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Strategic innovation policies and the emergence of new clusters: the comparative experience of the binational Medicon Valley

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TITLE: Strategic innovation policies for the emergence of new clusters: the comparative experience of the bi-national Medicon Valley

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ABSTRACT

Medicon Valley is a bi-national life science cluster located in the Øresund region. This cross-border region includes a Swedish side and a Danish one. The fact of being a bi-national cluster constitutes a remarkable singularity.

This life science cluster ranks the third of Europe and among the top five in the world. Its main strongholds are the quality of scientific research; the innovative and business environment; the access to capital, mainly through venture capital, the availability of high skilled workers and the technology transfer and knowledge sharing between universities, hospitals and industries.

Such strongholds are the result of a combination of factors. The universities (mainly, Lund and Copenhagen Universities) and the long tradition of pharma industry are considered the initial drivers. The cooperation among all the agents seems to be other key element of the cluster. In fact, this experience is considered a successful example of the triple helix model. Furthermore, we have also to consider the role of public policies. Public agencies (as Vinnova) and later organizations as Medicon Valley Alliance are also relevant actors.

The paper focuses on the strategic innovation policies that helped to the emergence of this cluster, with the aim of comparing the implemented policies in both national sides of the cluster. Moreover, an assessment of the results in the two areas is attempted.

One outstanding characteristic of the policy instruments implemented to support innovation and specifically biotechnology in both countries is the systemic perspective. Moreover, a lot of the implemented policy instruments addressed to various policy goals. Most of the policies implemented were generic to stimulate innovation, mainly at the time of the emergence of the cluster. However, some specific measures also exist. The role of policy has been increasing at time of developing the cluster, with a broad use of biotechnology focused instruments.

1. Introduction

We analyse the Medicon Valley successful case. This cluster is well-positioned. In fact, it is considered the third biotech cluster in Europe and among the five most attractive bio-regions in the world. It relies on strong scientific base, experience on clinical research, long tradition of pharmaceutical industry, the innovative and entrepreneurial environment, the availability of capital for new companies and the high level of knowledge and technology transfer among universities, hospitals and industry.

Regional “clusters” have emerged largely without specific state support. However, Sweden and Denmark governments have actively supported the development of bioclusters, stimulating innovation and technological change via the creation of environments that encourage entrepreneurship, productivity growth, access to global markets and learning (Rosiello, 2005). In a similar sense, Rosiello and Orsenigo (2008) ask if biotechnology clusters can be built through policies and public support. They consider some success stories in which public intervention has been crucial, such as Singapore, Israel, Germany, Sweden, France or Washington.

Accordingly to Störing (2007), Medicon Valley is an example of the joint vision of the Danish and Swedish governments to create a region that would become Europe’s pre-eminent hub for life-sciences R&D and production. She highlights two important elements in this cluster: the role of the public sector as an initiator and the driving force and a cluster-building strategy starting from the development of the brand name to other aspects of the cluster’s development (networking, competence development).

The cluster is located in Øresund, a cross-border region which includes a part of the island of Zealand in eastern Denmark and a part of the Skåne region in the southern of Sweden. Both countries are very strong on biotechnology, from the perspective of research as well as from the industry point of view. The weight of the cluster in relation to overall life science industry in each country differs greatly. Thus, it is estimated that Danish part of the cluster represents the 80% of life science activity in that country, while the Swedish side suppose only about the 20% (Vinnova, 2007).

Although we focus on Medicon Valley, it should be noted the existence of other important life sciences clusters in both countries, among which highlight Stockholm-Uppsala Life Science in Sweden. But we can also find the following life science clusters in Sweden: Gothenburg, Linköping and Umeå. In Denmark, the center of biotech activity is Greater Copenhagen.

Furthermore, smaller biotech clusters have emerged around universities in the cities of Aarhus and Odense, and to a smaller extent, in Aalborg.

The methodology combines the literature review about this case, including available reports, statistics and web-based research with the field research. Thus, we visited the area to improve our understanding of the development and working of Medicon Valley cluster through interviews and personal contacts with key players and researchers. They have provided useful qualitative information for a better understanding of the emergence and growth of the cluster and to assess the effectiveness of the implemented policies.

2. A brief description of Medicon Valley innovation system

Medicon Valley holds 471 firms, 350 of which are life science companies. The number of employees in the life science sector accounts for 43.500 in 2006. Firms and employees are mainly concentrated on the Danish side, as table 1 shows. The small firms are predominant, but there are also a significant presence of large firms and even global players. The medium and large size companies account for the majority of the employment, in fact, the thirty large companies (all of them with more than 250 employees) in Medicon Valley represents the 75% of employment in this sector. Some of the large firms are Novo Nordisk, Lundbeck, Leo Pharma, Nycomed, Ferring, AstraZeneca, Pfizer, ALK Abelló or Coloplast.

Table 1. Life Science sector in Medicon Valley 2006

	Danish side	Sweden side	Medicon Valley
Employees	37.500	6.500	43.500
Number of firms	205	145	350

Source: Vinnova (2007)

This cluster houses the global headquarters of the five international pharma and medtech companies. The major pharmaceutical corporations, such as Novo Nordisk, AstraZeneca, LEO Pharma, H. Lundbeck, Nycomed, Ferring Pharmaceuticals or ALK-Abelló, constitute the backbone in Medicon Valley. There are also local companies, the majority of them university spin-offs. Their founders tend to keep functional links with their old university departments, regardless where they are located (Moodlyson, 2007). A fair number of new Danish companies are spin-outs from the established pharma and biotech firms (55% of the created firms are start-ups from academy and 45% spin-outs from the industry), while such spin-outs are extremely rare in Skåne (Vinnova, 2007). However, according to Vaekstfonden (2007) the majority of Danish companies established since the millennium have their origins in research institutions.

Medicon Valley hosts a very broad range of firms carrying out different activities related to life sciences. There are 119 red biotech companies, 24 pharma companies (7 major) and 183 medtech companies. The Swedish side has a high share of medtech firms, while the Danish part is more aimed to pharmaceutical and medical applications. The high number of life science companies in Medicon Valley has led to the development of a broad range of business service providers. There are 51 Contract Research Organizations and 27 Contract Manufacturing Organizations.

Furthermore, Medicon Valley has five universities offering life science education. They account for 45.000 life science students, generating 7.000 graduates every year. About 2.600 PhD students are enrolled at the Universities of Lund and Copenhagen, the main universities in this field. The university research is at very highest international standard, with a high number of biomedical publications (3.200 published articles and 15.000 peer review articles by year). Almost half of them (45%) are published in high impact scientific journals. The public research at universities in biomedical sector accounts at less 300 million euros per year in Medicon Valley.

The cluster has thirty-two hospitals managed by the three regional governments (Copenhagen, Zealand and Skåne), being eleven of them university hospitals. There are seven science parks and five incubators, but only two parks and other two incubators are focused on biotechnology or life science sector. The Copenhagen Bio Science Park (COBIS) opened at the end of year 2009 and it has its own incubator. This new player is the result of the political vision of the Ministry of Science, Technology and Innovation and the Capital Region of Denmark to strengthen the biotechnological competences of the region.

The Universities and main hospitals have own Technology Transfer Offices to support scientists to commercialize their research results.

The wide range and intensity of agents (universities, hospitals, large international and R&D based pharma and medtech companies, and hundreds of small and medium sized enterprises) becomes the cluster in Europe's most dense. Thus, the cluster could offer executives and scientists with industrial experience.

The region combines scientific achievement and industrial growth. It displays among the highest number of scientific publications, start-ups and jobs in Europe. The majority of the companies have emerged since the mid-1990s. Most of them have their origins in research institutions (university spin-offs). However, the creation of spin-outs from existing pharma and biotech companies is relevant in the Danish side, being rare in Sweden. The ease of

establishing new companies led to a substantial growth in the number of firms and employees. The employment increased by 10% in the Danish side from 1997 until 2006, and by 30% from 1997, while the growth was weaker in the Swedish area (5% from 2003 until 2006). Revenues, profits, add value and R&D have also grown, in absolute as well as in relative terms.

