Next generation regional innovation policy: how to combine science and user driven approaches in regional innovation systems

The chapter argues that the next generation regional innovation policy is a broad based innovation policy. Such a policy means complementing a science and technology driven policy with a more demand-based, user-driven innovation policy.
Finland has pioneered such a policy in its new innovation strategy. This reorientation is in line with the innovation system perspective extending the definition of innovation to include innovation as interactive learning. It is also in line with new research confirming that combining the two modes of innovation seems the most efficient. The unanswered question is however how this can be achieved.
In combining the two modes of innovation the cognitive distance between the two modes become crucial. The chapter argues that two 'bridging mechanism' could assist in achieving an optimal cognitive distance as a conditions for combining the two modes. The first is to acknowledge that the science and technology mode is not only restricted to scientific knowledge, but that also applied, engineering research has to be included. The second is to realize that learning can be developmental and not only reproductive and that learning work organizations have an innovative potential for generating such learning.

Este capítulo aboga porque la política de innovación regional de la próxima generación sea una política de innovación más amplia. Eso implica que la política basada en la ciencia y tecnología se complemente con una política de innovación, basada en al demanda e impulsada por el usuario.
Finlandia es el país pionero en aplicar este tipo de política a su nueva estrategia de innovación. Esta reorientación es acorde con la perspectiva del sistema de innovación que amplía la definición de la innovación, incluyendo la innovación en su aspecto de aprendizaje interactivo. También está de acuerdo con las nuevas investigaciones que afirman que la combinación de los dos modos de innovación parece resultar de lo más eficiente. Sin embargo, la cuestión es cómo conseguirlo.
A la hora de combinar los dos modos de innovación, la distancia cognitiva entre ellas resulta crucial. Este trabajo sostiene que hay dos «mecanismos de enlace» que podrían ayudar a la obtención de una distancia cognitiva óptima para lograr dicha combinación. El primero consiste en reconocer que el modo científico y tecnológico no ha de limitarse únicamente al conocimiento científico, sino que debe incluir a la investigación aplicada y a la ingeniería. Y el segundo consiste en el reconocimiento de que el aprendizaje puede ser progresivo y no sólo reproductivo, y de que la organización del trabajo aprendedoras poseen un potencial innovador para generar dicho aprendizaje.

Artikulu honek aldezten du hurrengo belaunaldiko eskualde-berrikuntzako politika berrikuntzako politika zabalagoa izan dadila. Horrek esan nahi du zientzian eta teknologian oinarritutako politika eskarian oinarritutako, hau da, erabiltzaileak bultzatutako berrikuntzako politika batez osatzea. Finlandia da berrikuntzako estrategia berri hori aplikatu duen herrialde aitzindaria. Birbideratze hori bat dator berrikuntzaren definizioa zabaldu egiten duen berrikuntzako sistemaren ikuspegiarekin, berrikuntza ikaskuntza-alderdian ere erantsi baitu. Halaber, ados dago berrikuntzaren bi aldeak uztartzea efizienteagoa bide dela baieztatu duten ikerketa berriekin.
«Loturako bi mekanismo» daude, uztarketa ezin hobe hori lortzen lagun dezaketenak. Lehenengoa da onartzea modu zientifikoa ez dela mugatu behar bakarrik oinarrizko ezagutza zientifikora, baizik eta ikerketa aplikatua eta ingeniaritza ere aintzat hartu behar dituela. Eta bigarrena da honako hau onartzea: ikaskuntza mailakatua izan daiteke, eta ez soilik ugalketakoa, eta lanaren antolaketa ezin hobe batek ikaskuntza hori sortzeko potentzial berritzailea daukala.

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1. INTRODUCTION

According to the World Economic Forum Growth Competitiveness Report Finland, Sweden and Denmark have consistently the last 5 years been among the 5-6 highest ranking nations with Finland and Sweden most years among the 3 highest ranking nations.[1] Norway is placed approximately ten rankings below the last year. However, this impressive performance of the Nordic states is achieved with very different innovation policies and strategies. On the one hand Finland has pursued a science-driven, high tech oriented strategy focusing on radical product innovations, with especially good results in the ICT sector, and Sweden a technology-based strategy of process innovations and complex product improvements, with both countries ranking as the top two nations with respect to R&D investments (Sweden 4% and Finland 3.8%). Denmark and Norway have on the other hand implemented a user-driven, market based strategy characterized by mostly non-R&D, incremental innovations using mainly a synthetic knowledge base especially within consumer goods sectors (e.g. furniture), sometimes with a design orientation, but not as a general rule such as in ‘made in Italy’ products, where the symbolic knowledge base is of paramount importance (the exception to this story is the strong pharmaceutical sector, whose product development of course is R&D based applying an analytical knowledge base). Norway resembles Denmark with an even lower R&D intensity with a main focus on incremental process innovations in resource extraction industries (Grønning et al., 2008). This picture corresponds nicely with the ideas of Lorenz and Lundvall (2006) about different but complementary

[1] This was before the global financial crisis, but even now during the crisis the Nordic countries are among the best performers.

