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A BENCHMARKING STUDY OF THE SWEDISH AND BRITISH LIFE SCIENCE INNOVATION SYSTEMS

Comparison of policies and funding

UPPSALA UNIVERSITY
VINNOVA

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A benchmarking study of the Swedish and British life science innovation systems

Comparison of policies and funding

Uppsala University

VINNOVA

Master's Thesis

February 2008

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Preface

In December 2006, VINNOVA was assigned by the Swedish Government to carry out an international study to shed light on the competitiveness of the Swedish sectorial innovation systems of pharmaceuticals, biotechnology and medical technology in international comparison.

The study includes analyses in three main focus areas in an innovation system perspective:

– The key players in the Swedish innovation system, who they are and their position in an international comparison.

– Trends, initiatives and commitments in other countries/regions.

– Comparative case studies to investigate the competitiveness of the Swedish innovation system.

The main question is what structure, growth and development capacity does the Swedish pharmaceuticals, biotechnology and medical technology industry have compared to other countries/regions excelling in this field?

The present master's thesis is one of the studies carried out as part of the project. The aim is to analyse and compare the British and Swedish life science innovation systems. The report includes one macro-level comparison comprising the UK, Scotland and Sweden and a micro-level comparison of the Cambridge and Uppsala regions. The competitiveness of the Swedish system is based on results and experiences from both the macro and micro-level and on their interconnectedness.

The project manager of the Government commission is Anna Sandström at the Strategy Development Division of VINNOVA and the author of the present master's thesis is Helena Bergqvist, Uppsala University.

VINNOVA in November 2008

Göran Marklund
Director and Head, Strategy Development Division

Contents

Abbreviations

BBSRC - Biotechnology and Biological Sciences Research Council
CIC - Cambridge Innovation Centre
CLIS - Cambridge Life Science Innovation System
CRO - Contract Research Organisation
CSA - Chief Scientific Adviser
CST - Council for Science and Technology
DA - Devolved Administrations
DcSF - Department for Children, Schools and Families
DfES - Department for Education and Skills
DIUS - Department for Innovation, Universities and Skills
DoH - Department of Health
DTI - Department of Trade and Industry
DTI - Department of Trade and Industry
E&Is - Evidence and Innovation Strategies
EEDA - East of England Development Agency
EEEP - East of England European Partnership
EEPA - East of England European Partnership
EERA - East of England Regional Assembly
FCO - The Foreign and Common Wealth Office
FP7 - The 7th Framework Programme
FCUK - Funding Councils UK
GDP - Gross Domestic Product
GERD - Gross Expenditure on Research and Development
GNP - Gross national Product
GOs - Government Offices
GPC - The Greater Cambridge Partnership
GSIF - Global Science and Innovation Forum
HE-BCI Higher-Education-Business and Community Interaction Survey
HEFCE - Higher Education Funding Council UK
HEI - Higher Education Institutes
HEIF - Higher Education Innovation Fund
HERD - Higher Education Research and Development
HFEA - The Human Fertilisation and Embryology Authority
HSC - Horizon Scanning Centre
ITPI - Price index for domestic supply

JTI - Joint Technology Initiatives
KTN - Knowledge Transfer Networks
LSC - The Learning and Skills Council for Cambridgeshire
MHRA - The Medicines and Healthcare Products Regulatory Agency
MRC - Medical Research Council
NDPB - Non-Departmental Public Body
NHS - National Health Service
NIHR - National Institute for Health Research
OSCHR - Office for Strategic Coordination of Health Research
PSA targets - Public Service Agreements
R&D - Research and Development
RAE - Research Assessment Exercise
RCUK - Research Council UK
RDA - Regional Development Agency
RES - Regional Economic Strategies
RPSGB - The Royal Pharmaceutical Society of Great Britain
S&Is - Science and Innovation Strategies
ScLSIS - Scottish Life Science Innovation System
SCRM - Scottish Centre for Regenerative Medicine
SDI - Scottish development International
SLIS - Swedish Life Science Innovation System
SME - Small and Medium-sized Enterprises
TBS 7 - The former Technology Bridges
TSB - Technology Strategy Board
UIC - Uppsala Innovation Centre
UKCRC - UK Clinical Research Collaboration
UKLIS - UK Life Science Innovation System
UKTI - UK Trade and Investment
ULIS - Uppsala Life Science Innovation System
VC - Venture Capital

1 Introduction

1.1 Background

This report is one of the consequences of VINNOVA's commission from the Swedish Government to conduct an international benchmarking of the Swedish Life Science innovation system. In the commission, it is stated that the emphasis should be on the competitiveness of Sweden in an international comparison. Also, the study should provide knowledge of trends and initiatives in other countries and regions[1]. This report comprises one part of the overarching study, which is managed by Anna Sandström (VINNOVA) and provides a case study of the life science innovation system of Sweden in comparison to Britain. The aim has been to fulfil the requests for knowledge on trends and initiatives for the UK and an analysis of Swedish competitiveness. Hopefully, the theoretical model and approach offer a sufficiently exhaustive description of the systems so as to form a solid basis for comparison and analysis of the competitiveness. Trends and initiatives of relevant actors have been given particular attention. Yet another consequence of the commission was to produce an updated version for the entire life science industry of the report entitled National and Regional Cluster Profiles. The updated report, written by Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi) is also linked to this report, since it provides information vital to a relatively up-to-date picture of the competitiveness of the Swedish system. For the innovation system analysis of Sweden, material from the National and regional cluster profiles 2007 constitutes a foundation that has been further analysed.

The report includes one macro-level comparison, comprising the UK, Scotland and Sweden and one micro-level comparison comprising Cambridge and Uppsala. The competitiveness of the Swedish system is based on results and experiences from both the macro and micro levels and on their interconnectedness.

1.2 Objectives

This report has two main objectives:

- To survey the industrial structure of the Swedish life science sector and illustrate how it has evolved in the last ten years.

- To analyse the competitiveness of the Swedish innovation system for the life science sector relative to the British one.

[1] Ministry of Enterprise, Energy and Communications, 2006

There are four main issues to be answered, and these are further divided into sub-issues. The first question relates to the first objective whereas the following three predominantly relate to the second objective. Naturally, the questions related to the second objective build to some extent on the outcome of the first question. An analysis of the competitiveness of the Swedish life science innovation system takes into account the current status of the industry structure and how it has evolved. The issues are as follows:

- What is the overall structure and development of the Swedish Life Science Industry?
    - What does the industry structure look like?
    - What has the growth of the industry been like for the last ten years in terms of number of employees?
    - What has the production and results development of the Swedish industry been like?

- How do the British and Swedish Life Science innovation systems appear and function in regard to certain aspects or activities that are important to an innovation system?
    - What is the knowledge development like in the British and Swedish innovation systems?
    - How does the financial support system function for innovative companies?
    - What are the main policies of the public authorities in Sweden and in Britain?

- How do the Swedish and British Life Science innovation systems perform?
    - Comparison of strengths and weaknesses

- What can we learn from the British innovation system in order to increase the competitiveness of the Swedish Life Science Innovation System?

1.3 Spatial delimitation

The number one priority in this work has been to conduct a comparative innovation systems analysis of the Swedish and British innovation systems. It was thought necessary to handle the discrepancy in size of the two nations and this has been addressed by conducting comparative analyses of innovation systems on different levels in the innovation system. Sweden is compared not only to the UK but also to Scotland. The comparison with Scotland adds an innovation system that is very similar to the Swedish one in terms of size. Not only is the number of inhabitants in the same range as

Sweden (approx. 5 million[2] compared to over 60 million in the UK[3]), but the life science industry is also about the same size in terms of number of employees and number of companies. Although part of the United Kingdom, Scotland is in several respects an independent region of the Union. Therefore, the Scottish innovation system can be addressed both in connection with the overall UK innovation system, as well as being compared as the innovation system of one country to another.

In this work, it is recognised that much of the important initiatives and innovation takes place on a more local level. As an instrument to provide depth to the study, innovation systems on a sub-regional level were also compared; Cambridge and Uppsala. The reason for choosing these specific examples to compare is outlined in section 7.1.1 It has been discussed in many reports whether the nature of a biotechnology industry is best described as biotech clusters using cluster theory, or on a regional level, or whether it should be described by such theories as Global Commodity Chains and/or Global Production Networks. These theoretical approaches have been studied. However, it was concluded that, given the task to conduct an international benchmarking study whilst simultaneously dealing with innovation systems on various spatial levels, sticking to just one of them would be too complex and delimiting. In this study, the primary focus is not on exploring the spatial nature of the life science innovation system or what spatial approach gives the most suitable description. Nevertheless, the chosen approach does create interesting questions. In addition to comparing Uppsala to Cambridge, there is a description of the connections between each sub-region and the national level above the sub-regional level. These interconnections might then also form an issue for comparison. This was taken into consideration when describing the sub-regional innovation systems and is dealt with separately in chapter 11. The innovation systems of Cambridge and Uppsala are described and compared in the micro-level block and the innovation systems of the UK, Scotland and Sweden are described in the macro-level block. The final analysis of the competitiveness of the Swedish compared to the British innovation system takes into account the results and experiences from all innovation systems studied.

[2] http://sv.wikipedia.org/wiki/Skottland
[3] http://sv.wikipedia.org/wiki/Storbritannien

2 Choice of analytical model and approach

The choice of theoretical approach in this report is a combination of the functional analysis developed at Chalmers University of Technology, and the approach used by the Centre for Business and Policy Studies in their study of the Swedish life science industry and innovation system. The overall aim and logic is similar to the functional analysis in that the analysis builds on a successive processing of information, from facts and more extensive descriptions to a refined analysis. However, several aspects of the functional analysis are not included in the approach of this report mainly due to time limits. The logic of the approach used in this report is described in the approach model in figure 2.1[4]. The industry survey of the Swedish life science industry provides a knowledge base for the characteristics of the industry. A snapshot is presented of what the industry actually looked like in 2006 and its development over time. The actors within the innovation system are presented in the system structure. Starting with the actors in the system, the activities in it are then described. These activities then form the basis of a further level in the pyramid of information processing; the strengths and weaknesses identified in each activity and innovation system. The discussion of these strengths and weaknesses forms the primary basis for comparison between the Swedish and British systems and also the final perception of the Swedish systems' competitiveness. Each of the levels of the pyramid is given further individual description.

[4] Author

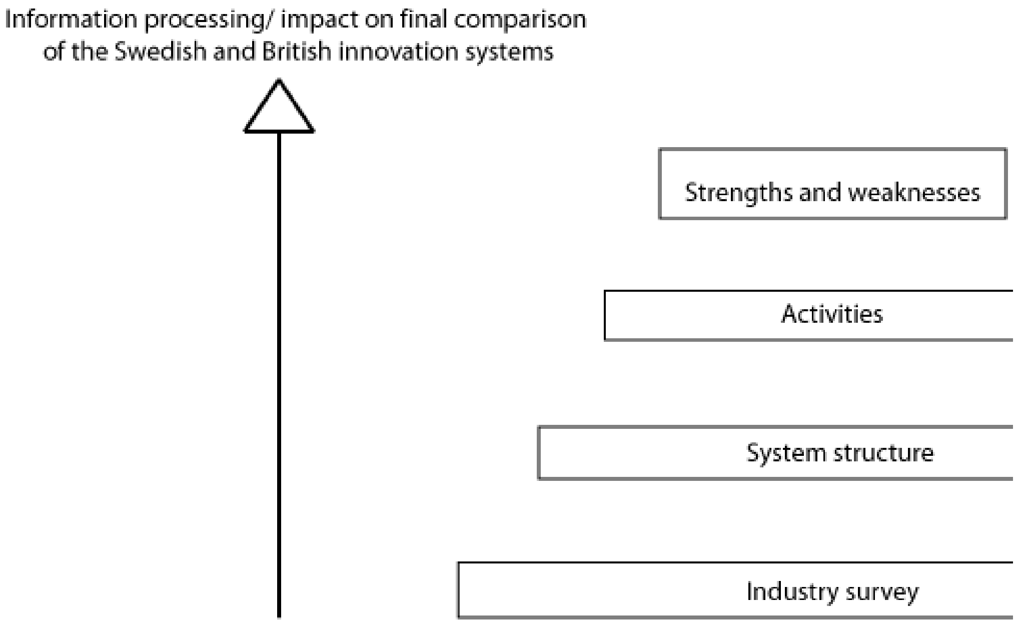

Figure 2.1. Approach model for identifying strengths and weaknesses in an innovation system.

2.1.1 Industry survey

The industry survey has been thoroughly conducted for Sweden; the industry structure, the employment development and the development of results and productivity are outlined for the life science industry. A corresponding industry survey for the UK has not been conducted. A more delimited survey was conducted for Cambridge to form a basis for comparison with the Uppsala life science innovation system. Generation of the industry survey for Sweden is described in more detail in the industry survey section.

2.1.2 System structure

The system structure, that is the actors or components of the innovation system, have been outlined and take their inspiration from the functional analysis[5]. The categories of actors examined was also determined by initial bibliometric studies of the major actors in the innovation systems. The different categories chosen are public authorities, industry partnerships and associations, research institutes and universities, innovation centres, science parks, incubators and networks/funding networks.

2.1.3 Activities

In this report, specific activities were identified and described rather than the functions in a functional analysis. The activities are those "which affect

[5] Perez E., Oltander G., 2005.

the development, spread and use of innovations”[6]. The activities are also the determinants of the innovation system which *we* can affect, in order to influence the innovation processes[7]. The similarities and differences of the activities and functions are outlined in tables 2.1 and 2.2.

Similarities:

Functions	In a functional analysis, the functions analyse the functional pattern of the system, the dynamics[8].
Activities	Analysing and comparing innovation systems by using activities focuses on what happens in the systems and how they change[9].

Differences:

Functions	The functions answer questions like “why has the system evolved in a certain way” to a greater extent than the activities[10]. Since the static components are described by the system structure in the functional analysis[11],
Activities	The activities are more descriptive of the status of the innovation system and, compared to the functions, contain less analysis of why the systems developed in certain ways. The questions associated with the activities are more of “what does the system look like?” and “how has it changed?” than “why has it changed?”. There is no corresponding system structure where components of the system are dealt with separately. As a consequence, the activities are more inclusive of such information[12].

The use of activities was inspired by the innovation system analysis approach used in a report from the Centre for Business and Policy Studies (Medicin för Sverige). As described in table 2.1, the activities are much like the functions but were chosen on the assumption that they are well suited since the focus is on comparing different countries’ sectorial innovation systems rather than analysing one specific national innovation system[13]. In this report, specific examples of initiatives or programmes currently in place in the system have been used to provide a description of how the activity is

[6] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, Page 30.
[7] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007. Page 30.
[8] Perez E., Oltander G., 2005, page 17.
[9] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, Page 30.
[10] Author’s conclusion.
[11] Perez E., Oltander G, 2005, page 17.
[12] Author’s conclusion.
[13] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, Page 37.

dealt with and conducted. This is followed by a more analytical discussion of the strengths and weaknesses identified within the activity. This approach was chosen based on the extensive comparisons that lay ahead of the *status* of different innovation system and the competitiveness of the system's life science industries.

Comparisons of innovation systems ideally should be very comprehensive as well as detailed[14] and much effort has been put into this work in order to achieve this. The framework that the activities present aim to focus on comparable important aspects of the innovation system and is backed up by the underlying descriptions of the system structure and (for some systems) the industry structure.

The focus of this benchmarking study has been on the financial and policy aspects of the life science innovation systems and only partly coincides with the activities defined in the Centre for Business and Policy Studies report[15]. Due to restrictions in time, several important activities of the innovation system, like the regulatory and organisational environment for instance, has not been covered. The demand is defined as externally determined and is not described. However, the effect of such aspects of the innovation system is not completely neglected though when concluding strengths and weaknesses in other activities. The aspects covered by the functions in an ordinary functional analysis have had an impact on how the activities were chosen. The activities used in this report also differ somewhat between the different innovation systems studied. This is because some flexibility is needed in order to capture what is predominantly affecting the innovation system at hand. The activities that are included in all innovation systems are as follow;

Knowledge development:
In the knowledge development, the knowledge generation is described in terms of what affects the direction of research and how the funding of university research and all research is conducted by public and private actors. The access to knowledge is also described in the knowledge development and includes the technological knowledge base and market-related knowledge base. Finally, knowledge transfer within the system is considered. The focus is on knowledge transfer between academia and industry and is also linked to commercialisation activities.

Financial Support Systems:
In the financial support system, there is a description of how different actors contribute to the access of capital. General access to capital as well as more specific access from private and public sources is described.

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[14] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, Page 35.
[15] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, Page 32-33.

Policy Development
The policies of public authorities and, to some extent, other organisations plus how these actors actually implement their policies were considered vital to a report such as this. The report sets out to compare the strengths and weaknesses of two national innovation systems in a global context. Therefore, this has been treated as one of the activities in the innovation system under the heading of policy evolution.

The activity descriptions are based on reports, strategy documents and previous studies. There was extensive examination of the websites of the actors in the system structure to update and follow up information given in the reports and strategies. Interviews were also conducted with actors situated in London (or Swindon), Stockholm, Cambridge and Uppsala (see references for a complete list). Specific issues relating to the activities have also largely been handled by e-mail.

2.1.4 Strengths and weaknesses identified

For each activity section of each innovation system, the strengths and weaknesses identified as relating to that particular activity are described and discussed. The discussion focuses on the activity and innovation system at hand but in the analysis, connections to results and experiences from other innovation systems are also taken into consideration. Naturally, the results from "lower" levels in the information pyramid might affect the analysis of particular strengths and weaknesses as well; for instance, how the employment development might be connected to certain strengths or weaknesses related to an activity.

2.1.5 The interconnectedness of innovation systems

In this report, a specific section is attributed to a discussion of the interconnectedness between the spatial levels. The discussion is based on the results and experiences gained from comparing different levels. The comparison focuses on the policies among actors in the innovation systems, their relative strengths and how these policies are implemented.

2.1.6 Innovation system comparison

One of the questions to be answered in this report is what the competitiveness of the Swedish life science innovation system is like compared to the British. This is the final question to be answered, and is based on the industry surveys, system structures and activities of the innovation systems considered. However, the comparison mostly starts at the top level of the information pyramid (see figure 2.1). The conclusions drawn from the strengths and weaknesses related to the activities are compared in order to answer the question of competitiveness. The approach used to handle the outcome of the different innovation systems on micro-and macro-levels is outlined in figure 2.2. On the micro-level, the life science innovation systems of Uppsala and Cambridge are analysed and compared. The industry survey is restricted to the industry structure. Development over time of employees, results and productivity is not described. On the macro-level, a full industry survey has been conducted for Sweden. There is no industry survey for Scotland and the UK due to data limitations; the system structure is also absent on the macro-level. This is because a full system structure for all macro-level innovation systems would have been very time consuming and it was reasoned that a detailed study could be limited to the sub-regional comparison. The strengths and weaknesses identified among the activities in the three macro-level systems are used as a basis for a macro-level comparison of Sweden-Scotland and Sweden-UK. Combined with the interconnectedness of the spatial levels, the macro and micro-level comparisons then form the desired basis for addressing the issues of the relative competitiveness of the Swedish life science innovation system and what there is to learn from the British way.

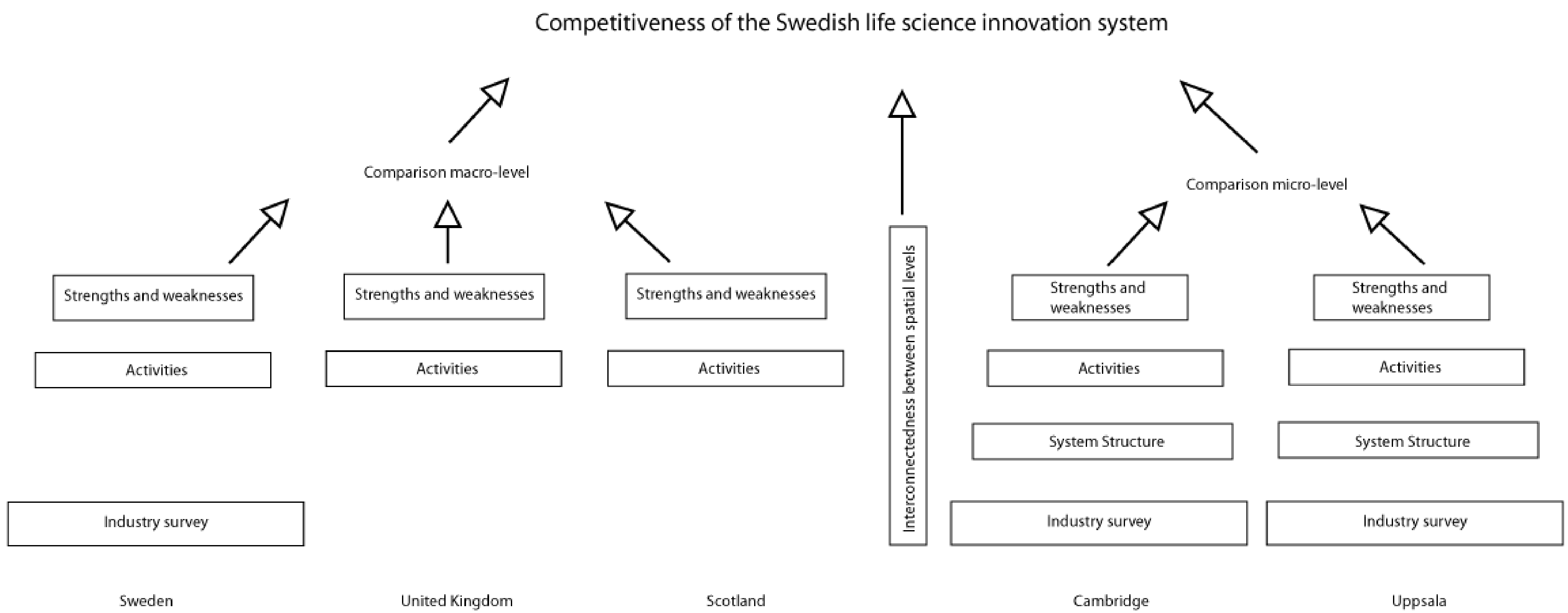

Figure 2.2. Approach model for innovation system comparison

3 The Swedish life science innovation system

3.1 Industry survey

This section outlines certain quantitative features of the life science sector and describes the overall industry structure. This provides a snapshot of the industry as at 2006 and shows the structure of the business segments that have been identified as jointly comprising the life science industry. The regional distributions and size of the individual companies are shown. Other features of interest in terms of getting a grip on the industry are the foreign ownership and results of the industry, positive and negative. There is then a description of the employment development of the industry and the different business segments which provides vital information on the performance of the industry. Naturally, the employment development is important in such a perspective, and the results have been used as starting point for a number of discussions later in the report. The development of production and relative results is also outlined and finally there is a discussion of the overall results. Firstly, the classification and scope of the industry are described followed by a description of the individual business segments. The industry survey presented here is from a previous report, entitled National and Regional Cluster profiles by Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi)[16]. The texts below are largely derived from this report and were written by Helena Bergqvist and Anna Sandström.

Today, life science is considered a critical foundation for long-term innovation and growth in the industry and societies of many countries. The life science industry is an important sector of industry which has economic and political significance in today's Swedish society. Up-to-date knowledge on the extent, structure and development of this industry is essential for sound policy decisions.

3.1.1 Classification and scope

The present study focuses on companies but does not account for other parts of the innovation system, such as the healthcare sector, public authorities, universities or other research organisations which are important players in the life science innovation system.

The overview presents different aspects of the Swedish life science industry and is based on the life science company database created and categorised by VINNOVA. Data has been compiled because the official NACE categories (usually used to classify companies by industry) cannot easily be

[16] VINNOVA VA 2007:16.

used for life science companies, as they are scattered among many categories. NACE categories can thus be used to identify some of the relevant companies and in the present study have been combined with other sources of information to obtain the total company population. It should be noted that there is a delay between registration of a new company and that company sending in its first annual report to the Swedish Companies Registration Office. Also, other changes due to mergers, acquisitions and liquidations appear with some delay in the statistics. The companies have been classified into different sectors, business segments and core activities. The sectors are defined as the medical technology sector, the biotechnology sector and the pharmaceutical sector and the companies are also further divided into business segments. The companies' activities are categorised as follows: manufacturing, consultancy, product development and research and development (R&D) as shown by figure 3.1.

Activity category

Broad research & development
Companies with exploratory research and development within a broad field of expertise or with several parallel development projects/product lines. Within some companies there is also sales and marketing activity and manufacturing.

Companies without products on the market are shown in a separate field. In this context, co-operative agreements and licensing providing revenue have also been counted as "products on the market".

Narrow research & development
Companies with exploratory research and development within a narrow field of expertise or concentrating on one development project/product line. Within some companies there is also sales and marketing activity and manufacturing.

Companies without products on the market are shown in a separate field. In this context, co-operative agreements and licensing providing revenue have also been counted as "products on the market".

Product development
Companies which principally develop their own products/services, i.e. incremental product development without elements of exploratory research.

Consultancy
Companies which principally carry out consultancy and commission activity. All CRO companies are included here.

Manufacturing
Manufacturing of biotech products, drugs or medicotechnical products. Including companies specialised in manufacturing but also the production units of integrated companies with more than 500 employees.

Figure 3.1 Companies are classified into the activity categories described.

The analysis includes cluster profiles, development of employment and the economic development. The cluster profile is based on the distribution of individual companies in sectors, the size of the companies in terms of employees, business segments, geographical location and activities. In addition, R&D-intensive companies are classified based on whether they have a product, service or licence on the market and are conducting broad or narrow R&D. The firm development describes how the number of employees has developed for the life science industry, including sectors and business segments over a ten-year period, 1997-2006. The economic development analysis investigates production in terms of net turnover per employee and value added per employee. The latter is described in order to indicate the contribution of the life science industry to the Swedish GDP. The development of relative results describes the results after financial items relative to the net turnover. Together, these three aspects: the cluster profiles, development of employment and economic development, aim to provide insights into the size, structure, development and performance of the Swedish life science industry between 1997 and 2006.

Each company has been individually categorised into both a business segment and what sector or sectors the company belongs to according to each company's main business. Companies with their main activity in business segments other than those listed below are not included in the study. Due to the definitions of the three sectors, there are companies whose activity can be categorised as belonging to more than one sector. For instance, there are many companies within drug discovery that could be defined as neither exclusively pharmaceutical nor exclusively biotech. Therefore, each company has been classified into one specific business segment, whereas there is an overlap between the three sectors. The characteristics of companies falling into the medical technology sector are that they develop medical products that are not drugs. The characteristics of companies falling into the pharmaceutical sector are that they develop drugs and various other kinds of therapeutic products or methods. The pharmaceutical sector also includes diagnostics. The biotechnology sector is characterised by companies developing the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services. In the sector categorisation of each individual company, the approach or method used to solve a problem or satisfy a customer or patient need was often crucial to this categorisation. Together, these three sectors constitute what is known as the life science industry. The business segments included in this study are described below. The sectors under which companies in a particular business segment may have been categorised are also indicated below. The OECD definition of biotechnology activities has been used to identify biotech companies.

Business segments

Drug discovery and development

Companies found in *Pharmaceuticals* and *Biotechnology*.
- Research and development of new drugs and therapies. Very few pharmaceutical companies develop new drugs without using biotechnological tools. However, not all companies have the development of biopharmaceuticals, i.e. drugs based on large biological molecules such as proteins, as their goal. Rather, the large biological molecules are targets for the drugs developed. The drugs are often small molecules produced by

organic chemical synthesis. In some cases, manufacturing, sales and marketing is also included in the individual company. The companies seek to develop new therapies to put on the market or licence to pharma companies generating up-front and milestone payments, royalties and possibly revenues from sales on divided markets, depending on the agreement.

Drug delivery

Companies found in *Pharmaceuticals* and *Biotechnology*.
- Companies in the drug delivery business segment are conducting research on how the active substances in medicines can be made to reach their target molecules in the body and how a satisfactory uptake of these substances can be ensured. Their clients are mainly biotech and pharma companies involved in drug discovery and development. An increasing business area includes developing new formulations for existing drug substances so that they can be used for new indications. Using existing substances reduces development time, as they have already passed the regulatory process for another indication. The field of nanobiotechnology is expected to generate new solutions on how to administer drugs more specifically. Polymer chemistry, nanotechnology and surface chemistry are examples of possible required expertise.

Biotech medical technology

Companies found in *Biotechnology* and *Medical technology*.
- Provides health services with that part of medical technology which has a biotech basis according to the OECD definition, including equipment and instruments for in-vitro fertilisation, cell cultivation, substitute plasma, blood management, plus the use of biodegradable biomaterials to replace or repair damaged tissue.

Diagnostics

Companies found in *Pharmaceuticals*, *Biotechnology* and/or *Medical technology*.
- The companies develop tools and techniques for diagnostics and most of their customers are healthcare sector, clinical laboratory analysis companies and end consumers for home use. In the company population in question, all biotechnology diagnostic companies, often developing antibody-based tests, also fall into the pharmaceutical classification. Medical technology diagnostic products can be technical appliances for measuring or visualising diagnostic results or in-vitro diagnostic tests. One difference compared to companies developing new drugs is that the process from concept to commercialisation of diagnostic products, processes and services is usually shorter.

CRO companies

Companies found in *Pharmaceuticals* and/or *Biotechnology*.

- CRO (Contract Research Organisation) companies include clinical research organisations dealing with products and services for assisting other companies in clinical trials and regulatory processes. Clinical research organisations need to be familiar with international regulations and regulatory bodies as well as having well-developed contacts in clinical research, hospitals and authorities. Some CROs have developed a technological platform or analysis system that is managed within the company and accessible to companies in the pharmaceuticals and/or biotechnology sectors by contract research.

Drug production (not biotech)
Companies found in *Pharmaceuticals.*
- Companies specialising in drug production and without their own research operations are included in this business segment. The use of biotechnology in the manufacturing of drugs is not included. Rather, those companies are found in the Bioproduction category. Important issues include development of cost-effective process and production technology as well as regulatory requirements.

Biotech tools and supplies
Companies found in *Biotechnology*.
- The companies develop products and services for use in production, processes, research and development. This includes equipment for bioseparation, biosensors, biomolecular analyses and bioinformatics. Their customers mainly consist of other biotechnology companies, the pharmaceutical and medical technology sector and university research teams but also other industries basing their products on biological raw materials, for instance in the food, forestry and agricultural sectors. Their expertise lies in the application of interdisciplinary expertise combining technologies such as electronics, ICT, mechanics, optics and materials engineering with life science to develop their products and services.

Bioproduction (healthcare related)
Companies found in *Biotechnology* and *Pharmaceuticals.*
- Biotech production of drugs, biomolecules, cells or microorganisms for use in healthcare related products such as diagnostics and pharmaceuticals. These are specialist manufacturing companies whose clients include the pharmaceutical sector, other biotech companies or research groups. The biomolecules are often enzymes or antibodies. The companies’ core expertise is development of cost-effective production solutions - adapting their activity to internationally stipulated regulatory requirements on quality and safety, plus an ability to adapt to customer requirements.

Agricultural biotechnology
Companies found in *Biotechnology*.
- Plant-related products. Plant or tree breeding utilising biotech methods as tools in the cultivation work. However, few companies use gene technology

as a method for obtaining specific properties in the end products (genetic modification). Also included is plant protection based on naturally occurring microorganisms or biomolecules as well as the processing of land-based raw materials with the aid of biotechnology. Companies working with genetic modification for agricultural purposes need to be aware of, and have a strategy for addressing, attitudes in society regarding the use of gene technology in plant cultivation.

Environmental biotechnology

Companies found in *Biotechnology.*

- Biotech solutions to environmental issues such as water purification, land decontamination (bioremediation) and waste management, and laboratory analysis. Their customers include municipalities, construction companies, and industries requiring purification of water used in manufacturing processes. Companies within this field have very diverse focuses and it is therefore difficult to highlight a common core expertise. Some of these companies use non-pathogenic, naturally occurring microorganisms and the laboratory analysis companies develop specific testing methods and analytical measurement tools, to measure toxic substances for instance. However, biosensors are included in the Biotech tools and supplies business segment.

Food-related biotechnology

Companies found in *Biotechnology.*

- The products of companies in the field of food-related biotechnology include biotechnically-produced components or ingredients for the development of foods with positive health benefits, e.g. probiotics. The term functional food denotes a product with a documented, well-defined, product specific diet-health relationship. The aim of these products is to reduce the risk of developing diseases rather than cure them.

Industrial biotechnology

Companies found in *Biotechnology.*

- Process development of biotechnology applied to industrial processes for large-scale biotechnological production, e.g. designing an organism to produce a useful chemical or using enzymes as industrial catalysts to produce valuable chemicals. Industrial biotechnology solutions tend to consume fewer resources than traditional processes used to produce industrial goods. The forest, pulp and paper industry and the food industry has not been included since the core competence in those companies is not biotechnology even if the technology is used to some extent.

Healthcare equipment

Companies found in *Medical technology.*

- Companies producing fittings and furniture for health services such as lighting, patient lifts, examination couches and treatment tables. To be included, their major business must be products for the healthcare sector.

The companies are often manufacturing companies with an understanding of needs within the healthcare sector.

Active and non-active implantable devices

Companies found in *Medical technology*.

- Companies producing fittings and furniture for health services such as lighting, patient lifts, examination couches and treatment tables. To be included, their major business must be products for the healthcare sector. These are often manufacturing companies with an understanding of needs within the healthcare sector.

Anaesthetic/Respiratory Equipment

Companies found in *Medical technology*.

- Development of anaesthetic equipment and solutions for supervision or control of respiration. The products are mainly used for critically ill patients i.e. within the intensive care unit (respiratory equipment) and in the operating theatre (anaesthetic and/or respiratory equipment). Anaesthetics may be delivered to the patient intravenously or by inhalation. Products are developed in a combination of medical expertise, including the anaesthetic properties of different gases, various engineering fields such as mechanics and electronics for pneumatic systems, valves and sensor technology, and computer programming for monitoring and control systems.

Dental devices

Companies found in *Medical technology*.

- Development of instruments and technical appliances used by dentists. It includes the development of dental implants and screws and the manufacture of disposables and supplies for use in dental clinics. Dental laboratories on the other hand, are not included.

Electromedical and imaging equipment

Companies found in *Medical technology*.

- Technical equipment used for patient care and supervision or visualising of conditions. This business segment includes a broad range of products used in many medical fields such as magnetic resonance imaging, computed tomography, positron emission tomography and dialysis equipment. Many companies are large with diversified business and may also develop products which fall into other business segments. The companies identified require technical as well as medical expertise, in such fields as radiotherapy, haematology, cardiology, dialysis and oncology.

Ophthalmic devices

Companies found in *Medical technology*.

- Companies dedicated to surgery or medical appliances within the field of ophthalmology. The required expertise ranges from ophthalmic surgical technology like cataract surgery. Products include laser vision products, cataract products and computer software for imaging the inside of the eye. The latter may be used for diagnosing eye conditions.

Surgical instruments and supplies for electromedical and imaging applications

Companies found in *Medical technology*.
- Includes instruments and tools used in patient care or surgery, and accessories for electromedical and imaging equipment. This business segment includes companies developing products that may facilitate different medical procedures, i.e. scalpels, forceps, dissectors and clamps. The required expertise ranges from production of instruments to knowledge within the different surgical fields. There are also companies developing products connected to surgery, such as hypothermia products.

Medical disposables

Companies found in *Medical technology*.
- Disposable products used in patient care, such as dosage cups, hypodermic needles, sponges, contrast agents, wound care products etc. Some of the products can be used in research and at clinical laboratories. These companies are often manufacturing companies. Knowledge of industrial processes, sterilisation techniques and material chemistry is important. Some companies are characterised by a knowledge wound healing processes and optimum wound-care conditions.