The drug development pipeline is impressive, with a portfolio of more than 200 products. In fact, it is the Europe's fastest growing biotech cluster measured by products in development. The excellent clinical development profile and facilities have attracted an increasing number of international companies and activities to the region.

The cluster holds core competences in the areas of diabetes and metabolism, neuroscience, cancer, inflammation and allergy. It is also at the forefront of personalized medicine.

Biotechnology research is carried out by universities, specialised institutes and firms. Among the research institutes, we must mention the Biomedical Center (Lund), the Clinical Research Centre (Malmö), Copenhagen Biocenter, the Center for Diabetes and Stem Cell Research (Lund), SweGene-Proteomics Center (Lund), the Carlsberg Research Center (Copenhagen), the Hagedorn Research Institute (Copenhagen), the Statens Serum Institute (Copenhagen), and Lund Institute of Technology. Several new research institutions started their activity in 2009. Thus, the Novo Nordisk Foundation founded the Centre for Protein Research at the University of Copenhagen and one of the world's largest bio banks at Statens Serum Institut in Copenhagen.

The cluster also hosts a number of Centres of Excellence, such as the centres for nanotechnology and stem cell biology at Lund; for bioinformatics and microbial biotechnology at Danish Technical University; and for comparative genomics and epigenetics at University of Copenhagen.

We have to point out new high-level infrastructure planned for the future: two ambitious research facilities in the city of Lund (European Spallation Source and MAX 4 at MAX-laboratory) and a new centre dedicated to develop new forms of treatment based on stem cells has planned in Denmark to start in 2012.

The private sector invests more than the public sector in R&D. The biopharmaceutical corporation Novo Nordisk has the greatest budget for innovative activities in Medicon Valley (about 1.000 million of euros in 2008). According to Medicon Valley Alliance (2009), this cluster represents the 13,5% of biotech R&D activity on EU in 2006.

Danish and Swedish venture and business development markets are among the best performing in Europe. Denmark ranked in 2006 as the first European country measured by the amount of private capital invested as a percentage of GDP (Nature Biotechnology, December 2006). The annual venture capital investment in Denmark ascends to DKK 2.5 billion in 2006¹, of which DKK 1.4 billion is invested in life sciences, and 80% of them made in biotech companies (DKK 1.1 billion).

The cluster benefits from a constant injection of national and international capital. About half of the venture capital came from foreign investors. Danish biotech's industrial base seems to be particularly strong as regards the capability to attract venture capital investment and placement of IPOs (Initial Public Offering) by biotech firms.

More than 210 venture capital organizations and registered business angels operate in Medicon Valley. Ten Danish venture capital funds are dedicated to biotechnology/life science sector, while three specific life science venture capital funds highlight in Sweden. Together they have approximately EUR 1.6 billion assets under management on the life science sector. Among the venture capital fund it must be noted the importance of the government-owned entities Vaekstfonden and Industrifonden.

3. A general overview of policies and institutions

3.1. Overview of innovation policies

The paper is mainly focused on the policy processes and in particular, on R&D policies. However, this does not mean to ignore the context in which those policies are implemented.

The region's strengths and competences (business environment, science base, access to talent and capital, support structure, infrastructure and quality of life) are the result of a combination of factors. The universities, the pharma industry and the collaboration among all them seem to be key elements of this successful cluster. The active role of public sector to promote those competencies through a broad range of policy instruments reveals crucial. A wide range of public policies to stimulate innovation in general and even other specific for biotech have been implemented.

One outstanding characteristic of the policy instruments implemented to support innovation in general and, in particular, biotechnology in both countries is the systemic perspective utilized. Thus, all the elements of the innovation system have been considered, even the interaction among the different actors.

¹ One euro is equal to 7,446 Danish crowns (DKK).

Rosiello (2005) highlights the active role in promoting the development of the biotechnology industry through the implementation of systemic strategies and the general prevalence of horizontal initiatives.

A first approach based on the results of previous projects, such as BioPolis² or EPOHITE³, shows that policies supporting research and education (even supporting specific biotechnology education measures) have been used in both countries. There were some initiatives to support business studies courses in university science degrees in biotechnology, but they are not widespread. The exploitation of public biotechnology research is also considered via the stimulation of entrepreneurship, spin-offs and collaborative research between industry and public sector research organizations in both countries.

The Danish profile presents a strong focus on knowledge base (including human resources) and transmission. Danish policy has a persistent commitment to the promotion of the biotechnology knowledge base with both generic and biotechnology specific instruments. The regulatory perspective aimed to improve the framework conditions for innovation has also been an important issue. The conditions to carry out fundamental research, but also for innovation in the pharmaceutical sector or to do clinical trials are of great importance. Fiscal measures and demand side seem to be less relevant instruments.

The development of the knowledge base is a high priority in Sweden, combining generic and specific instruments. There has been a strong government commitment to basic research and education policies to create qualified human resources. The policy goals related to knowledge transmission are also pursued especially with policies directed towards exploitation and industrial development.

Overall, the main policies addressed to the growth of biotechnology in Medicon Valley are the promotion of biotechnology basic research, instruments to support firm creation and the availability of financial capital to high growth sectors. The commercialization of technologies and collaboration between public and industrial research also constitute important instruments. On the contrary, policies such as regulation, commercialization of research results, and academic cooperation policies have been less relevant. The evolution trend on last

² BioPolis Inventory and analysis of national public policies that stimulate research in biotechnology, its exploitation and commercialisation by industry in Europe was funded in the period 2002–2005 under Sixth Framework Programme. Its main goal was to develop a tool for benchmarking biotechnology policies.

³ Efficiency of innovation policies in high technology sectors in Europe (EPOHITE) was funded within the EU STRATA Programme within the Fifth Framework Programme in the period 2001-2003. Biotech was one of the studied sectors.

decade reveals an increasing significance of more important areas (biotechnology basic research, creation of firms and capital available for dynamic sectors) and also a great emphasis on socioeconomic and ethical aspects and legislation on intellectual property rights. An outstanding element is that they have supported their knowledge base by targeting industry-oriented research, while sustaining the efforts in fundamental research.

It should be highlighted the wide range of implemented actions, mainly generic ones to support and reinforce the existent specific instruments. Moreover, each instrument tends to be aimed to achieve several policy goals. All in all, the different policy instruments seem to achieve the planned results. The evaluations carried out about the effectiveness of the policies share this pattern. Only some critics could be found regarding the results of the research commercialization and intellectual property rights policies.

The literature acknowledges the highly coordination characteristic of policy-making systems for innovation in the Nordic countries. It means a coordination process among strategic policy decision-makers, before strategic decisions of the government concerning instruments are made. Following that scheme, the design and implementation of biotechnology policy in Denmark seems to be highly coordinated. Traditionally, Sweden has not devised a comprehensive policy for bioindustry, seeming that the regulation system has emerged more by default than by design. This does not mean an absence of policies for biotechnology or the irrelevance of public agencies, but also that there is no strong (formal) coordinating mechanism. In fact, organizations such as universities and regulatory agencies play an important role in shaping the innovation process and the bioindustrial development (Löfgren & Benner, 2005).

3.2. Main institutions

The Øresund Region belongs to two different states (Denmark and Sweden), and therefore it is affected by the policy levels (national, regional and local) of both countries. However, it has no common governing body functioning.

The Øresund Committee was formed in 1993 as a regional forum for voluntary cross-border political cooperation. The Committee consists of politicians from both countries and has been hard working for eliminating national administrative boundaries. It acts as an embassy of the Øresund Region.

In 1994 the Øresund Region was approved to receive support as a border region from the EU's structural funds. As result, more than 250 regional projects have been part-financed by the Interreg IIA and Interreg IIIA programmes. The majority of the projects, some of them of

great relevance, such as Medicon Valley Academy (MVA), Øresund University, Øresund Science Region were initiated by the Øresund Committee.

At the beginning of nineties the Øresund Committee started a project aimed at the identification of the areas' core competencies and comparative advantages in biotech and pharmaceuticals. It was in this context that 'Medicon Valley' was launched. In 1996, cross-border joint programmes undertook a series of joint measures to promote Medicon Valley internationally to attract foreign venture capital and companies to the region. The basic idea was to develop cross-border partnerships between industry, universities, hospitals and investors.