'modes of innovation' (the STI and DUI modes of innovation). These empirical facts and theoretical perspectives have a very important policy implication in that there is no 'one size fits all' policy, i.e. no optimal or best innovation strategy with respect to promoting competitiveness and innovation in various industries in different regions and nations in a globalizing knowledge economy (Tödtling and Trippl, 2005). Instead innovation policies must be fine tuned to take into account the respective industrial structures and social and institutional environments and sets-up, i.e. that innovation policies must be adaptive and context sensitive.

2. A NEW APPROACH TO INNOVATION POLICIES

As Finland has been one of the countries that most vigorously and with quite a lot of success has pursued a science based/ push innovation policy, it is noticeable to see arguments for a more broad based innovation policy in its new innovation strategy which was presented in June 2008. It is argued that securing growth and competitiveness in a globalizing knowledge economy cannot any longer only be based on a sector and technology oriented strategy, and that a demand-based, user-driven innovation policy must be implemented alongside a supply-driven policy for R&D. For this to become publically and politically manifest it is also proposed to expand the Cabinet Committee on Economic Policy into a Cabinet Committee on Economic and Innovation Policy, and in a parallel move to rename, in terms of its tasks and composition, the Science and Technology Policy Council into a wider Research and Innovation Council (Ministry of Employment and the Economy, 2008).

This reorientation towards a more broad based innovation policy is completely in line with the innovation system perspective of extending the definition of innovation from the traditional linear view of starting with science and ending up with new products to a view of innovation as interactive learning (Lundvall, 2008). This implies that all industries and sectors can be innovative, i.e. not only R&D intensive, high tech firms and sectors but also medium and low tech firms and sectors implying that innovation is not equal to but instead more than R&D intensity. This could, according to Lundvall and Borras (2005), be referred to as a development from 'science' and 'technology' policies to 'innovation policy', which is illustrated by the new Finnish innovation strategy.

Such a broad based innovation policy must, thus, include and combine the science and technology oriented as well as the demand-based, user-driven strategy, and needs both narrow and a broad defined innovation systsems to be implemented and carried out (Lundvall, 1992; 2008). Regional innovation systems can also be defined in a narrow and broad way (Asheim and Gertler, 2005). Using Lundvall's definition at a regional level a regional innovation system broadly defined, includes the wider setting of organisations and institutions affecting and supporting learning and innovation in a region with an explicit focus on competence building and organisational innovations. This type of system is less systemic than the narrowly defined types of innovation systems. Firms mainly base their innovation activity on interactive, localised learning processes stimulated by geographical, social and cultural/institutional proximity, without much direct contact with knowledge creating organisations (i.e. R&D institutes and universities) (Asheim and Gertler, 2005).

It can, however, play a very important role in establishing a 'culture of innovation' in a region, since it due to its broadness reach out to more 'normal' people than the other type of innovation systems. Key aspects of this perspective are that it emphasizes the importance of partly embedding the innovation process at the work place (micro) level, and partly the dynamic interplay between the micro, meso and macro levels, where "macro-structures condition micro-dynamics and vice versa new macro-structures are shaped by micro-processes" (Lundvall, 2008, 101). A narrow definition of innovation systems on the other hand primarily incorporates the R&D functions of universities, public and private research institutes and corporations, reflecting a top-down model of science and technology policies.

Knowledge and innovation should, thus, not simply be equated with R&D. Innovative activities have much broader knowledge bases than just science based R&D, and there are many examples of nations and regions demonstrating a rapid economic growth and a high level of living standard with an industry competing on the bases of non-R&D based, incremental innovations (e.g. Denmark and regions in The Third Italy (Asheim, 2000)). Thus, a region's knowledge base is larger than its science base, implying that arguing for an increasingly more knowledge intensive globalising economy does not necessarily mean that innovation and competitiveness becomes more dependent on R&D.

3. THE *DUI* AND *STI* MODES OF INNOVATION

The distinction between non-R&D and R&D based (regional) economies implies the use of different modes of innovation (Berg Jensen et al., 2007; Lorenz and Lundvall, 2006). One the one hand we can talk about a broad definition of the mode of innovation as D(oing), U(sing) and I(nteracting) relying on informal processes of learning and experience-based know-how. The DUI mode is a user (market or demand) driven model based more on competence building and organizational innovations and producing mostly incremental innovations. On the other hand one finds a more narrow definition of the mode of innovation as S(cience), T(echnology) and I(nnovation) based on the use of codified scientific knowledge, which is a science push/supply driven high tech strategy able to produce radical innovations. These two modes of innovation will also be differently manifested with regard to regional specialisation and clustering. The narrowly defined innovation system correspond to the STI mode of innovation mentioned above, while the more broadly defined system is more easily accommodated by the DUI mode of innovation.

