large R&D-departments and many engineers, and also in cooperation with other units within a corporation given the firms are part of such an organisation.

The large system houses and OEM-suppliers in Horten were originally established through the commercialisation of R&D-results from some Norwegian technological R&D-institutes, and have a long history of interacting with these institutes. One of these is situated in Horten itself (a branch of the Defence Research Institute), the others in Oslo and Trondheim. Technology were transferred from the organisations to the firms, both when the firms were founded and also in connection with some later, major technological transformations in the firms. Public initiatives were important in the establishment and in further stimulating the innovativeness of the electronics industry in Horten. An explicit national effort to create a knowledge-based Norwegian electronics industry lies behind much of the development taking place in this area. Today, much more interactive cooperation and learning occur through cooperation in concrete innovation projects between firms and R&D-institutes as well as due to the movement of individuals between different firms and organisations.

The systems firms and OEM-suppliers in Horten have partly grown out of the national innovation system that they rose from, through collaborating increasingly on product development with foreign R&D-institutes and firms. Foreign corporations own three of the system firms and OEM-suppliers. The Horten firms, however, have control over their core technology and competence inside the corporations. For example, AME Space (130 employees) is the only firm inside Alcatel to master the SAW-technology (Surface Acustic Wave). The competence is embedded in human capital and in personal relations between researchers in the firm and in Norwegian R&D-institutes, thus, the competence may be difficult to transfer.

Business relations in Horten are historically integrated in national, and increasingly in international, rather than local social structures. Nevertheless, the local level has revealed increasing significance for some parts of the innovation activity in the electronics industry in Horten since the 1980s. The importance of the local level concerns in particular the unique competence build up among labours in the area, for example gained through several years of trial and error in innovation projects, and by the local subcontractors. The local subcontractors have largely started since 1980 as a result of the system firms closing down most of the production in-house.

The local subcontractors are not involved in product innovations as such. However, they play an increasingly important role in transferring prototypes into effective industrial production, and have been involved in manufacturing at an earlier phase the last ten years. Instead of just receiving drawings and documentation from their customers in order to produce, the subcontractors increasingly give advice and comment on drawing and design before the product is finally developed. The intention is to obtain products that can be produced and tested effectively, and using the cheapest usable components. Organisational innovations occur in the local production system through more long term and binding cooperation between system firms and suppliers. Location close to suppliers is an advantage to industrial development as well as to start ups of new production processes. It is easier to organise fast and frequent meetings to discuss solutions and undertake changes of a new production start up, if important suppliers of components and modules have a proximate location.

3. What about regional innovation systems?

What do the results from the three empirical studies mean for our theoretical understanding of regional innovation systems? The regionalisation argument referred to in the introduction has lead to increasing focus on the term regional innovation system. Regions are seen as important bases of economic coordination at the meso-level: 'the region is increasingly the level at which innovation is produced through regional networks of innovators, local clusters and the cross-fertilising effects of research institutions' (Lundvall and Borrás 1997: 39).

Agglomerations, and in particular regional clusters, are, thus, regarded as places where close inter-firm communication, socio-cultural structures and institutional environment may stimulate socially and territorially embedded collective learning and continuous innovation. The crux of the argument is that the proximity between different actors makes it possible for them to create, acquire, accumulate and utilise knowledge a little faster than firms outside of knowledge intensive, dynamic regional clusters (Maskell et. al. 1998). Much of the regional capability found in dynamic regional clusters is rooted in inter-firm networking, inter-personal connections, local learning processes and 'sticky' knowledge embedded in social interaction. The 'stickiness' of some form of knowledge is seen as one of the few remaining genuinely localised phenomena in the current global economy (Malmberg 1997). Then, unique regional capabilities cannot be transferred to other places, 'it can only be built up over time' (Lawson and Lorenz 1999: 310).

Regional innovation systems (RIS) is partly a new theoretical construct in order to analyse and grasp important aspects of the working of regional clusters, a reference to some actual development tendencies in the building of networked innovation architectures in some regions, as well as a tool in policy making to create systems of innovation in support of business competitiveness on a regional scale (Cooke 1998). RIS may be delimited by first defining regional clusters, that are geographically bounded concentrations of *interdependent* businesses (Rosenfeld 1997). Although firms in regional clusters may cooperate with firms, R&D-institutes etc. in many places, the firms are part of *local networks*, often in the form of production systems, where the shipbuilding industry at Sunnmøre is a good example. However, the firms may be interlinked in other ways, for example by the use of a common knowledge base (as seen by the TESA cooperation at Jæren), the same raw materials, and generally base their interaction on social values and collective visions that foster trust and reciprocity.

