Innovation policy for economic resilience:

The case of Sweden

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Keywords: Innovation system; innovation policy; Sweden

JEL: O25; O31; O52

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Innovation policy for economic resilience: The case of Sweden

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Abstract

This paper provides an overview of the Swedish innovation system and the main strategies for Swedish innovation policy, with specific focus on VINNOVA's place-based support to specialised areas integrating competences from different sectors in society. The overview reveals a recent shift from place-based specialisation to thematic areas underpinned by a societal challenge driven logic to policy intervention. The analysis indicates that a strong focus on R&D and science-driven innovation serves as a barrier for successful transition, and that the recent shift implies a greater need for policy coordination across different fields and scales. This makes agencies like VINNOVA less autonomous with regard to design as well as implementation of innovation policy and points to the need for reaching a balance between demand-oriented and supply-led strategies in which place-specific context matters and innovation policy must be attuned to and embedded in the particularities of the regional and national economies it aims to target. Linking smart specialisation strategies (S3), EU's overall industrial and innovation policy for regional diversification and restructuring, with VINNOVAs new system innovation policy approach would be one way of doing this.

Introduction – innovation performance and policy preconditions in Sweden and Finland

The Nordic countries have – in relation to their size and impact on the global economy – generated disproportionally much attention from scholars interested in innovation systems policy. Part of the reason for this is that some of the most influential scholars in this research field are active at universities in the Nordic countries, but an equally important explanation has to do with the strong performance of these economies. According to the World Economic Forum Growth Competitiveness Report Finland and Sweden have consistently the last years been among the five highest ranking nations with Finland and Sweden most years among top three. Also Denmark and Norway has been ranked among top 15 the past years. This impressive performance is achieved with very different innovation policies and strategies. 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.

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 the country's 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, but 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 broader Research and Innovation Council. This reorientation towards a more broad based innovation policy is 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. Innovation is not equal to but more than R&D intensity. This could, according to Lundvall and Borrás (2005), be referred to as a development from 'science' and 'technology' policies to 'innovation policy', which is illustrated by the new Finnish strategy.

However, in spite of the large amount Finland has spent on its R&D and innovation policy as well as the – on paper and in plans – best organised R&D system, which was used as a model of international organisations such as the OECD, the R&D and innovation system has not been able to promote new path development. Due to this, the Finnish economy is now in a deep crisis. This must be described as a serious system failure. In contrast, Sweden was characterized in OECD's review of its innovation policy as the most resilient economy in Europe, always being able to come out of crisis having restructured and upgraded its economy to do something more knowledge intensive and technologically advanced. The Swedish economy has, thus, displayed a capacity of adaptation (path extension) as well as adaptability (new path development), which together defines resilience. According to the introductory paragraph of the OECD review, the Swedish development is described in this way: Sweden 'can look back at an extraordinarily successful history of economic and social development. It started the industrialisation process as a relatively poor, resource-based country in the mid-19th century and is now an advanced society with a welfare state widely referred to as the "Swedish model". On various counts Sweden ranks among the world's most innovative countries today. It overcame the limitations of a small domestic market through a high degree of internationalisation, not least through the emergence of large Swedish enterprises. Innovation has long been a pillar of Sweden's development, even before innovation was explicitly considered a key driver of economic growth and social development. ….., innovation is also the key to Sweden's future in a globalised world' (OECD, 2013, 17).

The present report makes an attempt of explaining the success of the Swedish innovation system through a historic overview of the main strategies for Swedish innovation policy, with specific focus on VINNOVA's different attempts at promoting innovation through place-based support to specialised areas integrating competences from different sectors in society (industry, university, public sector). In the most recent strategies this is referred to as strong R&I milieus and strategic innovation areas, however the way of describing this, as well as the main mechanism given attention by policy support, have evolved over the last decades.

VINNOVA's place based support to specialised innovation areas

The process towards what is now called Strong Research and Innovation milieus started in 1979 when one of the predecessors of VINNOVA, STU (The Board for Technical Development) decided to take a role as a change agent by promoting basic research in new and potentially important areas for Swedish industry. Such areas, where stronger academic competence was considered to be needed, were IT, microelectronic and biotech.

The first explicit promotion of strong R&I milieus was started in 1990 in the form of the so called interdisciplinary material consortiums (11 in total). This effort had a ten years perspective, and was funded with the National Science Research Council. In 1995 another ten year program was initiated, called the competence center program, which can be seen as a further development of the concept which was introduced with the material consortiums. 28 centers were included in the program as a platform for linking long-term R&D university R&D to industrial needs and competences through physical center formation with commitment of financial and human resources from both parties. It was originally administered by NUTEK, predecessor of VINNOVA. Replaced by the VINNEX program in 2005, it reflects the innovation system construction objectives of VINNOVA by seeking to create new concentrations of competences which conduct multi-disciplinary research of relevance to the development of new products, processes and services (Brorstad Borlaug, 2015).