The distinction between the two modes of innovation helps on the one hand to avoid a too one-sided focus on promoting science-based innovation of high-technology firms at the expense of the role of learning and experience-based, user-driven innovation. However, on the other hand it also indicates limits of such innovation strategies in a longer term perspective and, thus, emphasizes the need for firms in traditional manufacturing sectors and services more generally to link up with sources of codified knowledge in distributed knowledge networks (Berg Jensen et al., 2007). In the OECD review of Norwegian innovation policy it is argued that 'Norway is a rich country, but it would be even richer if innovation activity were more intense, as it could be, given that framework conditions for innovation activity … are relatively favourable' (OECD, 2008, 56). What is here called 'more intense innovation activity' is most probably R&D based innovation activity taking place in a STI mode of innovation. An example of this could be SMEs which may have to supplement their informal knowledge, characterized by a high tacit component (i.e. the DUI mode of innovation), with competence arising from more systematic research and development (i.e. the STI mode of innovation) in order to avoid being locked-in a price squeezing, low road competition from low cost countries. Thus, in the long run, it will be problematic for most firms to rely exclusively on informal localised learning, but must also gain access to wider pools of both scientific and engineering knowledge on a national and global scale (Asheim et al., 2003). However, still the DUI-based type of innovations will remain the key to their competitive advantage, as strong tacit, context specific knowledge components, which is found in e.g. engineering knowledge dominating the DUI mode, is difficult to copy by other firms in different contexts (i.e. it will not become ubiquitive), and, thus will be the basis for sustaining the firms' and regions' competitive advantage also in the long run (Porter, 1998).

4. SOLUTIONS TO THE LONG TERM PROBLEMS OF THE DUI MODE OF INNOVATION

4.1. Solutions DUI I. Distributed knowledge networks

Integration into more globally distributed knowledge networks and value chains can represent one solution to the problems of 'lock-in' due to lack of innovative capacity, which eventually could place firms and regions in a low road, cost squeezing form of competition. As a result of the growing complexity and diversity of contemporary knowledge creation and innovation processes, firms increasingly become parts of network organised innovation projects (either as part of MNCs or in value chains of suppliers and subcontractors). This implies a growing need to acquire new knowledge to supplement their internal, core knowledge base(s) – either by attracting human capital possessing competences based on a different knowledge base or by acquiring new external knowledge base(s) by collaborating with external firms through R&D cooperation, outsourcing or offshoring of R&D, and/or with research institutes or universities, which underline the importance of firms' absorptive capacity. The strategy of acquiring and integrating external knowledge base(s), therefore, implies that more and more a shift is taking place from firms' internal knowledge base to increasingly globally 'distributed knowledge network'[2] and 'open innovation' (Chesbrough, 2003). This is manifested by the increased importance of and attention to clusters, innovation systems (regional, national and sectoral), global production networks and value chains for firms' knowledge creation and innovation processes, demonstrating that 'the relevant knowledge base for many industries is not internal to the industry, but is distributed across a range of technologies, actors and industries' (Smith, 2000, 19). The creation of regional innovation systems

[2] A globally distributed knowledge network is 'a systemically coherent set of knowledges, maintained across an economically and/or socially integrated set of agents and institutions' (Smith, 2000, p. 19).

through increased cooperation with local universities and R&D institutes, and through the establishment of technology transfer agencies, may provide access to knowledge and competence that supplements firms' locally derived competence. This not only increases their collective innovative and absorptive capacity, but may also serve to counteract technological 'lock-in' (the inability to deviate from an established but outdated technological trajectory) within regional clusters of firms.

Thus, there seems to be a generic and global trend towards integration and collaboration in firms' knowledge creation and innovation processes. The development towards more and more distributed knowledge networks can, for example, be traced in several biotechnology clusters over the last 10-15 years. In fact, due to the strong growth of potential biotechnology applications, particularly in life science, it has been increasingly hard for firms as well as regions to host all necessary competences within its boundaries. This has resulted in a local node, global network geography of the life-science industry (Coenen, 2006; Coenen *et al.*, 2004; Gertler and Levitte, 2005). Such local node-global network geography of knowledge creation, innovation and production is, however, not only found in typically analytical based industries applying a STI mode of innovation (such as biotech) but can also be identified in industries combining analytical and synthetic knowledge bases and STI and DUI modes of innovation. The wine industry could provide such an example (Guiliani, 2005; Guiliani and Bell, 2005).

These development tendencies, thus, challenge both the traditional endogenous approach and the 'local buzz-global pipeline' view on the importance of local vs. non-local knowledge resources (Bathelt *et al.*, 2004). So far, all the way from Marshall's writing on industrial districts, it has been assumed that business interactions (from exploiting localization economies) and knowledge flows were co-occurring (and co-located) phenomena. Furthermore, it has been maintained that local interactions and collective learning processes, or what is sometimes called 'local buzz', largely take care of themselves by just 'being there', while building 'global pipelines' to knowledge providers located outside the local milieu requires institutional and infrastructure support, as one cannot expect that it occur spontaneously (Bathelt *et al.*, 2004).