The public-private network organization Medicon Valley Academy was created in 1997 to stimulate the formation of a cross-border biorregion, by promoting local integration and cross-fertilization between industry and academia. It was initiated in 1995 by Lund and Copenhagen Universities as a three year EU Interreg II project. Its first work was in the area of extending and deepening the links between research, hospitals and industry through applied development projects as well as information inter-exchange and focused lobbying. That organization changed its name to Medicon Valley Alliance (MVA) in 2007.

4. Research policy

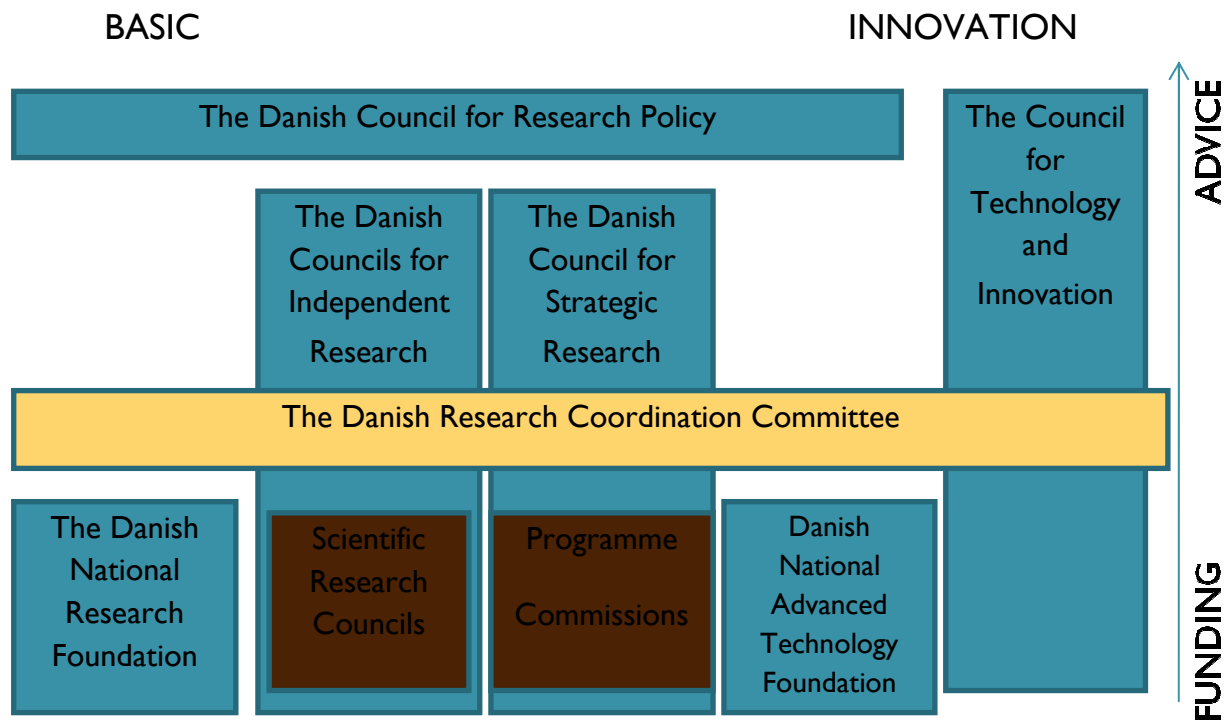
4.1. Research policy framework

Health-related biotechnology and life sciences are strategic focus areas in Denmark and Sweden. Both governments are engaged in increasing their contributions.

Firstly, we focus on the entities and processes to implement research policy. Three main actors are responsible for administering funds for research and innovation activities: the research councils, the mission-oriented agencies and the (semipublic) foundations.

In the Danish case, below the Ministry of Science and Technology there is a national system of research advisory and funding councils. The two advisory bodies were the Danish Council for Research Policy and the Danish Council for Technology and Innovation. The former advises regarding research policy and the second on innovation in the business community. The main funding institutions of biotechnology research in Denmark are the National Research Foundation, the Councils for Independent Research, the Council for Strategic Research, the Council for Technology and Innovation, and the National Advanced Technology Foundation. The Research Coordination Committee is responsible for coordination among all government research funding bodies.

Figure 1. The Danish Advisory and Funding System for Research and Innovation



Source: Danish Government (2008)

The Danish National Research Foundation is an independent foundation to strengthen basic research (in natural sciences, technical sciences, health sciences, social sciences, and humanities). Its primary policy instrument for research promotion is to set up and fund research centres of excellence and it also grants independent groups of scientists to form centres of excellence.

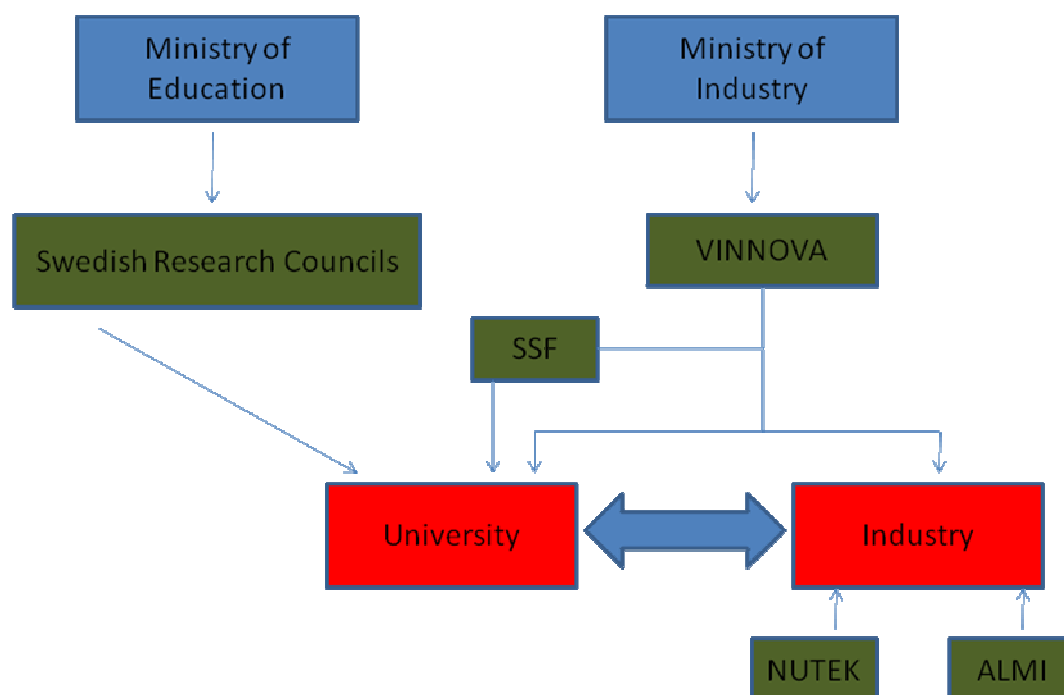
The Danish Council for Independent Research support research through response mode mechanisms. So, funding fields are based on the initiatives (both single-discipline and cross-disciplinary) of researchers themselves.

The Danish Council for Strategic Research supports politically prioritised research areas and contributes to strengthen interactions between public and private research. The programme NABIIT, launched in 2004, coordinates biotechnology research activities among other fields (nanotechnology and information technology).

The Danish National Advanced Technology Foundation aims to encourage growth and strengthen employment by supporting strategic and advanced technological priorities. It focuses on nanotechnology, biotechnology and information and communication technology.

Innovation policy in Sweden is influenced by many ministers. There are three major public research councils in Sweden. The largest is the Swedish Research Council (VR) dependent on the Ministry of Education and Science and aimed to fund high quality basic research in all fields. The main sources of government funds for biotechnology have been the Swedish Research Council, the Swedish Foundation for Strategic Research (SSF) and the Swedish Agency for Innovation Systems Vinnova.

Figure 2: The Swedish System for Funding Research



Source: Own elaboration.