CRO medtech

Companies found in *Medical technology*.
- Medical technology contract research organisations provide services for development, manufacturing and quality control of medical technology products. They often develop software or IT solutions for problems arising within the medical technology sector or provide expertise in developing medical products and devices. However, instead of selling a product, they provide a service based on their technical platform or other expertise. The expertise of some companies includes knowledge about regulatory requirements and how to achieve market approval.

IT and training

Companies found in *Medical technology*.
- Companies developing software and IT solutions for patient care or supervision etc. Also included is training software for patients and personnel in the healthcare sector. The products often facilitate the handling and integration of large volumes of information or provide analytical tools for clinicians that could function as diagnostic support.

The companies are also categorised into different activities, according to the scheme below[17].

3.1.2 Industry structure

Results

Overall industry structure

The overall industry structure is shown in figure 3.2. The total number of companies active in research and development, product development, consulting or manufacturing within the included business segments of biotechnology, pharmaceuticals and medical technology in Sweden is approximately 620 with a total of almost 34,500 employees. This does not include companies focusing on marketing and sales. Those companies have over 7,200 employees distributed among some 210 companies. This gives a total size of the industry of some 830 companies and 41,700 employees. There are also many companies with no employees which have not been included in the figures of this chapter and which are still active, according to Swedish Companies Registration Office. One business segment not included is laboratory equipment not specifically designed for use in the biotechnology, pharmaceuticals or medical technology sectors. If this was also included, the total number of employees and number of companies would be approximately 42,400 and 850 respectively. Research-intensive companies and manufacturing companies far outnumber the companies in other activities and jointly make up more than 80% of all included life science companies. Among the companies with broad R&D, the vast majority have a product or licence on the market. Companies with narrow R&D have a product or licence on the market to a much lesser extent. There are some cases of very small companies conducting broad R&D. The information obtained during the categorisation process implies that they often collaborate with a university or are spin-offs from university departments. It should be kept in mind that the business segments add up to the total number of employees whereas the three different sectors do not. This is because there are overlaps between the sectors.

[17] Bergqvist H., Dolk T., Sandström A., 2007, page 11

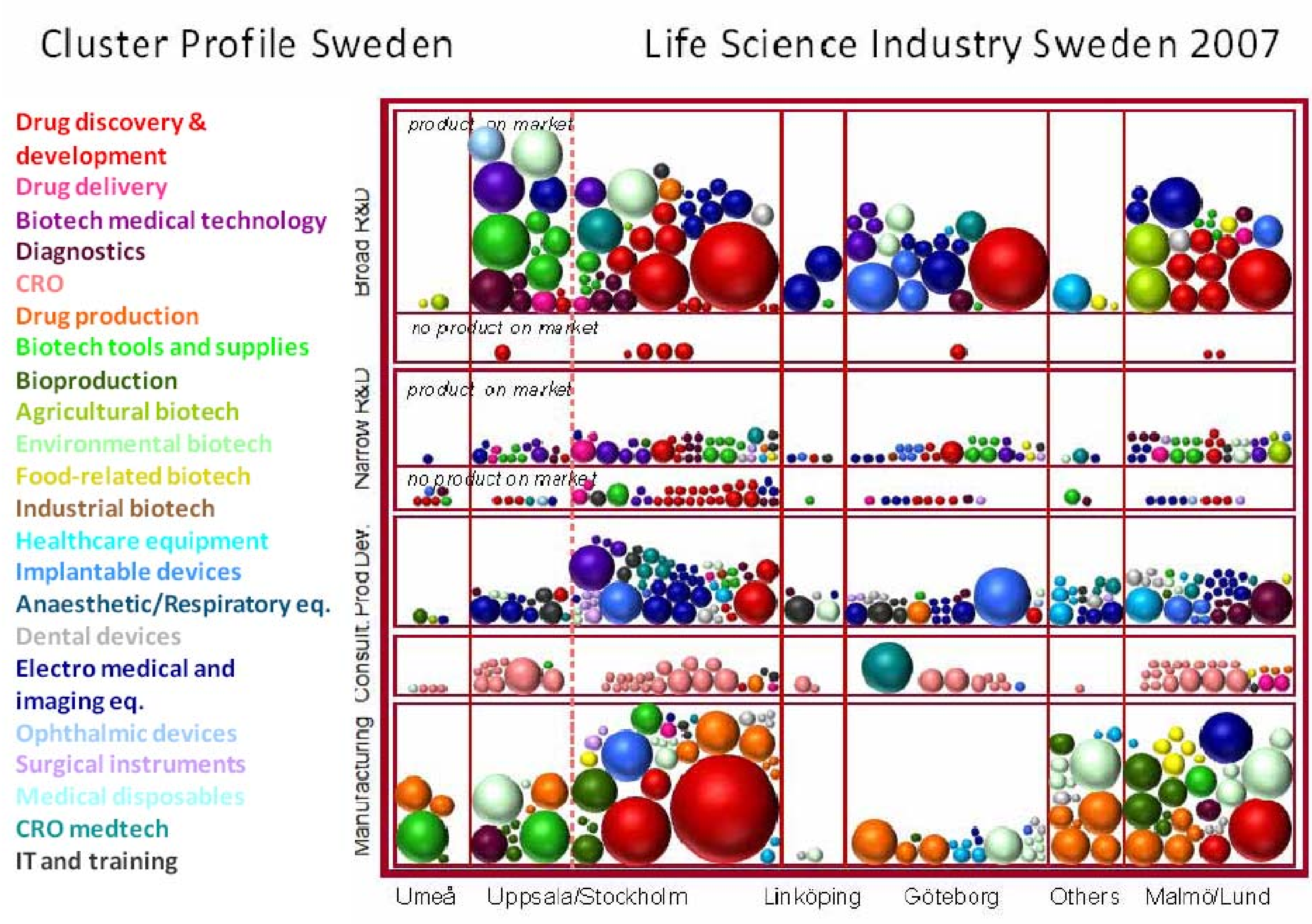

Figure 3.2. Life science industry Sweden 2006/ National and Regional Cluster Profiles, Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi), 2007.

Parent company nationality
Figures 3.3 and 3.4 show the parent company nationality. Foreign-owned (in terms of parent company nationality) life science companies are often large companies active within broad R&D or manufacturing. Almost without exception, they are companies that have managed to put a product on the market. Companies with narrow R&D, with or without products on the market, are unlikely to be foreign-owned. The consultancy sector is also underrepresented among the foreign-owned companies. There is a similar distribution between the different sectors in regard to foreign ownership among the companies. Companies with non-majority foreign ownership are not included in the foreign-owned companies. Foreign-owned pharmaceutical companies are often US-owned, Swiss or British. There are also several Dutch-owned companies, such as Qpharma and Polypeptides laboratories, plus Danish-owned Novozymes Biopharma AB and NeuroSearch Sweden AB. In terms of number of employees, British ownership dominates due to AstraZeneca.

Among the foreign-owned biotech companies, parent companies from the US are well-represented; the largest are GE Healthcare Biosciences AB and Pfizer Health AB. Parent companies in the Netherlands own DSM AntiInfectives Sweden AB, EuroDiagnostica and LTP Lipid Technologies Provider AB. Parent companies in Switzerland own Syngenta Seeds AB and Ferring AB. Most of the foreign-owned medical technology companies are owned by parent companies from the US. They are often medium-sized (50-249 employees) or large companies (>249), like Cederroth International AB, Becton Dickinson Infusion Therapy AB, St. Jude Medical AB, Advanced Medical Optics Uppsala AB, GE Medical Systems Sverige AB. The largest British-owned companies are Astra Tech AB and PaperPak Sweden AB. Luxemburg is also relatively well-represented, which is not the case for the other two sectors. The largest Luxemburg-owned companies are Phadia, Allergon and Ascendia MedTech AB.

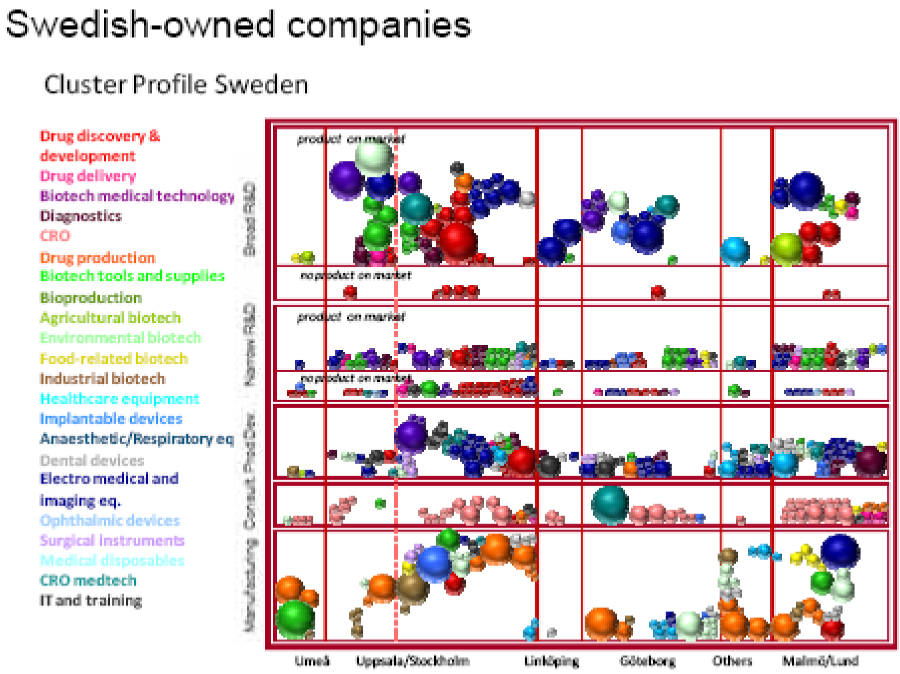

Figure 3.3. Parent company nationality: Swedish-owned companies

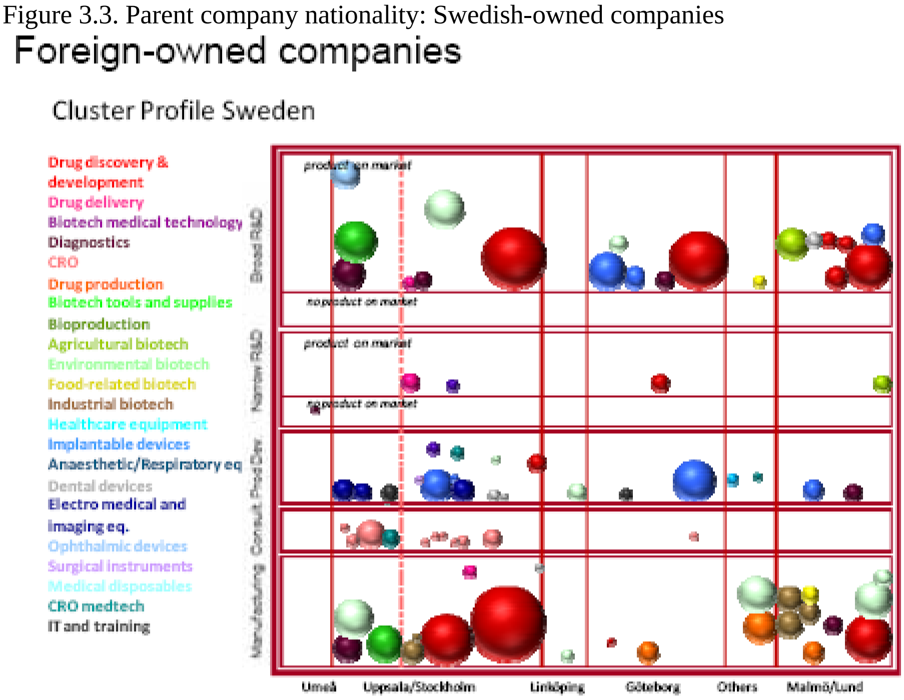

Figure 3.4. Parent company nationality: Foreign-owned companies

Positive and negative results

The companies with positive results after financial items in 2006 are shown in figure 3.5. The large companies are overrepresented among those with positive results. Companies that conduct broad R&D also mainly show positive results. Within the group of companies with a product on the market, the companies that conduct broad R&D have predominantly positive figures whereas those that conduct narrow R&D are mainly on the negative side. Manufacturing companies mostly show positive results. Companies with zero results appear in the above ball-diagram of companies with positive business results.

The companies with negative results after financial items are shown in figure 3.6. The small companies are overrepresented among the companies with negative results. Small drug discovery companies often show negative results. Of the companies that conduct narrow R&D, more show negative results in comparison to those that conduct broad R&D. Many of the consultancy companies show negative results. Also, many recently started small companies number among those with negative results.

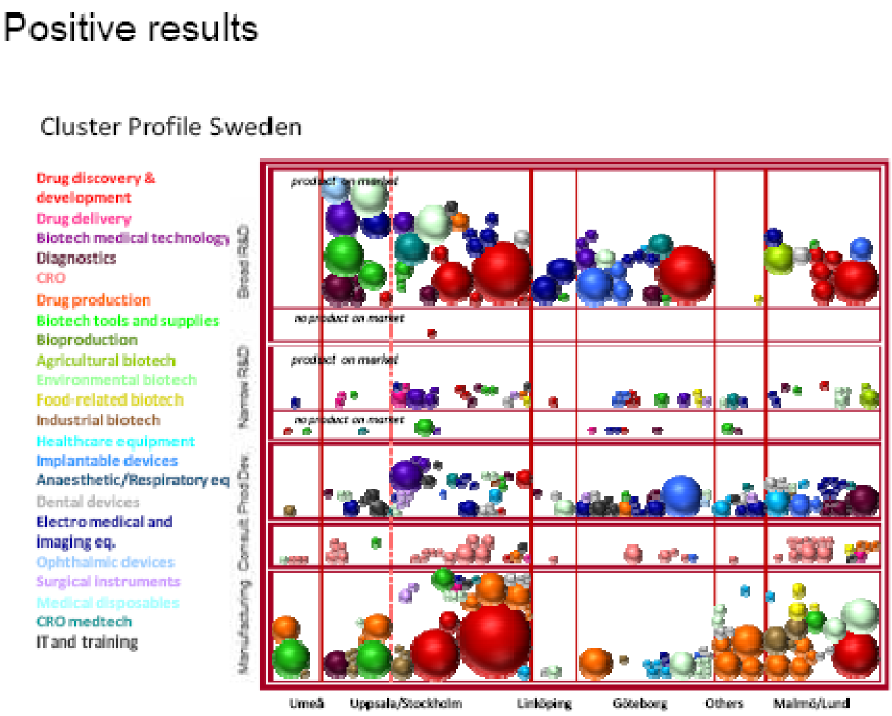

Figure 3.5. Cluster profile Sweden; only companies that had positive results in 2006[18]

[18] National and Regional Cluster Profiles, Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi), 2007.

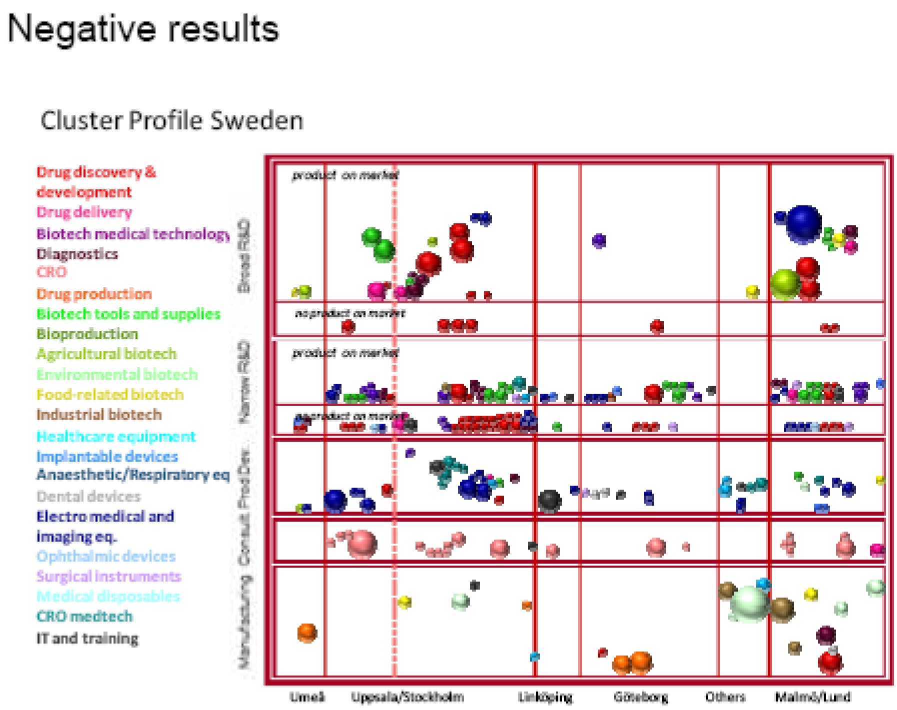

Figure 3.6. Cluster profile Sweden; only companies that had negative results in 2006.[19]

Discussion of results in industry structure

The results from the industry structure show that life science is still a very important industry for Sweden in a socioeconomic perspective since it employs so many people. It is also interesting to note that there are several sectors or activities connected to life science; this adds to the socioeconomic importance in terms of employees. One striking feature of the industry structure is the very large number of very small companies. These were given special attention in the data management and will be further discussed under employment development.

The socioeconomic benefit to society does not solely lie in the employment provided by an industry. Naturally, it is also important that the industry shows positive results. Among the research companies, this in turn is largely determined by whether the company has a product on the market or not. The results show how important it is to society for companies to develop beyond the early stages and ultimately reach the market. Also noteworthy is the fact that among the largest companies, many are foreign-owned. An evident risk of foreign ownership is that new investments and localisation decisions might not turn out to Sweden's advantage since the link with Sweden might

[19] National and Regional Cluster Profiles, Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi), 2007.

be weakened. On the other hand, attracting capital to Swedish industry from abroad is highly beneficial for the industry in several ways.

Life science is a heterogeneous sector, as shown by the classification used. Many companies overlap different business segments and there is an increasingly diffuse border between the pharmaceutical and biotechnology sectors. This is largely due to the biotech methods used in pharmaceutical research and biotech companies involved in drug discovery or other research fields formerly associated with pharmacology.

3.1.3 Employment development

Results

Growth of the sectors and business segments over the periods 1997-2006 and 2003-2006.

The collection of data to build the company database was initiated in 1997 for the biotechnology sector and in 2003 for the medical technology and pharmaceutical sectors. The 1997-2003 result of the two latter sectors as well as the data from the total life science industry over the period 1997-2003 should therefore be interpreted with caution since one underlying factor of the growth is that the firm population for 1997-2003 may be incomplete. Thus, an unknown share of the increase of over 80% for the medical technology sector is likely due to the absence from the database of companies with medical technology activities before 2003. The error is likely to be smaller for the pharmaceutical sector since many of the smaller companies are also found in the biotechnology sector; these were included in the 1997 biotechnology database, as were the major players like Astra and Pharmacia. With this in mind, however, all three sectors have grown since 1997, as shown in figure 3.7. The life science industry as a whole has grown by more than 10,000 employees over the ten-year period 1997-2006. Small and medium-sized companies (SMEs) are primarily responsible for this growth. Excluding companies larger than 500 employees, the SMEs still stand behind the vast majority of the increase in terms of employees. One explanation for this is that although some large companies have increased in terms of employees, others have seen major declines. The R&D-intensive companies, large companies included, also make up the vast majority of the increase in terms of employees, meaning that predominantly R&D-intensive companies are responsible for the large increase in the entire life science industry. However, over the period 2003-2006, the life science sector has remained practically unchanged in terms of employment. The medical technology and biotechnology sectors have declined, whereas the pharmaceutical sector has increased. The non-R&D-intensive biotech companies show a decline of 20.5% whilst the R&D-intensive companies have increased by 2.7%. The R&D-intensive medical technology companies also declined slightly, whereas the non-R&D-intensive companies increased by 3.4%.

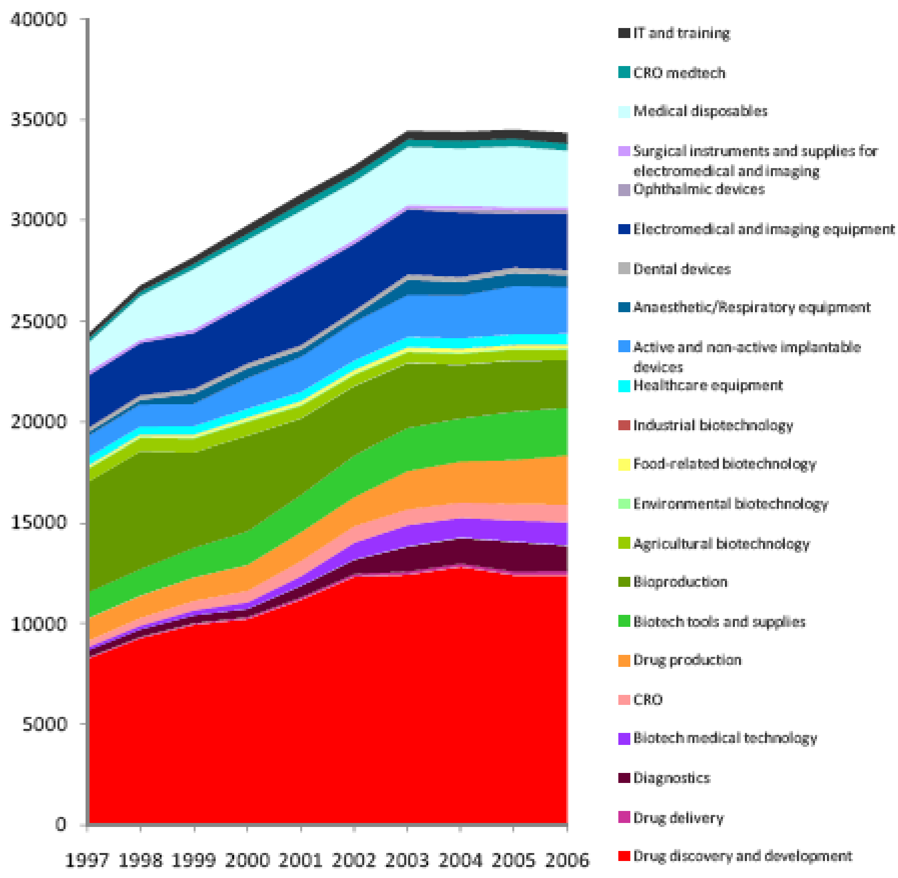

Figure 3.7. Employment development of the life science industry.[20]

Another way of analysing the expansion is to focus on the companies that have grown and show their characteristics. It turns out that over the ten-year period, the population of growing companies has increased by over 100% overall. In the group of growing companies, R&D-intensive companies are responsible for 64% of the increase. It should be noted that among the companies having more employees in 2006 than they did in 1997, many have decreased their number of employees since 2003.

Decline

Over the ten-year period, about 80 companies ceased to have employees (according to what was known in 2007). However, the majority of these companies are still registered with the Swedish Companies Registration Office. Fifteen companies have gone through liquidation or bankruptcy, including Melacure, UmanGenomics and Virtual Genetics Laboratory. About 20 companies have merged with, or been acquired by other companies, such as Bioglan (W.Sonesson) and Cresco Ti Systems AB (Astra Tech) in 2002, Neopharma (Solvay Pharmaceuticals AB) in 2004,

[20] Bergqvist H., Dolk T., Sandström A., 2007.

Carmetec AB (NNE) and Arexis (Biovitrum) in 2005, Pfizer Consumer Healthcare (Mc Neil) and Biacore (GE Healthcare Biosciences) in 2006 and recently Biolipox (Orexo). Medscand Medical AB moved its entire business to the US in 2005. In 2003, Siemens-Elema ceased to exist. One division was moved to the US, another merged with Dräger and moved to Germany, and still another was sold to the Getinge group (Maquet Critical Care), which still has 360 employees in Sweden. Most of the companies which ceased having employees during the period were firms with fewer than ten employees. Compared to biotechnology and pharmaceutical companies, medical technology companies are underrepresented in relative terms among those that are disappearing. The pharmaceutical companies are overrepresented among the disappearances and the business segments of drug discovery and development and diagnostics have the highest relative shares of disappearances on a business segment level. Several business segments within medical technology have relatively low disappearance rates; for instance, aids for disabled people, electromedical and imaging equipment and medical disposables. Among the biotechnology business segments, biotech tools and supplies have a relatively low disappearance rate.

Turning to the activities of the disappearing companies, manufacturing and consulting are underrepresented whereas R&D is overrepresented. Apart from companies disappearing from the population of companies with employees, there are about 70 companies that have decreased their number of employees over the period 1997-2006, half being medium-sized companies. Characteristic of the latter group is that the R&D-intensive companies are underrepresented relative to their share of the total population. The decreasing medium-sized companies also showed a spike in the number of employees in 2002.

Stagnation

Among the very small life science companies with 1-5 employees, the expansion in terms of number of employees is quite low, as it is among those established several years ago. The vast majority of very small life science companies that were over six years old and held 1-5 employees during the 1997-2000 periods had not grown over eight employees in 2006.

Discussion of results in the employment development

The results from the employment development are interesting. If one chooses to talk about success stories, the 1997-2006 development is encouraging. However, this would give a simplified picture of the development. At the end of the 90s and very beginning of the new century, the Swedish life science industry showed itself to have strong growth potential. Since 2003, the expansion was replaced by stagnation, and for some business segments there has been a decline. It is therefore very important when conclusions are drawn that the different results generated from the various periods under consideration are highlighted.

In 2002, there was a decline in the overall state of the market. As will be shown in a subsequent section, this was reflected in the development of relative results. At least, there was a sharp decline in the result measure chosen which coincided with the recession. The 2002 dip seemed to have affected employment development with a year’s delay. In 2003, the expansion of the industry stagnated and many companies were found to peak in 2002 in terms of employees, but decreased thereafter.

The results show that the increase for the industry over the period 1997-2006 is predominantly explained by an increase in SMEs. The R&D-intensive companies also underpin this increase. Policy implications to derive from these results might be that efforts to support R&D in existing companies are very important and also that there seems to be a strong connection between growth in terms of employees and research, particularly for SMEs.

It is important to understand why so many very small companies have not increased in terms of employees. There are also many companies that have ceased to have employees but remain registered. In addition, companies that have never had any employees are not included in the study. Only those that had at least one employee for at least one year in the period 1997-2006 have been included. Jointly, these companies comprise an interesting population for further studies on growth constraints.

3.1.4 Development of production and relative results 1997-2006

Results

In order to understand the economic development of a highly research-intensive and dynamic industry, it is interesting to trace the production and relative results development for the life science industry in the ten years 1997-2006. The production development is described as net turnover per employee, as well as productivity (value added per employee) and value added. The latter is described in order to indicate the life science industry’s contribution to Swedish GDP. The development of relative results is defined as results after financial items divided by net turnover. Items affecting comparability have been addressed and are subtracted from the results after financial items, thus generating a relative results ratio linked to the core activity. The chosen business ratios show the development of the entire life science industry as that industry’s three sectors: pharmaceuticals, biotechnology and medical technology. Since the number of companies increases over the period, the net turnover of the different sub-sets of the life science population has also been calculated in relation to the total number of employees of that particular subset. Table 3.1 explains how the business ratios are defined and how they were generated.

Table 3.1 The business ratios used

Terminology used	Calculated according to:
Relative result	Σ (results after financial posts - items affecting comparability)/Σnet turnover
Net turnover / employee	Σ deflated net turnover / Σ employee
Value added	Σ deflated value added in absolute terms
Productivity	Σ deflated value added / Σ employee
ITPI (Price index for domestic supply)	1997 = 100
Medical technology sector	ITPI for medical, surgical and orthopeadic equipment, directly derived from Bolagsverket
The biotechnology and the pharmaceutical sector	ITPI for drugs and other pharmaceutical products, directly derived from Bolagsverket
The life science industry	$\left(\frac{\sum_{\text{Med tech companies}}^{\text{Net turnover all}}}{\sum_{\text{Life science companies}}^{\text{Net turnover all}}} * \text{ITPI Medical products}\right) + \left(\frac{\sum_{\text{Med tech companies}}^{\text{Net turnover all non}}}{\sum_{\text{Life science companies}}^{\text{Net turnover all}}} * \text{ITPI Pharma products}\right)$
Σ	All companies within the group of companies considered
Additional terminology used	**Definitions**
Financial posts	Revenue from interest - costs of interest = net interest income
	Dividend
	Capital gain
Items affecting comparability	Occurrences and transactions that are not extraordinary but may cause a problem when comparing different accounting periods. For instance, selling fixed capital assets.

The net turnover value of each company and year has been deflated. The biotechnology and pharmaceutical sector was deflated by ITPI (Price index for domestic supply) for drugs and other pharmaceutical products and the medical technology sector was deflated by ITPI for medical, surgical and orthopaedic products. A weighted average of these ITPI deflators was used for the different life science industry sub-sets. This was weighted according to the relative volumes of medical and non-medical technology companies, relative to the total volume. Deflating the values enables the effect of pricing inflation to be taken into account. Increased product quality could also be a reason for increased prices, but this has not been taken into account. The figures illustrating the chosen business ratios follow in order of relative results (figure 3.8), net turnover per employee (figure 3.9), productivity and value added (figure 3.10). The text, on the other hand, describes each sector starting with the entire life science industry followed by the biotechnology, pharmaceutical and medical technology sectors.

The life science industry

The development of the relative results (results after financial items relative to net turnover) of the life science industry has had a bumpy ride since 1997. There are three distinct peaks in the relative results development. Over the ten-year period, the relative results of the life science industry range from 10% to 60%. The relative results are lower when larger companies are excluded. 2002 was generally recognised as a bad year on the stock market. This is also the case for the life science industry, particularly for SMEs. The development for SMEs turned around and peaked in 2004 whereas, if larger companies are included, the peak occurred in 2005. Including larger companies, the R&D-intensive companies have higher levels of relative results than non- R&D-intensive companies. However, the situation is reversed for the SMEs, which show negative results until 2003, with a large dip in 2002. In both populations, the fluctuations are significantly higher for R&D-intensive companies. The net turnover per employee has increased over the ten-year period. The 2002 decline also appears in this data. The SMEs had a lower increase until a few years ago. The R&D-intensive life science companies show a clear positive trend, whereas the non-R&D-intensive companies have more or less stagnated over the same period. Initially, in 1997, the R&D-intensive companies had much lower levels of net turnover per employee, but are now far ahead of the non-R&D-intensive companies. The former group has had a strong development particularly in recent years. The SMEs also show this kind of pattern. R&D-intensive companies started off at lower levels in 1997 than the non-R&D-intensive companies but caught up to almost the same level in 2006. The value added in absolute terms increased strongly over the period. This is also the case for productivity, indicating that the increase is not only a consequence of sector growth in terms of number of companies and employees. R&D-intensive companies show the strongest increase both in absolute and relative terms. Based on the productivity values for 1997-2006, an estimated average growth of productivity has been derived for the ten-year period and reaches almost 9%. For the entire life science industry, this value can be compared to the estimated average growth of all industries, 6.5%. When calculating the ratio of value added in absolute terms for the life science industry relative to the GDP of all industries, this ratio is shown to have increased over the ten-year period, from approx. 10% to almost 25%. Thus, the development of the life science industry in terms of productivity turned out to be significantly stronger than for all industries in Sweden.

The biotechnology sector

The biotechnology sector is associated with volatility, at least on the stock market, which is in accordance with the fluctuations of the relative results of the biotech SMEs. The fluctuations of both medical technology and pharmaceutical SMEs are lower. Including larger companies, the relative results fluctuate moderately and the biotechnology sector shows a slightly increasing trend over the ten-year period. However, it is important to note that a decline has occurred since 2004. In 2006, there was only a weak increase compared to 2005. Nevertheless, biotech SMEs have had a substantial increase since 2005, but nowhere near *their* record year of 2003. The R&D-intensive SMEs fell to their lowest level of the ten-year period in 2002, coinciding with the stock market’s lowest quotation for the biotechnology sector. The non-R&D-intensive SMEs were also affected but have shown positive relative results for most of the period. Including larger companies, the R&D-intensive biotech companies have grown to the same level of relative results as in 2003, constituting an exception to the other biotech sub-sets mentioned. However, the level of relative results for non-R&D-intensive biotech companies is significantly higher. The net turnover per employee has increased since 1997. There was a peak in 2001 and a trough in 2003. The 2006 value exceeds the peak value. The R&D-intensive companies have not quite fully recovered to the 2001 peak value, whereas the non-R&D-intensive companies are far ahead of their highest peak value, which occurred in 2002 and was followed by a sharp decline in 2003. The R&D-intensive companies show a stronger increase over the ten-year period than the non-R&D-intensive companies. The value added in absolute terms for the biotechnology sector has increased sequentially, with a peak in 2001 followed by a dip in 2002. The curve seems to level off from 2005. This is also the case for productivity. In terms of value added in absolute terms, the R&D-intensive companies have caught up with the non-R&D-intensive companies in recent years. This is not the case for productivity.

The pharmaceutical sector

The development of the relative results of the pharmaceutical sector is strongly consistent with that of the entire life science sector, both in terms of the level of relative results and in time, when larger companies are included. This is due to the large impact of AstraZeneca. When considering the diagrams, it should be kept in mind that AstraZeneca has been categorised as an R&D-intensive company in this material. Turning to the SMEs, the pharmaceutical sector mainly presents negative results over the ten-year period. Just like the corresponding biotechnology population, they are largely overlapping company populations. The relative results of pharmaceutical SMEs fell drastically in 2002. Over the period 2002-2006, both the R&D-intensive and non-R&D-intensive SME populations have increased. Including larger companies, there is a decline between 2005 and 2006 irrespective of R&D intensity, but all relative results are positive. The pharmaceutical sector shows a strong development of net turnover per employee out of the three sectors considered. There was a trough in 2002 but in recent years all the sectors have grown considerably in terms of net turnover per employee, reaching their highest level over the ten-year period in 2006. When the larger companies are excluded, the levels over the period are slightly lower and the increase not as strong as when they are included. The R&D-intensive companies have had a stronger development than the non-R&D-intensive companies, as did the biotechnology sector. The 2006 value of the R&D-intensive companies is higher than the corresponding value of the non-R&D-intensive companies. However, the SMEs have developed differently. The overall development has been upwards but, turning to the R&D-intensive companies, their values were higher at the beginning of the period. The value added for AstraZeneca in 2000 has been exchanged for an average of the preceding and following years due to a major deviation in the value added that year compared to the other years. This also applies to the pharmaceutical sector and R&D-intensive companies. The pharmaceutical sector has had the largest increase in productivity among the three sectors. Both value added and productivity show a stronger increase for R&D-intensive companies than the non-R&D-intensive companies. In recent years, the value added in absolute terms and the value added per employee has shown a particularly strong development for R&D-intensive companies whilst both measures have declined for non-R&D-intensive companies.

The medical technology sector

Compared to the pharmaceutical and biotechnology sectors, the medical technology sector fluctuates less and has had positive relative results. This is regardless of what sub-set of companies one chooses to look at in terms of R&D intensity and size of companies included. The medical technology sector shows higher results for R&D-intensive companies than non-R&D-intensive ones. This holds true both for SMEs and when larger companies are included. Like the pharmaceutical sector, this sector is characterised by a few larger companies such as the Getinge group, Phadia, Astra Tech, Gambro and Elekta. However, the development of SMEs strongly resembles that of the entire medical technology sector. One important exception is the results after financial items for Gambro in 2000, which had such a large impact on the overall result in that particular year it was excluded from the data. The net turnover of the medical technology sector compared to the other sectors has been high since 1997. The trough in 2003 has been more than recovered. It is interesting to note that the R&D-intensive companies had lower levels of net turnover per employee than non-R&D-intensive companies at the beginning of the period and that at the end of the period, the situation was reversed. Both the value added in absolute terms and the productivity for medical technology are lower overall than for the other two sectors and the increase has not been quite as strong. The R&D-intensive and non-R&D-intensive companies started out on the same levels in 1997. The R&D-intensive companies are now significantly ahead.