It is this idea of an almost automatic shaping of endogenous learning and innovation capacity by just being co-located in an agglomerated environment, which also lies behind Porter's understanding of how competitive advantage is *created* (Porter, 1990; 1998). Recently, observers have questioned if cluster learning is a pervasive and 'collective' process only conditioned by territorial agglomeration as such (Asheim, 1996; 2000). New research has shown empirically that there exists an uneven distribution of knowledge and selective inter-firm learning due to the heterogeneity of firms' competence bases, which cannot be fully compensated by regional universities or other parts of a region's 'collective absorptive capacity' (Guiliani and Bell, 2005).

Thus, it is an important question if more planned and systemic approaches are needed in a globalising knowledge economy in order for regional advantages to be deliberately *constructed* (Asheim *et al.*, 2006). This argument is grounded in the fact that the contemporary globalising knowledge economy - characterised by outsourcing/offshoring of both production and R&D, open innovation, dominating TNCs, and intensified competition from developing economies of which China and India are the 'star' examples, - is becoming more knowledge intensive, and explicit, codified knowledge consequently increasing in importance. This is, however, as already pointed at, not limited to activities based on an analytical knowledge base but also include activities based on synthetic and symbolic knowledge bases combining the STI and DUI modes of innovation. Simply leaving the question of how constructed advantage is attained just to the 'territory' in the Marshallian way, when tacit knowledge was most important, or to the Porterian primacy of (market) rivalry, is probably not enough. Due to new theoretical developments which will be outlined in detail in later sections and which imply a much more nuanced view of how to understand knowledge, learning and innovation, as well as ongoing research showing that development of innovation systems and quality of governance matters most with regard to economic performance both for developed and developing economies (Fagerberg and Srholec, 2008), regional innovation systems will be in a better position to cope with the new challenges of the globalising knowledge economy. This can represent a useful context for implementing a pro-active, public-private partnership based, broad innovation policy aiming at constructing advantage at the regional level. Such regional innovation systems should be organised as creative knowledge environments (Hemlin et al., 2004), and must play a central role both with respect to supporting and generating local as well as non-local knowledge flows and innovation.

4.2. Solutions DUI II. Developmental learning

However, even staying within a DUI mode of innovation gives more innovative possibilities than previously recognised. This position is linked to research challenging the traditional view of learning as only incremental (or reproductive/adaptive) (Cooke, 2007). Ellström (1997) emphasizes that learning is not only reproductive or adaptive (resulting in imitation) but that it also can be developmental and creative. Ellström uses these categories to make a distinction between developmental learning which he sees as the 'logic' of knowledge exploration on the one hand, and reproductive or adaptive learning which represents the 'logic' of knowledge exploitation in his view. New research on the relationship between forms of work organisation in EU and the impact on job stress, worker satisfaction, labour market flexibility, learning, innovation and patenting confirms that learning also can be developmental and creative due to the high degree of work autonomy and learning dynamics found in *learning* forms of work organisation. This study, distinguishing between four main forms of work organisation: 'learning', 'lean', 'Taylorist' and 'simple structure', shows that not only does the learning work organization result in less job stress and greater worker satisfaction, it also implies more labour market flexibility, superior conditions for learning and innovation, and even a larger propensity for patenting (Lorenz and Valeyre, 2006).

The study shows a clear north-south divide with regard to the dominating forms of work organization with Northern Europe dominated by learning forms of work organization, while Southern Europe has work organizations characterized by either Taylorist or simple forms. The positive impact of the learning form of work organization on innovation is confirmed by another study reporting that 'low road' practices using short-term and temporary contracts, having a lack of employer commitment to job security, low levels of training, and so on are negatively correlated with innovation.

In contrast, it is found that 'high road' work practices characterized by 'high commitment' organisations or 'transformed' workplaces are positively correlated with innovation (Michie and Sheehan, 2003). This implies that a DUI mode of innovation which has learning work organizations as its micro foundation in addition to the interactive form of innovation at the meso level not only should be expected to produce incremental innovations but also has the potential of creating radical innovations due to the presence of developmental learning. Thus, such an 'upgraded' DUI mode of innovation could well establish itself as a 'high road' strategy in the globalizing knowledge economy. However, this possibility would potentially be strengthened through combining the DUI mode of innovation with the STI mode as will be discussed in a later section in this chapter and which also the OECD review of Norwegian innovation policy pointed at (OECD 2008).

This perspective is highly relevant in the Norwegian case since it constitutes the theoretical platform for the VRI program (Policies for regional R&D and Innovation) funded by the Norwegian Research Council. The program builds on constellations of Triple-Helix actors which are referred to as 'regional development coalitions' understood as the inter-linking of learning organisations ranging from work organisations inside firms via inter-firm networks to different actors in the region.