VINNOVA was established in January 2001. The most important new aspect which VINNOVA represented compared with the previous funding organisations for technology policies, was an explicit emphasis on the innovation systems perspective. Previous programs were all assessed for their contribution in securing efficient innovation systems.

The VINNOVA version of a CoE program was initiated in 2001 and launched in 2003. This first program was named VINNVÄXT (Regional Growth through Dynamic Innovation Systems), and organised as a competition between regions in which triple helix organised regional coalitions of stakeholders can apply for funding. The basic ambition of such a top-down construction explicitly encouraging bottom-up initiatives is to address system-failures in a more fine-tuned way than traditional regional innovation policy has been able to. This is also the novelty of the program which has achieved international recognition.

A shared characteristic among the VINNVÄXT initiatives is that they build on pre-established regional strongholds, rather than attempts to establish new activities from scratch. One aspect promoting the vision of exploiting existing strengths instead of entering new knowledge domains is the requirement of an equal amount of co-funding from local and regional (public and/or private) funds as what is received from the VINNVÄXT program. Allocation of such resources requires deep engagement from pre-existing organisations, not least firms, with an interest in the initiative.

The VINNVÄXT program is designed to promote long-term sustainable innovation support, taking into account the specific needs and available resources in respective regions. In line with such a long-term strategy, the concept of region is defined in functional terms in the program, instead of following traditional administrative boundaries.

In the Government's research policy proposition from 2005 a strengthened support of strong R&I milieus was proposed by increasing the funding of international leading research milieus. Based on this new funding VINN EC and Berzelii centres (and also other similar centres) were established. These centers were strongly focused on excellent, basic research which was considered of potentially strong strategic relevance for Swedish industry as well as on the milieus' ability to contribute to innovation and sustainable development. VINN EC replaced the competence centre program, and was also a ten years program for promoting strong R&I milieus. Compared to the competence centre program the VINN EC program was explicitly based on an innovation systems perspective in line with VINNOVA's mission of building and promoting efficient innovation systems. In addition, a triple helix model was applied to emphasise the importance of a pro-active role of the public sector. By locating these centres in the innovation milieu of HEIs VINNOVA aimed at securing that potential university spin-offs could be the starting point of new research based and high-tech companies.

The Barzelii centres were co-funded by VINNOVA and the Swedish Research Council and are basically a complementary support form to VINN EC, where the model of VINN EC/the competence centres would not work. These centres should primarily be focused on excellent basic research with a large potential for innovations. These centres should also be organized as a triple helix operation with close collaboration between universities, industry and the public sector to secure that the commercialization potential of the research would be properly exploited. An aim of the program is to promote scientific excellence at the international research frontier in areas with a large potential for innovation, which often will be areas where established industry hesitates of investing capital or within totally new areas which have not been economically exploited by industry. The program does not make any explicit requirements for active industry participation from the beginning, but expect this to happen during the last five years period.

There are four important elements of VINNOVA's definition of strong R&I milieus which represent the agency's implicit and explicit theoretical perspectives. First, the innovation system perspective of knowledge creation and innovation being a result of collective processes where several stakeholders take part is clearly stated. Key stakeholders are the knowledge exploration and the knowledge exploitation subsystem of a (regional) innovation system, as well as the public sector/regional government; i.e. the triple helix (Etzkowitz and Leydesdorff, 2000). Secondly, research and innovation should be concentrated within a given area, which can range from specific technologies to more generic knowledge (e.g. biotech and nanotech). Thirdly, a regional innovation system perspective is shining through when arguing that the activities should be concentrated in one or two geographical areas of the country (see also Lundequist and Waxell, 2010). This also to a large extent resembles Porter's basic definition of clusters as 'geographic concentrations of interconnected companies and institutions in a particular field' (Porter, 1998). Finally, the importance of linking up to international R&I milieus is underlined.

Looking at the three types of strong R&I milieus VINNOVA has launched so far, two of the three have all the three stakeholders in a triple helix constellation in place while the third one, the Barzelii centres, mainly represent a strong research environment where research at the international cutting-edge is believed to have a large innovation (i.e. commercialisation) potential. The two first types, VINNVÄXT and VINN EC differ somewhat as VINNVÄXT initiatives have the knowledge exploitation subsystem (i.e. industry) as the point of departure, while VINN EC primarily is based on a strong research milieu (i.e. university) but also have the two other stakeholders in place (see figure 1).