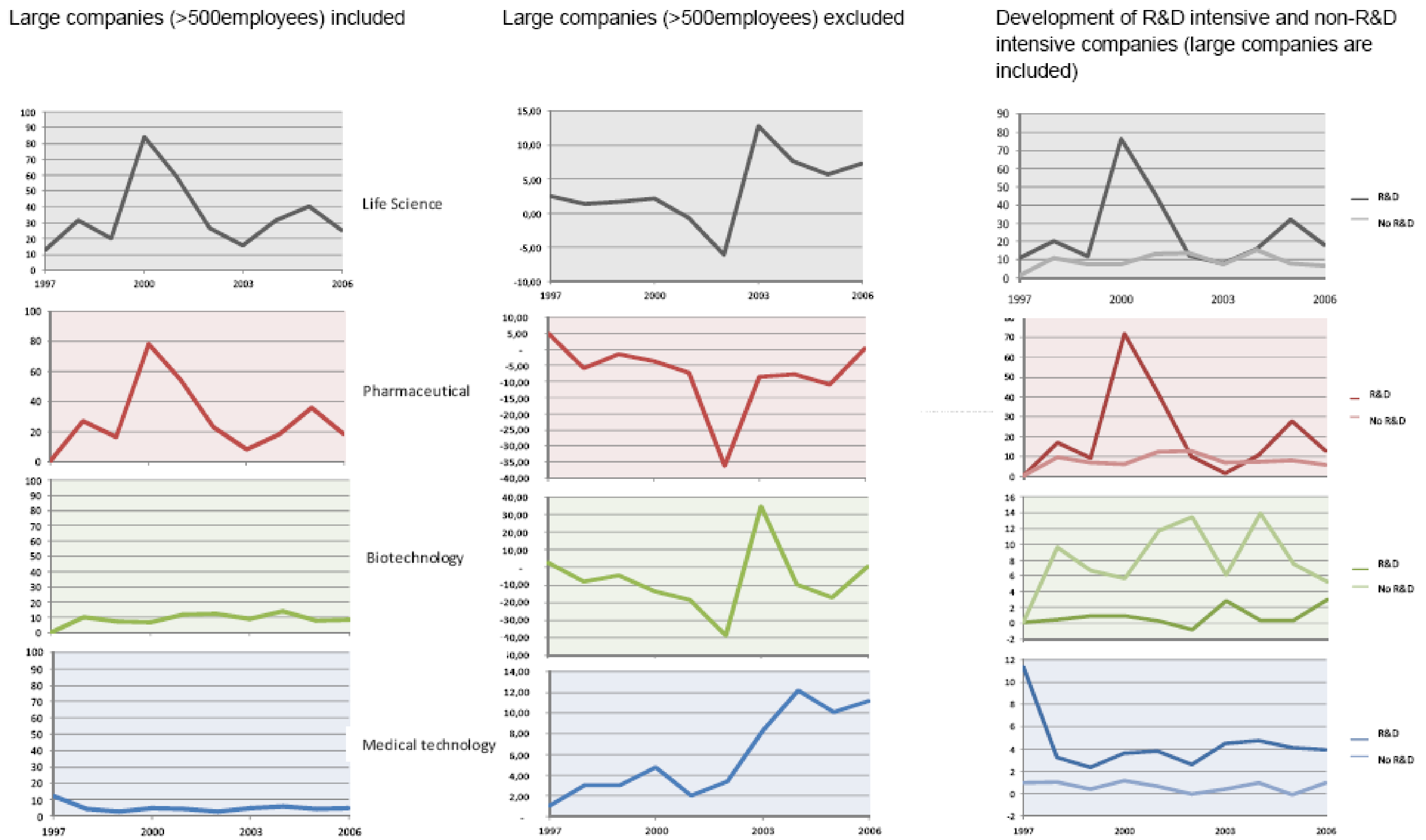

Figure 3.8. Relative results (%) / National and Regional Cluster Profiles, Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi), 2007.

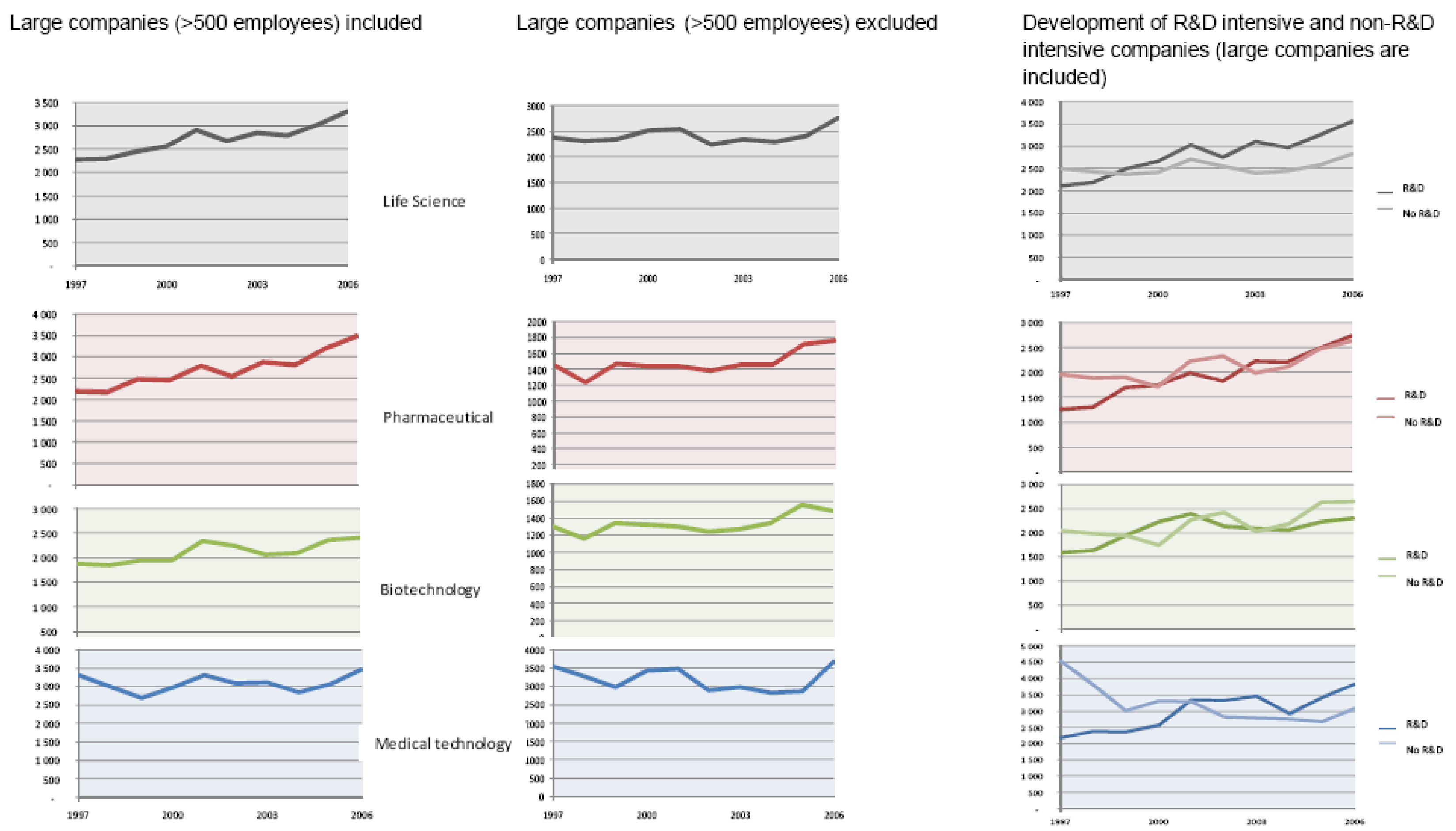

Figure 3.9. Net turnover per employee (SEK k)/ / National and Regional Cluster Profiles, Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi), 2007.

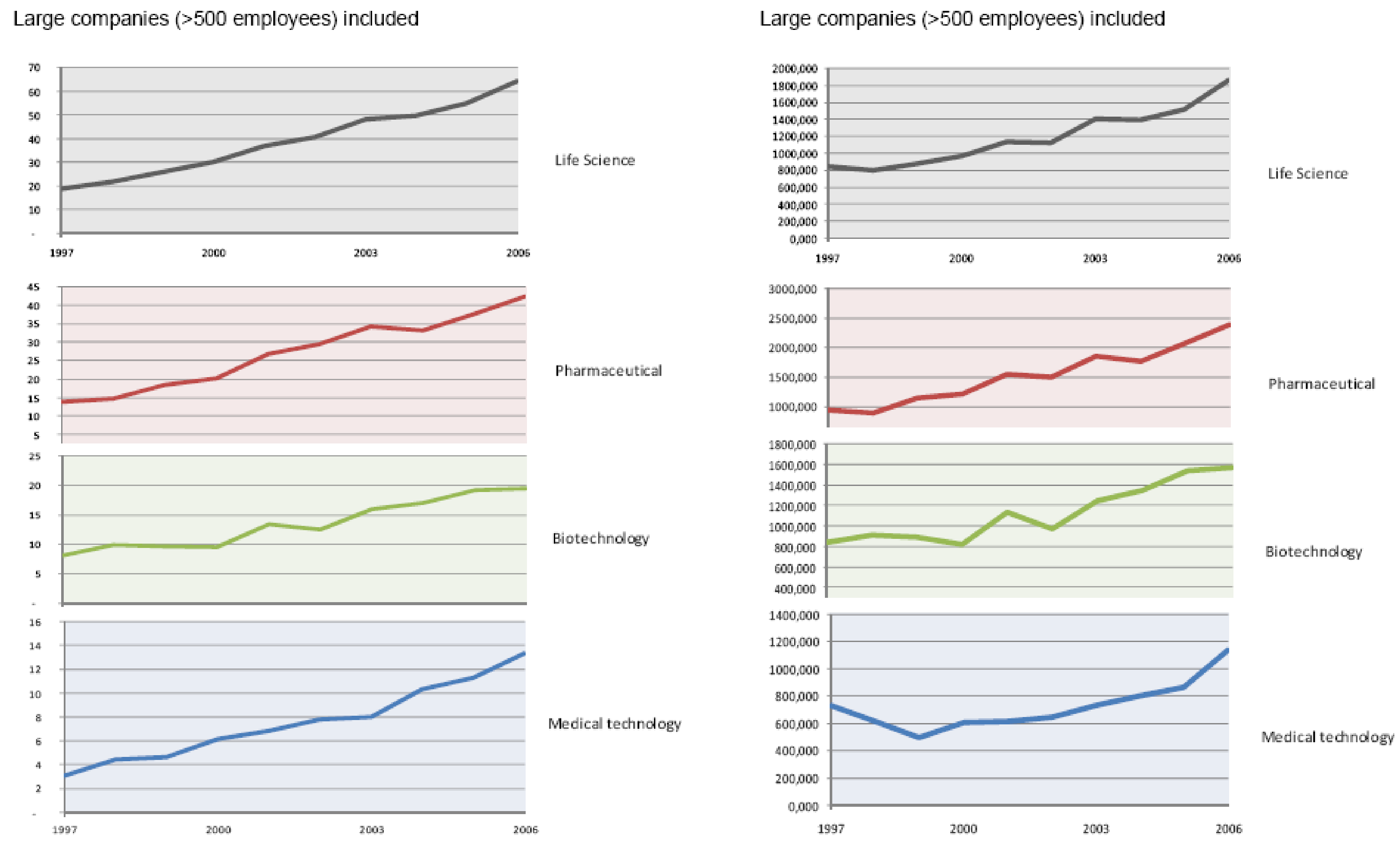

Figure 3.10. Value added in absolute terms (SEK bn) and value added per employee (SEK k)/ / National and Regional Cluster Profiles, Anna Sandström and Helena Bergqvist (VINNOVA) and Tage Dolk (Addendi), 2007.

Discussion of results

The development of relative results, value added and productivity is more encouraging for the life science industry than for employment development. However, when considering biotechnology, there has been a decline in the relative results in 2004-2006. The relative results of SME biotech companies have increased since 2005, but this increase should be viewed in the light of the very low levels of previous years. This is still nowhere near the levels of 2003 which was a record year for biotech SMEs. The 2002 stock market dip seems to correspond more to the situation of the SMEs than that of the large companies. One explanation could be problems for the SMEs in accessing venture capital. Also, the fluctuations on the stock market seem more affected by the R&D-intensive companies than the non-R&D-intensive companies.

Looking at the development of net turnover, not only do the results indicate a positive trend but also that the R&D-intensive companies are the winners in terms of this measure. The biotechnology sector constitutes an exception. One explanation for this could be that within this sector, the non-R&D-intensive companies decreased in terms of employees by over 20% from 2003 to 2006. This might imply that many of the unsuccessful non-R&D-intensive companies are no longer around or that they have made more cuts to the number of employees in order to handle downturns in their business. It should be borne in mind that net turnover is calculated per employee of the entire sector.

The value added per employee and productivity was also compared for R&D-intensive and non-R&D-intensive companies. Just like the net turnover results, the R&D-intensive companies came out highest in the comparison. The exception was the productivity development for biotechnology. As described above, the decrease in number of employees among the non-R&D-intensive biotech companies could partially explain this.

The high productivity development compared to all other industries shows the potential of this industry. Combined with the positive trend in value added, in real terms and per employee, it shows the important role the industry could play in a knowledge economy. Several measures were calculated per employee, so the positive trends could not be solely attributed to the growth of the sector in terms of employees, especially as the trends for net turnover and value added are also positive over the period 2003-2006 when the employment development stagnated. The positive trends but with stagnated employment development would be an interesting issue for future studies to elucidate.

The importance of AstraZeneca is demonstrated by the large effect their relative results, value added and productivity have on the total sector. This implies that it is the very large companies that are the driving force in the Swedish life science industry. The result of the pharmaceutical sector's development is particularly a consequence of the AstraZeneca development.

3.2 Activities

The three activities chosen as the focus of this report will be outlined in turn for the Swedish life science innovation system (SLIS). Firstly, the knowledge development of SLIS, then the financial support system and finally the policy development.

3.2.1 Knowledge development

Generation of knowledge elements

Factors affecting the direction of research

The discussion in recent years about the factors affecting the direction of research has focused largely on the commercialisation of university research and industrial funding of university research. Many of the participators in the debate were linked to life science. In 2002, there was much concern about the effect of commercial interests on the future of the "free research". It was claimed that commercial interests would have a negative impact on the direction of research and create ethical conflicts[21]. Several actors reacted more or less against this and supported a development towards more entrepreneurship in academia and needs-driven research[22]. VINNOVA, with its task of funding needs-driven research, advocated the view that both research types were necessary[23]. In the debate, it was pinpointed that in many cases research groups with strong links to the industry are the most productive research environments[24]. As far as life science is concerned, the discussion climate has turned towards a much more positive attitude to the commercialisation of research. For example, the policy shift at Karolinska Institute[25] in the 90s, when Professor Hans Wigzell was president[26]. The lack of grants to researchers was seen as more of a problem than potential conflicts of interest[27].

[21] Ullenius C., 2002.
[22] Hällsten M., Sandström U., 2003, pages 11-13.
[23] http://www.VINNOVA.se/In-English/About-VINNOVA/.
[24] Laredo 1999, Darby och Zucker 1995, 1998, cf. Sandström 2003.
[25] Interview Sandström, Anna; VINNOVA; 200801.
[26] Interview Sandström, Anna; VINNOVA; 200801.
[27] Wallberg-Henriksson, 2002.

The most hotly debated area today in regard to the direction of life science research is the selection of key technologies. This is discussed in the policy section (3.2.3).

Public Research funding

University research is financed either by public grants, external funding or interest from equity funds. Sources of external funding include research councils, foundations, EC, companies etc. and most often have to be applied for by the researchers themselves. There are different views as to what should be defined as public funding among the different types of external funding. The public external funding includes funding from research councils (The Swedish Research Council, FAS and FORMAS), public authorities (VINNOVA) and EC framework programmes[28]. The views diverge in regard to foundations like the Knowledge Foundation and Swedish Foundation for Strategic Research.

The Swedish Research Council is the largest external financer and allocated SEK 500 million to medical research in 2005[29] and approx. SEK 580 million in 2006. It supports basic research by peer review[30]. Characteristic of medical research financing is that funding may be sought from many different sources but that they are quite small[31].

Swedish R&D expenditure for 2005 at the various life science-related universities is outlined in figure 3.11[32]. Public funding constitutes about 50% out of the allocation to the universities. Public grants to medical faculties decreased by 20% over the period 1993-2001.This was heavily critizied to have led to dependence on external funding. The share of public external funding from research councils to medical faculties also decreased by 20% over the period[33].

Public and civil R&D expenditure relative the GNP currently amount to 0.79% which is below the EC's 1% target but higher than most countries[34].

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[28] Drammeh B., 2005, page 3.
[29] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 40.
[30] Drammeh B., 2005, page 5.
[31] Hällsten M., Sandström U., 2003, page 7.
[32] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 41/ SCB 2007.
[33] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, pages 43 and 45.
[34] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 39.

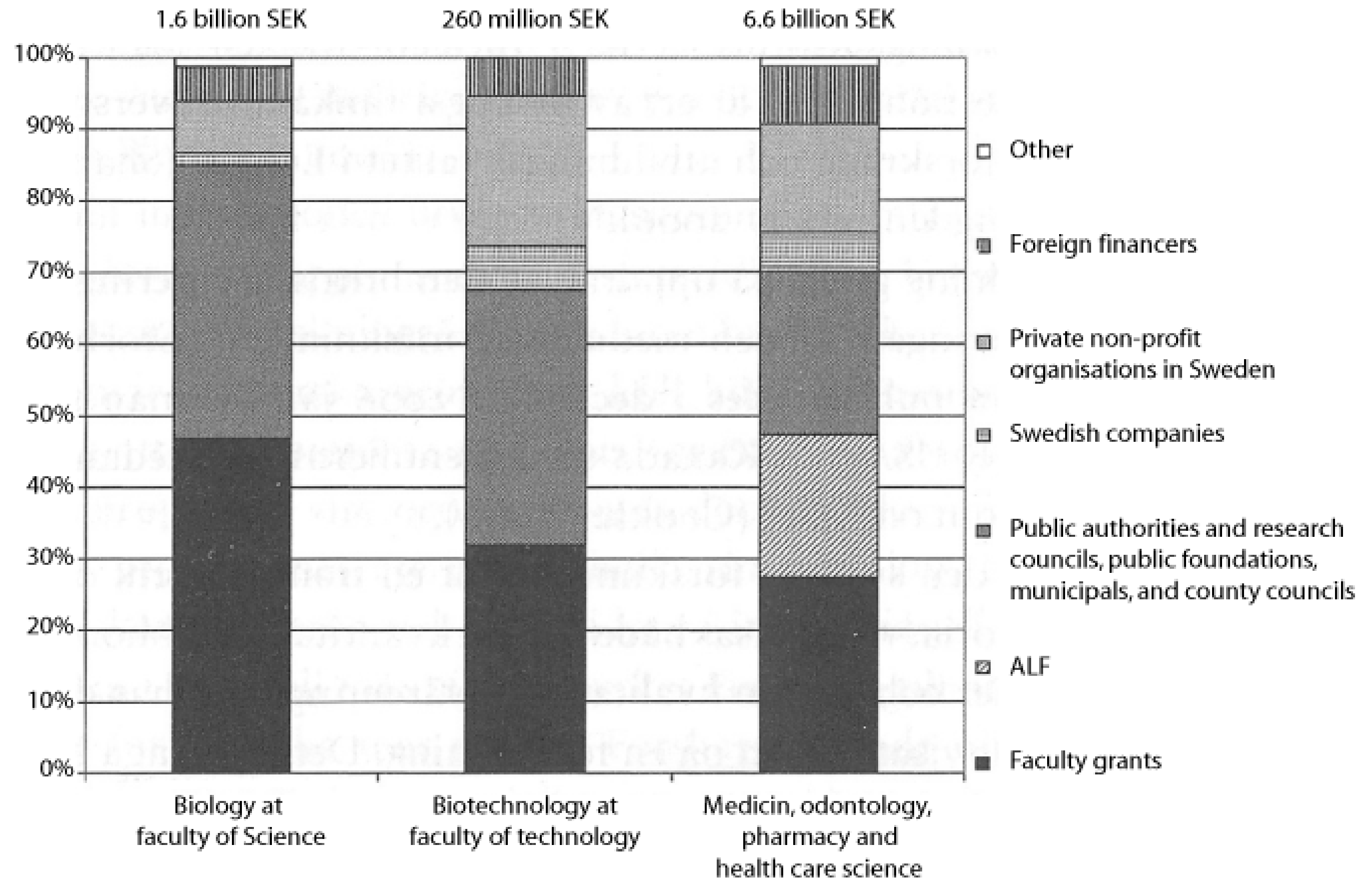

Figure 3.11. Resources and sources of resources for research within medicine and biotechnology in 2005.[35]

Industrial R&D expenditure and other private R&D funding

When it comes to industrial funding of university research, medical research achieves a relatively high share from industry. The share of industrial funding of university R&D also increased strongly over the period 1995-2001. Foreign companies are behind this increase whereas the Swedish companies have had practically unchanged contributions to university research over the same period[36].

Private funding is very important in Sweden, particularly for the research fields of proteomics and functional genomics. The Knut and Alice Wallenberg foundation has allocated SEK 240 million to the Human Proteome Resource over four years and SEK 800 million to functional genomics over five years[37]. The foundation for cancer research annually

[35] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 41.
[36] Hällsten M., Sandström U., 2003, page 9.
[37] Invest in Sweden Agency, 2003, page 24.

allocates about SEK 300 million to cancer research[38]. Overall, Swedish R&D expenditure in 2005 was SEK 102 billion of which industry bore 75% or SEK 76 billion[39]. It is also claimed that the share of funding from industry to medical research is relatively high[40] but, compared to technical faculties, industrial funding is not particularly so. In 2005, companies and foreign sources other than EC funding financed 11.5% of the research income at the technical faculties and 11% at the medical faculties[41]. The total R&D expenditure out of the GNP is shown in figure 3.12 and totals about 3.9%[42]. However, it should be noted that this is mostly a result of private funding[43], and within life science AstraZeneca obviously handles the largest share[44]. AstraZeneca's R&D expenditure also constitutes a significant share of the total R&D expenditure[45].

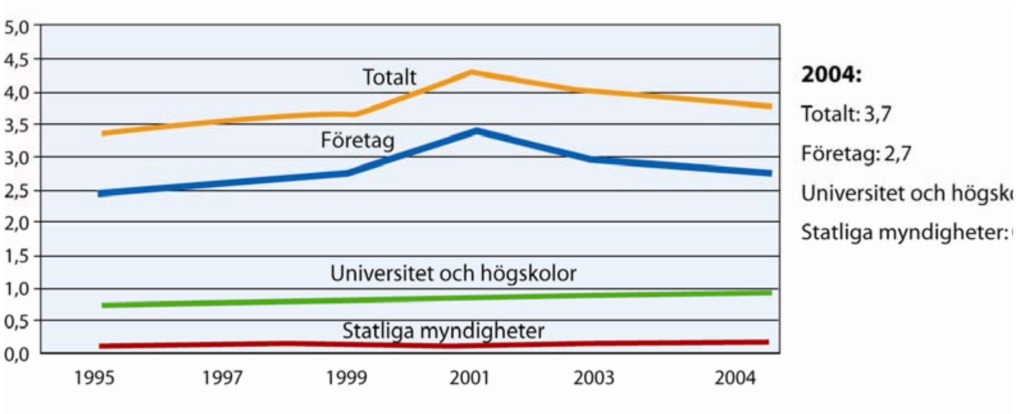

Figure 3.12. Share of total R&D expenditure out of GNP and the contribution per sector over time[46]. From the top: Total, Companies, Universities and finally Public authorities.

[38] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 40.
[39] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 39.
[40] Hällsten M., Sandström U., 2003, page 7.
[41] http://www.scb.se/templates/PlanerPublicerat/ViewInfo.aspx?publobjid=1519&lang=SV
[42] Main science and Technology Indicators 2005-1/ Congress of Swedish Association of Scientists 2006.
[43] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 39.
[44] Bergqvist H., Dolk T., Sandström A., 2007.
[45] Anvret M., 2008.
[46] Main science and Technology Indicators 2005-1/ Congress of Swedish Association of Scientists 2006.

Access to knowledge elements

Technological knowledge base

Historically, Sweden has a strong tradition in the life sciences. Clinical research has and still does have some prominent features in Sweden such as speed and transparency in the process[47]. The development of new methods within biotechnology research also builds on historical strengths. A great deal of world-class research has been produced from limited resources[48]. About 40% of all research currently undertaken at Swedish universities is within biosciences and biotechnology, which is comparable to the share in other countries[49]. In some research fields, such as functional genomics, proteomics, regenerative medicine, stem cells and technological platform development, Sweden is conducting internationally renowned research[50]. It should be noted that a number of these research fields in which Sweden excels receive large funding from private financiers; the Wallenberg foundation for instance.

On the other hand, there are several research fields in which Sweden used to have a strong technological knowledge base but now lags behind. Clinical research has already been widely discussed in this context, but there are unfortunately more examples. It has been claimed that there is a certain lack of competence within cell culturing for instance. In this particular field, the demands of existing companies as well as foreign companies that might potentially establish in Sweden are not matched by the current competence base[51]. Although there are risks in listening too much to the short-term demands of industry, not listening is also very risky[52]. Many different actors agree there is a need for more pull-thinking and less push-thinking in this regard[53]. According to Sweden Bio, it is demand from students that impacts the accessible educations to a larger extent than demand from industry. This kind of student-pull instead of market-pull may mislead students if their competence is not in demand by industry[54].

There might be connections between a lack of competence in some scientific fields that have been of particular interest to industry and the investment decisions made by the companies. The location of a European establishment for the production of influenza vaccine depends on a

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[47] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[48] VINNOVA, 2005, page 37.
[49] VINNOVA, 2005, page 33.
[50] Invest in Sweden Agency, 2004, page 2.
[51] Norrman Bo, Karolinska Institutet, 200705.
[52] Interview, Norrman Bo, Karolinska Institutet, 200705.
[53] Meeting at VINNOVA with representatives from the bioregions of Sweden, Interview, Norrman Bo, Karolinska Institutet, 200705.
[54] Sweden BIO, pages 7-9.

matching competence base[55]. Another example is the company GlaxoSmithKline (GSK) that declined to locate a specific establishment in Sweden due to a lack of a specific kind of competence they needed, cell culturing[56]. This competence is required by most biotech companies but it is too expensive for individual SMEs to build a large scale production unit.

According to the companies however, in medical technology and the biotech tools and supplies business segment, relevant competence is easy to come by. This may indicate a well-functioning exchange between university and industry[57].

Market-related knowledge base

A survey has shown that Swedish life science companies are demanding personnel highly specialised in directly applicable bioscientific fields. They are also demanding personnel who combine specialist competence with skills in marketing, economics etc. It has been claimed that there is a lack of competence in international business development in Sweden and particularly concerning competence about business development in smaller companies[58].

Characteristic of the life science industry is that a strong knowledge base within intellectual property (IP) protection is crucial. The importance of strong IP protection, particularly on the Chinese, US and Japanese markets, increases as does the recognition within industry of the importance of this knowledge base[59]. Within the companies (unlike many other industries), knowledge of industrial and intellectual property rights is considered something leadership should deal with rather than product development divisions. According to a survey with respondents in a managerial position within life science, the knowledge base is relatively strong compared to other industries [60]. However, it has been claimed that researchers do not have enough time, money or knowledge to deal with filing patents[61]. Due to time constraints and complexity of the issue, this report will not discuss whether the teacher’s privilege should be removed or not.

Initiatives to specifically increase the market-related knowledge base have been difficult to come by. The Knowledge Foundation has allocated SEK 60

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[55] Interview, Williams Ylva, Invest in Sweden Agency, 200705, Interview, Norrman Bo, Karolinska Institutet, 200705.
[56] Interview, Williams Ylva, Invest in Sweden Agency, 200705, Interview, Norrman Bo, Karolinska Institutet, 200705.
[57] Sweden BIO, pages 5-6.
[58] VINNOVA, 2005, pages 71-72.
[59] Awapatent, 2007, page 15.
[60] Awapatent, 2007, page 10.
[61] Tryggvason K., 2002.

million over seven years to a programme aiming to increase the general competence level in biotech and food SMEs[62]. The programme is a collaboration between a number of universities and the Swedish Institute for Food and Biotechnology[63].

Knowledge transfer

In 2003, an international committee showed that the research groups that had been allocated funding by the Swedish Research Council through a particular programme were maintaining high international standards as far as the research was concerned but falling short in terms of commercialisation activities. The researchers were not very interested in commercialising their research[64]. The 2005 life science strategy maintains that commercialisation of research and increased collaboration between academia and industry are key areas to address[65]. In consequence, VINNOVA was given the task of initiating a programme to increase this collaboration, plus a programme to increase the free movement of people between academia and industry and enhance knowledge transfer[66]. However, VINNOVA in 2008 stated that there is little movement between industry, academia and public authorities and far too few research contracts from industry to academia[67]. A current VINNOVA programme dealing with knowledge transfer is the research schools. The research schools will collaborate strongly with industry and are together allocated 200 million SEK over the next eight years. Biomaterials and brain research are among the ten areas selected for the research schools[68].

The institute sector has been found to play an important part in the commercialisation of research for SMEs in particular but is very small in Sweden[69]. A few very large companies dominate life science and so collaboration between AstraZeneca as well as Pfizer with public research organisations is vital.

However, there are indications that the knowledge transfer situation has shifted in a positive direction, at least as far as the Uppsala region is concerned. Uppsala Bio has struggled with the task of changing attitudes towards commercialisation within academia and they now perceive that "attitudes have shifted all the way"[70]. Another indication of the life science

[62] Rydell I., Wiqvist E., Zingmark A., 2007, page 17.
[63] http://www.kks.se/templates/ProgramPage.aspx?id=524.
[64] Swedish Research Council 2003.
[65] Ministry of Enterprise, Energy and Communicatios, 2005, page 17.
[66] Government Decision N2006/3329/ITFoU and Government Decision N2006/3328/ITFoU.
[67] VINNOVA, 2007, page 1.
[68] http://www.VINNOVA.se/misc/menyer-och-funktioner/Nyheter/Nyheter-2007/071220-Forskarskolor/
[69] VINNOVA, 2007, page 1.
[70] Interview, Sanders Rhiannon, Uppsala Bio, 200705.

knowledge transfer between academia and industry is the strong correlation between the regional distribution of research (measured in R&D expenditure for biosciences 2003) and the distribution of life science industries[71].

Strengths and weaknesses

Because private funding constitutes such a large share of the overall R&D expenditure[72] the research community, and Sweden as a knowledge economy, are also dependent upon these private investments. In one way, this poses a risk. It is important to note that this is particularly so within life science. A few very large companies, most importantly AstraZeneca, affect the situation greatly and so Sweden is dependant on their agenda and where they choose to invest. This is shown not only by the large AstraZeneca share of the total R&D expenditure, but by the fact (as demonstrated in the industry survey) that AstraZeneca also holds almost 30% of the total employment within life science industry and 50% within the pharmaceutical sector. This means that employment within the Swedish life science industry is largely dependent on AstraZeneca. It also means that a major share of the Swedish technological knowledge base within life science is a part of AstraZeneca. Thus, future decisions by AstraZeneca could impact Swedish competitiveness on the global arena in several ways. Due to several clinical failures, there have been major production and sales cuts at AstraZeneca Södertälje[73]. Historically, it is in production and sales that the large R&D-intensive companies decrease the number of employees first, since the resources are needed for even more research[74]. If the situation for AstraZeneca cannot be turned around, the next step will probably be to cut R&D expenditure. This was the case for Ericsson just a few years ago. Half of the R&D expenditure was cut. This situation was considered so alarming by the government that emergency action was required. VINNOVA was then given the task to analyse the situation and came up with an action plan worth SEK 3.5 billion over five years called Vinnitel. Not much happened though and the SEK 3.5 billion became SEK100 million[75]. Important lessons could be learnt from the IT sector and from other industries. The process that took place in Uppsala Life Science Innovation System (ULSIS), with core activities relocated from Pharmacia could also add to the current picture. There is a discussion in ULSIS about the extent to which the developments which followed Pharmacia's relocation was actually as positive as portrayed in the media[76]. Some claim that the positive picture

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[71] VINNOVA, 2005b, page 63.
[72] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 39.
[73] Dagens industri 2007-03-20.
[74] Gergils H., 2006, page 275.
[75] Gergils H., 2006. page 275.
[76] Waxell A., 2005, pages 57-58.

was largely exaggerated[77] whereas others claim that the media portrayal helped attract investors[78]. An interesting topic for further investigation would be to analyse how the connections of AstraZeneca to the local innovation system differ from those that Pharmacia had at the time of its relocation.

In Sweden, there seems to be a consensus among actors that more market-pull is needed in the technological knowledge base[79]. The difficulties arise when this market-pull must be translated into concrete rearrangements in the formation of education and research[80]. There again, too much market-pull would pose a risk of short-term decisions.

Suggestions on how to solve the problem of a lack of competence within cell culturing in Sweden include collaborative efforts such as an institute where, in lieu of a membership fee, companies could have access to a cell bank and the necessary operational competence[81]. Alternatively, a flexible solution could consist of a mobile laboratory with accessible competence for biotech companies[82]. It has been claimed that informal collaborations between individuals at various public authorities work well but are weak without economic instruments such as larger partnerships with a shared budget[83].

It is important to analyse what potential there is to increase direct investment in Sweden. There are various factors that play a part in decisions of where to invest, for instance tax incentives and available business support products, but the technological knowledge base no doubt plays an important part. One obvious negative effect of losing out on foreign direct investments is the missed job opportunities. Over the period 1999-2006, AstraZeneca's investment in the UK approached GBP 1 billion and created 550 science-related jobs. In Dunkirk, France, a GBP 114 million investment created 150 jobs and there are numerous investments in Asia to add to the list[84]. The reasons for not investing in Sweden in these cases might very well be related to completely different factors than the technological knowledge

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[77] Waluszewski 2003.
[78] Jonsson L., 2003.
[79] The Teknik och Tillväxt conference, Royal Institute of Technology, 20071115, Meeting at VINNOVA with representatives from the Bioregions of Sweden, Interview, Norrman Bo, Karolinska Institutet, 200705.
[80] Sweden BIO, pages 7-9.
[81] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[82] Interview, Norrman Bo, Karolinska Institutet, 200705.
[83] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[84] http://www.astrazeneca.com/node/pressreleaselist.aspx, press releases 1998-2007, particularly 2005.

base, but the example is put forward to illustrate the importance of Sweden to rise to the competition.

3.2.2 Financial support systems for innovation

Access to Venture Capital

General access to venture capital
According to Ernst &Young, access to venture capital for biotechnology in Sweden was exceptionally high in 2006. An increased risk willingness on the stock market and among venture capitalists plus a more mature biotech sector lay behind the record level of venture capital provided to biotech companies[85]. Access to venture capital in Sweden declined overall in the period 2001-2003[86]. In 2005, a clear positive view of the business cycle affected the medical technology and biotechnology sectors in particular and access to venture capital increased[87]. However, that increase should be seen in the light of the very low levels of 2004[88]. New regions captured the interest of investors and particularly the Swedish part of the Öresund region[89]. Investment has also shifted towards more growth investments (seed, startup and expansion)[90] although buyout activity is still very strong[91]. It has also been claimed that owner-commitment development efforts have improved in recent years[92].