This concept has been developed by action oriented organisational researchers taking their knowledge of how to form intra- and inter-firm learning organisations based on broad participation out of the firm context and applying it at the regional level as a bottom-up, horizontally based co-operation between different actors in a local or regional setting (Ennals and Gustavsen, 1999).

This perspective should be looked upon as a strategy for formulation of long term, bottom-up and partnership-based development strategies initiating learning-based processes of innovation and change. Of strategic importance in this context is the capacity of people, organizations, networks and regions to learn (Lundvall, 2008), and, thus, regional development coalitions resemble a regional innovation system broadly defined. The concept can, thus, be used to describe a region characterised by innovative activity based on localised, interactive learning and co-operation promoted by organisational innovations in order to exploit learning based competitiveness with a DUI-mode of innovation (Amin and Thrift, 1995). It is the aim of the VRI project, which with the exception of the Regional Innovation Strategy pilot actions of the EU commission (Bellini and Landabaso, 2007) is a rather unique innovation policy program in an international context by promoting broadly defined regional innovation systems, to achieve this.

4.3. **Solutions DUI III. The differentiated knowledge bases**

When one considers the actual knowledge bases and competences of various industries and sectors of the economy, it is clear that knowledge creation and innovation processes have become increasingly complex, diverse and interdependent in recent years. There is a larger variety of knowledge sources and inputs to be used by organisations and firms, and there is more collaboration and division of labour among actors (individuals, companies, and other organisations). However, the binary argument of whether knowledge is codified or tacit can be criticized for a restrictively narrow understanding of knowledge, learning and innovation (Johnson et al., 2002). Thus, a need to go beyond this simple dichotomy can be identified. One way of doing this is to study the basic types of knowledge used as input in knowledge creation and innovation processes. By way of suggesting an alternative conceptualization, a distinction can be made between 'synthetic', 'analytical', and 'symbolic' types of knowledge bases.[3]

Following received wisdom from the philosophy of science, an epistemological distinction can be identified between two more or less independent and parallel forms of knowledge creation, 'natural science' and 'engineering science' (Laestadius, 2000). Johnson et al. (2002, p. 250) refer to the Aristotelian distinction between on the one hand 'epistèmè: knowledge that is universal and theoretical', and 'technè: knowledge that is instrumental, context specific and practice related'. The former corresponds with the rationale for 'analysis' referring to understanding and explaining features of the (natural) world (natural science/know-why), and the latter with 'synthesis' (or integrative knowledge creation) referring to designing or constructing something to attain functional goals (engineering science/ know-how) (Simon, 1969). A main rationale of activities drawing on symbolic knowledge is creation of alternative realities and expression of cultural meaning by provoking reactions in the minds of consumers through transmission in an affecting, sensuous medium (table 1).

The distinction between the knowledge bases takes specific account of the rationale of knowledge creation, the way knowledge is developed and used, the criteria for successful outcomes, and the strategies of turning knowledge into innovation to promote competitiveness, as well as the interplay between actors in the processes of creating, transmitting and absorbing knowledge. The knowledge bases contain different mixes of tacit and codified knowledge, codification possibilities and limits, qualifications and skills required by organisations and institutions involved as well as specific innovation challenges and pressures, which in turn help explaining their different sensitivity to geographical

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[3] The distinction between analytical and synthetic knowledge bases was originally introduced by Laestadius (1998, 2007) as an alternative to the OECD classification of industries according to R&D intensity (e.g. high, medium and low tech) arguing that knowledge intensity is more than R&D intensity (e.g that engineering based industries such as paper and pulp also is knowledge intensive even if it does not show up as high-tech industry). It has been further developed in Asheim and Gertler (2005) and Asheim and Coenen (2005) to explain the geographies of innovation for different firms and industries using knowledge bases to show the broader organisational and geographical implications of different types of knowledge (e.g. how innovation processes are organised, patterns of cooperation, locational aspects and importance of proximity). The idea to distinguish between analytical and synthetic knowledge bases in this way was developed at a workshop in Lund in November 2001, organised by Björn Asheim and also involving Gernot Grabher, Aage Mariussen and Franz Tödtling, in preparation for a TSER project entitled 'TEMPO' to the 5th Framework Program of the EU. At this workshop the original analytical-synthetic distinction was expanded with a third category, symbolic knowledge base, to cater for the growing importance of cultural production (Asheim, Coenen, Moodysson and Vang, 2007). We acknowledge our debt to the above mentioned colleagues in the process of developing the concepts and analytical approaches.