The Swedish Foundation for Strategic Research (SSF) is an independent organization, funding basic and applied research in natural science, engineering and medicine. It has no specific initiative that targets biotechnology research. However, its research strategy aims to support strategic areas, and life science is one of its priority areas. It promotes postgraduate education and training, assists younger researchers, gives grants to prominent individual researchers and also supports strategic research centres. It also encourages the commercialisation of scientific results from public research institutions, developing policies for technology transfer and intellectual property rights partly through the formal agreements that enclose all funding decisions. The Swedish Foundation for Strategic Research adopted a

strategic plan in 2001, dividing its programme in three main policy instruments for funding research: Strategic Research Centres; Framework Grants; and Individual Grants.

NUTEK (National Board for Industrial and Technical Development) is Sweden's chief authority in the area of industrial policy. One of its main goals is to initiate research and development activities. It was divided into three in 2001: the Swedish Business Development Agency (NUTEK), the Swedish Agency for Innovation Systems (Vinnova) and the Institute for Growth Studies (ITPS). As a result of this restructuration, the new Nutek was given responsibility for promoting entrepreneurship, coordinating the regional growth programmes, and guiding entrepreneurs regarding business, including a seed financing fund which targets small high-tech companies. The funding of research was transferred to VINNOVA.

Vinnova has taken over many of the research funding activities of NUTEK and also deals with innovation policy analysis, although NUTEK was responsible for providing financing for new technology based enterprises up to 2002.

VINNOVA is a Swedish government agency with the mission of promoting sustainable growth by means of problem-oriented research and the development of effective innovation systems. It supports applied, industrially relevant, and technological research. Most of Vinnova's initiatives apply horizontally, but it has a sectoral focus on 18 growth areas with potential competitive advantage. As biotechnology is one of them, this agency has programmes specific to this field. This entity accounts for approximately 20% of government funding for biotechnology research. A majority of university projects involve co-funding and/or research collaboration with industry.

During summer 2009, there was a restructuring in these Swedish agencies providing for the old Nutek. Now, the three former agencies (Nutek, ITPS and Glesbygdsverket) were substituted by two new agencies: Tillväxtverket (Swedish Agency for Economic and Regional Growth) and Tillväxtanalys (Swedish Agency for Growth Policy Analysis) with an analytical role. A separation of analysis of growth and promoting growth through funding was the effect.

ALMI is a Swedish state-owned lender and provider of capital, aimed to promote the development of competitive small and medium-sized firms as well as to stimulate new enterprises to create growth and innovation. Its activity covers the whole process from idea to profitable business and so it has three business areas: Innovation, New Enterprises and Established Businesses. The main offered services are financing and business development.

Private foundations contribute significantly to public research, providing grants, donations and infrastructure. The Knut and Alice Wallenberg Foundation (KAW Foundation) is the most important private contributor in Sweden, whereas the Novo and Lundbeck foundations play an equally important role in Denmark.

Medicon Valley Alliance (MVA) is a network organization to promote cooperation and even the performance of the region. Such initiative has contributed to develop the region, encouraging the power of attraction for venture capital, research funds and human capital (Hospers, 2006).

Copenhagen Capacity and Region Skåne Inward Investment have promoted Medicon Valley internationally. The former is the official inward investment agency of the Greater Copenhagen region and promotes the region as a location for knowledge intensive industries such as biotechnology. Region Skåne Inward Investment is a publicly funded organization, set up to promote Skåne (Sweden) and offers services free of charge to companies and organizations that consider set up in this area.

4.2. Research policy instruments

Focusing on the implemented policy instruments, we should highlight the strong focus on research policy as a common characteristic in both countries. Biotechnology research policy is the dominant policy instrument in Sweden. The biomedical area traditionally accounts for a large share of Swedish public research resources, currently about a quarter of funding goes to medical research. Denmark dedicates more than 5% of its national R&D budget to biotechnology in 2004. In 2003, Sweden committed 3% of the national public R&D budget to biotechnology.

Starting for the generic instruments, the Danish FORSK2015 (RESEARCH2015: a basis for prioritisation of strategic research) contains twenty one proposals for promising strategic research themes to improve the basis for prioritisation of the strategic research effort areas. Biotechnology and molecular biotechnology are considered primary research areas, while medico technology is a secondary research area.

As part of the initiative to implement the national strategy Innovative Sweden, the Swedish government established action plans for five priority sectors in 2005. Pharmaceuticals, and biotechnology and medical technology are two of the priority sectors.

The Swedish government presents a research bill to the Parliament including suggestions of priorities within the research policy area. The bill “Research for a better life” for the period 2005-2008 considers as the high-priority research fields medical, technological and

environmental research. As a result of these proposals, life science research during the period 2005-2008 increased by approximately 20%. The Swedish Government bill “A Boost to Research and Innovation”, covering the period 2009-2012, provides the largest extra investment ever to have been made in Swedish research. It allocates additional resources of 462 million euros in central government support with respect the previous plan. In absolute terms, the largest increases will benefit research into medicine, technology and the climate. The additional resources allocated to strategic medicine fields account for EUR 54 million. Other special initiatives on the field of higher education and research included in this bill are the Government expansion of medical and dentistry training programmes.

Strategic Research Centres implemented by SSF are a generic instrument to provide settings in universities for interdisciplinary research of the highest international standard and of strategic relevance for present and future industry.

Network Programmes are a generic instrument to fund networks of research groups across Swedish universities, involved in large-scale, long-term research projects and the training of graduates and post-graduates.

The Swedish Foundation for Strategic Research has implemented two types of individual grants: Individual Grants for Advancement of Research Leaders (INGVAR) and Senior Individual Grants. INGVAR, started in 2001, aimed to identify, support and promote younger scientists expected to become future scientific leaders in academic and industrial research. The value of INGVAR grants in the biotech area for the period 2002-2005 was 3.1M EUR. The Senior Individual Grants programme, which started in 1997, aims to stimulate the research and education of postgraduates by prominent researchers. The value of Senior Individual Grants in the biotech area for the period 2002-2005 was 3.4M EUR. Individual grants are mainly in the areas of Industrial Biotech and Health Biotech, and their policy goals are to support high-level biotech research and the availability of human resources. Over the period 2002-2005, SSF provided 6.5M EUR for individual grants in biotech-related research to support.

Biotechnology has also been promoted in the framework of programmes to support interdisciplinary scientific developments. An example of a programme explicitly targeting biotechnology is the Strategic Programme on the Interdisciplinary Application of Nanotechnology, Biotechnology and IT and Communications Technology (NABIT) launched in Denmark in 2004. It aims to strengthen and contribute to new research at the interface among nanotechnology, biotechnology and information and communication technology to

making possible international breakthrough and/or important social utility value, including economic relevance.

The VINNOVA's strategic plan for the period 2003-2007 identified biotechnology as one of four knowledge platforms for sustainable growth. Furthermore, VINNOVA has identified eighteen priority areas for sustainable growth, five of them involve biotechnology. Pharmaceuticals and diagnostics and biomedical engineering are more related to biomedicine. The relevance of biotechnology within VINNOVA's strategic plan is also shown by its Biotechnology Department.

VINNOVA has launched the programme VINNVAXT to promote growth in a number of regions and is committed to give support to a new generation of Competence Centres, VINN Excellence Centers.

Grants for International Collaboration started in 2001 to strengthen research quality. In the period 2002-2005 eleven grants for biotech research were awarded amounted to 2,5 M EUR, some of them to collaborate with foreign centres.

Regarding biotech specific instruments, Denmark has long experience of designing and implementing programmes to promote biotechnology. The Danish research councils have been funding biotechnology research with specific initiatives since 1987. In the 1990s public support for biotechnology research activities combined institutional and competitive funding. These biotechnology initiatives also traditionally targeted collaboration between university and industry research. The most important specific policy instruments to promote knowledge base in Denmark were the BIOTEK and FØTEK.

BIOTEK programmes were initiated by the Ministry of Education to promote university research and education on biotechnology. They also promoted research collaboration between university and industry. The first BIOTEK programme ran from 1987 to 1990, allocating about 51 million of ECUs to biotechnological research across a wide range of areas, including health care and the development of pharmaceuticals and vaccines. BIOTEK 2 (1991-1995) funded a number of research centres (such as the Centre for Plant Biotechnology). BIOTEK transition programme started in 1996 and lasted until 1999, showing the trend to concentrate the funding on universities.