Still, there is a perceived mismatch in the Swedish life science sector between the investors and the industry. This is due to the large number of small or very small life science companies in Sweden[93]. Their businesses and requirements for venture capital do not correspond to the size of the investments that foreign venture capitalists are seeking to make. The product portfolios are often too narrow to present the volume required to attract investors even if the actual R&D or products are impressive to them. Foreign investors are surprised to find several companies carrying out more or less the same type of research and developing similar products but not forming mergers[94].

Sweden attracts more foreign venture capital than direct industrial investments. Compared to the UK, the Swedish level of R&D-related new establishments and expansion investments within life science is modest; 8%

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[85] http://www.e24.se/branscher/lakemedelbiotech/artikel_30637.e24.
[86] Invest in Sweden Agency, 2003, page 22.
[87] Press release 20051202 Swedish Private Equity & Venture Capital Association (SVCA).
[88] NyTeknik 2005-08-23.
[89] NyTeknik 2005-08-23.
[90] http://www.svca.se/home/news.asp?sid=337&mid=3&NewsId=9357&Page=9 and http://www.biotechumea.se/default.asp?id=4122&ptid=.
[91] http://www.apfond6.se/Page.aspx?id=10.
[92] http://www.svca.se/home/news.asp?sid=337&mid=3&NewsId=9357&Page=9.
[93] Bergqvist H., Dolk T., Sandström A., 2007.
[94] Interview, Williams Ylva, Invest in Sweden Agency, 200705.

and 3% respectively[95]. However, foreign capital constitutes significant shares in many biotech companies and is often introduced to the companies by Swedish channels, such as private equity funds[96]. The share of all foreign-owned Swedish biotech companies is 12.5%[97].

Other sources of non-public venture capital

The business angel market is small in Sweden compared to the venture capital-based systems in the Anglo-Saxon countries[98]. The business angel market constitutes one third of the total venture capital market in Sweden[99]. Business angels have played an important role in the life science sector and continue to do so, especially early on in the drug development process. However, media interest in this market is claimed by some to have exaggerated the importance of the business angels [100].

Public Funding

The largest share of venture capital accessible to Swedish life science companies is private, but there are also public financers like the Sixth AP Fund, Industrifonden and actors connected to the universities[101]. The Sixth AP Fund holds a total of SEK 15 billion with the largest share, 40%, allocated to life science companies. Industrifonden allocates about half its sector-specific investments to life science companies[102]. The capital from the Teknikbro Foundation has been taken over by Innovationsbron and will be used as seed capital for early-stage companies[103]. Private financers tend to avoid the early stages due to the higher risk compared to late stages in which commercial potential is easier to predict. Thus, public financers like Almi and Industrifonden that provide loans to companies in the seed or other early stages can play an important role and sometimes contribute to success stories such as Losec[104]. The public providers of venture capital in pre-seed, seed, startup and expansion stages are outlined in 3.13[105]. (This is an approximate description as the funding previously held in TBS 7 has now been pooled in Innovationsbron and the "kick-start" funding no longer exists). The figure is divided into pre-commercial (left) and commercial (right) stages of company development.

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[95] Invest in Sweden Agency, 2003, page 13.
[96] Invest in Sweden Agency, 2003, page 17.
[97] Invest in Sweden Agency, 2003, page 17.
[98] http://www.esbri.se/referat_visa_b.asp?id=62.
[99] Braunerhjem P., Wiklund J., 2006, page 9-10.
[100] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[101] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 83.
[102] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 86.
[103] http://www.teknikbrostiftelsenilund.se/pages_sv/aktuellt/news/050221.html.
[104] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 84.
[105] Claes de Neergard, 2004, page 19.

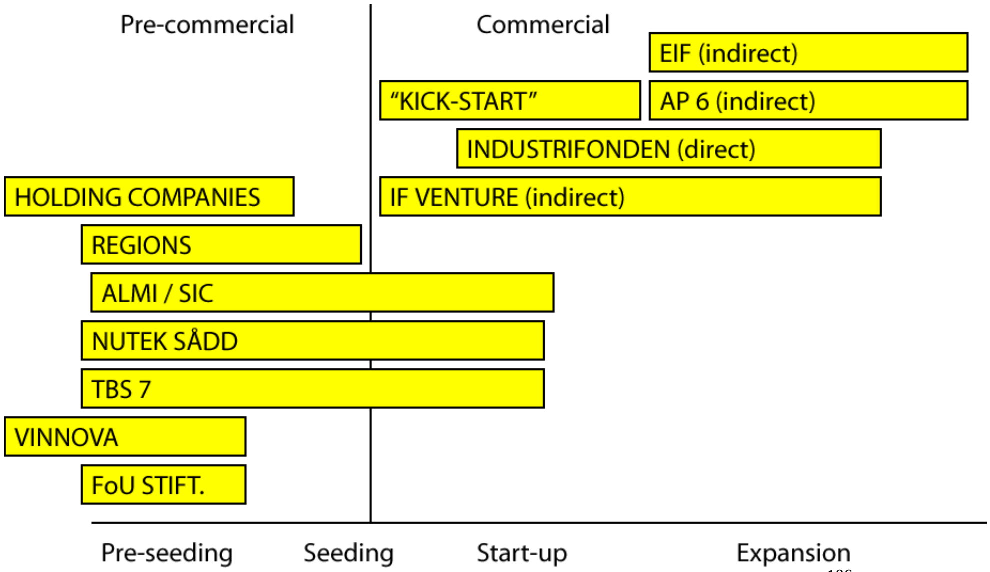

Figure 3.13. Swedish public landscape for seed and early-stage private equity[106].

Weaknesses and strengths identified

In the competition for foreign venture capital, Sweden is keeping up with UK when it comes to creating interest in the life science industry. The Swedish life science industry generally gets good grades from foreign investors. More than the type or amount of previously received funding, it is the technological height of the company that captures the genuine interest of investors[107]. The dilemma occurs at the next stage, when investors are seeking Swedish objects for their SEK 500 million investments. Swedish life science companies are often seeking a venture capitalist willing to invest about SEK 20 million. It is not really a case of critical mass in terms of the relative smallness of the Swedish market. The individual companies' IP portfolios are too small and this poses a problem. Even though their technological height is internationally competitive, the business is usually built on a single patent or family of patents[108]. It has been claimed that the absence of Swedish candidates for AstraZeneca purchases is also due to the small product portfolios[109]. This is the seamy side of the teacher's privilege, which makes it possible to build a company on a single idea with one or more patents. Cultural barriers between researchers who have long been in competition may prevent the merging of similar businesses into a single company. If the entrepreneurial role is played by the researcher who previously had to fight other researchers in the same field for funding, this might disrupt opportunities for collaboration. With a broader approach to

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[106] Claes de Neergard, 2004, page 19.
[107] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[108] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[109] http://www.e24.se/branscher/lakemedelbiotech/artikel_38819.e24.

the medical need, the probability of receiving venture capital investment would likely increase[110].

The access to venture capital is fairly good. A deficit could lead to Swedish companies being sold to abroad. Foreign ownership and interests presents both a risk and an opportunity. This could lead to increased foreign investment in Sweden and an inflow of capital[111] but at the same time the foreign interest also presents a risk that the location of the company activity, future investments or revenue from the venture will be in other countries. It therefore follows as a consequence of increasing foreign capital shares in the life science sector that relations with the foreign investors should be well taken care of on a follow-on basis, to ensure future economic benefit to the region/country. The low level of direct investment compared to the UK is a weakness.

The small size of the business angel market is a weakness according to some, particularly for the small companies[112]. The financing that business angels represent allows for a more organic growth for small companies than other types of financing. Small companies often lack the resources to grow by acquisition[113]. Again, the stagnation in employment within the life science industry makes it necessary to look into weaknesses that might be related to constraints to growth. On the other hand, a certain lack of financing in the early-stages might be beneficial for the innovation process. Small companies often have more radical innovation than larger companies but are also knocked out to a greater extent[114], creating an evolutionary process within the industry that is not entirely objectionable. Among the Swedish life science companies with 1-5 employees before 2002, the vast majority had not grown over eight employees in 2006[115]. It would be an interesting subject for further studies to examine what effect increased capital would have had on these companies. It could be argued that supporting startup companies is not as beneficial to achieving critical mass in the sector as it would be to support existing and more mature companies in larger projects[116]. On the other hand, it could be argued that the early-stage, very small companies play a vital role in the development of new knowledge and the commercialisation process. Also, if a lack of financing constitutes a bottleneck, then these important processes are halted[117].

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[110] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[111] Arvidsson G., Bergström H., Edquist E., Högberg D., Jönsson B., 2007, page 85.
[112] Swedish Foundation for Small Business Research, 2006.
[113] http://www.esbri.se/referat_visa_b.asp?id=62.
[114] http://www.esbri.se/referat_visa_b.asp?id=62.
[115] Bergqvist H., Dolk T., Sandström A., 2007.
[116] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[117] http://www.esbri.se/referat_visa_b.asp?id=62.

The initiatives towards commercialisation of research in Swedish universities predominantly focus in creating startups and to a lesser extent on the prevailing industry[118]. However, since the employment development within life science has stagnated there might be a mismatch that constitutes an obstacle to small companies accessing private venture capital. Consideration might be given to increasing the focus of public business support onto products in the latter stages of the company value chain; at least to some extent. Initiatives such as the VINNOVA programme Research&Grow could probably play an important role in increasing the growth of small life science companies. However, addressing obstacles to latter-stage growth from business support products is complex and relates to the issue of when public initiatives should not be used to interfere with market forces. "Public initiatives should not, for instance, compete with what business enterprises such as consultancies do. Public initiatives are better used in the early stages of business development, say, for reducing the technological risk through R&D incentives or for seed financing when market forces may fail to promote the innovation process. Due to state subsidy regulations, business support from public authorities to companies is also complicated. These issues have to be taken into account when trying to address constraints to growth with public initiatives" [119].

3.2.3 Policy evolution

This section examines the policies regarding certain issues of importance to the innovation system: Addressing the global challenge, the collaboration between actors in the innovation system and finally identifying key technologies of strategic importance. These issues were selected since they were found to occur frequently in the UK innovation system and their occurrence is therefore also described in SLIS. The policy study takes a reference point from the life science strategy launched in 2005 by the Ministry of Enterprise, Energy and Communications and how the recommendations given in the strategy have been managed. The strategy was supported by the entire reference group consisting of representatives of industry, academia, government, the public authorities concerned and several other organisations.

Collaboration

Collaboration within the triple helix

In the strategy programme, it is stated that the collaboration between the government, industry and other relevant actors should be developed with the

[118] http://www.VINNOVA.se/Press/Pressmeddelanden/2007/2007-03-29-Sju-universitet-finansieras-med-200-milliononer-kronor-for-battre-samverkan-med-naringslivet/.
[119] Interview, Sandström Anna; VINNOVA, 20080116.

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[120].

SAMBIO and SAMPOST are consequences of the strategy and both aim to increase the collaboration between academia and industry. SAMBIO also aims to strengthen opportunities for life science companies to participate in the 7th Framework Programme and will facilitate qualification opportunities for young scientists wanting to collaborate with industry and conduct industry-relevant research[121]. A national biotech council was proposed in the strategy in order to increase the power to act and the preparedness. No such council has been established, nor has a national programme to increase knowledge of life science been established[122].

Collaboration among financers

VINNOVA is requesting a more efficient collaboration between public research financers and private investors in research, in order to make the public investment in research more needs-driven[123]. Due to the global challenge, more power to act among financers and other actors is crucial and synergies should be sought after by investors[124]. It has been shown that Swedish allocations to research within life science are thinly spread compared to the other countries with which we wish to compete[125]. According to VINNOVA, the collaboration between public financers could be improved. More common programmes are needed in the innovation system[126].

Among the programmes and business support products available from VINNOVA, SAMPOST and SAMBIO require co-financing from applicant companies, which leads to total budgets of SEK 70 and 170 million respectively. Co-financing is normally a requirement in the VINNOVA funding programmes[127].

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[120] Ministry of Enterprise, Energy and Communications, 2005, page 18.
[121] http://www.VINNOVA.se/Finansiering/Utlysningar---forteckning/Pagaende-utlysningar/SAMBIO-2007/, http://www.VINNOVA.se/Finansiering/Utlysningar---forteckning/Pagaende-utlysningar/SAMPOST-2007-2/.
[122] Interview, Sandström Anna; VINNOVA, 20080116.
[123] Research and innovation strategy proposal 2009-20012 (VINNOVA) page 2.
[124] Research and innovation strategy proposal 2009-20012 (VINNOVA), page 3.
[125] Interview, Sandström Anna; VINNOVA, 20080116.
[126] VINNOVA, 2007, page3.
[127] VINNOVA, 2006, page 2.

International collaborations

Sweden needs to increase its participation in the international research collaborations, particularly within Europe and with America and Asia[128]. In the life science strategy, it is reported that there are bilateral collaboration agreements in place to strengthen collaborations with Japan, China and South Africa and that there are plans to include India and the US. These agreements are meant to facilitate the collaboration between Swedish research-funding or research-conducting public authorities and the corresponding foreign public authorities[129].

Key technologies

In the national debate, there are frequently recurrent issues regarding the selection of key technologies and the need to prioritise amongst business support products in order to achieve critical mass. There seems to be a consensus among most actors that building on certain research fields of strength is necessary. At the same time it has been highlighted that the full range of business support products, targeting different stages of the company development are absolutely necessary for the innovation system[130].

Some examples of publicly funded key technologies

The pharmaceutical, biotech and medtech industry is acknowledged as a key industry by the Swedish government[131]. The (life science) industry was one of the industries in the so-called industry discussions with representatives from industry, academia and public authorities. In the 2005 biotech strategy, VINNOVA recommended that SEK 2 billion in additional funding should be allocated to initiatives aiming to support the life science industry and, to some extent, other high-tech industries[132]. The outcome was about SEK 200 million over five years for life science programmes and initiatives[133]. VINNOVA identifies life science as a key industry and is not much more specific than that, although some strategic areas have been selected. However, some initiatives such as the Centres of Excellence could be seen as prioritising funds for selected key research fields. For instance, The Uppsala Berzelii Centre for Basic and Applied Research in BioNano Technology at Uppsala University was chosen as one of four strong research

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[128] VINNOVA, 2007, page 3.
[129] Ministry of Enterprise, Energy and Communicatios, 2005, page 27.
[130] The Teknik och Tillväxt conference, Royal Institute of Technology, 20071115.
[131] http://www.regeringen.se/sb/d/2954/a/45823.
[132] Interview, Sandström Anna; VINNOVA, 20080116.
[133] Interview, Sandström Anna; VINNOVA, 20080116.

centres that were allocated SEK 170 million over ten years. A large share of the funding is allocated by VINNOVA. The centre conducts interdisciplinary research on complex disorders such as Alzheimer's and Parkinson's and develops biotech analytic methods[134].

Addressing the global challenge

The Swedish science budgetary bill of 2007 states that Sweden should be "a leading knowledge economy characterised by high quality education and lifelong learning for growth and justice"[135]. It is also stated that there is a relatively high allocation for higher education to achieve this goal[136]. This is where the viewpoints divide. It is commonly stated that Sweden *must* compete with knowledge, innovation and renewal[137]. But there are different ways to measure just how much is allocated to research and how much more should be allocated. It was widely argued in 2007 that Sweden should allocate 1% of the GNP to civil research and that this allocation should consist of public funds[138].

In the life science strategy from 2005 mentioned at the beginning, different areas were identified that called for action to create or maintain Swedish competitive advantages. It highlighted the importance of addressing the global challenge and ensuring competitive conditions[139]. As per the strategy, competitive conditions include favourable tax regulations for research-intensive companies, good conditions for research and access to venture capital. Also mentioned is a need for clear regulations to enable companies to adapt to the conditions. The need for clarity and predictability in the tax regulations is still pinpointed by ISA[140].

Explicit initiatives and programmes to address the global challenge

The strategy recommended certain actions in order to create internationally competitive corporate conditions. Some of these have been dealt with. For instance, a biotechnical renewal in Swedish basic industries was initiated. A national system for development within drug discovery, diagnostics and medical technology was proposed in the strategy and the outcome was a

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134 http://www.VINNOVA.se/Verksamhet/Starka-forsknings--och-innovationsmillionoer/Berzelii-Centra/.
135 Ministry of Finance, 2007, page 35.
136 Ministry of Finance, 2007, page 38.
137 Ministry of Enterprise, Energy and Communications, 2005, foreword.
138 http://www.VINNOVA.se/misc/menyer-och-funktioner/Nyheter/Nyheter-2007/2007-12-20-FoI-strategi/, http://www.iva.se/templates/page.aspx?id=4909, http://www.vr.se/huvudmeny/pressochnyheter/nyhetsarkiv/nyheter2007/helaforskningssystemetmastestarkas.5.689ebdf7116f301a8858000685.html.
139 Ministry of Enterprise, Energy and Communications, 2005.
140 Interview, Williams Ylva, Invest in Sweden Agency, 200705.

delegation with a budget of SEK 30 million to develop such a system. Also recommended was an international benchmarking of the Swedish life science innovation system. This is apparently being addressed, since the present report is an international benchmarking. The overall project has a SEK 2 million budget over two years and will deal with the life science innovation systems from such countries as Denmark, India, Singapore and Canada.

There are also recommendations which were addressed to a lesser extent than recommended in the strategy, or not at all. For example, the management competence of newly established companies was not supported by any specific programme. The participation of SMEs in EC framework programmes was not addressed within the SEK 200 million budget of public funds. Instead, Sweden Bio has established an office in support of SME participation, partly financed by VINNOVA. VINNOVA also provides financial support during the application stage[141]. One consequence of the strategy was an analysis of the infrastructure for biotechnical production connected to clinical trials. The analysis identified a need for a pilot establishment for a scale-up that SMEs could access.

Since the Swedish export is currently highly dependent on a number of very large companies[142](particularly within life science[143]) it is important to support SMEs trying to enter international markets. The SMEs are often restricted to international growth due to a lack of financing. Therefore, the Swedish Trade Association has launched “export loans” that aim to reduce the risks when SMEs export and close large business deals. These loans are the result of collaboration between several financers like Almi and Swedfund[144].

Weaknesses and strengths identified

One of the recommendations of the strategy that was not transformed into action was a national programme to establish a dialog with politics and community to increase knowledge about life science[145]. As described in the technological knowledge base section, the Swedes are already relatively well informed about biotechnology. However, it could be argued that a strong knowledge base in the community will be increasingly important, thus justifying such a programme. According to the predictions of several actors, patients will play an increasing role as customers in the future[146].

[141] http://www.swedenbio.se/templates/Links.aspx?id=1973.
[142] http://www.swedishtrade.se/dagensexportnyheter/?pageid=8026.
[143] Bergqvist H., Dolk T., Sandström A., 2007.
[144] http://www.swedishtrade.se/dagensexportnyheter/?pageid=8026.
[145] Interview, Sandström Anna; VINNOVA, 20080116.
[146] Royal Swedish Society of Engineering Sciences, 2007, page 28.

The industry will have to address this and develop medicals with more of a customer focus and not just pure scientific approaches[147]. This means that the attitudes of the clients will affect the innovation process, either limiting the development or creating a demand for new products. Two consequences can be noted in this perspective. The information level among clients will be crucial. For instance, public attitudes towards some research fields are based on deficient knowledge or ignorance and can affect the direction of research. There again, it is important for researchers to listen to the concerns and opinions of the community. The Swedes have the highest factual knowledge of biosciences and biotechnology in the EC[148] and this must be maintained as a competitive advantage. There also needs to be a high level of factual knowledge among politicians, media and other policy-makers. The other consequence of the development towards more of a client-pull within life science is that innovation in procurement will play an increasing role, since this will affect what products and treatments the public comes into contact with.

The national biotech council that was proposed in the strategy in order to increase power to act and preparedness (not yet established), could play an important strategic role in Sweden. As will be described in UKLSIS, the Technology Strategy Board is the public authority which covers these functions for life science in the UK. Many actors in Sweden have pinpointed the fact that industry discussions need to be re-established. Thus, it seems there is currently a gap in SLIS which could be filled by an actor collaboratively (i.e. with representatives from different parts of the triple helix) taking on strategic responsibilities with the emphasis on life science. The global council has general strategic responsibilities[149].

Up to this date, spring 2008, many actors seem to agree that we need to select key technologies but no one wants to do the pinpointing[150]. It is a delicate matter to focus efforts and consequently decide who should be tasked with the responsibility of pinpointing[151]. A broad range of competence is needed and actors from industry, academia and public authorities etc. need to share the responsibility. This is also a question of collaboration between actors and in this perspective, there is a potential for a lot of improvement, as described in the knowledge development section.

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[147] Royal Swedish Society of Engineering Sciences, 2007, page 28.
[148] VINNOVA, 2005a, Page 58.
[149] http://www.sweden.gov.se/content/1/c6/08/49/73/29f74bfa.pdf, page 5.
[150] The Conference Teknik och Tillväxt, Royal Institute of Technology, 20071115 and Svt 24 debatt 20070912.
[151] Meeting at VINNOVA with representatives from the Bioregions of Sweden.

Sweden needs a consensus among actors on how to measure the size of publicly financed civil research. Naturally, there will always be discussion about whether enough money has been allocated or not, but the discussion is constrained from both sides as long as there is a discrepancy in the definition of what is included in the widely debated 1%. In order to achieve consensus in the discussion about a larger research budget, some of the focus should be turned by VINNOVA and other actors onto the definitions of the Ministry of Finance as well as discrepancies in the basic assumptions. The economic benefits of the increased research budget must be demonstrated. The economic benefits of a potential increase in the research budget should be analysed in a wider context than its most immediate effects.

4 The UK Life Science Innovation system

The UK life science innovation system (UKLIS) is described using the national activities as a point of reference. The aim is for UKLIS, Cambridge Life Science Innovation System (CLIS) and Scottish Life Science Innovation System (ScLIS) to jointly provide a full picture of the overall innovation system for life science in the UK on different spatial levels. There are obvious differences between Sweden and the UK when it comes to life science market size, number of universities, inhabitants and other factors which introduce difficulties into the comparison of UKLIS and SLIS. As mentioned in the choice of analytic model and approach, this approach hopefully gives a more adequate comparison. Unlike SLIS, the industry survey is not outlined for UKLIS since corresponding data for the UK was not accessible. Since there has been major restructuring among public authorities as recently as the summer of 2007, an additional section has been added to the policy development activity. Analysis of these restructurings was important in order to understand the aims of the policymakers. Interviews were therefore conducted with representatives from a couple of the public authorities concerned.

4.1 Activities

Just like the SLIS, the activities chosen are knowledge development, financial support systems and policy evolution.

4.1.1 Knowledge development

Generation of knowledge elements

Public funding

The Barcelona European Council set a target that R&D should reach 3% of GDP by 2010 for the European Union as a whole, with the public sector funding one third[152]. The spending review, "UK innovation framework 2004-2014", sets a target level of 2.5% of GDP by 2014. An enhancement of GBP 16.5 billion in real terms will be required, 2004-2005 prices[153] and will be reached by an average annual growth rate of 5.8% in real terms over the 2004 Spending Review period[154] (2004-2008). According to the DTI

[152] Former Department of Trade and Investment, 2004, 4.4.
[153] Former Department of Trade and Investment, 2004, 4.15.
[154] Former Department of Trade and Investment, 2004, 4.11.

Science Budget Allocation 2005, the Science Budget of DTI will increase by 26% to GBP 3.45 billion in 2007-2008 compared to 2004-2005 (see table 4.1). During the period 1997-2007, the Science Budget will have more than doubled[155].

Table 4.1. The Science Budget will rise to GBP 3.45 billion by 2007-2008[156]

£M	2004-05	2005-06	2006-07	2007-08
Science Budget	2734	3087	3235	3451
Of which				
Resource	2519	2883	3001	3197
Capital	215	204	234	254

The main public funders of life science research and their allocations are outlined in figure 4.1. This data has been gathered from Science and Innovation Investment Framework 2004-2014, budget reports and various other documents and was verified in interviews with DIUS and TSB representatives. The allocations include not only pure life science-related allocations. DIUS allocates funding to life science research through the research councils BBSRC and MRC and through the Higher Education Innovation Fund (HEIF) and the Technology Strategy Board. The Department of Health funds life science research through the National Institute for Health Research. The BBSRC is the UK's main founder of basic and strategic research[157]. The MRC allocates their largest share of funding to Molecular & Cellular Medicine.

[155] Former Department of Trade and Investment, 2005.
[156] Former Department of Trade and Investment, 2005.
[157] http://www.bbsrc.ac.uk/about/Welcome.html.

<table>
<tr><th></th><th>Department</th><th>Organisation</th><th>time period</th><th>CSR allocation from the science budget (m)</th><th colspan="2">Allocation target</th></tr>
<tr><td rowspan="22">HM Treasury</td><td rowspan="18">DIUS</td><td rowspan="4">BBSRC</td><td>2005-2006</td><td>GBP 326.5</td><td colspan="2" rowspan="4">BBSRC funds research that increases understanding of how living organisms function and behave, clinical sciences excluded.</td></tr>
<tr><td>2006-2007</td><td>GBP 386.5</td></tr>
<tr><td>2007-2008</td><td>GBP 427</td></tr>
<tr><td>2010-2011</td><td>GBP 471</td></tr>
<tr><td rowspan="4">TSB</td><td>2005-2006</td><td></td><td colspan="2" rowspan="4">Promote and support research, development and the exploitation of science, technology and new ideas to benefit business, increase economic growth and improve quality of life</td></tr>
<tr><td>2006-2007</td><td></td></tr>
<tr><td>2007-2008</td><td>GBP 197</td></tr>
<tr><td>2010-2011</td><td>GBP 267</td></tr>
<tr><td rowspan="3">HEIF</td><td>2006-2007</td><td>GBP 85</td><td colspan="2" rowspan="3">Strengthen links between academia and business and help take R&D to market</td></tr>
<tr><td>2007-2008</td><td>GBP 85</td></tr>
<tr><td>2010-2011</td><td>GBP 113</td></tr>
<tr><td rowspan="7">MRC</td><td rowspan="3">2005-2006</td><td>GBP 224</td><td colspan="2">Research and training support in universities and teaching hospitals.</td></tr>
<tr><td>GBP 238</td><td colspan="2">Research and training support in MRC units and institutes.</td></tr>
<tr><td>GBP 50</td><td colspan="2">Research training for post-graduate students and fellows</td></tr>
<tr><td>2006-2007</td><td>GBP 551.3</td><td colspan="2" rowspan="2">Improve human health through world-class medical R&D</td></tr>
<tr><td>2007-2008</td><td>GBP 543.4</td></tr>
<tr><td rowspan="2">2010-2011</td><td>GBP 707</td><td rowspan="2">GBP 1.7 bn</td><td rowspan="2">A single health research fund managed by OSCRH to support clinical trials etc.</td></tr>
<tr><td>GBP 1bn</td></tr>
<tr><td rowspan="4">DH</td><td rowspan="4">NIHR</td><td rowspan="2">2006-2007</td><td>GBP 50</td><td colspan="2">Capital Funding</td></tr>
<tr><td>GBP 703</td><td colspan="2">Clinical research in the NHS, research commissioned for policy development, and the NHS costs incurred in supporting research funded by other bodies such as the Research Councils and charities, the UK Clinical Research Collaboration</td></tr>
<tr><td>2007-2008</td><td></td><td colspan="2"></td></tr>
<tr><td>2005-2006</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3" rowspan="2">Total DIUS science budget (bn)</td><td>2007-2008</td><td>GBP 3.4</td><td colspan="2"></td></tr>
<tr><td>2010-2011</td><td>GBP 4.0</td><td colspan="2"></td></tr>
</table>

`Figure 4.1 Funding allocations to research from UK public authorities related to life science.[158]

Industrial R&D expenditure and other private R&D funding

In order to achieve the 2.5 % target, the government stresses that the private sector funding should defray 1.7% of GNP. The government highlights the need for the private sector to match the outlined aims, since the private sector contribution to research is relatively low[159]. As shown in figure 4.2,

[158] Compiled by Helena Bergqvist (VINNOVA) 2007.
[159] Former Department of Trade and Investment, 2004.

the level also decreased significantly over the period 1986-2000[160]. In 2005, business expenditures on R&D as a proportion of GDP were 1.08%. However, this is higher than the preceding years and the decline seems to have been arrested[161]. A relatively large share of the industrial R&D expenditure is from affiliates of foreign companies, 45%. The Strategy for International Engagement highlights this as a strength that need to be recognised to remain attractive and to further increase the UK attractiveness of foreign business and research expertise[162]. Out of the total UK R&D funding, foreign-owned businesses defray one third. In cash terms their investment increased from USD 4.7 billion in 1997 to USD 8.5 billion in 2001[163]. This data is general and not exclusive life science statistics. However, the BBSRC confirms that the situation applies to life science and that they are working to involve the industry to a greater extent and get an increase in industrial funding. They are also trying to achieve a balance between this aim and that of focusing on certain key technologies[164].

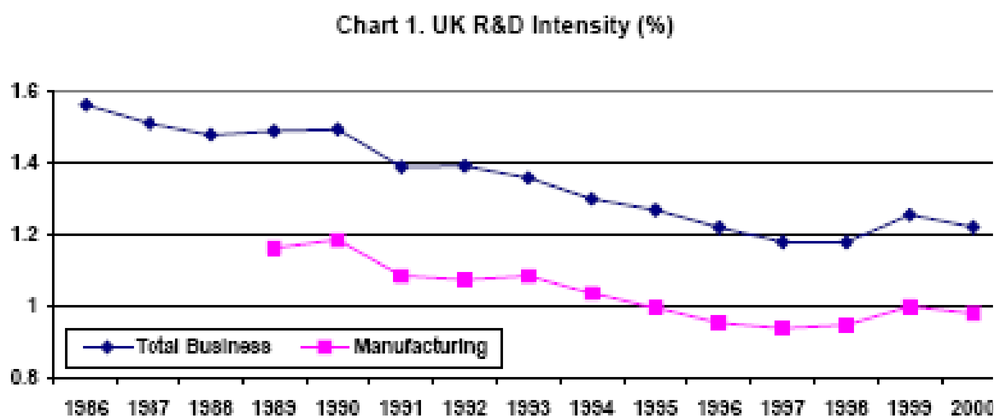

Figure 4.2. Total industrial R&D expenditure as a share of UK GDP at market prices[165].

Access to knowledge elements

Technological knowledge base

According to the Science and Investment Framework, the UK's current position in the world in regard to research excellence is second only to the US. In those research fields where UK is not second, the ambition is to close

[160] Becker B., Pain, 2003, page 14.
[161] Science and Innovation Investment Framework 2004-2014, Annual report 2007, page 26.
[162] Global Science and Innovation Forum, 2007.
[163] Technology Strategy Board, 2006.
[164] Interview, BBSRC, 20071016.
[165] Becker B., Pain, 2003, page 14.

this gap in the coming years. As shown in figure 4.3, Bioscience is among the areas ranked as second.

Research field	World ranking	Trend 96-05	Highlights
Bioscience	2	↔	• UK increasing overall citation and highly cited share.
Business	2	↑	• UK very high on citation "productivity".
Clinical	2	↑	• Agile research base – second in seven out of ten broad research disciplines
Environmental sciences	2	↔	
Humanities	2	↔	
Pre-clinical	2	↔	
Social sciences	3	↑	
Mathematics	4	↔	
Physical sciences	4	↑	
Engineering	4	↔	

Figure 4.3. World ranking of certain research fields in the UK based on PSA[166] target metrics.[167]

The UK has had a steady grip on second place since 1996 according to the figure. Pre-clinical and clinical research in the UK are also second in the world; the latter research field was included in the offering during the period and enhanced its position. starting in 2009 a new set of indicators will be used to simplify the metrics and increase focus on research quality[168]. UK bioscience strengths include the underpinning sciences such as cell biology, molecular biology and biochemical research. Genetics, stem-cells and nano-bio are gathering strength. Big Pharma is also strong in the UK according to

[166] Public Service Agreement, for definitions see; http://www.berr.gov.uk/files/file38817.pdf.
[167] Department of Innovation, Universities and Skills, 2007a, pages 12-13.
[168] Department of Innovation, Universities and Skills, 2007a, pages 12-13.

BBSRC[169]. Agricultural biotechnology and food biotechnology are not as strong though. One reason for this is that it is easier to "sell medical R&D investments". GMO in agriculture has faced lots of resistance in the UK which has affected these areas as well. There is a need for improvement in the scientific fields of bioinformatics, animal physiology and veterinary science. Overall, the UK is internationally competitive when looking at citations and publication data[170]. Since the 90s, there has been a major shift towards more demands on BBSRC and other research councils to demonstrate the effects of their funding in terms of economic benefits to society. There has been an increase in requirements by politicians to show results. One problem associated with this development is that such information is hard to access and therefore the availability of information might affect the work of the research councils[171].

Market-related knowledge base

"Greater responsiveness to the needs of economy"[172] is the headline of one science and investment framework chapter. This aim is linked to knowledge transfer and commercialisation, but it is also linked to the market-related knowledge base among researchers, CEOs etc. New patents filed, licensing agreements and income from business through consultancy have increased, as shown in figure 4.4. The increase in absolute terms is given in table 4.2. According to the Science And Innovation Investment Framework 2004-2014: Annual Report 2007, the increase in licensing agreements and income from licensing in relation to the decrease in the number of spin-offs since 2001 indicates more focus is being attributed to the quality than quantity of spin-offs. Since the likelihood of success and financial returns are higher for licensing than spin-offs, the former are encouraged and the increase has been very significant in just a few years[173]. In the comparison between the UK and the US, it should be noted that absolute levels of the indicators used in figure 4.4 are many times higher in the US. For instance, in 2003-2004 the IP income from licensing was GBP 632 million whereas the corresponding UK value is GBP 38 million[174].

[169] Interview, BBSRC, 20071016.
[170] Interview, BBSRC, 20071016.
[171] Interview, BBSRC, 20071016.
[172] Department of Innovation, Universities and Skills, 2007a, page 19.
[173] Department of Innovation, Universities and Skills, 2007a, page 19.
[174] Department of Innovation, Universities and Skills, 2007a, page 20 and HEFCE 2006, page 30.