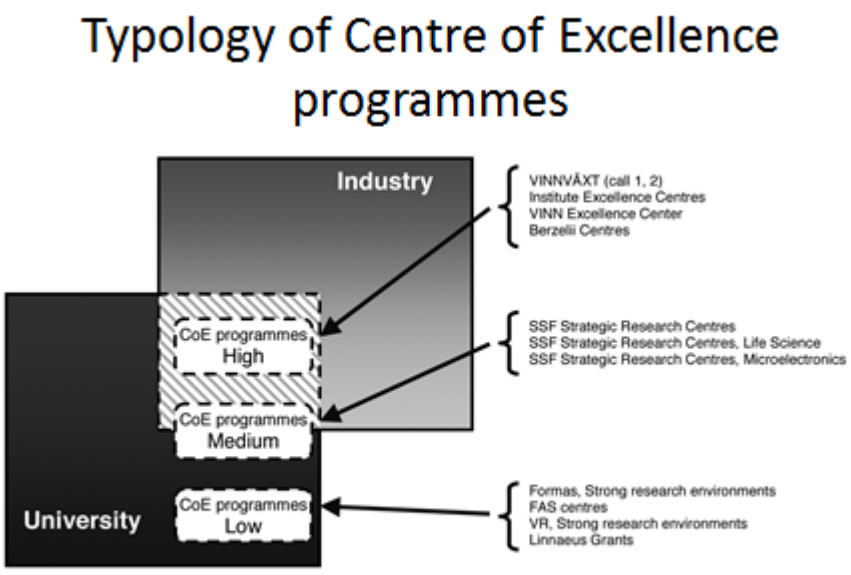

Figure: A typology of Centre of Excellence programmes: degree of university–industry collaboration.
Source: Lundequist/Waxell 2010, p. 272

Figure 1: Topology of Centre if Excellence programs. Source: Lundequist and Waxell (2010).

Regarding geographical focus the programs has a regional orientation, at the same time as it strongly encourages the regional actors' involvement in globally distributed knowledge networks. In the second and third call (2004 and 2005) international orientation was highlighted as an important criterion for evaluation. This meant that applicants that could show concrete collaboration with international CoEs within their field of specialization had better chances to receive support than those without such international linkages. However, looking at the actual performance of the initiatives funded so far, it seems like there is still scope for improvement with respect to internationalisation. Regions with strong research based universities and a global competitive industry with well-functioning regional innovation systems, such as Scania, Gothenburg and Uppsala (hosting first and second generation VINNVÄXT initiatives) can come up with good examples of success. Cases where, for instance, research at the regional university is not particularly relevant for the initiative or of too poor quality to be useful for the world leading industry in the region, have produced disappointing outcomes (Laestadius et al, 2007). This illustrates the dangers of applying a too strong regional focus and not allowing for national and even international knowledge flows in a distributed knowledge network perspective to compensate for lack of specific knowledge at the regional level.

Compared to Finland, Sweden has relatively few CoE (even if the same tendencies of too many new centres as found in Finland also are starting to appear in Sweden (Laestadius et al., 2007)). The program has applied a narrow approach to regional innovation systems promoting R&D based innovations, where universities play a strategic role as the key node in the knowledge exploration subsystem of the RIS. The first generation VINNVÄXT initiatives (funded in 2003) represented as diverse industrial fields as robotics, biotechnology and food production (i.e. example of industries drawing on analytical as well as synthetic knowledge bases). Second generation (2004) covered fields like ICT for process industries, various applications of biomedicine, and new niches for steel

production, fiber optics and health care. Third generation initiatives (2005) were even more explicitly crossing traditional sectoral boundaries by focusing on emerging technological fields like industrial/environmental biotechnology, innovative textiles, certain niches of electronics, and various aspects of the so called experience industry (including tourism and other industries drawing on a symbolic knowledge base).

VINNOVAs new strategy for innovation support – from place based specialisation to thematic areas

Over the past years, VINNOVA has increasingly endorsed a more societal challenge driven logic for innovation policy, not only in discourse but notably also in terms of resource allocation. At present 30% of VINNOVAs annual funding budget is committed to two programs that explicitly draw on this new paradigm, namely the Strategic Innovation Programs (20%) and Challenge-driven Innovation (10%). In addition, VINNOVA has strengthened their cooperation with other public research and innovation funding bodies such as FORMAS, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning and the Swedish Energy Agency to better coordinate the delivery of these policies across thematically different but increasingly interdependent policy domains.

The explicit ambition with this new strategy from VINNOVAs point of view is to create preconditions for international competitiveness within thematically coherent but technologically and cognitive diverse areas with perceived potential for promoting economic growth and providing solutions to the grand societal challenges. Departing from existing or emerging strength areas, the program will stimulate renewal, national collaboration and international positioning of these. A central proposition for the strategy is that new innovations of the future will emerge through new combinations of competences and experiences, transcending sectoral and technological as well as organisational domains (VINNOVA, 2013). As a consequence, the program targets diversification rather than concentration (in contrast to the place-based specialisation strategies referred above). This new strategy gets widespread support from recent research in innovation studies (e.g. Asheim et al, 2011; Coenen et al, 2016).

This reorientation of strategic focus, from specialisation and spatial concentration to thematic platforms transcending sectoral, geographical and organisational domains reflects a recent trend in European innovation policy where increased focus is geared towards addressing the grand societal challenges through exploiting variety and new combinations. A central question, however, is how such new fruitful combinations can be achieved and to what extent and on what levels policy can promote such development.

VINNOVA's Strategic Innovation Program was launched in 2012 and currently includes more than 60 innovation agendas (i.e. identified strategic areas which have not yet been formalized into operational programs) and 11 strategic innovation programs (i.e. consortia of stakeholders working together to promote a thematic agenda). The initiative is coordinated by VINNOVA in collaboration with FORMAS and the Swedish Energy Agency. Administration as well as financial and strategic decision making within the program is outsourced to the constellation of actors representing the respective areas. VINNOVA refers to this as a "bottom-up" process.