The most relevant instrument to encourage industry-oriented (and applied) research in public research institutions was FØTEK programme. The Danish government launched this Research and Development Programme for the Danish Food Sector in 1990. It covers both

biotechnology and other food-related technologies and combined basic research with a number of collaborative projects among researchers and food companies.

The efforts to support basic research in biotechnology increased substantially in Denmark with scientific programmes addressing the areas of health, pharmacology and food sciences. The programmes are the Health NASTRA Programme (1998-2001), Biotechnology in Food Research (1998-2002), Genetics (1998-2001) and Allergy/Immunology. At least 80% of the funding was particularly dedicated to biotechnology research. Other biotechnology research programmes, implemented by the Danish Government are not related with life science sector. In Sweden, Framework Grants support university researchers to undertake limited research initiatives in strategically important areas. The grants are for smaller projects than those funded by Network Programmes and Strategic Research Centres. The Swedish Foundation for Strategic Research makes calls for research proposals in specific topics, such as life sciences. The Swedish Research Council also provided funding support for infrastructure and equipment grants in the area of biotechnology, which represented an expenditure of 12.1M EUR in the period 2002-2005.

VINNOVA's Research Programmes is a biotech-specific instrument calling for research proposals in the areas of examination of ideas for new concepts in small biotech companies; innovation in foods; green materials; and pharmaceutical and diagnostics.

A series of initiatives have been taken recently to strengthen the biomedical research through the establishment of research centers and units that assemble the best resources in a set of highly relevant fields. Examples of these initiatives are Copenhagen BioCenter and Biotech Research and Innovation Center in Copenhagen; the Center for Stem Cell Biology and Cell Therapy, the Center for diabetes and Stem Cell Research and SweGene-Proteomics Center, all of them in Lund (Sweden).

4.3. Clinical trials

Due to a very long tradition in keeping national and comprehensive population and health data registers, the region offers major advantages for epidemiological and register-based research, allowing track patients over time. The permission to use the registers and the notification of diseases is a great advantage to do clinical trials. The bio-banks enable to carry out important. The regulatory authorities have a very good reputation.

Other advantages include well-functioning social health care systems, high enrolment rates, low drop-out rates, a high level of expertise and quality in clinical trials and good insights into the regulatory aspects. Obtaining approval to conduct a clinical trial Valley is quite

straightforward. All these factors mean that large-scale clinical trials can be performed with outstanding records of speed and quality. Non-European companies also frequently use the Scandinavian countries for performing clinical trials and registrations.

5. Other relevant policies for the development of life science sector

We should consider the other different policies aimed to stimulate biotechnology. The infrastructure, the collaboration between academic and industry, the tax system, the regulation about intellectual property rights, or even the welfare system are key elements to reinforce the R&D policy.

5.1. Business environment

Denmark and Sweden are considered excellent countries for business. Medicon Valley constitutes a business friendly region due to its healthy business environment. Setting up and operating a business is surprisingly easy. The legal environment does not restrain R&D activities. The level of regulation is minimum and based on trust. It is really easy to interact with government services. Corporate taxes are among the lowest in Europe (25% in Denmark and 26,5% in Sweden). The model of labour market, built on collective agreements and characterized by a flexicurity model with liberal hiring-and-firing rules, combined with a high level of social security; joint to the creative working environment are also attractive for companies. In summary, public authorities in Medicon Valley work with companies, not against them.

The unique interplay among public and private players ensures knowledge-sharing and creates synergies between research and development of new products and companies. And all that means a dynamic environment for innovation and the creation of new companies. The research environment, the qualified labour force, the strong cooperation between universities, hospitals and the pharmaceutical industry or the ease to collaborate at international level are important criteria to attract life-science industry investments (Ernst & Young, 2004).

Policy instruments attempting to encourage the creation of start-up companies, university spin-offs and the establishment of science parks and incubators also exist. The support structure for innovation with a broad range of science parks, incubators, and technology transfer offices seems efficient. They are located in close proximity to universities and other high technology environments. Only two incubators and two scientific parks are biotechnology dedicated and they were created recently.

Development agencies as VINNOVA play a key role since they contribute resources to expand the physical infrastructure, recruit people with scientific, managerial and legal skills, invest in projects involving a variety of actors, and leverage private investment.

Regarding the innovation management support schemes, there are programmes to stimulate small and medium enterprises demand for new technology. Their aim is to assess the firm technology needs. So earlier as in the mid-1980s, Denmark created county-based and subsidized offices to diffuse and help small and medium enterprises to access information about technologies, techniques, and markets. They conducted training courses to help firms to clarify their needs, define tasks, and suggest solutions. The Sweden scheme combines the creation and funding of company networks, support for technology brokers, and the application of advanced information and communications technologies. The TUFF programme started in June 1999 stimulates small and medium enterprises demand by supporting feasibility studies, inter-firm networking and cooperative projects.

Various public-private Danish organizations aimed to promote the entrepreneurship culture among young people. Thus, the International Danish Entrepreneurship Academy (IDEA) works to increase the number of competent entrepreneurs with a higher education. With IDEA growth houses, students and graduates from higher educations have the opportunity to test, develop and work with their own business ideas or collaborate with companies on turning ideas into business concepts.

Innovation voucher schemes have been established aimed at small and medium-sized enterprises in Denmark to start new innovative activities, accelerate innovative activities and enhance their competitiveness in collaboration with R&D institutions or other service providers. Staff training is explicitly allowed in Denmark. These scheme programmes are opened for international cooperation.

The Swedish government has initiated a series of innovation actions, such as the Innovation Bridge established in 2005, aimed at investing in knowledge-based innovations and start-up companies in a very early stage of development. It represents a national adaptation of the previous regional Technology Bridge Foundations.

NUTEK established the National Entrepreneurship Programme to increase the interest in entrepreneurship among the young for the period 2005-2007.

The VINNOVA programme Research & Grow could play an important role in increasing the growth of small life science companies. It offers grants to introduce or strengthen existing

R&D in small and medium-sized companies. Companies are stimulated to increase their knowledge base and also strengthen links to different types of R&D institutions.

VINNOVA established the VINNKUBATOR programme in 2003 to increase the number of new R&D-intensive growth companies.

Moreover, Sweden Bio (a Swedish national organization working for the benefit of the life science industry founded in 2002) has established an office to support the participation of small-medium enterprises in European framework programmes. VINNOVA financed partly this support.

The Swedish Trade Association has launched export loans aimed to reduce the risks of the exports by small medium enterprises and close large business deals. These loans are the result of collaboration between several financiers like Almi and Swedfund.

But there are also specific instruments oriented to biotechnology. The Swedish New Concepts programme is directed to broaden the product portfolio of small biotech companies. It has been running since 2003, funding 20 projects for the period 2003-2005 with an overall budget of approximate 2M EUR. The main policy goals covered by this programme are the adoption of biotechnology for new industrial applications and to promote business investments in R&D. Most of the companies supported by this programme are in the area of pharmaceuticals and diagnostics.

The pharmaceutical, biotech and medtech industry is acknowledged as a key industry by the Swedish government. In the 2005 biotech strategy, VINNOVA recommended an additional funding to support high-tech industries, among them the life science industry. The outcome was about SEK 200 million over five years for life science programmes and initiatives.

The Swedish Life Science Strategy established in 2005 includes favourable tax regulations for research intensive companies, good conditions for research and access to venture capital. Such strategy also recommended certain actions to create internationally competitive corporate conditions: a biotechnical renewal in Swedish basic industries and a proposal to develop a national system within drug discovery, diagnostics and medical technology, with a budget of EUR 2,8 million.

5.2. Financial support

Improving the availability of capital, in particular for small and medium enterprises is a key element in high technology activities, such as biotechnology. Establishing public agencies to provide loans and equity capital are specific measures implemented in Sweden as well as in Denmark.

Two initiatives were initiated to improve the financing situation in Denmark in the early 1990s (Jenson, 2001). The first one is the Business Development Finance Initiative Vækstfonden (or the Danish Growth Foundation), which was established in 1992 as a state backed investment company. It supports Danish companies to finance R&D, internationalisation and skills development projects. That institution operates as private venture capital company. It invests directly in companies, but also acts as a fund-of-funds investor in the private equity sector. The fund invests in early stage ventures mainly focusing on life science/medtech and high tech. It is part of the strategic objectives to work actively to facilitate access to international venture capital and drive the development of an internationally competitive private equity environment in Denmark. It also provides a guarantee of 50% to compensate the company losses on investment.