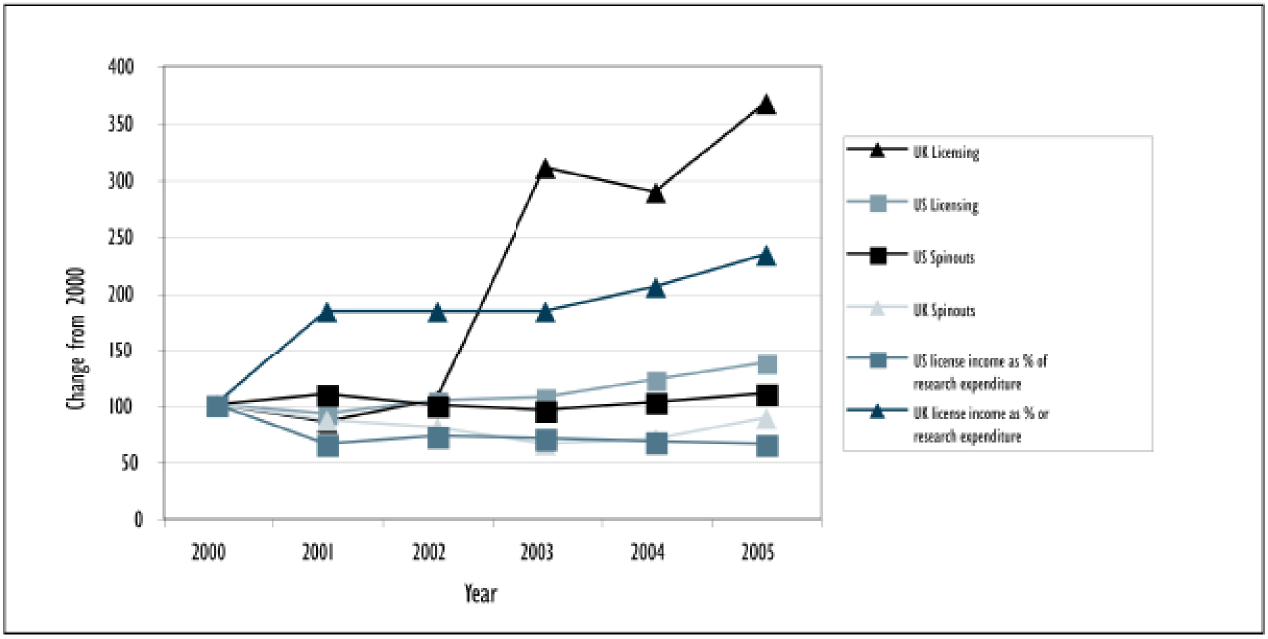

Figure 4.4. Relative changes of US and UK indicators.[175]

Table 4.2. Absolute values of the Higher Education Business Community Indicators (HEB-CI) over the 2000-206 period.[176]

Indicator - HEIs	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Number of licensing agreements	728	615	758	2,256	2,099	2,699
Income from licensing intellectual property (£ million)	18	47	37	38	57	58
Number of spin-outs	248	213	197	161	148	187

Some programmes and initiatives aim to increase the market-related knowledge base. For instance, the industrially relevant Continuing Professional Development (CPD) training aims to update the skills of graduates working in industry[177]. Additionally, there are several entrepreneurial encouraging schemes, such as the Enterprise Fellowship, Biotechnology Yes and the UK Bioscience Business Plan competition. The Bio-incubators of the UK are supported by a former DTI initiative; the Biotechnology Mentoring and Incubator Challenge (BMI), providing services and advice[178]. According to the BBSRC, there is a need to attract

[175] Department of Innovation, Universities and Skills, 2007a, page 20.
[176] Department of Innovation, Universities and Skills, 2007a, page 20.
[177] http://www.bbsrc.ac.uk/business/cpd/Welcome.html.
[178] http://www.bbsrc.ac.uk/business/skills/Welcome.html.

more skilled researchers within the research fields of bioinformatics and physiology[179].

Knowledge Transfer

Despite much excellent research being produced, the UK has struggled with a lagging behind in the production of new goods and services stemming from that research. The importance of business pull has been emphasised in several reports (the Lambert Review, the Innovation Report) and in the Government's technology strategy, driven by the Technology Strategy Board. The 2007 annual report of the Science and Innovation Investment Framework, states a positive trend in commercialisation and knowledge transfer activities from the science base. However these activities remain under the spotlight: "accelerating the translation of excellent research into new goods and services remains a key challenge"[180]. The DIUS wants to build on the progress achieved so far and take the agenda further[181]. This is demonstrated by the increased funding to knowledge transfer activities stated in the pre-budget report of 2007 as outlined in figure 4.5.

Total DEL[1]	**17,986**	**747**	**1,706**	**2,792**
	£ million			
	Estimate	**Projections**		
	2007-08	**2008-09**	**2009-10**	**2010-11**
Total UK science spending[2]	5,397	5,608	5,903	6,287
of which:				
DIUS science budget	*3,383*	*3,525*	*3,746*	*3,971*
DIUS funding for research and knowledge transfer in English Universities	*1,655*	*1,710*	*1,775*	*1,926*
UK science spending as a proportion of GDP (per cent)	**0.38**	**0.38**	**0.38**	**0.39**

[1] *Full resource budgeting basis, net of depreciation.*
[2] *Actual outturns are subject to spending decisions by the devolved administrations. Excludes non-cash items.*

Figure 4.5. Total UK science spending and the DIUS funding for research and knowledge transfer in English Universities.[182]

Knowledge Transfer within the bioscience community is a top rank issue on the UK innovation agenda[183]. Several actions have been taken to create an

[179] Interview, BBSRC, 20071016.
[180] Department of Innovation, Universities and Skills, 2007a, page 5.
[181] Department of Innovation, Universities and Skills, 2007a, page 7.
[182] Department of Innovation, Universities and Skills, 2007b.

environment that encourages translation of research and intellectual property into commercial products and projects[184]. The BBSRC should ensure that funded research will make a maximum contribution to British society and that commercialisation opportunities are sought[185]. The BBSRC view is that commercial activity in biosciences is "best pursued by the research generator" and therefore the BBSRC merely supports the innovation process in universities and institutes without holding the IP itself. In return, the universities should provide adequate means to support the commercialisation process[186]. The MRC on the other hand owns the IP rights on discoveries made by research conducted in MRC units and institutes and provide translators that will help researchers exploit these discoveries commercially[187].

Explicit programmes and initiatives supporting commercialisation and knowledge transfer

The major programme to promote knowledge transfer is the Technology Programme, consisting of the business support product Collaborative Research and the knowledge transfer initiative Knowledge Transfer Networks (KTNs). Collaborative Research aims to increase collaboration and joint funding with industry and is supported by the BBSRC through the Link scheme and the Industrial Partnerships scheme. The Link Scheme is a government-wide initiative that provides a 50% funding to collaborative projects in key scientific areas.

Important BBSRC initiatives, operated by the Business and Innovation Unit (BIU), to encourage knowledge transfer from the science base to the industry are outlined in table 2[188]. Emphasising the importance of "people change" and networking, programmes like the Industry Interchange Programme, Knowledge Transfer Partnerships, Industry Fellowships and Faraday Partnerships are supported by BBSRC[189].

The MRC has an 80-strong MRC Technology group (MRCT) tasked with bringing discoveries to market. Their role is to identify and protect research with commercial potential and assist with patenting and licensing on the

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[183] Department of Innovation, Universities and Skills, 2007a, executive summary and chapter 3.
[184] Department of Innovation, Universities and Skills, 2007a, executive summary and chapter 3.
[185] http://www.bbsrc.ac.uk/business/biu.html.
186 http://www.bbsrc.ac.uk/biobusiness_guide/Welcome.html, http://www.bbsrc.ac.uk/business/ip/Welcome.html.
[187] http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
[188] http://www.bbsrc.ac.uk/biobusiness_guide/Welcome.html.
[189] http://www.bbsrc.ac.uk/business/knowledge/Welcome.html.

global arena[190]. The MRCT drug discovery initiative invests GBP 10 million in linking MRC research with industrial chemistry and drug screening[191]. Other MRC products for knowledge transfer and commercialisation are notably the translators, mentioned above, that should “facilitate knowledge transfer across all stages of the research pipeline and in areas where the potential for commercial exploitation is not apparent”[192]. They serve as link brokers between industry, researchers and healthcare organisations[193]. Collaborative Studentships is another MRC product to facilitate links between an academic institution and a company[194]. There is a portfolio of MRC fellowship schemes in the clinical fields to increase collaboration[195].

The Higher Education Innovation Fund (HEIF) promotes knowledge transfer between academia and industry and academia engaging with business. HEIF has played a vital role in the quest to increase the commercialisation of research. Over the period 2006-2007, GBP 238 million was provided to knowledge transfer activities.

Strengths and weaknesses in knowledge development

In recent years, the UK science budget has increased in comparison with the Swedish one. The increase has taken place with a clear aim to provide research excellence second only to the US and has been accompanied by ambitious strategies. In areas where the UK is not currently second, measures will be undertaken to close the gap. The aims concerning life science are reflected in the budget allocations.

The declining business contribution to R&D expenditure has been an issue of major concern, but this development is said to have turned around. It is interesting to note that in the UK, the increase of the relative share of foreign capital in the overall industrial R&D expenditure is welcomed. This large share is seen as evidence of the attractiveness and competitiveness of the UK and it has been emphasised that this is a strength that has to be built upon continuously.

BBSRC points out the balance between focusing on priority areas by selecting key technologies and increasing industrial funding and involvement[196]. It has been recognised in the British innovation system that policies of different countries are subject to competition. It seems like the

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190 http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
191 http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
192 http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
193 http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
194 http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
195 http://www.mrc.ac.uk/OurResearch/Industrylinks/index.htm.
196 Interview, BBSRC, 20071016.

industry is also submitted to competition by the public authorities based on both the technology strength and potential economic benefit to society but also on the willingness of the industry to get involved and their willingness to increase their R&D budget. According to BBSRC, the agro-food industry used to have a higher priority but since few large companies showed interest in R&D, agro-food is no longer a priority. Many SMEs wanted to get involved within a programme entitled bioscience for industry, but did not have the resources. BBSRC was therefore the majority funder with industry funding10-20%[197].

The technological knowledge base is an obvious strength within biosciences and ranks as second only to the US. However, it seems the UK's strengths fall predominantly within traditional and basic life science research fields. In newer areas like bioinformatics, the UK has recognised its need for improvement.

The positive income development on licensing could be a consequence of both stronger technological knowledge base and stronger market-related knowledge base. Interesting to note is the very large increase in the number of licences as well since it has been a deliberate strategy from the government to increase consultancy and licensing due to the higher financial returns. This information is interesting in the context of the Cambridge development towards more consultancies in the life science industry (industrial structure and financial support system, Cambridge). Apparently, this development could also be a consequence of a governmental strategy.

The development towards increased commercialisation of research and knowledge transfer in general shows some strong results.It is still perceived as a challenge though and will remain in the spot light. The budget relating to these issues will increase slightly in the coming years. The work has been going on for a long time; for instance the MRC technology group has been around for 20 years. On the other hand, the cultural barriers between academia and industry have been very strong in the UK. According to Hampden-Turner and Trompenaars, pure science is more highly revered than its commercial applications by leading British universities[198]. Porter states that "an oft-noted and highly significant observation about Britain is that the best talent has by and large avoided industry".[199] Social norms have defined certain occupations as acceptable, and others as "simply commerce"[200]. An analysis of the reasons for this cultural barrier should take into consideration that British universities were established before the

[197] Interview, BBSRC, 20071016.
[198] Hampden-Turner, Trompenaars, 1993.
[199] Porter, 1990.
[200]Almeida P., Saunders S.B., 2002, National Innovation Systems and Patterns of Knowledge Flow: A Comparison of Diffusion of Biotechnology Innovations in the US and UK, page 7.

industrial revolution and in a strongly articulated class system. Some of the essence of this traditional view has been conserved within the universities [201].

4.1.2 Financial support systems for innovation

Access to Venture Capital

General access to venture capital

Access to finance in the UK is described as good. In 2005, over half the total annual European private equity investment was attributable to the UK private equity industry. Funds raised from investors increased from GBP 27.3 billion in 2005 to GBP 34.3 billion in 2006[202]. It is claimed that the British venture capital market is well-developed compared to other European countries and second only to the US[203]. This strength in financial access is also said to constitute a big advantage to UK business in reaching its full potential[204]. Similarly with other European companies, access is poorer in regard to startup companies and those lacking a track record. The growth of the UK market has been accompanied by an increasing share of larger investments in well-established business. Management buy-out activities, for instance, have received a large share. Although making an important contribution to UK productivity, it is reasoned that in the long-term these priorities will create a market structure that constitutes a barrier to business formation and growth[205]. Even small amounts of venture capital may be in short supply for smaller companies with growth potential[206]. This is an urgent issue, particularly for the bioscience sector where the risks are generally higher[207].

Other sources of non-public venture capital

Business angels have been around for much longer in the UK than the rest of Europe, and particularly Sweden which is said to have "got on the bandwagon as late as 2003"[208]. Today there are 35 angel networks in the UK, a decrease since 1999[209]. Recently there have been changes in the regulations regarding certain investments which might affect business angels within biotechnology, according to the British Business Angel Association (BBAA). The BBAA welcomes the government's decision to

[201] Hampden-Turner, Trompenaars, 1993.
[202] British Venture Capital Association, 2007, page 1.
[203] Former Department of Trade and Investment, 2003, paragraph 3.43.
[204] Former Department of Trade and Investment, 2003, paragraph 3.43.
[205] HM Treasury, 2003, page 6.
[206] http://www.dti.gov.uk/bbf/small-business/info-business-owners/access-to-finance/page37736.html.
[207] Former Department of Trade and Investment, 2003, paragraph 3.44.
[208] http://bulletin.sciencebusiness.net/ebulletins/showissue.php3?page=/548/art/4772.
[209] http://bulletin.sciencebusiness.net/ebulletins/showissue.php3?page=/548/art/4772.

support fund schemes approved within the Enterprise Investment Scheme. This scheme gives investors in certain qualifying companies the right to a range of tax reliefs[210]. One of the criteria is that the portfolio should include high-risk companies. Investment in early-stage companies should be 90% and the recent rearrangement prolongs the time period for the investor to find suitable companies. However, following the imposition of EU State Aid rules the BBAA is concerned that the annual GBP 2 million limit for investments in individual companies will constrain investors and individual entrepreneurs within "businesses on a fast growth trajectory and requiring high levels of early-stage funding (such as those in the biotech sector)"[211].

Public Funding

In the report "Bridging the Finance Gap: Next Steps in Improving Access to Growth Capital for Small Businesses", the government sets out its view of the reasons underlying the equity gap facing business seeking to raise modest sums of venture capital. They conclude that companies seeking up to GBP 2 million of growth capital, especially those seeking between GBP 250,000 and GBP 1 million, are mostly constrained in their growth by the equity gap. For larger companies, a shortage of venture capital can occur when seeking investment to modernise or diversify[212]. In addition to the constraints in supply, the factors underlying the demand should also be taken into consideration. The government report suggests that a lack of awareness of the various funding possibilities amongst entrepreneurs could present a constraint in growth and business formation. Furthermore, it claims evidence that fear of losing control is a major deterrent for many entrepreneurs seeking finance[213].

The equity gap has been addressed by a number of initiatives and programmes, like the Grant for Research and development, the Early Growth Fund, Regional Venture Capital Funds and Enterprise Venture Capital Funds. There are also initiatives like the Small Firms Loan Guarantee, Late payment and Community Investment Tax Relief. Since the number of publicly funded business support products that address the equity gap of early-stage and growth companies is so extensive, the descriptions of these are outlined in appendix 2.

Strengths and weaknesses identified in the financial support system

A weakness has been identified by the government in regard to the financial support system. There is an equity gap, which affects not only early-stage

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[210] http://www.eisa.org.uk/render.aspx?siteID=1&navIDs=21,97.
[211]http://www.bbaa.org.uk/portal/index.php?option=com_content&task=view&id=186&Itemid=53.
[212] http://www.dti.gov.uk/files/file37477.pdf.
[213] HM Treasury, 2003, page 6.

companies but also growth companies. Although the overall access to capital is very good, this is identified as an important problem. A mismatch between the size of investments required by the SMEs and the sums venture capitalists are willing to invest is also a problem[214]. However, these issues have been extensively addressed. There are numerous important programmes and initiatives which aim to bridge the equity gap and address the constraints on growth. It is interesting to note that this situation is very much recognised by public actors in the UK and is a high priority issue to solve.

The well-developed business angel market is a strength of the UK life science innovation system. The government provides investment incentives in order to increase the capital access to early-stage companies.

4.1.3 Policy evolution

Infrastructure and organisation

The main policy-makers of the British Life Science innovation system are outlined in figure 4.6. The scheme has been checked with representatives from the British innovation system. Still, it should be borne in mind that restructuring occurs frequently within British government infrastructure. The structure described in figure 4.6 is valid for 2008. Policymaking public authorities with a mainly advisory function are marked in red and public authorities that are executive bodies mainly implementing policy decisions are marked in blue. There has been an important restructuring among the actors in the last year (2007-2008). One new and important actor in the British Life Science innovation system is the Department of Innovation, Universities and Skills (DIUS), formed in June 2007. This department assumes the responsibilities for science and innovation from the former DTI which has become the Department for Business, Enterprise and Regulatory Reform (BERR). DIUS also assumes the responsibilities for further and higher education and skills from the former Department for Education and Skills (DfES), which has become the Department for Children, Schools and Families (DCSF).

In bringing together these responsibilities in a new department, the UK government aims to “build a dynamic knowledge-based economy”[215].

Another important rearrangement is the transformation of the Technology Strategy Board (TSB) into an executive and independent Non Departmental

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[214] http://www.dti.gov.uk/files/file37477.pdf.
[215] http://www.dius.gov.uk/functions.htm.

Public Body (NDPB)[216] which will "operate at arm's length from the government"[217]. Formally the TSB had the status of a Research Council UK (RCUK), even though it possesses a unique position among the public authorities. TSB will be described among the implementation bodies below, although it is also tasked with an important advisory function, and the remit to deliver *the* Technology Strategy. Furthermore, important changes are about to take place among the NDPBs involved in health research. Notably, a new body interconnecting the MRC and the NIHR will be up and running in 2009[218]. This is the Office for Strategic Coordination of Health Research (OSCHR) shown in figure 1 and which will be further outlined in the section on intragovernmental collaboration.

Advisers

The main policy advisors in the British innovation system are the Chief Scientific Adviser (CSA) and the Secretary of State for DIUS. The former is responsible for advising on scientific and technological policy and for the quality of scientific advice within the government[219] whilst the latter advises on investment in research and innovation[220]. The CSA also has the remit to ensure that government departments deliver Science and Innovation Strategies (S&Is)[221]. The S&Is should outline how science-related activities impact on the departments' objectives and PSA targets (Public Service Agreement). In addition to S&I targets, most departments have also developed Evidence and Innovation Strategies (E&Is) to increase evidence-based policy making[222]. The top-level independent advisory body to the UK Government on science and innovation issues is the Council for Science and Technology (CST)[223]. The CST gives advice not only to the Prime Minister but also to the First Ministers of Scotland and Wales on intersecting strategic issues[224]. One chair is reserved for the CSA, thus creating a link between the advice given by CST and that of CSA. With a chair in CST, CSA will provide advice to CST on probable response from the government to CST advice and give suggestions to CST on their work programme. There is also an independent chair tasked with the less formal development of views of the independent CST members[225]. The CST members are appointed by the Prime Minister[226].The Royal Pharmaceutical Society of

216 http://www.berr.gov.uk/innovation/technologystrategyboard/.
217 http://www.berr.gov.uk/files/file34882.pdf, page 3.
218http://www.mrc.ac.uk/AboutUs/OurStrategy/SingleHealthResearchFund/FutureDirections/index.htm.
219 http://www.number10.gov.uk/output/Page7484.asp.
220 http://www.dius.gov.uk/.
221 Department of Innovation, Universities and Skills, 2007a, page 47.
222 Department of Innovation, Universities and Skills, 2007a, page 47.
223 Department of Innovation, Universities and Skills, 2007a, page 46.
224 http://www2.cst.gov.uk/cst/about/.
225 The Council for Science and Technology, 2004, page 3-4.
226 Council for Science and Technology, 2007.

Great Britain (RPSGB), The Human Genetics Commission and The Human Fertilisation and Embryology Authority (HFEA) all have roles as Life Science Policy Advisers[227]. The most important public authority with a regulatory function is The Medicines and Healthcare Products Regulatory Agency (MHRA)[228].

Implementation

Ministers from different departments are brought together in the Sub-sub-committee on Science and Innovation, in order to increase collaboration and concordance in the implementation of innovation policies. Implementation of innovation policies is also conducted by the work of DIUS in close collaboration with DCSF and BERR. Within the fields of life science, implementation of the policies is further outlined by the RCUKs, notably BBSRC and MRC and on a regional level by the DAs and RDAs.

227 http://www.fertileage.com/User/Ads/ARTinUK.pdf, page 3, http://www.hgc.gov.uk/UploadDocs/DocPub/Document/hgc02-p4.pdf, page 2, http://www.dti.gov.uk/sectors/biotech/biotechmedic/reports/page22183.html

228 http://www.dti.gov.uk/sectors/biotech/biotechmedic/reports/page22183.html.

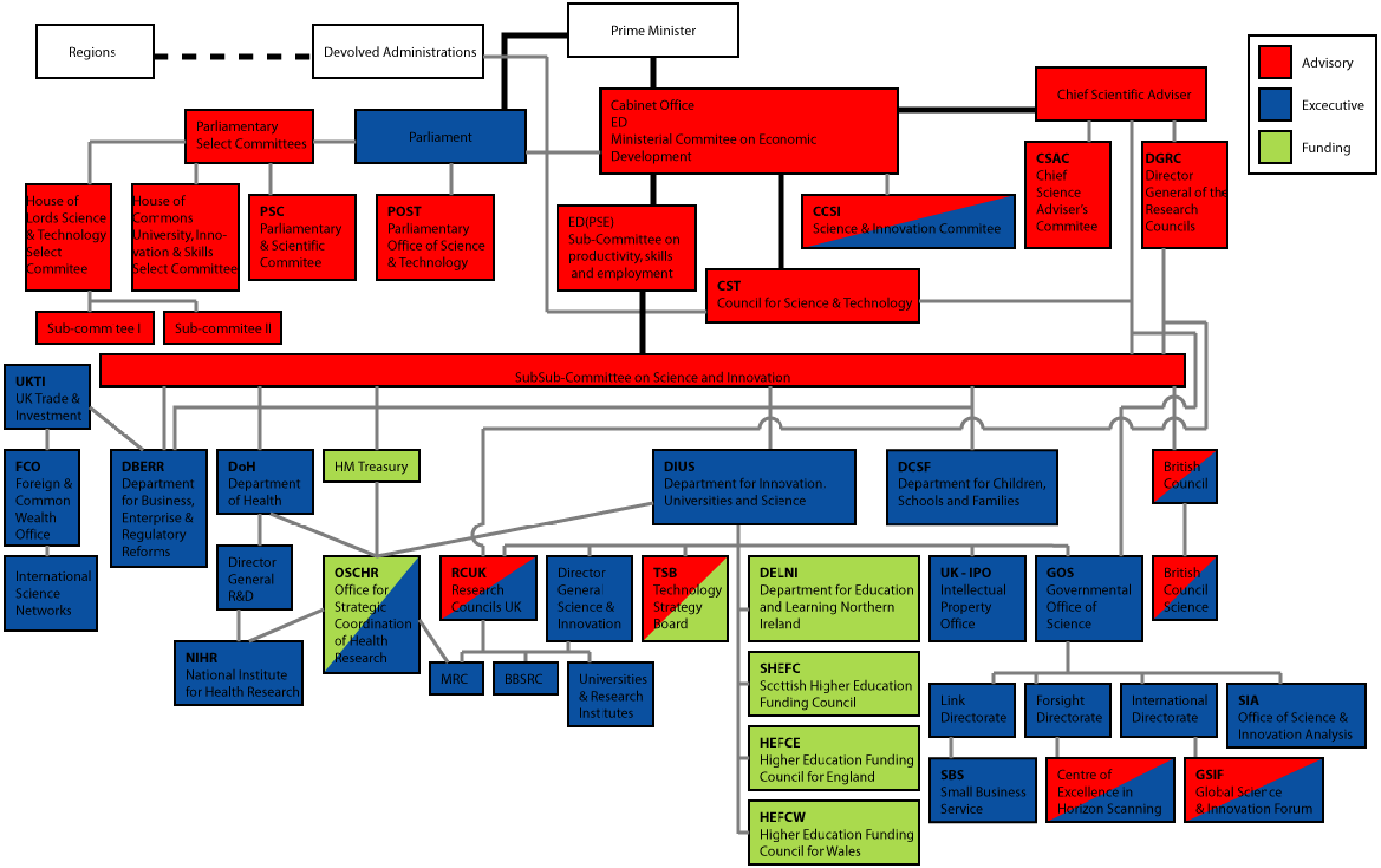

Figure 4.6.: Overview of UK Life Science Innovation System (UKLSIS) /Made by Helena Bergqvist (VINNOVA)

Collaboration and partnerships

The various policy documents launched by the government often highlight the importance of collaboration and networks. Particular emphasis is placed on the need for a more advanced collaboration between the university sector and industry, between national and regional levels, between governmental policy-makers and industry and within the government. There seems to be a principle of joint funding overarching the collaboration aims on all levels. The approach towards this principle is outlined for some of the major actors in the national life science innovation system.

Partnerships in funding

Partnerships are among the six main objectives in the BBSRC strategic plan. Joint funding is vital and partnerships with other financers and research councils have a high priority. In line with the collaboration aim is the recent opening to fund institutes of the Welcome Trust or other Research Councils as well as BBSRC institutes. The partnerships aim to promote multidisciplinary research, such as system biology[229]. To further promote the benefits of multidisciplinary research, the other research councils, government departments, private and charitable sectors are involved in setting the BBSRC research agenda[230]. The collaboration between financers will also lead to a streamlining of the available support activities, with the aim of making things easier for stakeholders[231]. Intragovernmental schemes are being established comprising several government funding bodies in funding collaborations[232]. According to BBSRC, these collaborations and joint schemes are a prerequisite to reach their strategic objectives[233]. The principle of joint funding is also applied to European and international funding sources. Apart from the possibilities of multidisciplinary research, the aim is to provide British researchers with access to facilities and research that will strengthen the UK's capability in key research fields and promote UK bioscience on the international arena[234]. The 7th Framework Programme (FP7) introduces Joint Technology Initiatives (JTIs). These are public/private investment partnerships in key technology areas which support industrially-driven research. The UK interest in these JTIs lies particularly in innovative medicines, with a budget of GBP 2 billion[235].

229 BBSRC strategic plan, page 31.
230 BBSRC strategic plan, page 31.
231 BBSRC strategic plan, page 35.
232 BBSRC strategic plan, page 32
233 BBSRC strategic plan, page 37.
234 BBSRC strategic plan, page 32.
235 Department of Innovation, Universities and Skills, 2007a, page 17.

A greater co-operation between public funders of health research was boosted this year by the establishment of the Office for Strategic Coordination of Health Research (OSCHR). The OSCHR will include a joint health research funding board. The board will include representatives from MRC and the National Institute for Health Research. The OSCHR will be in charge of delivering a single health research strategy that should build on the current UK strengths in this field and provide better support for clinical research[236]. According to the Director General of Research and Development at DH R&D, the OSCHR will "offer a tangible mechanism to facilitate the translation of health research into health and economic benefits for the UK"[237]. The OSCHR will also form a link between the government's health research strategy and the private sector. The organisational structure of the public authorities involved in the innovation system for health research is outlined in figure 2. This is the structure that will apply from 2009. As shown in the figure, the funding flow from NIHR and MRC will be co-ordinated by the OSCHR, although the NIHR and MRC in turn are funded by separate government departments. A single fund for health research will be created and elevated to GBP 1.7 billion in 2010-2011[238]. However, GBP 1 billion of this will be ring-fenced for NIHR. In Figure 4.7, this part of the life science innovation system is marked in green.

236 Department of Innovation, Universities and Skills, 2007a, page 6.
237 http://www.rdforum.nhs.uk/docs/cooksey_letter.doc.
238http://www.mrc.ac.uk/AboutUs/OurStrategy/SingleHealthResearchFund/FutureDirections/index.htm.

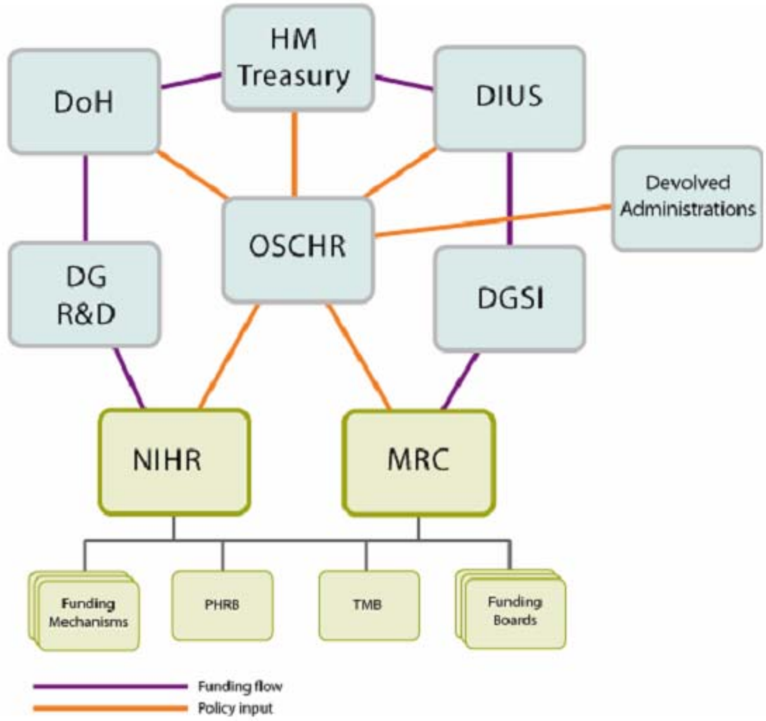

Figure 4.7. New structure among the departments and NDPBs involved in funding health research[239].

Intragovernmental collaboration

There has been a need to improve the intragovernmental management and use of science and innovation and measures have been taken for improvement. Steps include a rolling programme of science reviews and the overarching work of intragovernmental policy-makers like the Chief Scientific Advisers Committee (CSAC), the Council for Science and Technology and the Horizon Scanning Centre (HSC)[240]. The CSA is head of the interdepartmental Science and technology group[241] (now part of the DIUS Governmental Office for Science[242]) and is part of almost every important committee with an advisory function[243]. Intragovernmental collaboration has also been leveraged by the establishment of such things as the Global Science and Innovation Forum (GSIF), with DIUS, FCO, UKTI,

239http://www.mrc.ac.uk/AboutUs/OurStrategy/SingleHealthResearchFund/FutureDirections/index.htm.
240 Department of Innovation, Universities and Skills, 2007a, page 8.
241 http://www.britishcouncil.org/gost/advice.htm.
242 http://www.dius.gov.uk/pressreleases/press-release-20070720.htm.
243 http://www.britishcouncil.org/gost/advice.htm.

DoH, Royal Society and the RCUKs among the members[244]. The HSC together with the National School of Government on Professional Skills for Government (PSG) are working to leverage intragovernmental capability in science and innovation issues[245]. Progress against the aims defined in the ten-year framework will be consistently monitored by the government departments using a new set of unified progress indicators[246]. A recent example of serious commitment to increased collaboration within the government is the announcement of a GBP 120 million budget reserved for collaboration between TSB and the RCUKs for promotion of strengthened links between business and academia.

Collaboration between parts of the triple helix

The collaboration and interactions between the public/politics, industry and academia is referred to as the triple helix of an innovation system[247]. Increasing collaboration between industry and academia was recognised as a key objective as early as the 2003 Innovation Report and lots of measures have since been taken to change the prevailing anti-collaboration culture [248]. Examples are given in section 4.1.2, in the context of commercialisation of research. The public dialogue on key scientific issues is overseen by Sciencewise, a "mass public engagement programme on science and technology"[249] that held a GBP 1.5 million budget in 2006-2007[250]. The idea is to give the public a say in the policy-making process[251]. Brain research and stem cell research are examples of such issues for nationwide discussion. The issues which will dealt with are identified by the HSC. BBSRC has a commitment to inform the public about biosciences and ensure that the processes of BBSRC are transparent[252]. The same goes for MRC, tasked with promoting a public dialogue about medical research[253].

Addressing the global challenge

The UK government has developed several strategic plans to cope with the increasing global challenge of changing economic and research environments. The Framework for Science and Innovation sets out the aim for the UK to become a "key knowledge hub in the global economy" and the partner of choice for global businesses interested in locating R&D

244 Department of Innovation, Universities and Skills, 2007a, page 16.
245 Department of Innovation, Universities and Skills, 2007a, page 48.
246 Department of Innovation, Universities and Skills, 2007a, page 49.
247 http://www.nutek.se/content/1/c4/27/80/TripleHelixmodellen_definition.pdf.
248 Former Department of Trade and Investment, 2004, page 1.
249 Former Department of Trade and Investment, 2004, section 1.2.
250 Department of Innovation, Universities and Skills, 2007a, page 42.
251 http://www.sciencewise.org.uk/html/secure/documents/Stemcellspressrelease.pdf.pdf.
252 http://www.bbsrc.ac.uk/society/Welcome.html.
253 http://www.mrc.ac.uk/AboutUs/OurMission/MRC002337.

abroad. A reputation of outstanding scientific and technological discovery should attract collaboration with foreign universities. The aim is also to become a world leader in turning key knowledge into new products and services[254]. According to The Investment Framework for Science and Innovation 2004-2014, the UK science, research and innovation system should be designed so as to;

- Maintain overall ranking as second to the US on research excellence and the current lead against the rest of the OECD: close the gap with the leading two nations where current UK performance is third or lower and maintain the UK lead in productivity.

- Retain and build sufficient world centres of research excellence, departments and broadly-based leading universities, to support growth in its share of internationally mobile R&D investments and highly skilled people.[255]

In 2006, the intragovernmental GSIF published a" Strategy for International Engagement". The document aims to provide an overarching strategic framework. Strengthened international collaboration is identified as one of the keys in achieving research excellence. Attraction of international R&D investments and science is identified as the key to excellence in innovation[256]. The strategy emphasises the need to build upon current British strengths in attracting foreign knowledge and capital[257]. Excluded by the GSIF focus are identifying and prioritising which global or European facilities the UK should select to contribute to or host. Nor do they identify international partnerships or collaborations of strategic importance for establishments of facilities. From April 2007 onwards, these highly emphasised issues are being driven by a newly established Research Council; the Science and Technology Facilities Council (STFC), particularly tasked with these objectives[258].

Explicit programmes and initiatives addressing the global challenge

The BBSRC has taken measures to address the global challenge within biotechnology and biological sciences and promotes international collaborations[259]. Their funding schemes to support international collaboration comprise an International Scientific Interchange Scheme,

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254 Former Department of Trade and Investment, 2004, 1.45, DTI 2004.
255 Former Department of Trade and Investment, 2004, Box 1.1, DTI 2004.
256 Global Science and Innovation Forum, 2007.
257 Global Science and Innovation Forum, 2007.
258 Department of Innovation, Universities and Skills, 2007a.
259 http://www.bbsrc.ac.uk/international/Welcome.html.

international workshops dealing with issues of strategic importance and partnering awards with China, Japan and India, aiming at strengthening research links.

There is an increased emphasis on partnerships with China and Japan in particular. Guidelines have been set up with certain criteria that need to be fulfilled as a condition for partnering. In focus is what benefits for BBSRC science the partnership introduces and what future benefits could follow from the collaboration. The partnership should also present a unique opportunity of access to the foreign country's expertise. Evaluation is also affected by the prospect of joint funding from other sources.[260] The International Relations Unit at BBSRC is involved in creating international links on a policy level[261]. The BBSRC exploits international funding opportunities and promotes the strength of the UK science community abroad[262]. Relations with India are further strengthened by the UK-India Education and Research initiative (UKIERI). The four-year GBP 14 million budget is intended for the creation of research links. Joint commissions have been held with China, Korea and Japan in order to establish corresponding future links in priority areas[263]. The GBP 12 million Science Bridges scheme plus international fellowships will strengthen the links with researchers from the US, China and India.

In spring 2007, the Department of Trade and Industry (DTI) business support product Global Watch Service shut down as a result of the government streamlining of support services. The function served by the service will be undertaken by the Knowledge Transfer Networks (KTNs)[264].

Key Technologies

The TSB is currently tasked with driving forward the technology strategy which selects technology areas to be supported by public funds. Among the key goals of the TSB are to:

- Stimulate those sectors and businesses with the capacity to be among the best in the world to fulfil their potential.
- Ensure that the emerging technologies of today become the growth sectors of tomorrow.

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260 http://www.bbsrc.ac.uk/international/bbsrc/china.html.
261 http://www.bbsrc.ac.uk/international/iru.html.
262 http://www.bbsrc.ac.uk/international/Welcome.html.
263 Department of Innovation, Universities and Skills, 2007a, page 17.
264 http://www.dti.gov.uk/innovation/globalwatch/index.html.