A central feature of this new generation of innovation policy is thus an increased awareness of innovation systems being functionally open and globally connected systems. Since there are hardly any regional industries or economies any longer, and hardly any regional markets (except for some very specific parts of the service economy), policy aiming to promote renewal and new path creation is increasingly dependent on policies initiated, controlled and implemented elsewhere. Furthermore, given the increased awareness of related variety as a crucial source of industry dynamics and economic transformation, sector focused policies become obsolete unless they are adapted to this new reality. There is therefore a need for coordination both across spatial scales and across industrial domains. A challenge for such innovation policy is thus both the previously highlighted need for being place-based and context specific, and at the same time being adapted to and in line with policies at other levels of society. Such coordination implies taking into account exogenous sources of path development in local strategies, and making regional and national strategies correspondent to strategies implemented elsewhere. Failure to do so may very well work on a regional level in a short term perspective, but when such attempts of new path creation are to be up-scaled, lack of policy coordination and adaptation can prove to be major obstacles (e.g. Coenen et al, 2015).

Furthermore, the direct and specific policy measures aimed to contribute to renewal of existing strongholds in a regional economy are by default more easily accessible for already favoured actors because these have a stronger general capacity to benefit from such, and their knowledge base composition is in most cases attuned to, or even part of, those strongholds. If such actors have vested interests in established technologies and already existing modes of organisation (e.g. due to sunk investments) they have by default fewer incentives for contributing to new regional industrial path development (Battilana, 2006; Moodysson and Sack, 2016). From an innovation policy point of view it is therefore crucial to reach a wider target than the already dominant actors of the regional economy. New path creation calls for involvement of new entrants representing alternative fields. In the literature these are sometimes referred to as new niche experiments (Rip and Kemp, 1998; Schot and Geels, 2008). Opening up new pathways requires not only a well-suited support structure in the region but also wider institutional framework conditions (Coenen et al. 2015). Such institutional framework conditions can be regionally based (e.g. culture, entrepreneurial spirit) but are more often defined at other territorial scales (e.g. national regulations, global industry standards, etc.).

The impact of Swedish innovation policy of promoting university-industry collaboration

In Sweden there is a complementarity between R&D funding agencies, and to some extent also between their different instruments. VINNOVA's different instruments fill several important roles in the user-oriented segment of the innovation system, while other funding agencies supplement in the curiosity-driven segment. This has resulted in pluralism and a relatively well-functioning complementarity that is critical for the most successful strong R&I milieus. Particularly VINNOVA's centre grants play an important role that no other funding agency's instruments fulfill in the form of long-term support of R&D milieus' establishment and development of close company partnerships that gradually may help them to grow into becoming strong R&I milieus. There are relatively few funding agencies like VINNOVA that requires and encourages active industrial participation. Similarly, there are only limited incentives for an R&D milieu to strive to engage companies in R&D collaboration if the funding agency does not explicitly require such collaboration. Thus, in the

Swedish innovation system the link between universities R&D milieus and the R&D activity of companies is of strategic importance.

VINNOVA and its predecessors' funding instruments have in many respects evolved in a direction that has been beneficial for both the Swedish research infrastructure and industry. Together with similar funding instruments from a number of other R&D funding organisations (e.g. the Swedish Foundation for Strategic Research), they have contributed to a defragmentation of parts of Swedish academic R&D as well as to an increased interdisciplinarity (i.e. Mode 2).

In an evaluation on behalf of VINNOVA (VINNOVA ANALYS VA 2011:08) of five strong R&I milieus, studied through three successive generations of centre funding, it was clearly showed that companies' adoption of scientifically based working practices, recruitment of research graduates, competence development of existing personnel, as well as absorption of R&D results are facilitated if companies collaborate with leading R&D milieus and actively participate in joint R&D projects. Examples of successful grant instruments generating such results would be VINNOVA's VINN Excellence Centres (VINN EC).

From an evaluation of the second, third and fourth round of VINNOVA's Excellence Centres (VINNOVA Report VR 2009:34) the international panel concluded that the centres are engaged in high-level, scientific and engineering research that address many of the important challenges society faces. Their work contributes to the development of high-level competence through training of university students and through engagement of industry partner personnel. There is an impressive range of projects being undertaken on a wide spectrum of important topics from biomedicine to engineering to communications technologies. The centres are national leaders in their fields; much of the science is internationally leading or internationally recognized.

There is significant industry partner participation in articulating partners' needs and therefore in guiding the research. There is productive translation of science to the companies; however, innovation and technology development is generally left to the companies. Hiring of graduates of the centres by the company partners is common and a good indicator of success in producing people of high competence for Swedish industry, and this is one pathway for increasing the national capacity for the intended innovation and technology development.