Table 1

Differentiated knowledge bases. A typology

Analytical (science based)	Synthetic (engineering based)	Symbolic (artistic based)
Developing new knowledge about natural systems by applying scientific laws; know why	Applying or combining existing knowledge in new ways; *know how*	Creating meaning, desire, aesthetic qualities, affect, intangibles, symbols, images; know who
Scientific knowledge, models, deductive	Problem-solving, custom production, inductive	Creative process
Collaboration within and between research units	Interactive learning with customers and suppliers	Learning-by-doing, in studio, project teams
Strong codified knowledge content, highly abstract, universal	Partially codified knowledge, strong tacit component, more context-specific	Importance of interpretation, creativity, cultural knowledge, sign values; implies strong context specificity
Meaning relatively constant between places	Meaning varies substantially between places	Meaning highly variable between place, class and gender
Drug development	Mechanical engineering	Cultural production, design, brands

Source: Asheim and Gertler, 2005; Asheim et al, 2007; Gertler, 2008.[4]

distance and, accordingly, the importance of spatial proximity for knowledge creation. Thus, the dominance of one mode arguably has different spatial implications for the knowledge interplay between actors than another mode of knowledge creation. Analytical knowledge creation tends to be less sensitive to distance-decay facilitating global knowledge networks as well as dense local collaboration. Synthetic and symbolic knowledge creation, on the other hand, has a tendency to be relatively more sensitive to proximity effects between the actors involved, thus favouring local collaboration (Moodysson *et al*., 2008).

As this threefold distinction refers to ideal-types[5], most activities are in practice comprised of more than one knowledge base. The degree to which

[4] In elaboration of the specificities characterising the symbolic knowledge base I benefited greatly by the assistance of my wife, Dr. Bente Larsen, Department of Art History, Lund University.

[5] Ideal types are a mode of conceptual abstraction where the empirical input constituting the ideal types exists in reality, while the ideal types as such do not.

certain knowledge bases dominates, however, varies and is contingent on the characteristics of the firms and industries as well as between different type of activities (e.g. research and manufacturing).

The underlying idea behind the differentiated knowledge base approach is not to explain the level of competence (e.g. human capital)[6] or the R&D intensity (e.g. high tech or low tech) of firms but to characterise the nature of the basic (or critical) knowledge input on which the innovation activity is based (hence the term 'knowledge base') (Moodysson, 2007). According to Laestadius (2007) this approach also makes it unnecessary to classify some types of knowledge as more advanced, complex, and sophisticated than other knowledge, or to consider science based (analytical) knowledge, characterizing the STI mode of innovation, as more important for innovation and competitiveness of firms, industries and regions than engineering based (synthetic) knowledge or artistic based (symbolic) knowledge, which is the dominating knowledge input in the DUI mode of innovation. This is once more a question of contingency with respect to the firm, industries, and regions in focus.

4.4. Solutions DUI IV. Combining the DUI and STI modes of innovation

A fourth solution would be the option of combining the dominating DUI mode of innovation of the majority of firms with the STI mode. New research confirms that combining the two modes of innovation seems to be most efficient, i.e. firms that have used the STI-mode intensively may benefit from paying more attention to the DUI-mode and vice versa (Lorenz and Lundvall, 2006). In this way, on the firm levels these two modes of innovation can (and should) co-exist, but they will be applied in different combinations depending on the dominating knowledge base(s) of the regional industry.

As already referred to above the 'Science, Technology and Innovation' (STI) mode of innovation, based on the use of codified scientific knowledge, could broadly be associated with the analytical knowledge base, while the 'Doing, Using and Interacting' (DUI) mode, relying on informal processes of learning and competence building and experience-based know-how, would mostly resemble the synthetic (and symbolic) knowledge bases. However, once again we shall argue that such a dichotomy becomes too crude especially when discussing the possible combination of the two modes of innovation.

Here the perspective of cognitive distance becomes crucial (Nooteboom, 2000). If the cognitive distance between the two modes of innovation is perceived by key actors to be too wide, then it will not be possible to combine the two modes and to view them as complementary modes of innovation instead of incompatible alternatives. There will be a lack of absorptive capacity within firms and regional clusters to acknowledge and appreciate the potential gains of the other mode of innovation as well as to access and acquire the necessary competence to combining the two modes of innovation.

There are, however, two key 'bridging mechanisms' which could assist in achieving

[6] Giuliani (2005) and Giuliani and Bell (2005) confusingly refer to 'level of competence' as 'knowledge base' instead of using the term 'competence base' to avoid misunderstandings.

an optimal cognitive distance as a necessary condition for combining the two modes. The first of these deals with understanding that the STI mode is not only limited to an analytical knowledge base, but can also include synthetic and symbolic knowledge bases. In the case of the synthetic knowledge base this can be illustrated by reference to applied research undertaken at (technical) universities, which clearly must be part of the STI mode, but operates on the basis of synthetic (engineering) knowledge (of course drawing on basic research at science departments of universities creating new analytical knowledge), while the case of symbolic knowledge can partly be substantiated by the new tendency of changing design education from being artisan based to be placed at universities with research based teaching, and partly by the steadily increasing research in game soft ware and new media, which in some countries, e.g. in Denmark, is located at new, specialized universities (e.g. the IT university in Copenhagen). This broadening of what constitute the STI mode of innovation shows that also activities based on synthetic and symbolic knowledge bases needs to undertake new knowledge creation and innovation in accordance with a STI mode, and, thus, needs systemic relations with universities or other types of R&D institutes (e.g. in a regional innovation system context).