Key technology areas are chosen based on their potential to substantially contribute to the growth of the UK economy[265]. More specifically, the areas are chosen based on the UK capacity to develop the technology, the potential impact and what share of the global market the UK could reach within the technology area of consideration[266]. Among the seven key technology areas are Bioscience and Health[267].

The BBSRC technology strategy further identifies seven key technology areas of strategically importance and where the industrial needs calls for increased investment: Bioprocessing, integrated mammalian biology, exploitation systems biology, biocatalysts and biotransformation, genomics underpinning healthcare, intelligent storage retrieval and analysis of large databases, crop sciences and bio-nanotechnology[268]. The majority of BBSRC funding is allocated to priority areas through the responsive mode mechanism. The priority areas are identified by seven strategy panels that are also responsible for delivering strategic objectives[269]. There is an opportunity to react to research fields in need of funding that lie outside the identified priority areas. This research is supported through initiatives that have a defined target, budget and duration[270]. In addition to the priority areas identified, there are cross-committee priority areas that are interdisciplinary and have a high priority status equal to that of the priority areas[271]. Within the priority areas, the BBSRC is encouraging large grant proposals. Larger grants should boost multidisciplinary research and solve problems in strategic areas as well as helping provide critical mass in the priority areas. In order to become globally competitive, it is emphasised by the BBSRC that research groupings require a larger volume in numbers and expertise[272]. The MRC has defined their current research priorities as Clinical and public health research, Infections and vaccine research, Global health, Biomarkers, Ageing-related research and Sustaining capability in areas of strategic importance[273].

One research field that seems particularly prioritised by the government is stem cell research. Over the period 2006-2008, a total of GBP 100 million has been allocated to stem cell research. As a comparison, the BBSRC total

265 http://www.dti.gov.uk/innovation/technologystrategy/tsb/index.html.
266 Spittle G., 2005, Developing UK Capability and Creating Wealth.
267 Technology Strategy, 2005, Page 16-17.
268 http://www.bbsrc.ac.uk/business/biu.html.
269 http://www.bbsrc.ac.uk/science/areas/Welcome.html.
270 http://www.bbsrc.ac.uk/science/areas/Welcome.html.
271 http://www.bbsrc.ac.uk/science/areas/Welcome.html.
272 http://www.bbsrc.ac.uk/science/areas/Welcome.html.
273 http://www.mrc.ac.uk/OurResearch/PriorityAreas/index.htm.

allocation over the same period of time totals about GBP 800 million[274]. Since stem cell research is considered a key issue, the Sciencewise programme will particularly focus on stem cells.[275] A UK stem cell initiative was established in 2005 which led to a ten-year research vision (shown in figure 4.9), that will be addressed by the MRC.

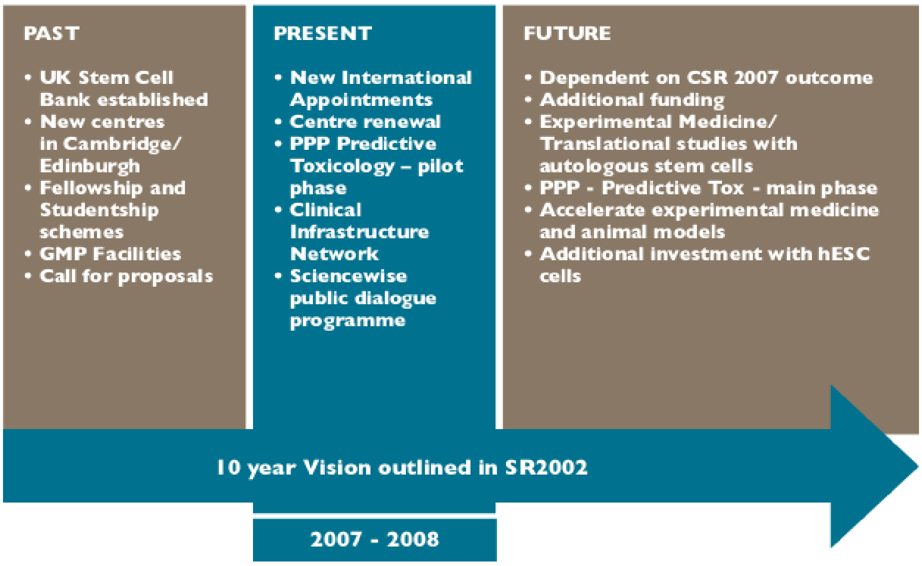

Figure 4.9: Progress and plans in stem cell and regenerative medicine.

Strengths and weaknesses identified

The question might be asked whether the responsibility of working with innovation is best located with the responsibility for academia or business. In the new structure, they are located with the responsibility for academia, or "universities and skills". However, according to BERR, the new structure enables issues of innovation, business and academia to be more closely linked. The important restructuring that has occurred in the British innovation system was justified by the aim of bringing about a more co-ordinated approach towards innovation. The parts of the former DTI and DfES that worked close to innovation issues can now work as one entity. The DTI had been criticised for having too broad an approach to innovation and the aim of the restructuring was also to decrease bureaucracy. Bringing together competencies from a department dealing with academia and those from a department dealing with business is claimed to be beneficial for the sake of knowledge transfer from academia. The responsibility for academia

274http://www.dh.gov.uk/en/PolicyAndGuidance/HealthAndSocialCareTopics/StemCell/StemCellGeneralInformation/DH_4124082.
275 Former Department of Trade and Investment, 2004, section 1.2.

is now more connected to the responsibility for innovation and DIUS will work closely to BERR[276]. As it turns out, critical voices have claimed that the departemental rearrangement occurred too fast[277]. It is too soon to evaluate if the restructuring in fact has achieved what it aimed for, but the power to act on the highest possible level in order to bring together academia and business is no doubt to be considered a strength.

Although different actors have identified a need for improvement in regard to collaboration in funding, the issue has been dealt with within government and the triple helix in general. It is intended that the new funding structure involving MRC and NIHR will facilitate funding collaboration. This is one example of how the funding streams among UK financers are more streamlined. It is recognised that more financers need to pool their resources in certain projects. There is also a "pooling of board members" so to speak, in order to increase the collaboration between decision makers/policy-makers. There are several examples of innovative ways of increasing intragovernmental collaboration. The rolling programme of science reviews for example. The new remit of TSB also adds to the aim of increasing collaboration. According to TSB, their new role will increase collaboration between the TSB and the RCUKs, which TSB claims already has started out very well particularly concerning life science. Also, TSB will have an increased collaboration with the RDAs. The TSB perceive that the government listens to them and the technology strategy has had a large impact[278].

It is a strength that the need for increased collaboration has been dealt with. However, the British infrastructure of public authorities within science and innovation still involves numerous actors. The question might be raised as to whether a system with such a large number of committees and sub-committees and sub-sub-committees is well-suited to working collaboratively with science and innovation. Also, according to TSB, the collaboration with industry needs to be improved both in terms of formal and informal mechanisms[279].

The international interaction aims within life science predominantly comprises the US, India, China and Japan. The China and India initiatives are quite new, but the BBSRC now has an office in Beijing and there will be one in the US and in India as well. Currently, it is only possible to receive seed funding from BBSRC to strengthen collaboration. Specific international projects cannot be allocated funding. There is ongoing discussion and there might be a shift in the future. The BBSRC acknowledges that the international collaborations are relatively few. This is

[276] Interview, BERR. 20071016.
[277] http://www.guardian.co.uk/education/2008/oct/25/student-grants-higher-education-bill
[278] Interview, Technology Strategy Board, 20071016.
[279] Interview, Technology Strategy Board, 20071016.

explained by a lack of incentives to collaborate, particularly with India and China. There is reluctance in going into international partnerships[280]. The international collaborations are currently based on the net economic benefit for the UK research. In the future more attention will probably be given to "economic benefit to UK economy"[281]. The willingness to participate in international partnerships is affected by the risk of money leaving the UK[282].

The identification of key technologies is addressed by BBSRC, MRC, TSB and several other public authorities. The TSB identifies key technologies rather broadly, and the research councils and RDAs then specify what areas of strength to further build upon or what emerging technologies to support. For instance, stem cell research is a priority in Scotland and MRC has a major focus on translational medicine. The TSB does not control the priorities of the RDAs but the aim is for priorities to be aligned and the technology strategy to be followed. It is shown in the budget allocations that the talk of identifying key technologies is more than just talk. The 100 million stem cell research allocation from BBSRC is one illuminating example. Overall, the funding streams are large and concentrated in the UK.

There are no specific mechanisms to weight the lobbying from industry in order to ensure that the lobbying of certain industries is not dominating the TSB agenda when selecting key technologies. This might inflict a problem in regard to such things as emerging technologies which do not have the same lobbying powers. According to the TSB though, there is already a lot of focus on emerging technologies and the priority areas coincide with the true areas of strength[283]. Similarly, there are no specific mechanisms to ensure that the strength of certain regions does not dominate the TSB agenda more than the strength of others in the selection of national key technology areas. Again, it is claimed this has not constituted a problem so far since the collaboration with the RDAs is well-functioning. The starting point is to identify the major strengths of the UK and these are built upon[284]. The BBSRC does not have any corresponding mechanism either but like the TSB they do not perceive any specific problems. They collaborate with regions that are already strong[285].

[280] Interview, BBSRC, 20071016.
[281] Interview, BBSRC, 20071016.
[282] Interview, BBSRC, 20071016.
[283] Interview, Technology Strategy Board, 20071016.
[284] Interview, Technology Strategy Board, 20071016.
[285] Interview, BBSRC, 20071016.

5 The Scottish life science innovation system

5.1 The choice of Scotland

Scotland was chosen as a comparison to the Swedish life science innovation system for several reasons. Just like Cambridge and Uppsala, there are some similarities and differences that make the innovation systems a particularly interesting comparison. The Scottish life science industry is smaller than the Swedish with 33,500 and 34,500 employees respectively[286]. The definitions of what kind of companies that count as life science companies probably differ though and the Scottish figure would be lower with the definitions used for the Swedish companies, which should be kept in mind when comparing the industries. However, according to several sources one important difference is that the number of employees is increasing within the Scottish sector[287] whereas the Swedish life science sector has stagnated and in some sectors even decreased in 2006 compared to 2003, as described in the industry survey of SLIS. Scotland is also particularly interesting to compare to Sweden since their government, and many key actors in the innovation system have reached a consensus to become a world leader in several life science research fields[288]. These goals notably focus on achieving critical mass in a "globally focused, sustainable life sciences sector built on a fully connected national strategy"[289]. If Scotland is found to successful in achieving this, it would be an interesting example for Sweden to learn from. The issue of critical mass and what a small country can do to get around this limiting factor is approached in Scotland and is also very interesting in a comparison with Sweden.

One such research field where Scotland aims to become a world leader is stem cell research. Therefore it is particularly interesting to look further into the case of Cellartis, a Swedish stem cell research company that was attracted to Scotland and has localised a production facility in Dundee. The case study conducted on Cellartis focuses on what importance different activities have had on the localisation and investment decision of this individual company. The case of Cellartis is used as a tool to highlight and discover potential competitive disadvantages in the Swedish life science innovation system compared to the Scottish. In addition, the case study

[286] K:\Skottland\Scottish Development International Biotechnology and Life Sciences in Scotland – SDI.mht.
[287] http://news.bbc.co.uk/1/hi/business/6210100.stm.
[288] Scottish Enterprise, 2007a, page 3.
[289] Scottish Enterprise, 2007a, page 3.

provides a concrete example of how policy-makers in Scotland have reasoned in regard to priority areas.

5.2 Activities

5.2.1 Knowledge development

The knowledge development is described in this section with a focus on the technological knowledge base. The top-ranked universities' main competence fields are outlined. Also described is their competence within stem cell research. This will give a background on what knowledge within this and related fields was accessible for Cellartis at the time of their establishment in Scotland. The impact of the competence level on the localisation decision will be analysed in section 5.3.

Generation of knowledge elements

Public Research Funding
In 2004, The Gross Expenditure on Research and Development (GERD) constituted a lower share of the Scottish GDP than the corresponding UK average. However, the Scottish share of Higher Education Research and Development (HERD) from GDP is larger than other regions as well as being on an internationally high level compared to other OECD countries. This puts Scotland in the first quartile of the OECD countries[290]. The Scottish universities and research institutions attract GBP 410 million funding per year[291].

Both the Scottish executive and the former DTI are public financers of research in Scotland, the majority of funding is allocated by the Scottish Executive, as shown by figure 5.1[292]. The expenditure had the largest increase in 2002-2004, mainly due to the increased Scottish Executive allocation. The Expenditure on research from DTI to Scotland in 2005-2006 is approximately on the same level as in 2001-2002 [293].

[290] Scottish Executive, 2007, page 3-4.
[291] F:\Skottland\Life Sciences in Scotland.mht.
[292] Scottish Executive, 2006a, chapter 2.
[293] Scottish Executive, 2006a, chapter 2.

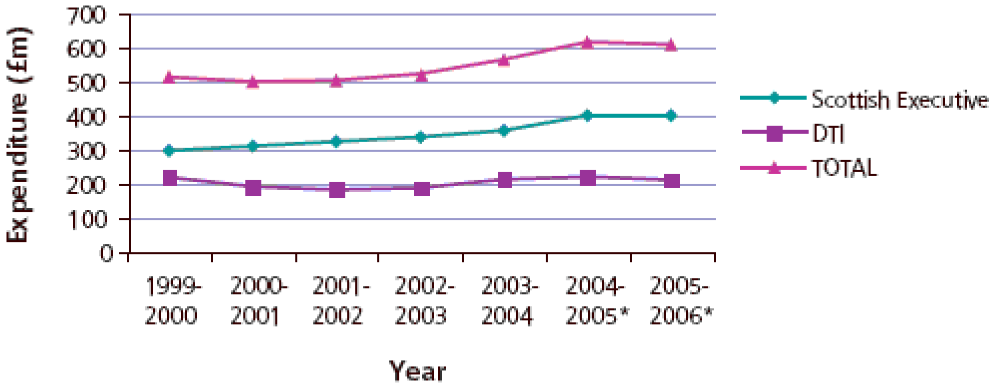

Figure 5.1. Public expenditure on science in Scotland, Scottish Executive compared to DTI. Real terms, base year = 2004-05[294].

Industrial R&D expenditure

The Business Enterprise Research and Development (BERD) expenditure as a percentage of GDP in Scotland and other regions is shown in figure 5.2. The Scottish level is many times lower than the South East level for instance, but about the same level as London. Of the Scottish GDP, BERD contributed only 0.59% which is low considering the size of Scotland's economy. The UK average of BERD of GDP is 1.08%, almost twice as large, and even that level is considered too low by the UK government (see UKLIS). The Scottish level is also low when compared to the OECD average. However, over the period 1999-2005 there was a significant increase in the Scottish BERD level by 29% which is far higher than the UK BERD increase rate[295]. The manufacturing pharmaceutical sector's R&D expenditure has shown particularly strong growth. The development has occurred simultaneously with an overall decline of the number of employees in the sector and a shift from low value processes to a highly specialised, high-value sector[296]. However, the increase of BERD occurred predominantly in 1999-2003 and in recent years the development has stagnated in real terms. American-owned firms were responsible for half of the BERD in Scotland, with Scottish firms undertaking only 24%[297].

[294] Scottish Executive, 2006a, chapter 2.
[295] Scottish Executive 2007b, page 51.
[296] http://www.scotland.gov.uk/Publications/2006/06/27171110/4.
[297] Scottish Executive 2007b, page 51.

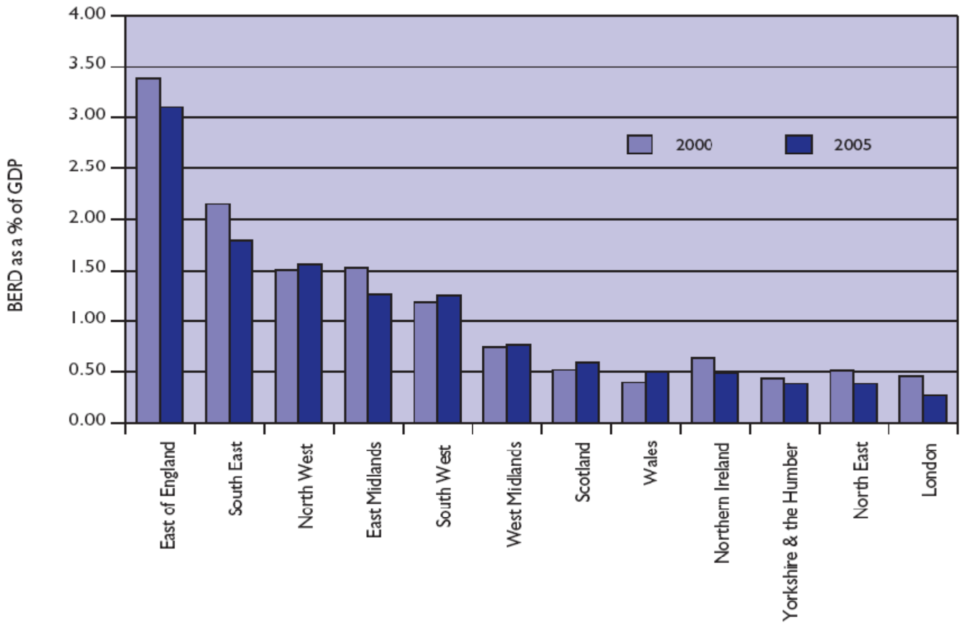

Figure 5.2. BERD as percentage of GDP for the UK regions[298].

Although the focus here is on Scotland, it is interesting to note that the level of BERD as a percentage of GDP in London is very low. Much lower than, say, the neighbouring East of England region. This picture was also supported by the Office of National Statistics[299]. The situation is an issue of concern for the government. No specific reasons were found to explain the low BERD in London. However, there might be a connection to the large Higher Education Research Expenditure (HERD). Almost a quarter of the total HERD is allocated to London. If there is actually a connection, it would be particularly interesting to study what knowledge transfer and people exchange there is between academia and industry in London[300].

Access to knowledge elements

Technological Knowledge Base

According to the Scottish Executive, Scotland has a relatively strong competence base in life science. Their statement is based on investment in research per capita (40% over the UK average), the number of scientific citations, Research Assessment Exercise outcomes and proportion of life science graduates[301] etc. The Research Assessment Exercise (RAE) of 2001 rated about 50% of the Higher Education research as internationally competitive[302].

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[298] Scottish Executive 2007b, page 52.
[299] Office for National Statistics, 2006, page 14.
[300] http://www.lda.gov.uk/server/show/ConWebDoc.1340.
[301] Scottish Executive 2005a, page 7.
[302] Scottish Executive, 2006b, page 12.

In the RAE ranking 2001, Edinburgh University came first on the list of Scottish universities[303]. According to the Guardian University Guide, it ranks second in the medical field in the UK[304]. The University highlights biomedical research among its strengths with the emphasis on stem cell research. The Institute for Stem Cell Research aims at clarifying the mechanisms underlying differentiation in stem cells with the objective to create a scientific base for cell therapy.

Dundee University describes its laboratory of translational medicine research collaboration as one of its core strengths. Partners in the collaboration are the Universities of Dundee, Aberdeen, Edinburgh and Glasgow, Scottish Enterprise, and the NHS in Scotland Grampian, Greater Glasgow, Lothian and Tayside. Wyeth, a large pharmaceutical company has also been attracted to the collaboration and co-invests GBP 33 million[305]. According to Dundee University, its strongest research fields are notably diabetes, cancer research proteomics, neuroscience, genomics and stem cell research[306]. Dundee recently joined the ITI Life Sciences Stem Cell Technologies R&D programme. Dundee will contribute its screening expertise to the programme's objective to enable automated processes to produce large quantities of high quality stem cells. The university describes the development of this capacity as ground-breaking and claims it will make Scotland the world leader in stem cell research[307].

According to Scottish Enterprise, the University of Glasgow also counts as one of the UK's leading universities. Its research into oncology and molecular pharmacology achieved the highest rating in the last Research Assessment Exercise[308]. According to the University , its expertise lies especially in molecular mechanisms controlling cell signalling and development[309].

Some other important collaborative initiatives building on the technological knowledge base and of particular importance for the goal of becoming a world leader within stem cell research, are the Scottish Centre for Regenerative Medicine (SCRM), the Translational Medicine Research Collaboration and the Centre for Biomedicine. The new GBP 59 million SCRM establishment aims to become a world leader in stem cell research and is a collaboration between Scottish Enterprise and the University of

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303 http://www.ukeas.com.tw/rankings.htm, based on RAE 2001.
304 http://en.wikipedia.org/wiki/University_of_Edinburgh.
305 http://www.talentscotland.com/view_item.aspx?item_id=47607.
306 http://www.scottishdevelopmentinternational.com/pages/Industries/Life-Sciences/Overview/index.asp.
307 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=734&rlID=574.
308 http://www.scottish-enterprise.com/sedotcom_home/life_sciences/life-sciences-research/life-sciences-clinical-expertise-oncology/life-sciences-clinical-expertise-oncology-academic-groups.htm.
309 www.gla.ac.uk.

Edinburgh. The SCRM includes a centre for scale up development and manufacturing of cells as well as clinical trials. The focus lies on the commercial opportunities arising from the research[310]. Launched in 2006, the Translational Medicine Research Collaboration is a partnership between the US pharmaceutical company Wyeth, Scottish Enterprise, NHS Scotland boards and the four universities of Dundee, Aberdeen, Edinburgh, and Glasgow. The partnership aims to combine commercial, clinical and academic expertise in diseases like diabetes, cancer and stroke. The focus is on bridging the gap between laboratory drug discovery and the clinics[311]. In 2006, the first stage of the Centre for Biomedical Research was also completed. The Centre is a collaboration between the Scottish Enterprise, NHS Lothian and the University of Edinburgh and is a joint public/private finance venture. The focus of the Centre is attracting international companies and expertise to the region and commercialising research[312].

There are several other examples of centres being initiated in 2006[313]. Together, these centres firmly pinpoint some important features of the Scottish life science innovation system; a consensus in the intention to become a world leader in life science, a recognition of the importance of collaborative investments and efforts including both public and private sectors and also recognition of the importance of building up an excellent knowledge base to attract companies and experts from abroad (as well as retaining Scottish talent).

Market-related knowledge base

One of the main contributors to Scotland's worldwide image as a centre of scientific result is Dolly the sheep. Dolly was cloned at the Roslin Institute near Edinburgh and created global interest, putting Scotland on the life science map. By contrast, PPL Therapeutics, the company that assisted in cloning Dolly, has served as a warning example of failing to apply science to profit. Heavy losses caused by a number of high-cost, high-risk treatments not balanced out by saleable products led to the company being sold[314]. Still, Scotland seems to have learned its financial lesson. The severely dented biotech sector gained experience in management and an infrastructure was created to support it. One important initiative was the proof of concept programme. Funding is available through the programme to high quality projects with strong commercial potential. Funding is available in the GBP 50-200k range. The programme is said to have increased the quality and viability of research commercialisation of[315]. In

[310] Scottish Enterprise, 2007a, page 18.
[311] Scottish Enterprise, 2007a, page 15.
[312] Scottish Enterprise, 2007a, page 19.
[313] Scottish Enterprise, 2007a, page 19.
[314] http://news.bbc.co.uk/1/hi/business/6210100.stm.
[315]http://www.wsep.co.uk/innovativeactions/downloads/presentations/UK_Ireland%20Networking%20Event/SE%20Innovation%20Support%20Pipeline%20Presentation.ppt.

the Scottish Life Science Strategy, it was recognised as critical that industry and public sector agreed on their roles and worked together more to fill the gaps relating to certain target areas of the innovation system[316]. An aim to become self-sufficient as soon as possible emerged in the private sector as a consequence of the Dolly lesson. Awareness of the importance of commercial applications and spreading of risk increased. A number of products in the portfolio are needed but at the same time risk-spreading should not result in products being so thinly spread as to make it hard to launch them onto the market[317].

International knowledge base
The Scottish Life Science Strategy states that "Scotland must create, attract and retain the best talent because of all the key ingredients for success, the most important is people. We need the best people in science, in technology transfer and development, and in commercial management"[318]. The Scottish Executive and other stakeholders have realised the importance of an excellent technological and market-related knowledge base and are following a clear three-step process to attract an excellent international knowledge base. Scotland as a country is subject to competition from the international expertise. This is realised and pinpointed in the strategy which concludes that talented individuals must have excellent prospects for a career and development[319]. The Executive has launched a fresh talent initiative called the Working in Scotland Scheme, aimed at attracting highly skilled individuals to Scotland and allowing international students to stay in Scotland after they have completed their studies[320]. In addition, a clear intention behind the large public and private investments in different centres like SRCM, the Centre for Biomedicine etc. is to attract foreign expertise and retain the Scottish expertise within the country[321].

Knowledge transfer
According to the Scottish Executive, the transfer of knowledge from universities and colleges to business has increased and is rather high compared to other parts of the UK[322]. This is explained by the relatively high number of Higher Education Institutes (HEIs) in Scotland. According to an evaluation undertaken by the Higher-Education-Business and Community Interaction Survey (HE-BCI), the HEIs of Scotland are said to play a major part in the commercialisation of knowledge[323]. The level of spin-offs from Scottish universities per million of population is not only

[316] Scottish Executive 2005a, page 11.
[317] http://news.bbc.co.uk/1/hi/business/6210100.stm.
[318] Scottish Executive 2005a, page 10.
[319] Scottish Executive 2005a, page 10.
[320] Scottish Executive, 2006a, objective 2.
[321] Scottish Enterprise, 2007a, page 6.
[322] Scottish Executive 2007b, page 53.
[323] Scottish Executive 2007b, page 66.

higher than the UK average but also than the US and Canada average[324] (figure 5.3). However, there was a sharp decline in the early years of the 21st Century. In terms of patents filed per 10,000 people, Scotland lies behind the UK average[325] whereas in terms of revenue on the IP generated, Scotland comes second amongst the UK regions, as shown in figure 5.4[326]. The Scottish Executive has spent over GBP 80 million on commercialisation and knowledge transfer activities since 1999[327].

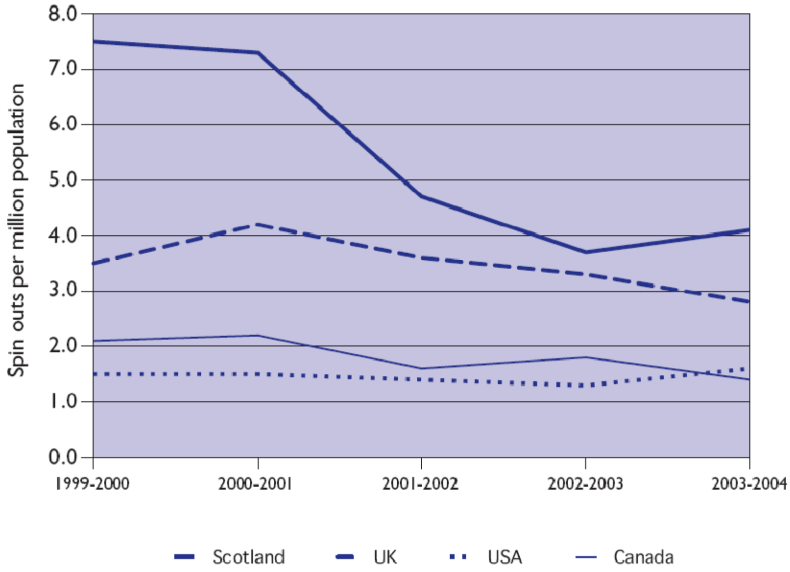

Figure 5.3. Number of university spin-off companies per million people in Scotland, the UK, the US and Canada, from 1999/2000 to 2003/2004[328].

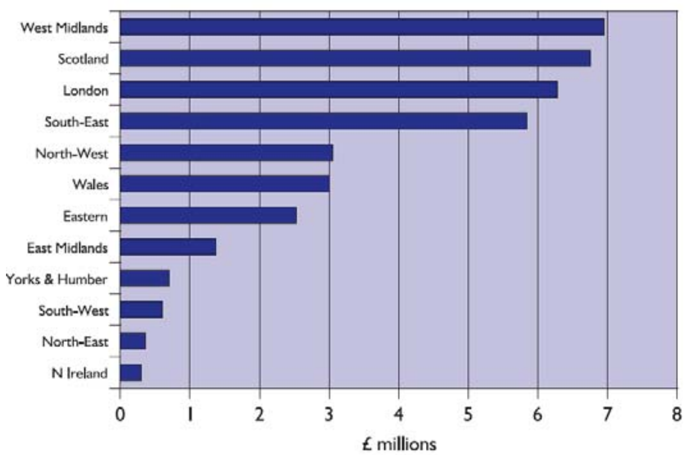

Figure 5.4. Total revenues from intellectual property by region, 2003-2004.[329]

[324] Scottish Executive 2007b, page 54.
[325] Scottish Executive 2007b, page 54
[326] Scottish Executive 2007b, page 55
[327] http://www.scotland.gov.uk/Topics/Business-Industry/science/16607/21286.
[328] Scottish Executive 2007b, page 54.

Strength and weaknesses

Scotland has a strong life science profile as its technological knowledge base. Its aims and goals are very high and there have been major investments and efforts in recent years to reflect these aims in the budget allocations. This is demonstrated in research fields like regenerative medicine. There has been a significant increase in collaborations and joint ventures between different actors in this research field.

The market-related knowledge base used to be a weakness within life science but has been addressed by initiatives like the proof of concept programme. The life science industry itself has increased its awareness of the importance of spreading risks and the situation has improved. The overall economic revenue from IP is high and the turnover per spin-off more than doubled in 2005/2006 compared to 2003/2004[330]. However, there was also a sharp decline from 1999 in the number of spin-offs from university per million people. There might be a connection to the proof of concept programme, which was launched in 1999 and aims to improve the level and quality of research commercialisation [331]. This might have led to fewer but more commercially viable projects being funded.

A Scottish strength nowadays is to turn IP into economic benefit. Scotland is second among the UK regions in terms of revenue from IP.

It is interesting that the GERD consists of a larger share of HERD than the UK average and a lower share of BERD, meaning that public funding makes up an unusually high share compared to the rest of the UK. It is claimed that the HEIs have contributed considerably to the increase of knowledge transfer and commercialisation and their knowledge transfer budgets have increased[332]. The university teachers support increased commercialisation of university research and advocate that the Scottish Executive could increase knowledge transfer by encouraging joint activities from industry and academia. They state that "spending on research and knowledge transfer is the best way to build up the Scottish economy and therefore welcome the increased spending in this area"[333]. They also criticise the industry for not putting enough effort into research and commercialisation of research and the Scottish Executive for not putting greater pressure on the industry in this

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[329] Scottish Executive 2007b, page 55.
[330] http://www.scotland.gov.uk/Publications/2006/08/HEBCI, http://www.scotland.gov.uk/Topics/Statistics/Browse/Business/PubHEBCIS2003-04.
[331] http://www.sie.ac.uk/startupguide_finance.aspx.
[332] The Association of University Teachers Scotland, 2004, pages 1-3.
[333] The Association of University Teachers Scotland, 2004, pages 1-3.

matter[334]. It is interesting that the attitude towards research commercialisation is so positive from the university teachers' perspective too. The strong ambition of academia to take part in joint activities with industry is a strength.

On the other hand, there seems to be a weakness in the industrial approach to knowledge transfer and the low BERD share of GDP needs addressing. It should be kept in mind that this is a general description and no specific information about attitudes within life science has been found. Scotland shows strength in regard to attracting *foreign* research-intensive companies and foreign skills. It is a stated high priority for Scotland to keep the foreign companies and their skilled personnel within the region. Foreign companies like Wyeth, Cellartis and Cognia[335] (American-owned) that choose to locate in Scotland, seem to do this following ambitious collaborative efforts from private and public Scottish actors. It should be kept in mind though that the attraction of the companies include large public investments. The outcome for society has not been studied thoroughly enough in this report to state to what extent the efforts and investments have been beneficial to society.

Although Scotland strives to attract and keep expertise within the region, there has also been criticism of the Scottish structure of university funding. Compared to England, Scotland allocates funding to a larger number of HEIs. Some claim that larger funding streams to fewer HEIs and ring-fenced funding for specific purposes are required if a brain drain from Scotland to England is to be prevented.

5.2.2 Financial support systems

Access to Venture Capital

General access to venture capital
Critical voices claim that Scottish companies suffer from limited access to capital for overseas growth and research and development. Also that Scottish companies are too small to be internationally competitive. The life science sector in particular is said to be poorly connected to the investment community[336]. A worrying reality for the Scottish life science sector is that few of the companies actually make money[337]. According to the finance director of medical diagnosis firm Axis-shield located in Dundee, they are "fairly unique in terms of life science companies in Scotland in that we are profitable"[338]. Others claim that the access to VC in Scotland is strong. During 2006, the life science sector in Scotland is said to have been very

[334] The Association of University Teachers Scotland, 2004, pages 1-3.
[335] http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=734&rlID=398.
[336] Scottish Executive, 2005a, page 13.
[337] http://news.bbc.co.uk/1/hi/business/6210100.stm.
[338] http://news.bbc.co.uk/1/hi/business/6210100.stm.

successful in fundraising throughout all the different stages of the development cycle[339].

Other sources of non-public venture capital
The business angel market in Scotland has increased in recent years and 2007 was a record year for Scotland. There is a strong focus on life science[340]. It is said that "Informal, business angel investment is the most significant source of external equity finance for young companies" in Scotland. About 75% of the accessible business angle market is invested in early stages[341].

Public Funding
The life science sector of Scotland has developed with governmental support. The Scottish Executive has a clear strategic focus to support the industrial and academic research base in order to become a globally competitive bioscience hotspot. One of the key goals of the Scottish Executive is to increase the level of investment in life science and performance in achieving this goal will be measured by the annual trend of equity investment in Scotland versus the rest of the UK. Another key objective is to attract foreign direct investment to add value to Scotland and measure the performance on an annual basis by the number and quality of foreign direct investments achieved[342].
The aims are reflected by the 2006-2007 investments made by numerous actors on activities aiming to achieve critical mass in life science. Examples are given in table 5.1 below and are direct consequences of the Scottish Enterprise Life Sciences Plan, which in turn is a response to the Industry Life Sciences Strategy for Scotland[343].

Table 5.1. Business support in 2006-2007 in response to the goal of achieving critical mass[344]

Initiative	**Allocations to life sciences in 2006-2007**
Proof of concept and proof of concept plus	GBP 2.4 m
RSE Fellowships	GBP 163 k
Scottish Health Innovations	GBP 350 k
Intermediary Technology Institutes	GBP 15 m
Life Science Business Advisory Service	GBP 230 k
Co-investment, seed and business growth funds	GBP 2.2 m

339 Scottish Enterprise, 2007a, page 12.
340 Smith M., The Herald 20080121, http://www.theherald.co.uk/business/news/display.var.1979830.0.Business_angels_warn_of_capital_gains_tax_threat_to_investment.php.
341 http://www.finance.co.uk/business-angel/.
342 Scottish Executive, 2005a, Page 14.
343 Scottish Enterprise, 2007a, page 29.
344 Scottish Enterprise, 2007a, page 29.

R&D for SMEs and MNCs	GBP 5 m
Physical infrastructure projects	GBP 9.3 m
Other life science projects	GBP 4.8 m
Regional Selective Assistance Grants	GBP 5.5 m

It has been claimed that there was an equity gap needing to be addressed in the market for equity investments *above* GBP 2 million. Thus, the Scottish Venture Fund was launched in 2006 with a GBP 20 million budget for the period 2006-2008[345]. This fund aims to help companies grow[346]. Scottish Enterprise has also launched initiatives to help companies grow and address the equity gaps facing many companies with substantial growth potentials347. The current access to capital from (partly) public funded venture capital funds in Scotland covers the range from GBP 20-100 k investments to GBP 10 million investments[348].