The overall conclusion from this evaluation is that these milieus have produced substantial results and impacts across the entire triple helix constellation. The most obvious results are (all quantitative data are underestimates):

- 2700 scientific publications
- 46 granted patents
- 153 PhD degrees
- 99 licentiate (or MPh) degrees
- 245 master's theses

In an evaluation of the Competence centre program in 2003 the conclusion was that the most important results were the knowledge, competence and network - both between universities and industry and among companies - that were generated. The active participation of industry in the leadership of the centres and their strategic orientation as well as in common R&D projects have

resulted in the research being oriented towards new, industry relevant and scientific challenging areas. Results from ongoing R&D projects have quickly diffused to and made us of by the companies. The collaboration resulted among other things in 760 scientific publications co-written by researchers from universities and companies. By 2006 the research within the 28 centres had resulted in 5.300 international, scientific publications, 410 PhD and 210 MPh graduates (of which more than 50% was directly funded by the program), as well as approximately 1.130 theses at various levels. The 28 centres had participated in 160 EU project, 185 guest researchers had been received, and 105 international symposiums had been organized. 15 of the 28 Competence centres also had international collaborators.

Impacts on companies

The quantifiable impacts on the companies that were identified in this evaluation are that 44 (96%) of the granted patents were issued to Swedish-based companies and that 119 of the PhDs (78%) currently are active in Swedish industry. Impacts that are more difficult to define but which during interviews with the companies were identified as having great commercial significance for the companies, are among others:

- New knowledge that has been further developed by the companies themselves. This has resulted in new as well as improved and more competitive materials, processes, products, and services reaching the market and thereby resulting in higher turnover
- Improved background for decisions on critical/strategic technological choices
- Software developed by R&D providers that is being used by companies to speed up and increase the quality of internal processes, which in turn has resulted in increased competitiveness
- Competence development of existing personnel through participation in R&D projects together with R&D providers and other companies
- Increased competence of the personnel at large through recruitment of PhD and to some extent also MSc graduates
- New internal work practices in R&D related matters
- Access to laboratory facilities and valuable networks

Moreover, it can be concluded that the stable and long-term relationships between the triple helix partners that have existed throughout this period strongly suggest that the companies have gained commercially benefits from the collaboration.

Impacts on R&D providers

For the R&D providers, the long-term and large centre grants have created opportunities to establish relatively broad collaborations with other R&D milieus both within and outside their own institutions, primarily but not exclusively in Sweden. This has resulted in a disciplinary diversification that has made the R&D providers more attractive to companies. Recent years' successes with proposals have no doubt facilitated achievements of critical mass for the R&D milieus. Lund University clearly illustrates and confirms such a development.

In the evaluation referred to above of the five strong R&I milieus three of the five milieus have continued to develop well and have now been scientifically productive for decades and have hence established solid international reputations as well as stable international collaborations. This in turn facilitates recruitment of graduate students and senior researchers, both nationally and internationally. In parallel with the establishment of scientific qualifications, the R&D providers have earned the collaborating companies' obvious trust.

The three leading R&D milieus in this evaluation are so obviously successful both scientifically and in terms of their company collaborations that they from a prestige and marketing perspective are very important for their universities, while they at the same time generate substantial external income. Indeed, the three R&D milieus are part of their respective university's prioritized R&D profiles. Two of them have also received funding through the Government's strategic research initiative, which may be interpreted as further recognition of their achievements.

A development towards a more strategic way of planning and carrying out research seems to have taken place at universities as a result of the policy of promoting strong R&I milieus based on a triple helix model. An evidence of this is that some of the larger universities (e.g. Lund and Uppsala universities) have started to implement internal research evaluation carried out by international peers. The change in application procedure that was introduced in connection with the launch of Centres of Excellence (Linneaus) grants from the Swedish research council in 2006 (the same is the case of the large VINNOVA grants such as VINN EC and Berzelii centres) and confirmed in the research and innovation bill by the Government in 2008, has definitely contributed to the development of strategic planning at the universities. The new procedure only allows the universities as an organization and not the individual researchers or research groups to apply for funding. This new procedure has made it necessary for universities to establish an internal evaluation and prioritization process to determine which application should be submitted to the various research funding organisations. Traditionally, universities had no experience in carrying out such internal, quality assessment. The fact that the efforts to and focus on establishing and promoting strong R&I milieus has increasingly been given higher priority during the last years, has made such institutional and organizational changes at the universities even more important.

Impacts on society

The main positive, socio-economic impacts from a policy of promoting strong R&I milieus are the strengthening of HEI's research environments to become more international competitive, the increased innovativeness and competitiveness of participating companies, and the higher number of PhDs that have been added to the Swedish workforce, thereby increasing its competence and absorptive capacity. The R&D providers contribute to the country's research infrastructure and the compound increased competitiveness of the companies are both likely to have had substantial positive employments impacts in Sweden. R&D results and PhDs have also spread to companies and sectors that have not directly participated in the strong R&I milieus, including the medical technology industry, pharmaceutical industry, construction, forestry and packaging. Additional opportunities for technology and competence dissemination, particularly to SMEs, arise through participating research institutes. The five strong R&I milieus evaluated have altogether resulted in 15 spin-off companies that in 2009 had a turnover of SEK 160 million and had 130 employees. The fact that strong R&I

milieus, R&D providers as well as participating companies, become internationally known both on the scientific area and on commercial markets means that Sweden's image as an advanced research and technology based nation is further strengthened.