The second is the Danish Equity Guarantee Programme, which tries to promote the development of companies since 1994. The programme included guarantees in the form of venture capital for small companies. The scheme aimed to help development-oriented business being interesting for external investors.

In the late 1990s additional measures were taken. Two innovation companies were created in 1998 to invest in innovative business (seed financing and start-up phase), financed with two thirds of public capital. The programme is particularly directed to companies that are even too risky for established venture capital investors. A Loan Guarantee Scheme for start-ups was launched in 1999 coordinated by Vækstfonden to encourage the banking sector to increase its loan capital offers for start-ups.

A Denmark's Entrepreneur Fund, Seed Capital Denmark, was established in 2005 by the Government as a venture fund to increase innovation through private-government partnership. Currently, the fund has a total capital base of about DKK 500 million, of which DKK 300 million are reserved for new investments.

The Danish Government is supportive of young and high-risk-start-ups through the Danish Investment Fund (DIF), a state owned financial company with a capital base of about 320 M EUR.

Other Danish initiative is the Business Angel Network established in 2000.

Sweden has very similar initiatives in the financial side. The governmental capital available, especially for the early phases, is provided in the form of soft loans, subsidies and equity capital. The Swedish Industrial Development Fund Industrifonden is an independent foundation established by the government in 1979. It offers venture capital, competence and a

network of contacts to small and medium-sized companies. Industrifonden invests directly in companies as well as through a network of regional venture capital firms. The focus is on creating value in its portfolio companies and takes a long-term approach as an investor, lender or guarantor. This long-term focus is possible thanks to the evergreen structure of the fund and its strong capital base. All investments are made on commercial terms together with entrepreneurs and coinvestors.

Nutek (Swedish National Board for Industrial and Technical Development) included a seed financing fund which targets small high-tech companies and the Nutek Investment Forum CapTec - an annual investment forum for young technology-based firms.

The government-owned venture fund entities could be considered one of the key players and driving force of the development of the cluster. Vaekstfonden was established as a state investment fund in Denmark in 1992. It operates as an independent entity in the capital market, facilitating the supply of venture capital in terms of start-up equity and high-risk loans. Industrifonden or Swedish Industrial Development Fund was founded by the Swedish state in 1979, being the Sweden's largest venture capital company. It is focused on creating value in its portfolio companies and takes a long-term approach as an investor, lender or guarantor. Both entities invest directly in companies, but act also investing in private venture capital firms or in other funds.

5.3. Financial support

One crucial aspect for commercialisation of academic research is the regulation of intellectual property rights. It should be noticed that biotechnology is one of the most patent intensive industries, which relies mainly on academic research.

The traditional regulation of intellectual property rights in Sweden and Denmark was an unusual system. Legislation from 1949 in Sweden and from 1955 in Denmark transferred the right to inventions to employers. In both cases an exception was made for teachers and scientists at universities and other institutions of higher learning, where patents, as well as other kinds of intellectual property rights, were owned by the inventor/scientists, and not by their institutions or funders. Thus, the university inventions appointed the inventor as the owner of the patent. The researcher was granted with 100% of the patent revenue (Valentin & Jensen, 2007).

Nowadays, key differences exist for the regulation of intellectual property rights. Sweden keeps the traditional system, while the Danish Law on University Patenting (LUP) effective from January 2000, transferred to the employer university rights to patents on inventions

made by Danish university scientists alone or as participants in collaborative research with industry. As result, a Swedish professor enjoys full ownership over intellectual property generated by academic research (the “teacher exception”), while in Denmark since 2000 the ownership is shared between researcher and institution. Therefore, researcher is only granted with one third of the patent revenue.

Instruments aiming at supporting the commercialization of different technologies at a horizontal dimension were mainly the Centre Contracts. They were implemented in Denmark in 1995 to improve the interplay between public and private activities and the transfer of knowledge between universities and the industry. Approximately 20% of their funding was allocated to biotechnology-related R&D projects (Enzing et al., 1999).

The Danish Technological Institute (DTI) allocates part of its budget to assist start-up companies in intellectual property matters and other regulatory and management issues (Assouline, 1999).

Different education and consultancy initiatives were implemented to improve the patenting culture in Denmark. One of them is the introduction of academic courses in intellectual property rights at universities and governmental research institutions.

The initiatives towards commercialization of research in Swedish universities predominantly focus in creating startups and to a lesser extent on the prevailing industry.

The current Swedish Research and Innovation Bill also includes an initiative to increase the commercialization of research results, with a budget of SEK 150 million per year. It proposes that teachers in universities and other higher education institutions should inform their employers of patentable results to step up the commercialization and utilisation of research results.

An important initiative to foster commercialization is the "Medicon Valley Project", aimed to build up partnerships between industry, universities, hospitals, science parks, investors and business services.

Various strategies were implemented during the nineties to foster commercialization of biotechnology in Denmark. As it is acknowledged in the EPOHITE report, all of them relied on the consideration that biotechnology can only grow if it is fuelled by an excellent knowledge base. Thus the measures to expand basic research activities in public sector research institutions can be considered as an indirect first step for fostering commercialization. Moreover, knowledge generation was strategically combined with industry needs in certain sectors.

From the Swedish part, the Knowledge Foundation has allocated SEK 60 million over seven years to a programme aiming to increase the general competence level in biotech and food small and medium enterprises. The programme is the result of collaboration between a number of universities and the Swedish Institute for Food and Biotechnology.

The Swedish life science strategy considered commercialization of research and increased collaboration between academia and industry as key areas to address.

Although the so-called institute sector (research institutes funded jointly by industry with the 60% and the government) is very small in Sweden, plays an important part in the commercialization of research, in particular for small and medium enterprises.

The availability of capital for small and medium-sized high-tech enterprises is other key element to achieve commercialization.

The VINN-Verification programme established by VINNOVA is aimed to reduce technical and commercial risks, identify the most appropriate commercialisation strategy and develop a concept that is appropriately protected in the ongoing commercialisation process. This make possible for researchers, subsequent funders and industrial partners to assess more clearly the potential, risks and forms for the continued commercialization of the research results. It is part of Verification for Growth, a programme that is run jointly by VINNOVA and Innovationsbron AB. The VINNKUBATOR programme also address to commercialization. VALOR is an InnoNet project that aims to ensure that European investments in research are converted into commercial benefit more effectively. It focuses on the valorization process: the translation of research results into commercial benefit.

None of the three main Swedish research councils funding basic research have policies or initiatives for technology transfer or IPR related to biotechnology. Universities are playing an increasingly active role through setting up technology transfer offices.

5.5. Collaboration policies

According to the systemic perspective present in the design of the different policy instruments, many of them include strengthen the collaboration among their goals. Here we focus on the programmes more directly addressed to stimulate collaboration.

The Danish Technological Institute (DTI) founded by industry leaders in 1906 to provide technical training. Its purpose is to further the interests of the business community and society in general by the advancement and propagation of technological progress. It focuses on the needs of small firms and one of its divisions is devoted to chemistry, biotechnology, and

environment. It still supports a network program to help firms establish joint marketing, production, and product development arrangements.

The Danish Centre Contracts is a scheme designed to enhance collaboration between universities, semi-public research institutions and industry implemented in 1995. Long-term competence building is one of its explicit objectives. It is also heavily oriented towards development of relatively radical innovations.

Innovation Incubators, is a special form of incubator scheme to stimulate collaboration on innovation, but not necessarily radical innovations. The specific characteristic of Technology Incubators as opposed to traditional science parks or Business Innovation Centres is that they provide knowledge, advice and capital for innovative entrepreneurs. Thus, their overall purpose is to support new, small innovative companies in Denmark by securing a closer interaction between innovative entrepreneurs, research and capital about the development of new products and services. The majority of the projects are placed in high growth industries. Information technologies, biotechnology and medico/health account for more than half of the pre-seed capital projects.