The other 'bridging mechanism' is the recognition that partly learning is not only reproductive but can also be developmental, and partly the innovative potential that a learning work organisation can display in being the operative context for such learning. Even the most analytical, science based company will obviously benefit from organizing its work in such a way that learning dynamics is created by giving their employees autonomy in their work. This has to build on the principles of broad participation of functional, flexible workers in accordance with the Nordic model of a learning work organization (Ennals and Gustavsen, 1999).

5. TECHNOLOGY VERSUS. APPLICATION DEVELOPMENT: A CONCRETE EXAMPLE OF HOW TO COMBINE THE STI AND DUI MODES OF INNOVATION

In order to illustrate the importance of these 'bridging mechanisms' even further we shall give a concrete example taken from a large, international company that is world leading within its area.[7] This is an engineering company whose products are based on a synthetic knowledge base with all the typical characteristics of this knowledge base: problem-solving and custom production based on interactive learning with customers and suppliers. Knowledge is partly codified with a strong tacit component, and is clearly context-specific. Core competence of the company is to comprehend the complex construction process of the equipment in a holistic way. The point is not to understand the individual 'machines' being needed, but to understand the individual machines as part of a system. This is a very complicated process with more than 1.000 different steps, which clearly underlines the problem-solving and custom oriented production

[7] Aker solution producing drilling equipment for offshore oil and gas production. Together with National Oilwell, an American owned company, located next to Aker just outside Kristiansand, they supply around 90% of the global market for offshore drilling solutions.

of a typical synthetic, engineering based company. This is a good example of the importance of tacit, context (i.e. product)-specific knowledge as one of the most important sources for sustaining the firm's competitive advantage.

When asked about how they organized their innovation activity the R&D director of the company made an important distinction between *application development* ('machine' development) and *technological development*. *Application* development means solving concrete problems in connection with building the specific equipment for customers. This is carried out drawing on internal engineering competence as well as in interaction with suppliers and customers, and is, thus, an example of the DUI mode of (incremental) innovation. In addition professional R&D firms (consultancy firms) domestically and abroad are used. *Technology* development means development of more general platform technologies, which represents the technological basic competence for carrying out application development. While the application development is only made in-house or in user-producer relationships, technological development takes place in cooperation with (technical) universities as applied research projects, and represents, thus, the STI mode of innovation but still based on synthetic knowledge.

Concerning cooperation with university this can take place on normal open conditions when it is a question of general technological platform development, but not with respect to how to apply this general technology in application development. Then results from research on technological development are applied in concrete, individual projects, which underpin the competitive advantage of the company.

In cooperation with universities on applied research projects *geographical proximity* matters most, and instead of always accessing the best competence globally found at places such as MIT, the company chooses to focus on the geographically closest available competence. Thus, they prioritize building up research cooperation with the regional university (i.e. University of Agder, Grimstad campus) by among other things employing some professors in 20% positions in the company as a way of strengthening the competence at the university to be applied in collaborative research projects. In addition they take a central part in funding and using a regional, applied research organization (Teknova). The company called this form of carrying out applied research 'cooperation at the operational level', which, according to the company, is the right level of research collaboration for technological development. To achieve this, geographical proximity is of great importance. In addition the company cooperates with national (Norwegian Technical University in Trondheim) and international top universities (e.g. Carnigie Mellon University, Pittsburg and Denmark's Technical University, Copenhagen) in research projects on technological development, which always involve company funded PhD's to secure a more long-term 'payback' for the company. In order to strengthen the relationship to the company they also make sure that one of the supervisors is coming from the company, which provides *organizational* as well as *institutional* proximity (Boschma, 2005).[8]

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[8] In contrast to R&D work geographical proximity is not important for the manufacturing of the many parts used in the final assembly of the equipment as there, at least in principle, should be no iteration in carrying out such operations.

This example illustrates how such a 'bridging mechanism' can work to solve the problem of a too wide cognitive distance, and, thus, achieve a combination of the two modes of innovation. Furthermore, the example illustrates how 'second best' regional universities can be used and upgraded by large companies to become active partners in collaborative R&D projects in addition to the companies also using non-local, more internationally leading universities.