As mentioned in the introduction Sweden is the only Nordic country with a high-tech export profile. This should partly indicate that a high-level R&D is of strategic importance for Swedish industry's competitiveness, and partly that the pursued R&D and innovation policy have been successful. However, in spite of these intuitive observations, there has for many years been a discussion especially domestically in Sweden if there exists a 'Swedish paradox'. It has been argued that significant financial and human capital has been traditionally invested in business R&D; however, producing comparatively low output in the form of GDP growth rates and export value in high-tech goods (Ejermo et al, 2011). This interpretation of the 'Swedish paradox' has, however, been contested in an article in Research Policy where the conclusion is that there is no such thing as a paradox. The authors argue that if such a system failure existed the paradox would manifest itself in slow growing sectors which could not transform R&D into growth. However, what they found was that the 'paradox' only occurs in fast-growing manufacturing and service sectors, where the gap between R&D input and value added is the largest (see figure 2). This can be explained by the diminishing marginal return to R&D investment in high-tech sectors, which are dependent on R&D for maintaining and successfully increasing their international competitiveness (Ejermo et al, 2011). The article concludes that economic growth is dependent on sectors with growing R&D/value added gap, that growing R&D-intensity is a systemic and needed feature of the Swedish economy, that high R&D intensity is a product of the industry structure with many large MNEs, and, finally, that there is a decoupled link between R&D and GDP (gross domestic product) as companies invest in R&D to create profit not necessarily to generate growth (Ejermo et al, 2011).

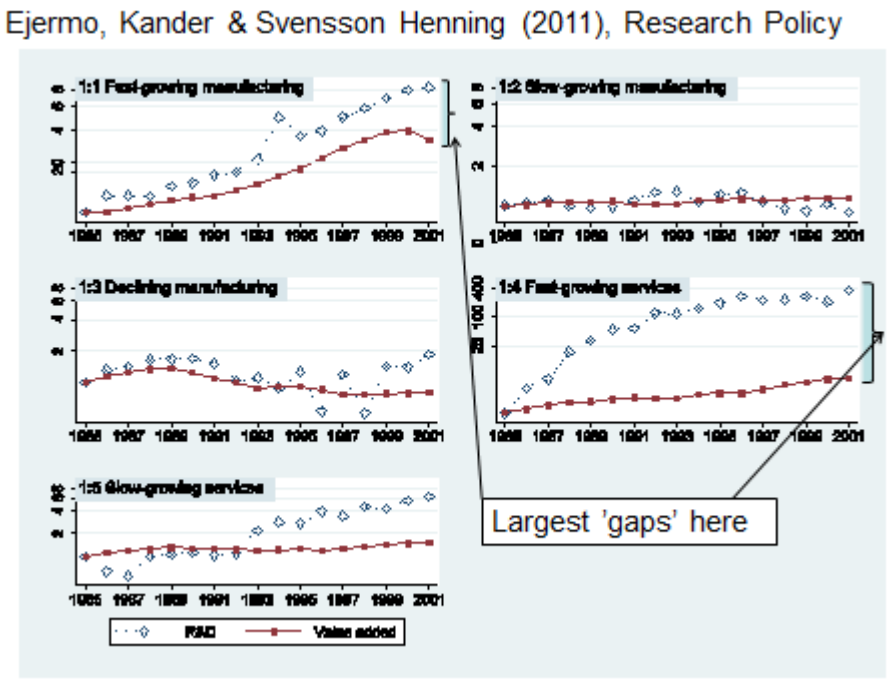

Figure 2: Gap between R&D input and value added (Ejermo et al, 2011).

The perceived problems with the current system

However, even if a Swedish paradox does not exist, there is what could be called structural problems in the Swedish economy and industrial structure. One such structural problem is the dominance of large global (mostly Swedish) companies, that invest in R&D in Sweden but have located the production abroad, which means that the cost of R&D is captured in Sweden, while there is a leakage with respect to the benefits. Another structural problem is also related to the dominance of large firms in the Swedish economy investing in process innovations, which secures high productivity but less new jobs and economic growth. This leaves less space for entrepreneurship and innovative SMEs which could develop radical product innovation to boost job growth and strong economic performance.

Part of this problem might be connected to the fact that the large programs promoting strong R&I milieus building on a triple helix model are designed for the participation of large companies due to the matching funding requirement. Partly the coincidence between the activities of the R&D milieu and the host university's prioritized R&D profiles which essentially are a prerequisite for developing a strong R&I milieu might also be a contributing factor. Understandable, there is a correlation between the two in that strong R&D milieus generally speaking constitute an asset for the university, which reasonable defines its prioritized R&D profiles based on already strong R&D milieus. This may possibly result in lock-in effects, wherein already strong R&D milieus may be favoured at the expense of ones that could develop into new strong R&I milieus. However, this problem is potentially much smaller in Sweden than in some other Nordic countries (especially Norway).