The Danish Ministry of Trade and Industry initiated in 1994 the business-related sector programme Business Development in Central and Eastern Europe. It is aimed to facilitate the establishment of commercial collaboration between companies. More specifically, the programme aims at developing the capacity of small and medium enterprise in programme countries to work within market economic conditions; transferring know-how in management, technology and marketing from Danish enterprises to the programme country enterprises; and contributing to increased trade between Denmark and the programme countries through establishment of commercial collaborations between participating enterprises.

But there are many other generic initiatives, mainly established by the government, to stimulate collaboration in Denmark.

The elements of the Danish technology diffusion system are the Approved Technological Service Institutes (ASTI), which includes the Danish Technological Institute (DTI), advanced technology centers and other centers; technology information centers; private consultants; local technology centers; and the five universities.

There are also other institutions in Denmark to promote technology diffusion. In the late 1980s, more than two dozen applied research centers were established to help industry with its technological problems. The centers are focused on key Danish industries or technological strengths, such as biotechnology.

The Danish Network Programme is a government initiative which ran from 1988 to 1993, aimed to stimulate Danish companies in large numbers to overcome their resistance to cooperation. The idea was to promote networking between firms to help them face increasing international competition.

The Danish Council for Technology and Innovation established the Innovation Consortia in 1995 to support research and development projects performed by consortia. It integrates company research and development activities and generic research conducted at public research organisations.

The Authorised Technological Service Institutes (Godkendte Teknologiske Serviceinstitutter) (GTS) established in Denmark in 1996 provide consultancy services and act as cooperation partner by helping businesses to gain access to public research.

The Danish Technology by Highly Oriented Research (THOR) programme emerged in 1997 to stimulate cooperation between industry and universities.

In 2003, the Danish government presented a plan to further strengthen cooperation between education, research, trade and business. A central issue is the interface between the public system of universities, GTS institutes (Approved Technology Service) and incubators/science parks, and private industry.

Danish Industrial PhD Fellowship Programme has been established by the Danish Agency for Trade and Industry to encourage partnerships between enterprises and universities. The exchange of staff is a major part of the programme. Additionally, there exist some other initiatives to promote the mobility of researchers between universities and industry in Denmark. One example includes the support of unemployed researchers who take a job in a small or medium-sized biotechnology company (Assouline, 1999).

The Swedish Competence Centres programme, launched in 2003 by NUTEK, is a long-term generic effort to strengthen the link between university and industrial research. It is aimed to achieve a stronger industrial impact and concentration of resources by creating multidisciplinary academic research environments in which industrial companies participate actively. As a result of the success of that initiative VINNOVA intends to establish 25 new Centers, under the new brand VINN Excellence Centers. Three of the new Centers conduct research in biotech-related fields.

The Swedish TUFF (Teknikutbyte för företagsutveckling) programme, launched in June 1999 by NUTEK, encourages trade in technological services between public R&D technology providers and groups of small and medium enterprises. It aims at facilitating the trade in

technological services between universities, research institutions and SMEs. In 2001, the SSF and VINNOVA jointly launched the programme VINST, Researchers in Collaboration with Smaller High-tech Companies to promote economic growth. Projects must be conducted in collaboration between researchers and companies with research and/or advanced development activities. Twenty-one proposals have been approved by this programme, and six of them are on the area of health biotechnology, with a budget of 2M EUR in the period 2002-2005.

VINNVAXT Programme is a generic regional innovation programme introduced in 2002 to promote efficient collaboration in functional (rather than administrative) regions between companies, research institutions and public organisations. VINNVAXT is built around the idea of stimulating regional growth through dynamic innovation systems. In fact, it is complementary to the Government's Regional Growth Programmes.

The Key Actors programme, started in 2006, is aimed to develop expertise, methods, processes and structures that will make key players in the Swedish innovation system more professional in their roles with regard to collaboration between research players, companies and other players in society at large, as well as to the utilisation of knowledge and the commercialisation of research results. The first part of the programme started focused on universities and the measures for 2007-2008, focused on research institutes and companies and were related to the professionalisation of collaboration efforts.

Swedish Innovation Incubators are aimed to bridge research environments, innovative entrepreneurs and finance companies in order to develop and transfer research and innovative ideas to commercially sustainable innovative projects and enterprises. The VINNKUBATOR programme considers that incubators should be developed, manned, and located so that they become world-class forums where commercial demands and complementary cutting-edge competence can meet and interplay with leading researchers, innovators, investors and entrepreneurs.

Focusing on more specific instruments, we should be noted that different programmes were launched in Denmark to combine knowledge generation with industrial needs. The aim is to achieve a close match between industry and university activities and foster commercialization of biotechnology.

The promotion of the collaboration between public and industrial research is an objective of the FØTEK programme. The political support for strengthening academic cooperation among public research institutions and other disciplines decreased over time. While a main objective

of the BIOTEK programmes in the mid 1990s was to support research networks, this kind of promotion disappeared totally in 2001.

The Danish National Advanced Technology Foundation promotes collaboration between businesses and research institutions within nanotechnology, biotechnology and information and communications technology.

The Danish Council for Science, Technology and Innovation has recently initiated a proof of concept scheme, which offers the possibility of a grant of up to DKK 750.000 for the maturation of ideas based on research in hospitals and universities. This measure started as a pilot project in 2006 aimed to strengthen technology transfer from public research to private enterprises. It allocates 1,6 Million euro for the period 2006-2007.

The Copenhagen BioCenter is based on cooperation between university groups, research and clinical hospital units, and industry. In addition, a privately financed and operated biotech science park was established as part of the BioCenter. The vision is to create a strong cross-disciplinary environment that will encourage rapid development of new ideas from basic research discoveries to commercialization.

In the Copenhagen Region the innovation network Biologue was founded by the Danish Ministry of Science, Technology and Innovation and University of Copenhagen in 2005, to strengthen the research collaboration between universities, hospitals and companies. The network is aimed to strengthen, support and expand biomedical R&D, education and training in and among academia, hospitals and industry. It consists of several academic, governmental and regulatory partners, numerous member companies and the vast majority of biomedical researchers in Denmark.

BioLogue is founded by the Danish Association of the Pharmaceutical Industry (Lif) and Dansk Biotek, the Danish Ministry of Science Technology and Innovation and a membership alliance of leading Danish biomedical companies. Partner institutions include University of Copenhagen, The Danish University of Pharmaceutical Sciences, The Royal Veterinary and Agricultural University, Statens Serum Institut, Copenhagen Hospital Corporation, Copenhagen County Hospitals, Biotech Research & Innovation Centre, and Copenhagen Tech Transfer Consortium.

National Platform for Systems Biology is an initiative to establish a platform for developing a Danish infrastructure integrating large amounts of biological data. The core of the platform is network biology and systems biology, focusing on protein-protein interaction data. This long-

term initiative consists of an integrated joint project involving three research groups at the Technical University of Denmark, University of Southern Denmark and Aarhus University.

The Swedish Technology Link Foundations, founded in 1994, aim to link research and knowledge intensive activities at universities with regional business (especially SMEs) facilitate patenting, licensing and commercialisation of knowledge and research results from the universities (Palonka, 2000, Vinnova, 2001).

The VINNVAXT Programme has been granted financing four regional bio-related initiatives from 2003 and 2004 for 10 years. These initiatives are Uppsala Bio, New Tools for Life initiative, Goteborg Bio and Innovation Gransland. The latter is related to food biotech and the three former to health biotechnology. However, none of these four programmes is referred to Medicon Valley life science cluster. The overall amount of funding channelled through for each bio-related initiatives is approximately 11M EUR (SEK 100M). The policy goals covered include availability of human resources, the adoption of biotechnology for new industrial applications, encouraging business investment in R&D and transmission of knowledge from academia to industry.

Innovations in Foods, launched in Sweden in 2003, support contributions to medical, biological, and biotechnological knowledge that stimulate the development of innovations in the food industry. Calls are made for cooperative proposals from researchers, companies and other actors that will contribute multi-disciplinary knowledge required for the development of innovative food products with health-promoting characteristics. Industrial partners must participate in these projects and contribute 20-50% of the total budget. Between 2003 and 2004, 9 projects have been selected representing a total budget of 4.4M EUR (SEK 40M). Four main policy goals are covered in this programme: the support of high level industry-oriented research, transmission of knowledge from academia to industry, the adoption of biotechnology for new industrial applications, and the promotion of business investment in R&D. The majority of the projects funded in this programme are in the areas of food biotechnology and health biotechnology.