Several publicly funded business support products aim to support SMEs. For instance, the Scottish Executive has launched SMART: Scotland, intended to help small and medium-sized businesses. The aim is to improve their competitiveness by developing highly innovative and sustainable commercial products which simultaneously contribute to the welfare of Scottish economy[349]. Characteristic of Scottish public business support is that there should be economic benefit to the region. Companies can receive support from Scottish Executive for Technical and Commercial Feasibility Studies or research development provided they are based in Scotland or soon to be located in Scotland[350].

Access to Public Funding – The stem cell industry

The stem cell industry is a relatively risky business since it is still very new and the startup costs are extensive. Due to long lead-times, pay-back from commercial products lies in a distant and uncertain future for the investors. The Scottish stem cell industry therefore struggles with the hurdle of attracting private investment. The government has accessed the VC problem for the stem cell industry by encouraging risk-averse investors to consider it. Centres of Excellence within this area which aim to facilitate trans-national partnerships, have also been established with governmental support. These centres aid in the commercialisation of stem cell research by creating the surrounding infrastructure. A concrete example is the GBP 1.85 million funding the Scottish Stem Cell Network will get from Scottish Enterprise Edinburgh and Lothian over the next ten years to enable interdisciplinary collaboration between researchers, clinicians and others in the stem cell

345 Scottish Executive, 2005a, pages 6-8.
346 UK Trade and Investment, 2007, page 3.
347 Scottish Executive, 2005a, pages 6-8.
348 UK Trade and Investment, 2007, page 3.
349 http://www.scotland.gov.uk/Topics/Business-Industry/support/16879/6782.
350 http://www.scotland.gov.uk/Topics/Business-Industry/support/16879/6782.

field. Another GBP 35 million was allocated to a new centre for stem cell research, the Centre for Regenerative Medicine, to be sited in Edinburgh University. A GBP 5 million investment fund will additionally support translational stem cell research. A matching principle is used to encourage the share of private equity; each private investment will be matched by an equal public funding[351]. For instance, the Translational Development Fund will support the activities required to translate stem cell development into practical use in clinical applications. The intention is to fund research or commercial activities and co-invest in Scottish projects as one of several financers[352].

Strengths and weaknesses

Scotland seems typified by the determination and consensus of many actors to follow a plan that will put Scotland on the map as a world leader in certain life science fields. At least this is the picture that emerges from studying documents on the wide range of actors that are already on the bandwagon. There is a consensus in the long-term strategic plans aiming to achieve common goals in 2020! The strategic approach to building a strong life science industry is reflected in many ways, but one of the most obvious is the publicly funded business support. The business support products are direct consequences of strategic plans well-rooted in a broad range of representatives of the life science innovation system.

It was recognised as a weakness by some actors in ScLIS that the equity gap for companies seeking investment above GBP 2 million was not addressed. This resulted in the establishment of the Scottish Venture Fund. It is a strength that potential gaps in the financial support system are identified and filled by new actors, as with the Scottish Venture Fund, or by existing actors in the system. The business support products currently cover the whole range from seed capital to GBP 10 million investments. On the other hand, the opposite situation with easy accessible funding to late stage projects that might not be viable should also be avoided. Finding the right balance is crucial and it remains to be seen how strongly the Scottish life science industry will develop. As was described previously, the number of spin-offs from the universities has decreased whereas the turnover per spin-off has more than doubled. This might indicate that the Scottish proof of concept programme has indeed been successful in picking winners and should be considered a potential strength.

Since the venture capital market in Scotland seems to be fairly strong, the perceived equity gap above GBP 2 million might have been due to a similar mismatch between investors and companies claimed in Sweden[353].

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[351] http://www.ukscf.org/news/news_items/item14.html.
[352] Scottish Enterprise, 2007b.
[353] Interview, Ylva Williams, Invest In Sweden Agency, 200705.

The life science industry itself has increased its awareness of the importance of spreading risks and it is a strength that the situation has improved. The overall economic revenue from IP is high and the turnover per spin-off has more than doubled in 2005/2006 compared to 2003/2004[354]. However, there has also been a sharp decline from 1999 in the *number* of spin-offs from university per million people. There might be a connection to the proof of concept programme, which was launched in 1999 and aims to improve the level and quality of commercialisation of research[355]. This might have led to fewer but more commercially viable projects funded, which should be considered a strength .

The Scottish Enterprise has made a strategic choice to focus on the growth of companies. The strategy document Smart Successful Scotland also states that "increasing new business startups is not enough to impact significantly on overall productivity. There remains significant scope to improve productivity levels in established businesses"[356]. It is reasoned that critical mass in the number of larger companies is necessary in order to increase productivity levels[357]. This opinion is presented in The Life Science Strategy of Scotland which is supported by a wide range of representatives[358]. It is viewed as more important for the number of large and established firms to be growing than number of firms to be increasing. These could function as a training ground and eventually create more companies[359]. The approach is reflected not only in the relatively high focus on growth in established companies, but also in the determination to attract foreign companies by business support. The Scottish life science innovation system differs from many other countries in this matter and its development will be interesting to follow. It is acknowledged that there is not enough evidence to state that this approach is more effective than a system encouraging startups in general, but the determination remains a strength. The picture that emerges is that there is definitely a Scottish way of doing things in the life science innovation system.

There is a major focus on economic benefit to Scotland in the business support products and the efforts to attract investments and direct investments to the region. It is interesting that business support from the Scottish Executive is accessible not only to companies that are already established in the region bur also to companies soon to be located in Scotland. The business products functions as a measure to attract companies from other parts of the UK and from abroad. The Swedish company

[354] http://www.scotland.gov.uk/Publications/2006/08/HEBCI, http://www.scotland.gov.uk/Topics/Statistics/Browse/Business/PubHEBCIS2003-04.
[355] http://www.sie.ac.uk/startupguide_finance.aspx.
[356] Scottish Executive, 2004, page 15.
[357] Scottish Executive, 2004, page 15.
[358] Scottish Executive, 2005a, page 6.
[359] Scottish Executive, 2005a, pages 6-8.

Cellartis is one such example, as will be described in section 5.4. It could be argued that late stage business support to individual companies is too risky since there are no guarantees that the company will stay put and contribute economically to the region that provided its business support[360]. This risk is taken into consideration by the Scottish Executive and the different actors providing such business support follow specific schemes and criteria in order to ensure economic benefit to the region. The decision criteria of ITI Life Sciences in the Cellartis case for instance is an example of how Scottish governmental policies are implemented thouroughly.

5.2.3 Policies

Critical mass

This section deals with key technologies, the issue of critical mass and collaboration. This approach was chosen for the Scottish Life Science Innovation System since the selection of key technologies and collaboration was so tightly connected to achieving critical mass in the Scottish policy documents. The Scotland life science strategy states that since Scotland is a small country, it needs to focus on the opportunities holding the greatest potential value to the region. According to the strategy, this means that the public sector and research community should engage with the private sector in areas where Scotland could become a world leader and sustain its leadership. This in turn refers to sectors that have a large potential to grow if supported as well as sectors that could win investment from abroad[361]. In line with the view presented in the strategy document is the identification of key technology areas as described below.

Key technologies

In Scotland, as in the rest of the UK, key technologies are identified within life sciences and other areas. The Scottish Executive was tasked by the Science Strategy to implement the policy of priority areas across all financers in Scotland. A shared understanding of the importance of priorities aims to create co-ordination between financers in order to enlarge the size of each funding[362]. The funding policy of both public and non-public bodies, like the Scottish Funding Council, Scottish Enterprise, the health department etc., is to focus the support efforts on businesses active within research fields with the potential for international competition. The life science strategy recognises that Scotland must be globally focused in order to become globally competitive. This means “Scotland’s industry and researchers will address global markets and compete on a global scale whilst concentrating their efforts on specific areas where they have real

[360] Interview, Neil Madeleine and Åström Jonas Uppsala Bio 20080205, Interview, Sandström Anna, VINNOVA, 20080116.
[361] Scottish Executive, 2005a, page 12.
[362] Scottish Executive, 2006a, page 19.

competitive advantage and know Scotland can compete with the best"[363]. As a consequence, there has been a rationalisation in the number of initiatives and support bodies. A Scottish Science Advisory Committee has been established by the Executive to identify Scottish Strengths and what areas have key strategic importance[364]. The establishment of the three ITIs is also a step towards the development of key technologies in the long-term perspective[365]. The ITI Life Sciences identifies key technologies, conducts foresighting activities and identifies future areas of interest[366].

The life science industry has been identified as one of the six national priority industries "that offer major opportunities for economic growth" and has therefore been allocated about GBP 40 million from the 2006 Scottish Enterprise budget[367]. The UK government and the Scottish Executive both hold stem cell research as one of the key technologies of the future. Selective support to build on the existing competence is being delivered and in Scotland, measures are being taken to reach this goal in a three-stage process.

Critical mass by collaboration

However, in the efforts to achieve critical mass in Scotland several other measures have been adopted as well. The strategy points out that in order to reach the goal, efforts must be made jointly by the various public and private actors, as well as beyond regional borders[368]. A small country cannot afford not to make the best possible use of its resources. Critical mass is achieved and international markets can be accessed by collaboration and joint ventures. It is also noted in the strategy that the fact that Scotland *is* a small country should *enable* actors to work efficiently in partnership[369].

Recognition of the importance collaboration between different actors in the innovation system has in achieving critical mass is demonstrated in several ways. The establishment of the Translational Medicines Research Collaboration, the centre for biomedicines and the SCRM could be viewed in this perspective. The formation of a national strategy for Scottish life science was backed by the Scottish Executive, universities, research institutions, industry, NHS Scotland, Scottish Funding Council and Scottish Networks[370]. Industry was given an important role in the formation of the strategy and the process was overseen by the Scottish Life Science Industry

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[363] Scottish Executive, 2005a, pages 6-8.
[364] Scottish Executive, 2006a, page 19.
[365] Scottish Executive, 2005b, Business - University collaborations in Scotland – The Scottish Executive's response to the Lambert review, page 1.
[366] F:\Skottland\ITI Life Sciences Current areas of interest.mht.
[367] Scottish Enterprise, 2007a, page 28.
[368] Scottish Executive, 2005a, page 12.
[369] Scottish Executive, 2005a, page 12.
[370] Scottish Enterprise, 2007a, page 3.

Advisory Group[371]. One of the results of this was the formation of the Scottish Life Science Alliance, which includes representatives of these actors[372]. The alliance has the remit to implement and develop the strategy[373]. One corporate representative of the alliance described the role of the government as that of a catalyst that made things happen. But to take integration to a higher level, the various groups and actors themselves must recognise that "it is only through a focused and coherent approach that a small country like Scotland can fulfil its vision to become a key player in the global life science industry"[374]. The partnership between American giant Wyeth, Scottish Enterprise and four universities would not have taken place had it not been for a strong connectivity already in place in Scotland[375].

Global challenge

The Scottish Life Science Strategy sets out the goal for Scotland to have "a globally focused, sustainable life sciences sector built on a fully connected national strategy that exploits strengths in scientific excellence, financial services and innovative business models and that develops, retains and builds upon Scotland's talents" [376]. In the tough and fast-changing global competition, Scotland is firmly determined to rise to the challenge[377]. In doing so, it has recognised the importance of learning from others and that benchmarking needs to be done in the best environments in the world. The process involves finding opportunities for partnerships with foreign regions that would be beneficial for the Scottish life science cluster and provide entrances to overseas markets[378]. The US and China are recognised as the most important strategic countries[379]. The strong focus on achieving critical mass by increased collaboration and the concentration of efforts on key technologies is also tightly linked to the Scottish way of addressing the global challenge and is characteristic of the Scottish life science innovation system in particular. The Scottish Life Science Strategy states that the competitive position of Scotland depends on weather it succeeds in growing and attracting larger companies[380]. Strategic investments in the technological knowledge base, like the Scottish Centre for Regenerative Medicine (SCRM), the Translational Medicine Research Collaboration and the Centre for biomed, are fundamental in the Scottish approach to

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[371] http://www.scottish-enterprise.com/sedotcom_home/life_sciences/life-sciences-in-scotland/about-life-sciences-scotland.htm.
[372] Scottish Enterprise, 2007a,, page 7.
[373] http://www.scottish-enterprise.com/sedotcom_home/life_sciences/life-sciences-in-scotland/about-life-sciences-scotland.htm.
[374] Scottish Enterprise, 2007a, page 7.
[375] Scottish Enterprise, 2007a,, page 7.
[376] Scottish Executive, 2005a, page 6-8.
[377] Scottish Executive, 2005a, pages 6-8.
[378] Scottish Executive, 2005a, page 12.
[379] Scottish Executive, 2006a, page.
[380] Scottish Executive, 2005a, pages 6-8.

addressing the global challenge and aim to attract both skilled researchers and research-intensive companies to the region.

Explicit examples of programmes or initiatives to address the global challenge

The Scottish approach to addressing the global challenge aims to go beyond increased exports and inward investment. Value should be generated also by knowledge flows and the internationalisation of operations. SDI plays an important role in this work[381]. In 2005, criticism was levelled that the life science industry had too few transport links to the US and other international life science locations. Several life science international partnerships are currently in place[382], but the increase in the HEI's budget for global connections only increased slightly in recent years as shown in figure 5.5 below[383]. Notable among the international partnerships are the partnership between the University of Dundee and Singapore's Agency for Life Science. The aim is to develop a research and training co-operation[384]. There is also a partnership between Scottish Enterprise and Massachusetts to facilitate matchmaking and collaborations for Scottish companies and the establishment of Massachusetts companies in Scotland[385]. Globalscot, a network of 950 senior business leaders spread all over the world functions as connection broker and provides expertise to other Scottish companies wishing to go global. The aim is to support the growth of the Scottish economy and ensure that life science is well represented[386].

£000s	**2002-03 Budget**	**2003-04 Budget**	**2004-05 Budget**	**2005-06 Budget**	**2006-07 Plans**	**2007-(Plan**
Growing Business	110,636	102,063	109,386	101,386	116,386	126,3
Skills and Learning	132,556	157,079	155,929	155,779	155,779	155,7
Global Connections	77,594	100,000	82,000	82,000	82,000	82,0
Management and Administration	75,000	92,000	91,528	91,879	91,879	91,8
Careers Scotland [2]	20,993	-	-	-	-	
Voted Loans (Net)	2,277	437	437	437	437	4
Resource accounting and budgeting charge	9,622	9,622	9,622	9,622	9,622	9,6
Total	**428,678**	**461,201**	**448,902**	**441,103**	**456,103**	**466,1**

Figure 5.5. Scottish Executive's draft 2006 budget showing budget allocations and planned budget allocations to HEIs[387].

381 Scottish Executive, 2006a.
382 Scottish Executive, 2005a, pages 6-8.
383 Scottish Executive, 2006c, pages 102.
384 Global connections magazine – For Scottish Companies Doing Business Internationally, issue 11, page 2.
385 Scottish Enterprise, 2004, pages 1-3.
386 http://www.sdi.co.uk/pages/Our-Services/Globalscot/index.asp.
387 Scottish Executive, 2006c, pages 102.

5.2.4 Strengths and weaknesses

Although no in-depth study of success indicators of the ScLIS has been performed, the determination of ScLIS was found to be striking. The focus is on achieving critical mass, by increased collaboration and concentrating efforts on specific areas in order to become world leaders. It seems to be as simple as that in the Scottish system. It remains to be seen what outcome the approach will generate. It is probably important in this context that the life science community of Scotland does not have as long tradition of organic growth as has (more or less) been the case in Cambridge and Uppsala. The rather more selective, focused and top-down approach probably would be difficult to implement in a system with a history of organic growth, and probably less successful. The point made is that, even though the Scottish way might prove to be successful, it could be very difficult to copy its success in “older systems”.

Growing and attracting large companies is strongly addressed since it is perceived as a current weakness of the Scottish life science industry that these are to few. They are viewed as strategically important for the competitiveness of the entire life science community of Scotland, due to economic and knowledge related spill over effects.

It has been recognised that international links needed to be strengthened and measures have been taken to address this deficiency. However, the partnerships currently in place from SDI for example only cover a couple of strategically important countries, the US and Singapore. Partnerships with several other strategically important countries fall short. Still, the links with international research locations and markets are looked after informally by the Globalscot initiative.

5.3 Case study: Cellartis

In 2006, the Swedish stem cell company Cellartis established a production facility in Dundee. Lots of attention was given to the location decision, from Swedish public authorities and even the government. In this report, the case study of Cellartis was found to be an illustrative example of how the Scottish life science policies are implemented and the strategic approaches to increase the competitiveness of Scotland. The aim was not primarily to address the question why Cellartis chose Scotland for the establishment, since the strong economic incentives presented to the company quite quickly answer this question. The focus is on how Scottish authorities reasoned when providing these incentives and why corresponding incentives were not, and are not, a reality in Sweden.

5.3.1 History of the company

Cellartis was established in 2001 by researchers at Sahlgrenska University Hospital and The University of Gothenburg. The company has shifted its focus from potential regenerative cell therapy treatments to the more lucrative production of stem cell lines as test lines for preclinical studies[388]. The strategic goal was to scale up the human embryonic stem cell technology and in order to speed up development, the company was part of several partnerships with both industry and university. In 2006, a research collaboration was initiated with Nova Thera in the UK. The partnership included Centres of Academic Excellence in Imperial College London, Cambridge University, Manchester University and the Roslin Institute in Scotland as research partners whilst the two companies held the commercial rights[389]. However, the partnership that has been at the centre of Swedish attention is the one with one of the Scottish Intermediary Technology Institutes, the ITI Life Sciences. The ITIs are publicly funded innovation funds that target commercialisation and development in both existing and new companies[390]. According to Cellartis, they were contacted by ITI Life Sciences with a favourable deal at with the same time as an investigation by Cellartis into the possibilities of an international expansion and the establishment of a production facility. The other alternatives were the US, Singapore, Switzerland and the Netherlands[391].

5.3.2 The selection of stem cells as a Scottish key technology and the selection of Cellartis for the partnership

Due to the policy of focusing on key technologies, many actors have selected stem cell research as a key technology. For instance, Scottish Enterprise decided to venture in the area of stem cell research and ITI Life Sciences also identified stem cells as a key technology. The ITI Life Sciences selection process starts with the identification of "major trends and drivers in the sector"[392]. The ITI Advisory group identifies options holding the largest potential of commercial viability. The advisory group consists of influential representatives of industry and academia with strong connections to global networks. They also help in the identification process by insight to global market potential[393]. Apart from the advisory board, ITI Life Sciences also consults with industry, the research community and investors in order to "identify future market needs and technology development opportunities"[394]. Based on this foresighting process, the key technology is

[388] http://www.drugresearcher.com/news/ng.asp?n=73553-cellartis-iti-life-sciences-stem-cells-scotland-ian-wilmut.
[389] http://www.cellartis.se/res/PDF/20060829pressreleasenovatheracellartis.pdf, press release 20060829.
[390] http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=36.
[391] Interview that Sweden Bio performed with Cellartis, previously accessible on internet.
[392] http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=410.
393 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=410.
394 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=727.

selected. The scope is then further refined based on specific assessment criteria, as outlined in table 5.2[395]. Areas outside the immediate focus area could also be taken into consideration based on these criteria. As shown by the set of criteria, the selection is largely based on economic benefit to the region. It is also important that, like the IP, the benefits from the investments can be controlled and that sustainable values are created that build upon Scotland's existing resources. The stem cell area was chosen based on the belief that it has strong potential in the long-term to help develop drug development processes as well as effective cell therapy processes and regenerative medicine[396]. According to ITI's foresighting, the market for cell-based tools within the pharmacy industry was worth USD 1.4 billion in 2001and rapid growth was expected[397]. Based on these foresights, Scotland has worked very hard to create a global platform for gradual development of this area[398]. Investments have been made in the Centre for Regenerative Medicine to build up the competence in and Cellartis was considered a good fit that complements the work planned[399].

Table 5.2 Selection criteria.[400]

Assessment criteria for potential programmes within key technologies:
Market attractiveness: scale and feasibility within a commercial time scale
Extent to which we can build, protect and defend valuable IP
Ability to create sustainable competitive advantages for future business
Scottish fit with available resources or existing applied research capabilities
Ability to achieve a positive return on our investment, including economic benefits for Scotland

5.3.3 The partnership

Cellartis will add to a three year programme that includes Glasgow University, Dundee University, Scottish Development International and Scottish Enterprise Tayside. The research collaboration aims primarily "to control the way in which a stem cell differentiates into another cell type, e.g. a liver cell or a heart cell; and to develop a robust process for producing large numbers of stable differentiated cells"[401]. The major part of the capital investments and operational conduct is financed by ITI Life Sciences. A total of GBP 9.5million will be available from ITI over the three years. About one third will be allocated to the new Cellartis production facility [402]. In return, ITI Life Sciences will own all IP generated by the project. They

395 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=727.
396 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=734&rlID=545.
397 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=734&rlID=545.
398 http://www.sdi.co.uk/pages/Invest-News/News/index.asp?newsid=1163.
399 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=734&rlID=545.
400 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=727.
401 http://www.itilifesciences.com/defaultpage131cd0.aspx?pageID=734&rlID=574.
402 http://www.sdi.co.uk/pages/Invest-News/News/index.asp?newsid=1163.

will not commercialise the assets themselves though. This will be a privilege of the partnership companies. The right of disposal over the assets will take the form of royalty licences handed to Cellartis by ITI Life Sciences, the latter in turn receiving a knowledge licence from Cellartis. The factory will be constructed according to the instructions of Cellartis[403]. In addition, Cellartis will also be allocated GBP 1.2 million from SDI as regional selective assistance, RSA. The size of the RSA is related to the employment Cellartis will contribute to Scotland. Furthermore, Cellartis qualifies for R&D tax incentives[404]. The intention of the Scottish actors with this partnership is that it will add benefit to the region by providing 75 new jobs and further build on the Scottish expertise in this area. By building up expertise, the idea is that even more companies and expertise will be attracted to the region, eventually making Scotland a world leader[405].

Matching Swedish offers
The Swedish public authorities were surprised by the sudden closure of the deal and regret the lack of contact undertaken by Cellartis in the matter[406]. From the point of view of Cellartis, the favourable deal from Scottish ITI combined with the risk of loosing the offer in the case of hesitation resulted in few attempts to obtain alternative offers from Swedish counterparts. There was contact with the former Swedish Animal Welfare Agency and the Swedish Foundation for Strategic Research. The latter is said to have turned down financial support, referring to the nature of the application. The application requested financial support for research being conducted within the company, which is frowned upon[407].

The question might also be asked what actual counterbids Cellartis would have got if discussions had taken place with VINNOVA for instance. As the CCO of Cellartis put it, “you can’t ask VINNOVA for 40 million”[408]. It is claimed that the public authorities are listening more to the needs of the life science industry in Scotland. ITI Life Sciences plays a major part in this. The national policy level of Sweden is also hard to impact from a regional level[409].

5.3.4 Factors underlying the establishment

This section is entirely based on the interview at Cellartis headquarters in September 2007 and an interview conducted by Sweden Bio with Cellartis.

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[403] Interview that Sweden Bio performed with Cellartis.
[404] Interview that Sweden Bio performed with Cellartis.
[405] http://www.cellartis.com/res/PDF/itistemcellprogrammejan071.pdf, press release 20070117.
[406] Interview, Sandström Anna, VINNOVA, 20080116.
[407] Interview that Sweden Bio performed with Cellartis.
[408] Interview, Hyllner Johan,Cellartis 20070906.
[409] Interview, Hyllner Johan,Cellartis 20070906.

Cellartis recognised that the development they were after needed to be done in partnerships. The research collaborations in Sweden were much appreciated but the partnership in Scotland also provided expansion capital. Matching expansion capital was not, and still is not, available in Sweden. As well as the economic incentives, there had to be a strong accessible knowledge base within this area in Scotland as well as liberal legislation. Cellartis also stresses the importance of access to a global market. As far as the research base and legislation is concerned, access in both Sweden and Scotland was perceived as good. It was reasoned that the available competence Sweden still remains accessible to Cellartis and that the Scottish competence has also become accessible. However, regarding the global market, Sweden falls short in the comparison. Not only is the UK market larger than the Swedish one, but more importantly the international markets are more easily accessed through Scotland. According to Cellartis the British networks are very strong and provide lots of assistance, with connections to Japan for example. The support from the Invest in Sweden Agency is much appreciated, but in Scotland there are many very strong organisations. The well-developed Scottish Stem Cell Network has also been important. There is no corresponding initiative in Sweden and according to Cellartis it is also a matter of communications. There simply aren’t as many direct flights between the US and Gothenburg as there are between Gothenburg and Edinburgh.

5.3.5 Attraction and retention factors in the Swedish and Scottish innovation systems

For the specific case of Cellartis, economic incentives, access to an international market and a strong technological knowledge base with recent large investments relevant to the company all came together to work for Scotland. This is an illustrative example of how the innovation systems of countries are subject to competition. Furthermore, it is an illustrative example of how the *governmental policies* are subject to competition. The study of the ScLIS shows in several ways that the system is competitive and that the competitiveness is largely created by governmental policies. The major underlying attraction factor of ScLIS in the Cellartis case is commitment from the Scottish government. Without commitment from the government, ITI Life Sciences would not have had the mandate and resources to offer such partnerships to foreign companies. The investments made in the technological knowledge base, like the Centre for Regenerative Medicine, also are dependent on government commitment. It should also be noted that the partnership is a consequence of the selection of the stem cell area as a key technology. Policies regarding the selection of key technologies seem to be well rooted in the system, and also the identification of stem cell research as one of them. In addition to government commitment, one important attraction factor relevant to the Cellartis case is the strong co-operation between different actors. This partnership has been highlighted as “a positive example of the co-operation between ITI Life Sciences, Scottish Development International and Scottish Enterprise Tayside.”

It is often discussed in Sweden whether the retention of research-intensive companies is good enough. Apparently, there were retention factors in the Cellartis case since that company did not *move* to Scotland; it *expanded* in Scotland. Due to certain retention factors it also remains located in Gothenburg. The retention lies predominantly in the two open doors available to Cellartis; by being located in Scotland there is easier access to international markets and by being located in Sweden there is access to AstraZeneca for instance. The dual location is valuable to the company. Cellartis perceives the technological knowledge base and research collaborations available in Sweden as strong. From their perspective, the Scottish establishment adds to what is already accessible to the company.

When it comes to attraction and retention factors, one interpretation of the Cellartis case could be that focus should be directed at clarifying why certain Swedish companies chooses to expand or invest abroad. It is also important to address the reasons underlying the decisions of companies that have considered investing in Sweden but chosen to invest abroad. According to Invest in Sweden Agency, there are many examples of companies talking of investing in Sweden but it does not result in much action[410]. The point here is that in discussing what actual risks there are of Swedish high-tech companies moving away from Sweden, it might be more important to focus on what was *not* invested in Sweden. There should be an awareness of what we are missing out on, and why.

[410] Invest in Sweden Agency 20080211, presentation of the report ”Utländska investeringar i den svenska life science industrin – framgångar på sluttande plan”.

6 Macro-level innovation system comparison

6.1 Sweden - UK

The Swedish public funding of knowledge development is characterised by a lot of funding sources with small amounts available from each of them. Even though co-financing is often required, the funding streams to individual projects and subject fields might be more scattered in Sweden than in the UK. In the UK, there has also been an important pooling of resources from different governmental departments in the UK funding structure. The OSCHR is one such example of public actors taking on the responsibility to increase co-financing. The OSCHR functions as an intermediary structure between Department of Health and the new Department for Innovation, Universities and Skills. The UKCRC is another. In the Swedish approach to increased funding streams, it seems like requirements of the individual research groups or companies to achieve co-financing are attributed more importance than governmental initiatives to increase collaboration in their funding.

In the UK, the relative share of industrial R&D expenditure has shown a decline the last decade. There again, public funding has increased and the trend is positive. In Sweden, the industrial R&D expenditure has also showed a decline but the public funders have not significantly increased their funding. The funding of Swedish and British life science research currently relies on different kinds of actors. In Sweden, the private funders defray a larger share.

The technological knowledge base within UK life science is ranked higher than the Swedish one and, considering the high political ambitions in this area as reflected in the increased public funding and efforts to increase industrial R&D expenditure, probably will remain that way.

Another interesting difference between the UK and Sweden is that there seem a stronger focus on licensing opportunities in the UK. It is an explicit strategy of the government to support licensing on the expense of spin-offs. The income as a percentage of R&D investment on licences has showed a rapid, strong increase in the UK.

For historical reasons, cultural barriers between academia and industry have been very strong in the UK but the situation has improved due to strong national policies and efforts. Also in Sweden, there are reports that the situation has been improved.

The access to venture capital is stronger in the UK, which is natural due to the much larger market. In particular, the UK business angel market is stronger and more mature than the Swedish one. Many Swedish actors agree there is currently a mismatch between small companies and investors in regard to investment size. The amount of venture capital needed by small Swedish biotech companies is much smaller than what the investors seek to go in with in a company. Also, the patent and product portfolios are often rather thin. A corresponding mismatch has been claimed in the UK as well. An equity gap has been identified in the UK for early-stage companies and companies in their early growth stage. The equity gap has achieved lots of attention from the UK government in past and current strategies and there are many important schemes in place to address the equity gap.

It has been recognised both in Sweden and in the UK that policies of nations are subject to competition, not least in regard to attracting world-class researchers and research-intensive industries. However, in the UK it seems that public funders subject industries to competition to greater extent. Their co-operation with national schemes and efforts aiming to address the global challenge, affect whether they remain priority industries or not.

In the policy evolution comparison, differences were found between UK and Sweden. First of all, the rearrangement that recently occurred in the UK departmental structure links innovation and universities more tightly together and the knowledge transfer between industry and academia is more strongly sought after. In Sweden, the current departmental structure has been criticised as lacking the necessary co-operation between the Ministry of Education and the Ministry of Enterprise, Energy and Communications.

In the UK, the industry has been attributed an increased policy impact in recent years by the elevation of the industry-led Technology Strategy Board (TSB) to the status of an executive body. The TSB assumed the responsibility of the major research and business supporting programmes of former Department of Trade and Investment.

VINNOVA and several other Swedish actors are calling for greater collaborations between financers, private as well as public. In the UK, the public authorities have taken on the responsibility of creating intragovernmental schemes which include several governmental funding bodies in funding collaborations.

The UK government and public authorities seem to have taken the selection of key technologies further than in Sweden. The dedication to prioritising research fields of strength is shown not only in policy documents but also in the actual funding flows, which are consequently less scattered than in Sweden. Focusing on key technologies has also been discussed widely in Sweden, but there are stronger concerns about who will do the pinpointing, how emerging technologies will be looked after and how the high quality of basic research will be secured. This was not found to be an issue of concern in the UK selection process.

Addressing the global challenge in the UK is largely about what strengths we have and what opportunities are there to make the most out of them. Creating an attractive environment for research-intensive industry is a major overarching theme in UK policies and overall seems to be more present across a wide range of issues. Awareness of the global challenge is also high in Sweden and there is a globalisation council with general strategic responsibilities.

Immediate access to the international market is very important for small life science research companies. The UK is ahead of Sweden due to its own large market and stronger links to other markets. The importance of critical mass is often pinpointed in Sweden. The critical mass issue is closely linked with the creation of links for small companies to access international markets. Similarly, the creation of international visibility should be addressed in the same context. There was a stated awareness of these issues and their interconnectedness in the Swedish Life Science Strategy. However, many of its important recommendations were never put into action. The attitude towards international research collaborations seems more positive in Sweden than in the UK which is important in assessing critical mass.

6.2 Sweden – Scotland

The share of the GDP allocated to research in Scotland is smaller than that of Sweden. The Scottish BERD-level is also relatively low, both compared to Sweden and to the rest of the UK. In Scotland, the level of HERD and the share that HERD makes out of the total research funding is relatively high. In both countries, it would be an interesting subject for further studies to examine the connection between levels of private and public funding. The funding situations differ significantly from each other although the high ambitions within life science research are very high for both countries.

It is also interesting to note that the growth of private R&D investment in Scotland is predominantly explained by manufacturing firms and a shift towards a more specialised high-value sector. It could be reasoned that once the shift has occurred, Scotland would face a challenge to continue increasing private R&D by means other than increasing the value added in existing sectors. There has indeed been stagnation in the BERD levels after the high-value shift and the ambitious policies of both governmental and non-governmental bodies to attract R&D-intensive foreign direct investment might be a consequence of this development.

It is difficult to compare the strengths of the technological knowledge bases in Sweden and Scotland within life science, since various ranking systems might be used. The profile areas of Sweden and Scotland coincide to some extent, in stem cell-, genomics- and diabetes research for instance. The regulation surrounding stem cell research is also very similar. Life science holds a strong position compared to other scientific fields in both Sweden and Scotland. The life science industry garners lots of attention in both countries and is in the focus of much debate, related to such issues as clinical research and what action needs to be taken to become internationally competitive.

It should also be noted that some major investments have recently been made in Scotland in certain profile areas and it will be interesting to follow the scientific development after the establishment of these collaborative research centres. In particular, it would be interesting to examine their effect on industrial development and the attraction of foreign direct investments as well as skilled researchers and students. It seems there is more of a definite intention in Scotland than in Sweden to access the international knowledge base through these investments.

Deficient market-related knowledge may have received a stronger wake up call in Scotland than Sweden due to the development facing the company that cloned Dolly the sheep. It does at least appear to serve as an anecdotal warning from policy-makers and there are claims of an improvement among life science companies.

Knowledge transfer and making business out of research also seem to achieve more political attention in government policies and strategies in Scotland. The government is working closely with industry in major policy areas. The distinction between the tasks of public agencies and private actors overlaps more in Scotland and there seems a strong consensus among the broad range of actors. When it comes to revenue on IP, Scotland comes out very high compared to other UK regions. It is also particularly interesting to note that university teachers in Scotland are very proactive in increasing the commercialisation of university research. The roles are somewhat reversed, since it is university teachers who are demanding more action from the industry in order to make practical use of the research. From a Swedish point of view, this discussion would be interesting to follow due to current debates regarding the levels of applied and basic research. It might be that universities in Scotland have acknowledged a somewhat different view of how society and individual university entrepreneurs could benefit from research.

It is claimed that the business angel market is more mature in the UK than in Sweden and this seems also to be the case for Scotland. When it comes to venture capital in general, the views regarding access diverge, just as in Sweden. The mismatch perceived in Sweden might be less severe in

Scotland due to the strong business angel market that reportedly invests predominantly in early stages of company development. Both Swedish and Scottish life science firms suffer from negative results though and it is highlighted that the number of firms that actually make a profit are far too low.

Perhaps the most prominent difference in governmental business support between Sweden and Scotland is the major focus on achieving critical mass in Scotland. This is reflected not only in governmental strategy documents but also in business support funding schemes. The attitudes towards direct funding of research-intensive foreign companies as an instrument of attraction also differ. The Cellartis case illustrates Scottish policies regarding business support products regarding such things as the procedure to ensure benefits to the local environment. It also highlights the collaborative efforts that are possible in Scotland. It might be fair to say that the Scottish life science industry has developed with a larger share of government support than the Swedish life science industry.

As a consequence of the higher focus on critical mass in Scotland, the focus on key technologies is also larger. However, there is awareness of the measures that need to be taken to ensure development of emerging technologies.

It might also be fair to say that Scottish life science policies and investments are more largely a result of a very high level of awareness of the global challenge and the competition it leads to in regard to government policies and attractive business environments. Since the decisions made in Scotland are the consequences of such a clear strategy which differs in many respects from Swedish policies, it is important to follow developments in Scotland and learn from their achievements as well as their mistakes.