Regional innovation system denotes regional clusters surrounded by ‘supporting’ organisations. Basically, regional innovation system consists of two main types of actors and the interaction between them (Asheim and Isaksen 1997). The first actors are the firms in the main industrial cluster in a region including their support industries. Secondly, an institutional infrastructure must be present, i.e. research and higher education institutes, technology transfer agencies, vocational training organisations, business associations, finance institutions etc., which hold important competence to support regional innovation. Thus, the development from a cluster to an innovation system may require (i) more formally inter-firm innovation collaboration between firms in the cluster, and (ii) a strengthening of the institutional infrastructure, i.e. that more knowledge providers (both regional and national) are involved in innovation cooperation.

Different types of regional innovation systems

However, it is important, analytically as well as politically, to distinguish between different types of RIS. Thus, Asheim (1998) distinguishes between three main groups of RIS in order to capture some conceptual variety and empirical richness in this phenomenon, which resemble the typology of Cooke (1998). The first type may be denoted as *territorially embedded regional innovation network* (Table 1), where firms base their innovation activity mainly on localised learning processes stimulated by geographical, social and cultural proximity without much interactions with knowledge organisations. The ship building industry at Sunnmøre (historically) constitutes an innovation network. This type is quite similar to what Cooke (1998) calls “grassroots RIS”.

The innovation networks may be further developed into *regional networked innovation systems*. The firms and organisations are still embedded in a specific region and characterised by localised, interactive learning. However, the systems have a more planned character through the strengthening of the regional, institutional infrastructure, i.e. more R&D-institutes, vocational training organisations and other local organisation are involved in firms’ innovation processes. The networked system is more or less regarded as the ideal-typical RIS; a regional cluster of firms surrounded by a local ‘supporting’ institutional infrastructure. Cooke also calls this type “network RIS”. Historically, the mechanical engineering industry at Jæren resembled an innovation system where TESA supported technological development among local firms. However, the area had, and still has, too few relevant R&D organisations to be denoted a ‘complete’ regional innovation system.

The networked innovation system represents an *endogenous* development model as an attempt to increase innovation capacity and collaboration through public policy instruments. For SMEs, in particular, to carry out more radical innovations there is often a need to supplement the informal, tacit knowledge with R&D-competence and more systematically accomplished basic research and development. In the long run most firms cannot rely only on localised learning, but must also have access to more universal, codified knowledge of, for example, national innovation systems. The creation of regionalised networked innovation systems through increased cooperation with local R&D-institutes, or establishment of some technology transfer agencies, centres for real services etc., may precisely give firms access to information and competence which may supplement local competence and, thus, increase the collective innovative capacity and counteract 'lock-in' of, in particular, regional clusters of SMEs.

The third main type of RIS, *regionalised national innovation system*, is different from the two preceding in several ways. Firstly, parts of industry and the institutional infrastructure are more functionally integrated in national or international innovation systems, i.e. innovation activity to a lager extent takes place in cooperation with actors outside the region. Thus, this represents more of an *exogenous* development model. Cooke (1998) describes this type as "dirigiste RIS". A typical example may be regional clusters where the knowledge providers stimulating firms' innovation activity mainly are found outside the region, as is exactly the case in the electronics industry in Horten. Secondly, the collaboration is to a larger extent based on the linear model, as the cooperation mainly involves specific innovation projects to develop more radical innovations and with the use of scientific, formal knowledge. Then, cooperation may be stimulated when people have the same kind of education (e.g. as engineers) and sharing the same formal knowledge, rather than belonging to the same local community.

Table 1: Some characteristics of three main types of regional innovation systems

Main type of RIS	*The location of knowledge organisations*	*Knowledge flow*	*Important stimulus of cooperation*	*Examples*
Territorially embedded regional innovation network	Locally, however, few relevant knowledge organisations	Interactive	Geographical, social and cultural proximity	Sunnmøre
Regional networked innovation systems	Locally, a strengthening of (the cooperation with) knowledge organisations	Interactive	Planned, systemic networking	To some extent historically at Jæren
Regionalised national innovation systems	Mainly outside the region	More linear	Individuals with the same education and common experiences	Horten

Based on this conceptualisation of RIS we make two points. First, the conceptualisation means that RIS may be a theoretical construct fruitful to study industrial development, as well as the basis for relevant industrial development strategies, in only a limited number of firms and regions, in particular regional clusters. It may not be a fruitful analytical framework and policy tools in peripheral areas and in declining industrial regions dominated by branch plant activities of TNCs (Asheim and Isaksen 1997, Pike and Tomaney 1999). Many peripheral areas often have too few firms in the same industrial sector or local production system to constitute a regional cluster, and then an important condition for local networking and interactive learning is missing. In the second kind of region it *may* be difficult in a short term perspective to bring about the kind of trust and cooperation between a large dominating TNC and local subcontractors necessary to form regional innovative networks.