Pharmaceutical and Diagnostics, launched in 2004, aims to link different scientific disciplines, such as medicine, biology, IT and engineering. It requires a clear indication of the commercial potential of the research and co-financing from industry of 20-50% of the total budget. The objective is to support research collaboration between academia and companies in pharmaceuticals and diagnostics, for projects involving a minimum of three different scientific disciplines and at least one company.

The Swedish life science strategy programme launched in 2005 stated that the collaboration between the government, industry and other relevant actors should be developed with the aim of increasing synergies in different departmental proposals. The focus of the collaboration should be on the long-term competitiveness of the Swedish life science industry as well as current conditions for industry, including taxes and regulations, etc (Vinnova, 2007).

SAMBIO and SAMPOST are consequences of such strategy and both aim to increase the collaboration between academia and industry. They require cofinancing from applicant companies. SAMBIO is a research programme aimed to extend and develop collaboration between companies and academic research in the biosciences. It also aims to strengthen opportunities for life science companies to participate in the 7th Framework Programme and to facilitate qualification opportunities for young scientists wanting to collaborate with industry and conduct industry-relevant research. It began in 2006 and is expected to run until the end of 2010.

SAMPOST is a national post-doctoral programme aimed to strengthen industrial development and competitiveness in the pharmaceutical, biotechnology and biomedical engineering sectors. This will be achieved by improving opportunities for the mobility and qualification of young, promising researchers who should be able to conduct high-quality, industrially-relevant research in cooperation with the industry. The programme will increase corporate access to new knowledge at the universities and improve the potential for both industry and the universities to convert results into innovation and growth.

The current Swedish Research and Innovation Bill includes increased strategic skills development funds, aimed to enhance opportunities for industrial research institutes to cooperate with both higher education institutions and the business.

The Swedish Brain Power program aims to develop a new holistic concept for integration and cooperation within a number of R&D areas that are important to the diagnosis and treatment of neurodegenerative diseases. It brings together 73 research groups at Sweden's leading medical universities and university hospitals.

The research schools, a programme established by VINNOVA in 2007, deals with knowledge transfer. They must collaborate strongly with industry.

Medicon Valley Alliance has launched The Life Science Ambassador Programme in 2008. This strategic globalisation initiative aims to improve collaboration with leading life science clusters in the world. So, it involves the establishment of close strategic ties between important life science clusters around the globe with exchanges of life science ambassadors.

Four clusters are at the moment directly linked through the exchange of Life Science Ambassadors: Medicon Valley, Kobe-Kansai (Japan), British Columbia (Canada) and Seoul (South Korea). The fifth cluster is expected to be included during the first half year of 2010, and the rest of the clusters will be included continuously in the programme onwards. When the programme is fully implemented in 2012, Medicon Valley will be home to representatives from 12 of the world's most innovative and prosperous life science clusters. The clusters selected are assessed to be the most innovative and prosperous life science clusters, which are expected to be the high performance clusters of the coming decades.

One remarkable characteristic is the limited interaction existent across borders. It could be explained by substantial differences in terms of industrial structures, institutional environments and national biotechnology systems (such as organization, industrial policy and taxation).

6. Conclusions

Public policies addressed to all elements of the innovation system and the interactions between them seem to be more effective than public policies that aimed only to one part of the innovation system. It should be noted the systemic perspective to design the policies in a two-way view. On one hand, the policies consider all the elements of the innovation system. On the other hand, each instrument also tends to attempt different goals. So, the systemic perspective and some kind of equilibrated engagement of all policy areas contribute to achieve the policy goals and improve the effectiveness of such policies.

The Centre-Contracts scheme is an important example of the general trend in Danish innovation policy to turn focus away from single, isolated elements of the conditions for innovation to enhance the coherence of the different elements in the innovation system. It gives incentives to bring together key actors in the system.

Other suggestion is to combine different policies instruments to enhance their effects. Thus, the combination of infrastructural instruments with support ones, such as education measures to foster exploitation in Denmark seems to be superior to approaches providing just infrastructures.

We must stress the importance of the generic policy instruments to contribute to the emergence of the cluster. Denmark and Sweden had targeted dedicated biotechnology instruments enclosed to horizontal measures, and seem to outperform the other European countries in most of biotechnology indicators. The role of policy has been increasing as cluster develops, with a broad use of strategic/targeted biotech oriented instruments.

The policy instruments implemented to promote biotechnology have been mainly part of the structural governmental support for scientific education, research and research infrastructure. However, specific instruments, established explicitly by policy decision making, also exists and are relevant for the success of the cluster. Among the targeted biotechnology instruments, basic and applied research, mobility of researchers between academia and industry, and collaborative research between industry and academia have been the activities receiving the largest funding volumes.

In general terms, the policy goals related to the knowledge base and the transmission of knowledge seem to receive more attention than the policy goals targeting market performance of biotechnology products and services and industrial development.

Rosiello (2005) highlights the active role in promoting the development of the biotechnology industry through the implementation of systemic strategies and the general prevalence of horizontal initiatives. This statement could be absolutely supported for this cluster.

The wide range of policy instruments applied in Medicon Valley life science cluster were designed on the basis of a combination of factors. The preconditions play a key role, but the existent long term strategies at national and regional levels are also relevant. Other elements such as preevaluations or industrial lobbying, although are present, have minor importance.

Among the preconditions, we should distinguish some facts contributing to the emergence of the cluster and policies that help to create the preconditions. Starting by the facts, the historical presence of pharmaceutical companies plays a very significative role in the emergence of the cluster. They contribute to the development of the cluster, in particular, through the talent and science base that have accumulated. These companies have collaborated extensively with academic groups and have also produced many skilled personnel to create or join to existent companies. The strong research carried out at universities and at lesser extent at hospitals, the long tradition of collaboration between academy and industry or the well-developed venture capital sector are also crucial ingredients to the success of the cluster. Vinnova (2008) acknowledges that the universities, and specifically, Lund and Copenhagen Universities as the initial drivers of the cluster.

Regarding the policies, we should identify two stages: the existent instruments at the time of the emergence of the cluster and so they could act as preconditions, and the policies implemented for the development and the growth of the cluster. Among the former we can stress the well-developed innovation system and, in particular, the investment in education

and basic research, the financial support to new firms, the good infrastructure, and the promotion of networks and public-private partnerships.

Most of the policies implemented in both countries were generic to stimulate innovation. This is really true for the policies existent during the emergence of the cluster. Bresnahan et al. (2001) asserts that the autonomous dynamics of a successful cluster might reduce the need and/or scope of public policy. Contrary to this assertion, the role of public policies at different levels seems to be increasingly important in the cluster studied here. Moreover, the targeted/specific biotech measures have high weight over time.

The assessment of the different policy instruments implemented in this cluster suggests its good performance. We can find only little exceptions to this trend. Only one of the interviewees considers a unique failure in the applied policies related to the commercialization of research and, in particular, the new Danish regulation on intellectual property started in 2001 that did not produce the planned effects. The existent evaluations of many instruments reinforce this view and, at the same time, show the government commitment to achieve results and improve the policies.

Overall, the main policies addressed to the growth of biotechnology in Medicon Valley are the promotion of biotechnology basic research, instruments to support firm creation and the availability of financial capital to high growth sectors.

Many important factors of this cluster cannot easily be mimicked or repeated in other areas. It happens with the importance of life science industry, the presence of old and large companies with niche strategies, the foundations supporting research and innovation or the entrepreneurial business tradition.

But we can learn from the implemented policies, and the focus on all the elements of the system. R&D seems a key area, but this alone is not enough. The availability of capital, the human resources, the infrastructure, the business environment, different regulations (labour market, clinical trials, ...) and the collaboration among the different players (formal, informal, and through some support structures) constitutes the policies that allow that the pre-existent biotech activity present in this region could become in a successful experience.

The existence of many specific instruments to promote and strength biotechnology rests on very broad horizontal support policies that reinforce the former. The implemented policies are the result of horizontal and specific policy instruments. The coordination and coevolution of these different instruments seems to be crucial to the growth of the cluster.

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