New firm formation plays an important role in securing the dynamism in an economy as the source of new business development, especially when based on newly created knowledge (i.e. knowledge based entrepreneurship) that can promote radical product innovations, which cannot be accommodation in the existing (large) companies. In this context the innovation systems is of strategic importance both as a selection mechanism and an environment for new variety creation. It should, therefore, be an important part of innovation policy to secure enough openness and diversity in the innovation systems to support new firm formation.

VINNOVA has, however, programs to support investment in early stages of innovation projects in SMEs (Research and Growth (Forska & Väx) and Small Business Innovation Research (SBIR) program). A study shows that the SBIR program works as an incubator where small enterprises can prepare for obtaining potential funding from private business angles and venture capitalists. The study documents that ten times more companies participate in the SBIR program than the ones that obtain private venture capital directly. Additional evidence shows that 18 of the 33 most 'hot' small technology companies in Sweden in 2011 have received economic support from VINNOVA.

For a long time a high road strategy of innovation based competition was thought of as being identical with promoting high-tech, R&D intensive industries in accordance with the linear view of innovation. More and more the recognition has evolved that a broader and more comprehensive view on innovation has to be applied to retain and develop competitiveness in the heterogeneity of regions. This implies that regional advantage has to be constructed more on the basis of the uniqueness of the capabilities of firms and regions than solely on the basis of R&D efforts (Asheim et al., 2011). This reflects recent research pointing to the complexity of modern products and their innovation processes, which requires a differentiated knowledge base perspective (i.e. distinguishing

between analytical, synthetic and symbolic knowledge) to be fully accommodated (Asheim and Gertler, 2005; Asheim et al. 2011). Such a broad based innovation policy is in line with the innovation system perspective of defining innovation as interactive learning combining an STI (Science, Technology, Innovation) and a DUI (Doing, Using, Interacting) mode of innovation (Lorenz and Lundvall, 2006). Following this line of argumentation, one of the recommendations in OECD's evaluation of Swedish innovation policy was that VINNOVA should get a wider mission including a broad based innovation policy, and not only focus on a R&D based policy (OECD 2013).

There are at least two main problems of a too strong focus on R&D and science-driven innovation. Such a policy tends to give a one-sided priority to emerging science based industries building on an analytical knowledge base at the cost of more traditional engineering based industries building on a synthetic knowledge base as well as rapid growing cultural industries building on a symbolic knowledge base. While new and emerging science based industries are very important in the continuous strengthening of the competitiveness of regions and nations, we should still keep in mind that when it comes to economic impact and employment non-R&D/science based economic activities clearly dominates in importance. In addition, the success rate of science-driven innovations to reap returns is quite low, which is one of the arguments for pursuing user-driven innovations. Moreover, an R&D and science-driven innovation policy favors larger cities and regions, which have the capabilities and capacities to carry out the knowledge exploration and exploitation required for innovation. Human capital, universities and research organizations tend to concentrate in the centre, leaving more peripheral and less advanced regions (the 'ordinary' regions) without sufficient innovation policy support. Furthermore, jobs will primarily be created for the well-educated and highly skilled part of the workforce (the creative class).

EU policy discourses have traditionally paid much attention to the quantitative aspects of knowledge creation, particularly with respect to investments in R&D. However, countries with high investments in R&D do not always perform better economically than those that invest less. One way to gain more insights into the conditions in which knowledge leads to economic and social development is to study how the relationship between creation of knowledge and its social and economic effects is conditioned by differences in economic, institutional, political and social factors. International comparative studies on how governance and institutions, as well as broader social and cultural factors, influence innovation, diffusion and economic growth in other countries will provide valuable insights into factors that need to be taken into account to achieve the objectives of national policies, i.e. about the conditions under which knowledge creation leads to economic and social development (see e.g. Cohen and Levinthal, 1990, Fagerberg et al, 2007). Through its Smart Specialisation strategy EU, for the first time, has provided a policy framework or platform for promoting and implementing a broad based innovation policy, which is of critical and strategic importance taking into account the failure of the linear, R&D based innovation policy of the EU pursued in the Lisbon declaration of 2000 with the main goal of allocating 3% of GDB to R&D. The goal was that this should lead to EU being the most competitive region in the world, while the outcome was very different (Asheim et al, forthcoming).