6. CONCLUSION: NORDIC CENTRES OF EXPERTISE AN EMPIRICAL ILLUSTRATION

This chapter aims at analysing the changing and diverse roles of regional innovation systems in the globalizing knowledge economy. The theoretical discussion in the preceding sections has emphasized the diversity with respect to RIS narrowly and broadly defined as well as the changing roles in promoting and implementing a broad based innovation policy building on different modes of innovation, types of knowledge and forms of learning. The empirical challenge is to analyse how to combine types of knowledge, forms of learning and modes of innovation with narrowly and broadly defined RIS in order to pursue a broad based innovation policy. More precisely the task is to identify which kind of 'mixes' are required to support different industries (new, emerging firms, traditional SMEs, large firms, MNCs etc.), and on what geographical level such support should be organized, to get a more realistic picture of what could be achieved at the regional level. Such analyses will provide us with a more precise understanding of the role RIS can play in the comprehensive pattern of NIS, SIS and also increasingly more globally distributed knowledge networks. We shall introduce such a broader empirical analysis by shortly illustrate the usefulness of the presented theoretical framework by looking at the strategy of establishing Centres of Expertise (CoE) in Finland, Norway and Sweden to see how this policy fits into the new strategy of a broad based innovation policy (in contrast to more narrow science and technology policies), and when the regional level in contrast to the national one represents the optimal geographical scale for implementing a policy of CoE.

Concerning Nordic experiences from the CoE strategy Finland pioneered this strategy. They started out with a few such centres (5) based on regional strength in university research and global competitive firms. In the early years this approach was successful. However, the strategy was generalised resulting in more than 20 CoE spread around the whole of Finland. As one easily can understand, a small country like Finland cannot display more than 20 regions with global competitive HEI/research institutes and industry, and, consequently, the strategy failed to produce positive outcomes in most cases. Recently the strategy was changed to become one of containing the many (mostly) regional CoE in a national network of CoE with some regional strongholds. According to the new innovation strategy in Finland this approach will be strengthened in the form of regional centres of innovation based on strategic strengths of the regions driving renewal.

Sweden has still relatively few CoE (Vinnväxt as well as Vinn Centres of Excellence, which are part of VINNOVA's (the Swedish Governmental Agency for Innovation Systems) regional policy portfolio), even if the same tendencies as found in Finland also is starting to work in Sweden with too many new centres. In Sweden the approach is strongly regional focused building on a regional innovation system/ Triple-Helix approach. So far the Swedish efforts have given mixed results. Regions with strong research based universities and global competitive industry and with a well-functioning RIS/T-H such as Scania (Lund), Gothenburg and Uppsala can come up with successful cases, while other cases where, for example, research at the regional university is not relevant or of a too low quality to be useful for the world leading industry in the region, have produced disappointing outcomes (e.g. Robot Valley centred around ABB in Västerås).

While CoE in Finland and Sweden are based on the existence of both a strong research based university (in principle) and a competitive industry, CoE in Norway is more like regional clusters without a regional university. Therefore, they rely heavily on national knowledge organisations, especially the Norwegian Technical University and its applied research organisation, SINTEF, in Trondheim, which is the largest independent research organisation in Scandinavia with more than 2000 researchers employed. It constitutes the core knowledge exploration node in the national innovation system for the leading Norwegian export oriented industries. On the other hand, while CoE in Finland and Sweden exclusively have a STI innovation mode perspective of a narrowly defined RIS (both basic, analytical and applied synthetic knowledge based research), in Norway many of the industries in the CoE also make use of a RIS broadly defined based on the DUI mode of innovation.

These experiences tell us that only a few regions in small countries like the Nordic display the necessary level of strong, research based universities to support world leading industries applying a STI mode of innovation. Such strong research and innovation environments (as VINNOVA calls them in Sweden) can also attract R&D departments and units from foreign MNCs. In these cases universities as the key node in the knowledge exploration subsystem of narrowly defined RIS have a strategic role to play. The Norwegian case is interesting partly as the CoE are based on non-local knowledge flows with respect to the STI mode of innovation (mostly synthetic knowledge based, applied research), using the node of the knowledge exploration subsystem of the NIS, and partly because many firms in the CoE also make use of a broadly based RIS characterised by the DUI mode of innovation.

With the exception of emerging firms building on newly created knowledge from basic university research based on analytical knowledge (knowledge based entrepreneurship), most firms in order to be competitive will also need applied research based on synthetic and symbolic knowledge bases (even drug development in DBFs display phases in innovation projects where synthetic knowledge is the most important (Moodysson et al., 2008)) as well as access to a wider setting of organisations and institutions supporting learning and innovation in accordance with a DUI mode of innovation in RIS broadly defined. This is especially the case for ordinary (i.e. not global competitive firms) firms (often SMEs) in ordinary regions without a strong research university. Such firms and regions will rely heavily on a RIS broadly defined supporting a DUI mode of innovation, which most successfully operates at the regional level due to the importance of geographical and social proximity for interactive learning, which characterises synthetic and symbolic knowledge bases. The challenge in these regions is to link this DUI based RIS to (most probably) a non-local STI based RIS.

In conclusion, this point to the need of pursuing a broad innovation policy implemented in a mixed system of broadly and narrowly defined RIS combining different types of knowledge, forms of learning and modes of innovation in order to promote development *in* as well as *of* regions in a globalising knowledge economy.

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