Secondly, in the conceptualisation of RIS there is a danger to focus too much on the regional level, not considering the need in some cases to integrate the strength of the place-specific and often informal competence with codified, more generally available ('ubiquitous') and R&D-based knowledge. This was exactly one of the main results from our three empirical investigations.

4. Conclusion

An important conclusion from the three case-studies is, thus, the significance of a *multilevel* approach to innovation systems and technology transfer as firms in regional clusters exploit *both* place-specific local resources as well as external, world-class knowledge respectively to strengthen their competitiveness. However, it differs between the three clusters in how firms came to make use of both global, national and regional/local resources in innovation processes, and it is the specific situation of each firm and cluster that define which geographical level will be most important for the innovation activity, knowledge creation and learning (Maskell et. al. 1998).

The national level has traditionally been of utmost importance for the competitiveness of the electronics industry in Horten. Historically, the firms have had nearly all their important contacts in innovation activity to R&D-institutes and customers in other parts of Norway. Right from the start technology were transferred from Norwegian research institutes to the new firms, later on joint development of new technology (mainly new products) with the research institutes and other firms takes place. The global level has become more important as some firms are bought up by TNCs, form strategic alliances with foreign firms or collaborate with foreign R&D-institutes. The local level has become more important through the formation of a specialised local labour market, externalisation of the system firms and the formation of closer collaboration between system firms and local subcontractors.

At Jæren and Sunnmøre the local and regional level historically has been decisive for technological development and competitiveness. Firms have to a certain extent developed competitive products with local farmers, fishermen and seamen as demanding customers. In both clusters, local organisations stimulate collaboration and technology transfer, and they have promoted the formation of shared, local specific competence of both a tacit and codified nature.

Many firms at Sunnmøre and in particular at Jæren have 'grown out' of the district, when it comes to technological development due to increased globalisation and growth of corporations. It also reflects a lack of relevant competence in the regional R&D-system, which hamper technology transfer between local knowledge organisations and firms. As some firms at Jæren and Sunnmøre are world leaders in their niches, they have to cooperate with the 'best' R&D-milieus, which they find at the national and international level.

The use of external competence networks in all the three clusters demonstrates the importance of national innovation systems, the existence of world leading national research groups and collaboration with global actors, also for innovation processes in regional clusters. Firms in the clusters develop new technology as radically new products with the use of formal, scientific knowledge jointly with actors outside of the regions. The extensive collaboration with external actors reveals that ideal-typical regional innovation systems, i.e. regional clusters 'surrounded' by supporting local organisations, are rather uncommon. At least, this is the case in Norway with its comparatively small regional industrial milieus; large, national R&D-institutes; and low cultural barriers between these institutes and the industry (even if the barriers may be high for some (smaller) firms). External contacts are also crucial for many SMEs. Thus, it may be necessary to modify the comprehension of small firms as very dependent upon the local industrial milieu in promoting innovation activity.

Although the three clusters do not constitute ideal-typical innovation systems, it is nevertheless vital to underline that innovation activity is also a regional phenomenon. Especially at Sunnmøre and Jæren regional resources and collaborative networks have strong - and in some cases - decisive significance for firms' innovation activity. Regional resources include unique combinations of knowledge and skills by the labour force, the presence of several specialised suppliers, the existence of local learning processes, technology transfer and spill-over effects supported by geographical and cultural proximity, as well as by cooperative organisations.

The three case studies also stress the importance of localised knowledge, including formal knowledge. Formal, scientific knowledge is vital in the kind of product development carried out in, for example, the electronics industry in Horten. However, key persons' experience based knowledge as well as artisan skills supplement the scientific knowledge. The informal knowledge includes both 'know-how' - knowledge and skills in the specific technologies the firms possess - as well as 'know-who' - information about persons in R&D-institutes and other organisations with special knowledge. The combination of these different kinds of knowledge is bound to individuals and cannot be moved without persons also moving. The knowledge is 'sticky' as the knowledge is partly embedded in local patterns of interaction, and in the fact that the local area holds persons with first-hand experience of the knowledge and on how to put it into use. The best way for firms to acquire this 'sticky' knowledge is to be located (through their own firms, suppliers or strategic partners) in areas where learning processes that develop new and economically useful knowledge takes place, as 'when the content of knowledge is changing rapidly it is only those who take part in its creation who can get access to it' (Lundall and Borrás 1997: 34). The place-specific knowledge, and the interactive way in which this knowledge is acquired, is also an important explanation of the tendencies of successful path dependency to be observed in several regional clusters, and could be said to represent important context conditions with respect to the competitiveness of the firms.

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