Conclusions: Policy recommendations from the evaluations to improve the system

If the concept 'strong R&I milieus' is 'googled', we only find references to Swedish cases. This should not be surprising, partly as these ideas are strongly influenced by an innovation system approach, which has been the leading paradigm in Swedish innovation policy (re: 'The Swedish Governmental Agency for Innovation Systems', which is the official name of VINNOVA), and partly because VINNOVA also earlier has been quite innovative in their launching of innovation policy agendas. The VINNVÄXT initiative is, for example, considered one of the most innovative approaches to a regional innovation policy internationally. Strong R&I milieus should be viewed as a strengthening of a territorial based innovation system, and can also turn out to be a new and innovative addition to the innovation policy arsenal. However, the concept is also clearly influenced by the triple-helix approach, but applying the word 'strong' gives it an edge compared to the normal use of the triple helix approach. One can identity many existing and potential triple-helix constellation having a collaboration between university, industry and government. However, this does not guarantee as such that these milieus also are 'strong' in the meaning of providing excellence both in knowledge exploration and exploitation. Other concepts that has been used internationally is 'Centres of Excellence', however this normally focuses primarily on excellence in research. Centres of Expertise come close to the concept of strong R&I milieus as it is used in Finland, but not generally. Concepts like 'creative knowledge environment' has also been launched lately by Swedish and British researchers (Hemlin et al, 2004), however, this concept is to be looked upon as more complimentary to an innovation system, as it primarily focuses on 'knowledge exploration', while innovation systems traditionally has concentrated more on balancing the 'knowledge exploration' and the 'knowledge exploitation' subsystems (Asheim et al, 2016). Thus, perhaps VINNOVA once more has just been innovative as a policy maker? This innovativeness has possible even been strengthened through the new emphasis on these milieus to establishing global links with equivalent milieus internationally with complementary skills, knowledge, technology and other resources and to help the players in the respective R&I milieus to position themselves globally, including supporting new, knowledge intensive companies to establish international alliance as well as to take co-ordinated and proactive action to develop strategic global alliances (also outside of Europe and North America). The novelty in this approach has partly to do with acknowledging the increasing importance of open innovation, i.e. to be able to cooperate with and tap into globally distributed knowledge networks, and partly that public policy traditionally only has supported university-industry interaction at a national level, and left the funding of cooperation with foreign R&I/R&D milieus to the enterprises, which of course represents a serious barrier especially for SMEs.

Such a new policy orientation seems to fit very well with an observable change in patterns of how firms organize their knowledge and innovation processes as 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 globally distributed knowledge networks can, for example, be traced in several biotechnology clusters over the last 10-15 years. Current developments in biotechnology and pharmaceuticals have also reduced the distance from basic research to innovations, which has put pressure on the universities to change their organization to better adapt to this new situation (from Mode 1 to Mode 2) (Lundvall and Borras, 2005).

A general observation is that more and more R&D based companies increasingly becomes more dependent on acquiring external knowledge by collaborating with strong research universities and

linking up to globally distributed knowledge and innovation networks. The competitiveness of Swedish companies as well as the attractiveness of Sweden as a location for foreign R&D based companies has, thus, become increasingly important in the formulation of R&D and innovation policies. Instead of just being sufficiently good in supplying Swedish companies with competence within relevant areas, it is now necessary to be among the best in the world to secure global competitiveness in the prioritized areas. VINNOVA's new strategy for promoting strategic innovation programs targets this challenge.

The VINN EC instrument essentially appears to be appropriative as it is to achieve this. VINNOVA might still strengthen the focus on facilitating the development of skills and knowledge that leads to an even higher degree of innovation and entrepreneurial action arising out of research of the centres. One additional ambition should be to facilitate participation of more than one R&D milieu as well as companies outside Sweden. It seems also likely that other types of funding instruments are required to support technologically less capable companies, including SMEs, regardless of industry sector, and to companies in industry sectors that are not already internationally competitive. VINNOVA should, thus, establish a means of sharing best practice of including small and medium sized enterprises (SMEs) among industry partners and a means of stimulating greater SMEs engagement in the centres. This would, however, probably require a widening of the VINNOVA mission to be allowed to follow a more broad based (and not only a narrow R&D based) innovation policy and strategy similar to the one found in Finland. Also this challenge is addressed in VINNOVA's new strategy for promoting strategic innovation areas.

In conclusion, three important reflections on the Swedish innovation policy in general and VINNOVA's role specifically can be made. VINNOVA has been successful in identifying and promoting new demand driven area of knowledge through dialogues and close collaboration with the triple helix partners. This role can neither be fulfilled by universities nor by industry independently. This demonstrates the strength of an innovation systems approach to innovation policy. Secondly, the evaluation studies have shown that there often is a 10-20 year time span before new knowledge creation produce measurable economic effects for society. This important fact is often forgotten in analyses of the impact of public investments in higher education R&D to stimulate innovation in the economy. Thirdly, the shift from place-based concentration and specialization towards more broad-based platform policies promoting thematic areas transcending technological and cognitive domains implies a greater need for policy coordination across different fields and scales, which makes agencies as VINNOVA less autonomous with regard to design as well as implementation. This last challenge, in turn, points at the need for reaching a balance between demand-oriented and supply-led innovation policy. While innovation systems studies have provided convincing evidence that place-specific context matters and that innovation policy must be attuned to and embedded in the particularities of the regional and national economies it aims to target (e.g. Asheim et al, 2016), the growing influence of smart specialization strategies on European regions somewhat paradoxically indicates alignment of policy agendas across a very diverse economic landscape.

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