7 Micro-level: The life science innovation systems of Cambridge and Uppsala

7.1 Sub-regional scope

7.1.1 Choice of sub-regions

The choice of the Cambridge and Uppsala biotech environments for the biotech sector innovation system comparison on a sub-regional level is justified by some similarities between the areas which make them comparable, and some differences in current and former strategies which make the innovation systems interesting to compare. Both cities have long academic traditions and a deeply-rooted city culture influenced by the universities. Not only do both clusters have universities with strong international reputations, the biotech academic activities have relatively major importance within the universities and internationally strong reputations. The biotechnology industry plays and has played an important role for the local labour market for decades in Cambridge as well as in Uppsala[411].

One factor that makes Cambridge interesting from a Swedish point of view is the well-known Cambridge Phenomenon. This is the striking success and speed of the development of the Cambridge cluster. The number of high-tech companies increased from 20 in 1978 to 360 in 1985 and 1,000 in 2006[412]. Cambridge always comes in as one of the top ranked areas on the European Commission ranking list. The economic growth of the region is on the same level as leading regions of the US[413]. The region is said by some to produce high economic value that stays within the UK and makes a significant contribution to the UK economy[414]. The phenomenon has been explained in different ways, with some actors advocating an organic growth, others the effect of extensive top-down initiatives[415]. This created an interest in the Cambridge Life Science Innovation System, henceforth referred to as CLIS. Uppsala Life Science Innovation System will be henceforth referred to as ULIS.

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[411] Region Uppsala, 2004, page 9.
[412] St John's Innovation Centre, 2006, page 1.
[413] St John's Innovation Centre, 2006, page 2.
[414] St John's Innovation Centre, 2006, page 2.
[415] http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78.

Another vital factor that makes it interesting to examine CLIS is the current discussion in Cambridge about constraints on growth. The Cambridge Phenomenon has led to many startup companies but few of them are profitable and they remain very small[416]. The reasons for this and to what extent the situation needs to be addressed are debated in Cambridge. The discussion has been described as "where are the big gorillas?"[417] This question is highly relevant to the aims of this report of analysing the competitiveness of the Swedish Life Science innovation system compared to the UK. Data on the industry structure of both Cambridge and Uppsala is accessible and makes it possible to compare the innovation systems of Cambridge and Uppsala in regard to the growth of companies and constraints on growth.

7.1.2 Previous work

There are already a number of reports dealing with the Cambridge life science sub-region. Likewise, the evolution of the life science industry in Uppsala has been the subject of previous investigation. A comparison of Uppsala and Cambridge was made by Uppsala University Industrial Relations Office in 2002. What possible value then could might another comparison add to the current knowledge base in the matter? It is in the nature of an industrial system to be dynamic[418]. The prospects of industries in terms of access to financial support systems and market demands vary over time. Policy standpoints also fluctuate since politicians and priorities are exchangeable. Comparisons and status reports which are a few years out of date on some issues do not give a valid picture of the current situation. Still, the system being analysed needs to be delimited in terms of space and time to understand the characteristic relationships, and thus delimit understanding[419]. This study of Uppsala and Cambridge will constitute sub-regional blocks in a wider analysis of the innovation systems of the UK and Sweden and hopefully provide a deeper understanding of the competitiveness of the life science innovation system in Uppsala and Sweden. A need has been noted for more comparative studies of the Uppsala innovation system[420], which is the point of this Uppsala-Cambridge comparison.

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[416] The Cambridge Cluster, Chapter 3.2.1.
[417] Owen G., 2004.
[418] Waxell A., 2005, page 51.
[419] Waxell A., 2005, page 51.
[420] Waxell A., 2005, page 180.

7.1.3 Delimitations of the innovation systems

The spatial delimitation is problematic due to the local, regional and national spatial levels being interconnected and diffuse[421]. The Uppsala Life Science Innovation System, ULIS, is defined as the local labour market of Uppsala and correspondingly, CLIS is the local labour market of Cambridge. Stockholm and London are not included in the delimited areas. The system structure analysis of Cambridge and Uppsala focuses on the sub-regional area. However, as described in the analytical model and approach in chapter 2, the interconnectedness between different sub-regions, regions and national actors is not neglected. The network overview and the activities take this into account. Notably, the *policies* affecting the sub-regional level are highly influenced by national strategies. This is further described in chapter 11. The priority here has been on sub-regional initiatives, actors and relationships etc.

7.1.4 Course of action

In this comparison of an innovation system on a sub-regional level in Sweden and in the UK, the focus has been on current status. Since limited statistics are so far available for 2007, data for 2006 has formed the basis for the comparison, with additional information from interviews and recently updated web pages to give as up-to-date a picture of the status as possible. Representatives from different actors in both CLIS and ULIS have been interviewed in situ in Uppsala and Cambridge. A full list of interviews conducted and conferences attended is given in the list of references. In order to put the current situation into perspective, bibliographical studies have been carried out on the activities to describe the development of the sub-region.

The comparison was conducted using a different course of action than previous comparisons by other authors. The industry structure of Cambridge has been analysed before, but naturally in order to make a fair comparison of it, the characterisation of the industry structure must be conducted in the same way. The industrial structure of life science in Uppsala has been characterised in this report, as part of the industry structure of the entire life science industry of Sweden. Managing an equally extensive survey of the UK Life Science industry over time was considered beyond the scope of this report. Therefore, the biotech industry of Uppsala in 2006 has been chosen for comparison with the industry structure of biotech in Cambridge for 2006. The generation of the industry structures has been conducted in the same way. For the sake of comparability, the classification into business segments applied to Swedish companies was also applied to the Cambridge

[421] Waxell A., 2005, page 44.

Biotech population and not the classification of the biotech population previously used by the East of England Regional Biotech Initiative (ERBI).

8 Cambridge life science innovation system

8.1 Industry structure Cambridge

Just like the industry structure generated for the Swedish life science industry, the companies within the life science industry in Cambridge have been classified in order to generate figure 8.1. However, it should be noted that the industry structure of CLIS does not include the individual business segments within med-tech. This is because, with a few exceptions, the data kindly submitted by ERBI did not include medical technology companies. This might also be due to a smaller med-tech sector in Cambridge than Uppsala but cannot be verified.

There are a total of 183 biotech companies in Cambridge, comprising 6,244 employees. This does not include marketing and sales companies though. The most striking feature of the industry structure of Cambridge is the large consultancy business segment, predominantly due to a large number of Contract Research Organisations (CROs). There is one very large CRO company shown in the figure. This is Huntington life sciences, which has been classified as a CRO since this is their own description of the company. This is one of the world's largest CROs and was established back in the 1950s[422]. The business segments of drug discovery and biotech tools and supplies are prominent in Cambridge. Some drug delivery, drug production and agricultural biotech companies are also part of the industry structure. Apart from Huntington life science, there are few very large companies. This has been attributed lot of attention in CLIS already, with conferences and discussions on the theme, "where are the big gorillas?". This refers to the absence of large companies.

Among the companies conducting broad R&D are many with no product on the market. The largest companies are naturally found among those that have put a product on the market. Among the companies conducting narrow R&D, most companies have reached the market. With a few exceptions, the narrow R&D companies are often very small. They are also often drug discovery companies. It should be noted that when contacting ERBI, they questioned whether the number of companies defined as having a product on the market had not been exaggerated. One explanation could be that in the industry structure classification, companies with any kind of product linked to their activity were defined as having a product on the market. However, there are several examples of research companies working

[422] http://www.huntingdon.com/index.php?currentNumber=0&currentIsExpanded=0.

towards the launch of a drug or a biotech tool. However in the meantime, they sell a simpler product that does not require extensive R&D. These companies have been categorised among those with a product on the market in order to be consistent with the Swedish (and Uppsala) industry structure. This phenomenon was not as frequent in the Swedish industry structure. Thus in that sense, the number of “product on the market” companies is exaggerated. Also, companies which sell a licence are also put into the product on the market group, in order to be consistent with previous work. Licences also occur among the companies within consultancy activity, but this activity is not further divided into sub-groups.

When considering companies established after 2000, it is shown that most of these were involved in either drug discovery or biotech tools and supplies. There are also many newly established CRO companies. However, it is interesting that the large CRO business segment is nothing new to CLIS, although it has increased significantly in recent years. The consultancy sector does indeed have a long tradition in Cambridge. Among the newly established companies conducting broad R&D, very few have managed to put a product on the market (yet). Among those conducting narrow R&D on the other hand, more than half the companies have a product on the market.

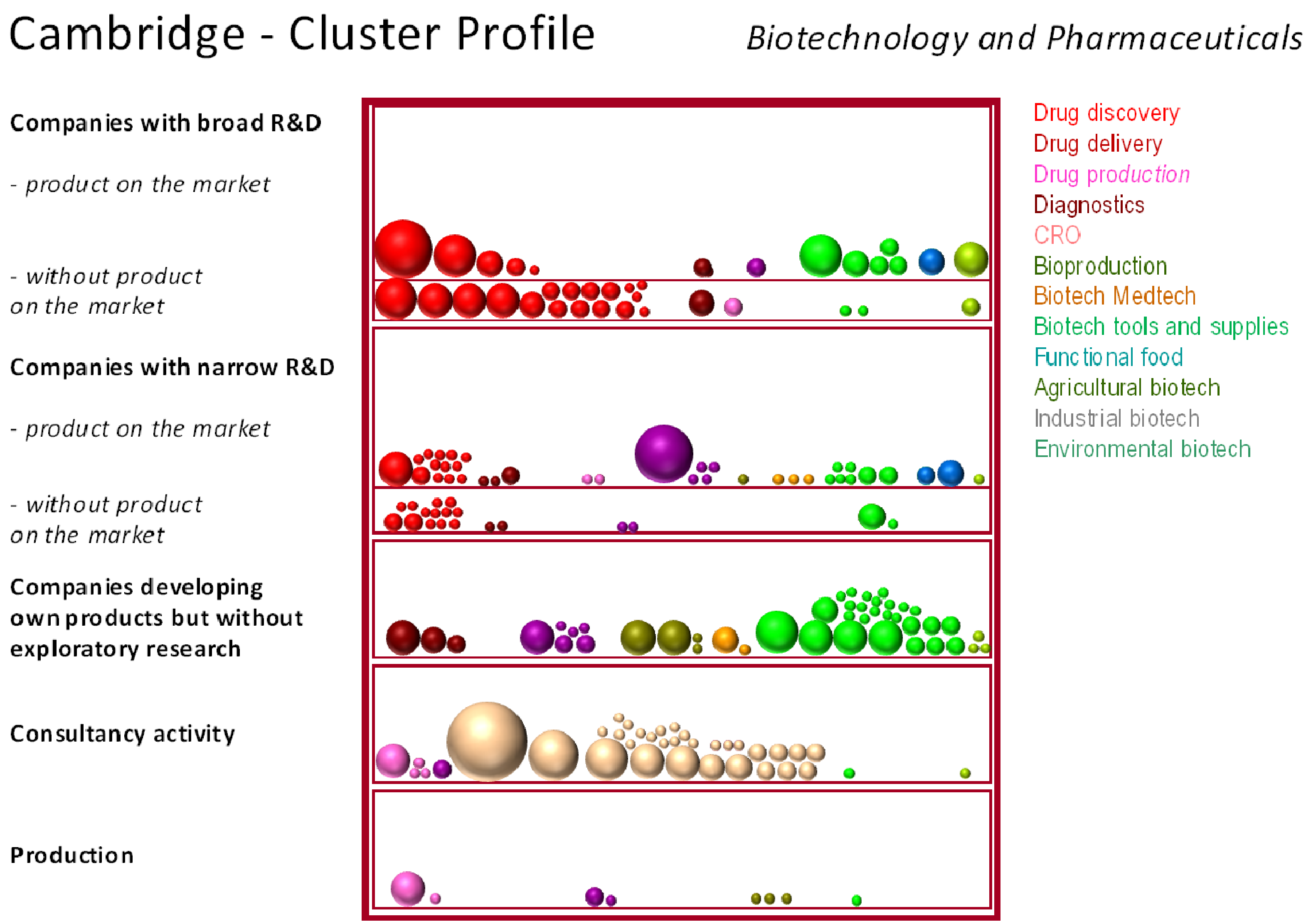

Figure 8.1 Industry structure of Cambridge /Helena Bergqvist (Author), 2007, VINNOVA, layout: Tage Dolk , Addendi, 2007

8.2 System Structure Cambridge

The actors of the innovation system are presented in the system structure of the CLIS. They were selected because they are the most vital pillars of the system. These are the companies, public authorities, industrial associations and partnerships, innovation centres and science parks. The most vital networks are also presented in the system structure analysis. Naturally the networks are made up of relationships between actors, but some of the actors classified in the above groups also could be seen as networks by themselves. Consequently, there is an overlap of the networks and actors presented. An interesting phenomenon of the innovation system of Cambridge (and in the UK as a whole) is the funding networks. This is a term used by HM Treasury in referring to the bodies that are both financiers and networks[423]. The system structure analysis seeks only to describe the components of the innovation system. In the activity analysis section, the activities within the innovation system and the role the actors play in the system are described and analysed.

The populations of networks and funding networks in East of England were generated by a search tool on the HM Treasury homepage and should give the total populations on a regional-basis relevant to the Life Science industry. All the networks and funding networks, public as well as non-public, were studied using their focus on certain key issues a point of reference. The results are assembled in tables 2 and 3 and analysed in the policy evolution activity section.

8.2.1 Public authorities

Starting from the top, the UK government's route to implementing the strategies and policies down to the sub-regional level of Greater Cambridge is crocket. Unlike Scotland, there is no correspondingly overarching Devolved Administration for England. England is directly answerable to the British Parliament and government and there is no legislative assembly for England. The nine regions are responsible for the execution of the public administration. The constitution within these regions differs. However, in all the regions there are Government Offices (GOs) sitting between Whitehall departments and regional organisations. The nine regional offices are gathered in a network with a Regional Co-ordination Unit that serves as an interface with the Whitehall departments[424]. The offices are part of the Department for Communities and Local Government and eleven Whitehall departments are represented in each GO. Each GO department manages extensive programmes on behalf of the corresponding Whitehall department and also ensures that East of England interests are represented in the

[423] http://www.entrepreneurs.gov.uk/directorySearch.cfm.
[424] http://www.gos.gov.uk/aboutusnat/.

national policy-making process. The GO for the East of England, GO-East, is led by the GO-East board of nine directors[425].

In the East of England Regional Assembly (EERA) elected representatives from the 54 local authorities are gathered in a partnership with representatives from social, economic and environmental interests. The aim of the assembly is to promote the well-being of the region by developing a consistent policy of promoting the East of England as "a world-class economy renowned for its knowledge base" [426]. The sub-governmental level administration is carried out at county or even local level within the county. The East of England region has over 50 councils, seven of them within Cambridgeshire.

8.2.2 Industry associations and partnerships

The development of the region and the crucial link to national public bodies like the Technology Strategy Board (TSB), Department for Innovation and Universities (DIUS), former Department for Trade and Industry (DTI) and Department for Education and Skills (DfES), are also looked after by the Regional Development Agencies (RDAs). The RDAs' focus lies in bringing investment to their region and increasing productivity[427]. The influence of RDAs and other regional bodies and partnerships has increased. They play an important role as the delivery bodies of government spending programmes. Business support programmes are carried out by the RDAs that also develop the Regional Economic Strategies (RES) to set the framework of economic development in the region[428]. The RDA of East of England is EEDA, the East of England Development Agency and is led by board members with a background in politics, business and the voluntary and community sectors. The board is appointed by government ministers[429].

On a sub-regional level, organisations such as the Greater Cambridge Partnership (GCP), the Learning and Skills Council (LSC) for Cambridgeshire and Business Link implement government agendas for skills and business development[430].

The interests of East of England are also looked after by the East of England European Partnership (EEPA). Their aim is to serve as a guide for organisations and companies in their contact with the European Commission and provide intelligence and advice on the development of funding policies.

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[425] http://www.gos.gov.uk/national/.
[426] http://www.eera.gov.uk/category.asp?cat=386.
[427] http://www.englandsrdas.com/businessefficiencyinvestmentandcompetitiveness.aspx.
[428] http://www.englandsrdas.com/economicdevelopmentandregeneration.aspx.
[429] http://www.eeda.org.uk/abouteeda/staff.html.
[430] Cambridge City Council, 2004, pages 8-9.

The aim is also to create strategic links with other European regions and promote East of England to decision makers at European level[431].

8.2.3 Innovation centres, science parks and incubators

St John's Innovation Centre
The Centre was established to support early-stage, knowledge-based companies. The tenants are also older technology based companies that bring maturity to the park and service companies that provide support in training, marketing, networking, public relations etc. This combination provides the base for regional, national and European networking. One of the virtual services of the centre is Enterprise Link, a business club for small high-tech companies[432].

Cambridge Innovation Centre (CIC)
The CIC is a science park with over 60 companies in R&D activities. University spin-offs, multinational pharmaceutical companies, venture capitalists, patent agencies, consultants and business support are gathered under the same roof[433].

Babraham Bio incubator
In the Babraham Bio incubator, startup and early-stage companies are offered combined laboratory and office accommodation[434]. Among the incubators purposes are to stimulate knowledge transfer awareness and to lead partnerships in the region to promote knowledge and skills[435].

ERBI
The primary objective of ERBI is to accelerate the growth of biotechnology within the sub-region. Partnering, collaboration and strategic alliances are encouraged. Its activities include hosting an annual bio-partnering exchange with delegates from all over the world. Among the services accessible to the biotech industry are finance and regulatory services. ERBI also provides consultancy to government departments[436].

8.2.4 Research Institutions and Universities

There are over 30 research institutes and universities in the Cambridge cluster[437], notably Cambridge University, the top-ranked UK university in regard to science and technology and the new Stem Cell Institute with over

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[431] http://www.east-of-england.eu/.
[432] Smeets A., 2006.
[433] http://www.cambridgescienceparkinnovationcentre.co.uk/about.html.
[434] http://www.babraham.ac.uk/facilities/Bioincubator.htm.
[435] http://www.babraham.ac.uk/facilities/objectives.htm.
[436] http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_11/_firsttitle.xsl/6.
[437] http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=3.

160 stem cell researchers[438]. The other universities are the University of Cranfield, University of East Anglia, Essex, University of Hertfordshire and University of Luton. There are also three university hospitals, Addenbrookes which is the research hospital for Cambridge, Papworth and Norwich[439]. Life science holds a strong position in the academic environment of Cambridge. There are 3,500 students and 350 research groups within life science. Among the key activities in the region are drug delivery and discovery, stem cell research, diagnostic, oncology, neurology and converging technologies[440].

8.2.5 Networks and funding networks

The East of England has a total of 55 high-technology networks, including some of the actors mentioned above[441]. Of the 55 networks, 30 are predominantly or exclusively involved in biotechnology (table 3). There are 22 funding networks in the East of England of which 21 are relevant to the biotech industry[442].The networks have been found by using the web-based search tool of the UK Networks Directory. The homepages of all of the networks and funding networks listed in tables 2 and 3 were examined in regard to their focus on the issues chosen. If one or more of these are formulated as key goals, key objectives, and key priority or in any other way described as an issue of major concern for the network or funding network, then it has been considered a focus. The entire basis of tables 8.1 and 8.2 below is in tables 3 and 4.

[438]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=2.
[439]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=2.
[440]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_52/_page.xsl/79,
http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=3.
[441] http://www.entrepreneurs.gov.uk/directorySearch.cfm.
[442] http://www.entrepreneurs.gov.uk/directorySearch.cfm.

Table 8.2. Science and life science networks for the East of England. Crosses indicate that a network has a focus on that particular issue[443].

Network	Key technology areas	Commercialisation	Applicable research/economic benefit to society	Collaboration	Global challenge
The Accredited Chamber of Commerce Bedfordshire and Luton			X	X	X
Biology in Business (BIB)		X			
Cambridge & District Chamber of Commerce & Industry					
Cambridge Enterprise Agency		X			
Cambridge Genetics Knowledge Park (CGKP)				X	X
Cambridge Network		X			
Corporate Liaison office		X		X	
Cambridge university Entrepreneurs		X			
Cambridgeshire Chamber of Commerce			X	X	
Cambridge County Council	X				
EEDA		X	X		X
East of England Innovation Relay Centre (EEIRC)			X		X
ERBI				X	X
Enterprise-link		X			
Essex Chamber of Commerce			X	X	X
Exemplas		X		X	X
gateway2Innovate		X		X	
The Great Eastern Investment Forum (GEIF)		X			
The Greater Cambridge Partnership (GCP)			X	X	X
Hertfordshire Chamber Of Commerce		X	X	X	X
i10		X		X	
East of England Innovation Relay Centre (EEIRC)			X		X
Invest East of England			X		X
Library House					
Local Industry Network		X			X
MedLink East		X			X
Norfolk Chamber of Commerce		X	X		X
Norfolk Network		X	X		
St John's Innovation Centre		X	X	X	X
East of England Stem Cell Network		X	X		
Cambridge University, Institute for Manufacturing		X			X

[443] Author/generated by the UK directory search tool at http://www.entrepreneurs.gov.uk/directorySearch.cfm.

Funding networks

Table 8.3. Science and life science funding networks for the East of England. Crosses indicate that a network has a focus on that particular issue[444].

Name of funding body	Key technology areas	Commercialisation	Needs-driven research/economic benefit to society	Collaboration	Global Challenge
3i Group plc					X
Cambridge Venture Partnership		X	X		
Research Councils' Follow-On Fund	X	X		X	
BBSRC's Follow-On Fund	X	X			
Cambridge Enterprise Seeds Fund (CESF)		X	X	X	
Cambridge Enterprise Proof of Concept Funding (PoC)		X			
Cambridge University Entrepreneurs' Business Plan Competitions		X			X
Amadeus and Angels Seed Fund (AASF)					X
Cambridge Angels		X	X	X	
Great Eastern Investment Forum (GEIF)				X	
GEIF Ventures		X		X	
Create East of England Fund			X		X
NW Brown Group, IQ VC fund				X	
Cambridge Capital Group	X	X	X		
Cambridge Gateway Fund	X				
Cambridge Research Bioventures		X			

444 Author/generated by the UK directory search tool at http://www.entrepreneurs.gov.uk/directorySearch.cfm.

Cambridge Research & Innovation Ltd					
ET Capital Fund		X			
Pall Mall Partners Ltd					
Prelude Technology and Prelude Ventures					
Iceni Seedcorn Fund LLP		X	X	X	

8.3 Activities

8.3.1 Knowledge development

This section describes the generation of knowledge elements. Of vital importance to understanding the generation process is the access to knowledge, both technological and market-related, and the knowledge transfer between academia and industry. The Cambridge Phenomenon is interesting to discuss in the context of knowledge transfer since the extent to which knowledge transfer has occurred between the actors has been highly debated in Cambridge.

Generation of knowledge elements

Factors affecting the direction of research

The region hosts a traditional strong research base in agriculture due to the surrounding agricultural landscape. However, among the first products produced by the cluster back in the 80s were human therapeutic products. The potential of human health products increased and attracted the interest of investors. Due to the requirement for a quick financial return, therapeutics continued as a favoured research field. The 90s saw an increase in platform technology companies when there was an increase in investor interest in technologies and services aimed at commercialising other companies' products. More tangible products were required. After the dotcom bubble, investors were more reluctant about high risk and steered the research and its commercialisation towards a product-based economy[445].

The impact of the University of Cambridge and the other local research institutes on the generation of a knowledge base is undoubtedly important. Additional to the knowledge bank hosted within the University and institutes, a highly skilled workforce pool has been generated and made available to the business community.

[445] The Cambridge Cluster, Chapter 3.2.1.

Public Research Funding

Cambridge University is allocated the highest amount of public research funding of all British universities. The distribution of total income (Private grants & contracts, HEFCE Recurrent Research Grants and other Government grants & contracts) between the top ten UK universities is outlined in figure 8.2. As shown in the figure, Cambridge also has the highest total income.

22. Available at <http://education.guardian.co.uk/higher/research/>

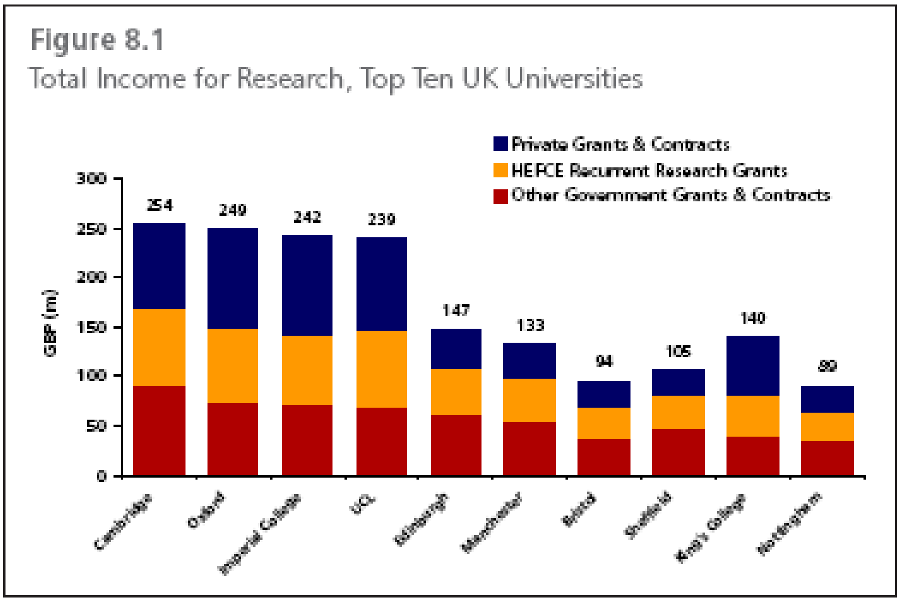

Figure 8.2. Total income for research for the top ten UK universities[446].

However, with the globally ranked top four universities as a point of reference, Cambridge is allocated the lowest amount of funding[447]. The competition comes exclusively from American universities. Adjusted for the number of academic staff, Cambridge comes in third out of the four, as shown in figure 8.3[448].

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446 Library house, 2006a, page 47.
447 Library house, 2006a, page 48.
448 Library house, 2006a, page 48.

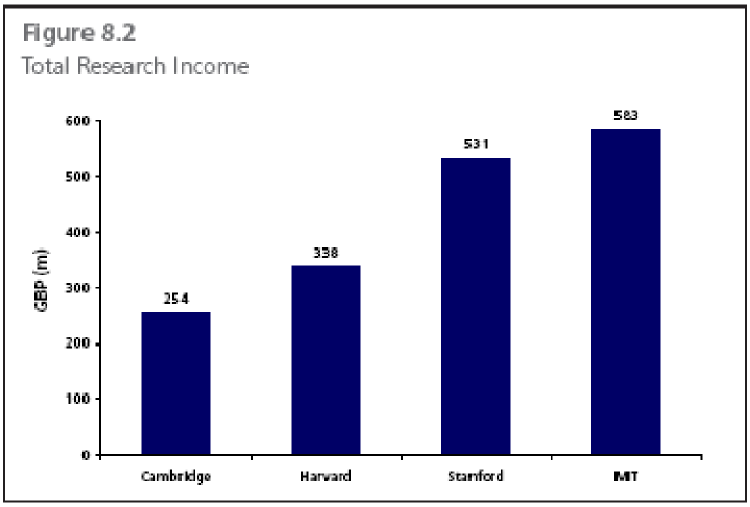

Figure 8.3.Total research income for the top four ranked universities in the world[449].

Industrial R&D expenditure

The East of England has the highest level of Business Enterprise Research and Development (BERD) of all the UK regions. In 2005, GBP 3.3 billion was spent on BERD. The region also has the highest R&D intensity measured as a share of total economic activity. BERD contributed 3.5% of GVA in 2005[450]. This is largely focused on a small geographic area and a small number of companies[451]. As shown in figure 8.4, the biotechnology and healthcare industries have higher relative R&D expenditure than other high-technology industries in the Greater Cambridge area[452].

[449] Library house, 2006a, page 48.
[450] East of England Development Agency, 2007, page 20.
[451] East of England Development Agency, 2007, page 33.
[452] http://www.gcp.uk.net/SITE/UPLOAD/DOCUMENT/CIR_HiTech_2006_Final.pdf.

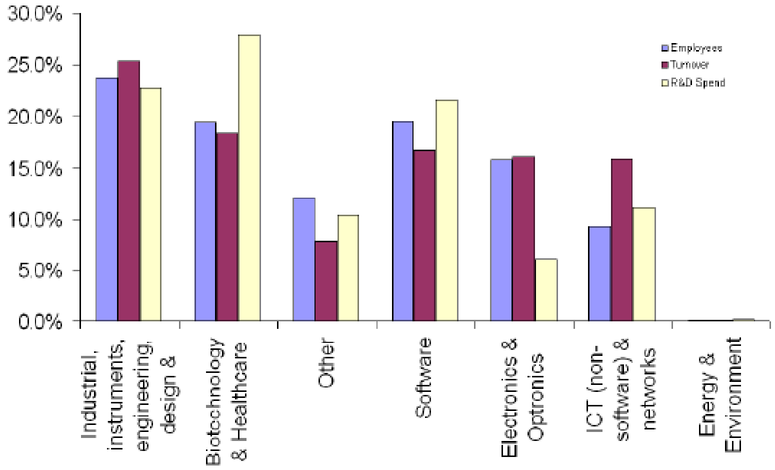

Figure 8.4. Number of employees, R&D expenditure and turnover of the Greater Cambridge Partnership companies, data over 2005-2006[453].

As mentioned in section 5.2.1, when dealing with BERD as a percentage of GDP in Scotland, London had a suspiciously low level compared to other regions. The East of England holds a much larger BERD level than London[454]. No specific reasons where found to explain this, but it may be speculated that there are connections to the very high relative share of total HERD allocated to London[455]. Also, in regard to differences between the East of England and London, there may be spatial delimitations complicating the interpretation of statistics.

Access to knowledge elements

Technological knowledge base

The life science knowledge base of Cambridge is highly ranked regardless of measurement chosen. Since Watson and Crick made their breakthrough discovery, 14 Nobel Prizes in medicine and chemistry have been attributed to Cambridge scientists[456]. This constitutes 20% of all Nobel prizes in medicine and chemistry[457]. Figure 8.5 outlines the strength of the technological knowledge base measured by number of publications per year compared to three highly ranked universities in the US. This comparison shows that as far as publications per year are concerned, Cambridge University compares well with Stanford and MIT.

[453] http://www.gcp.uk.net/SITE/UPLOAD/DOCUMENT/CIR_HiTech_2006_Final.pdf.
[454] http://www.lda.gov.uk/server/show/ConWebDoc.1340.
[455] http://www.lda.gov.uk/server/show/ConWebDoc.1340.
[456]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=3.
[457]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78.

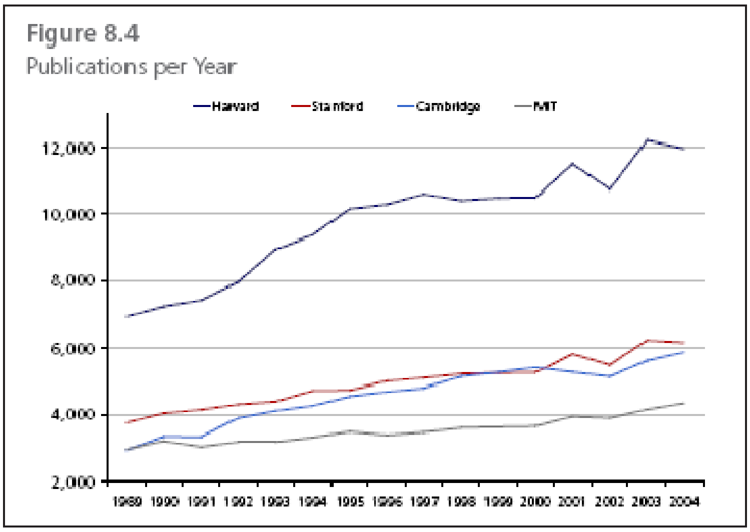

Figure 8.5. Number of publications over time for the top four ranked universities in the world, according to Library House[458].

Market-related knowledge base
Market-related knowledge is one of the most advocated underlying explanations for the Cambridge success story. The formation in 1960of a company called Cambridge Consultants is referenced as a key trigger for the growth of the cluster. Their focus was on the market and applicable research. According to ERBI, as early as the 1980s, the market knowledge of the bio-community included intellectual property exploitation, business skills and the importance of knowledge transfer[459].

Today, there are over 350 service providers in the region claiming to have biotech specialist competence and over 100 organisations engaged in the development of the bio-community, according to ERBI[460]. Life science makes up a substantial share of several of the activities aiming to increase the market-related knowledge base as shown in table 8.3.

Table 8.3. Life Science share of market-related knowledge base support services[461].

[458] Library house, 2006a, page 49.
[459]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=1.
[460]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=3.
[461]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78&xsl_arg=//BF%5FERBI%5FAB%5FBIO%5FFAF/&xsl_argx=3.

Specialist service provider offerings:	Share of actors with total or major focus on Life Science
Financial services	9%
Legal services	5%
Consulting services, 100% dedicated to pharma/biotech industries	15%
Other business services, offering a local biotech centre of excellence	31%

However, even though there are many accessible services aiming to increase management and market skills, the lack of competence in this area was viewed as the major constraint to growth among high-tech cluster firms in 2001, as outlined in figure 8.6. According to the industry representatives interviewed in Cambridge, this picture is still valid.

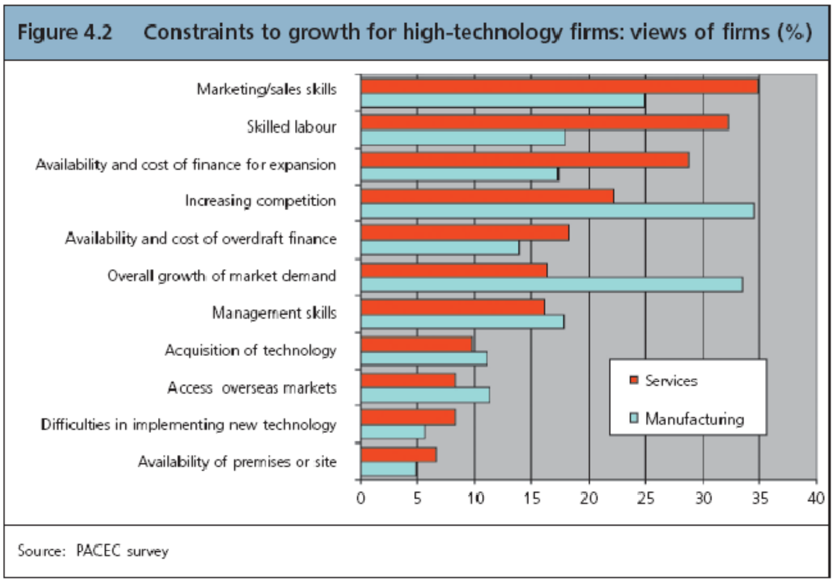

Figure 8.6. Constraints to growth for high-tech firms according to the firms themselves in 2001[462].

The 2001 result is derived from a survey of high-technology firms in the local labour market. Among the Finance sector and Business support sector, the lack of management skills is viewed as a constraint by almost 90% and the lack of marketing skills by almost 70% of the respondents[463]. It seems to be the general view that there is a shortage of managerial skills in the region, although the local Cambridge labour market is better off than other parts of the region[464]. The problem is addressed in the Regional Economic Strategy 2008-2031 (RES), an EEDA product that sets the framework for

[462] PACEC, 2003, page 58.
[463] PACEC, 2003, page 58.
[464] East of England Development Agency, 2007, page 51.

the work of Go-east and local public authorities and a number of schemes and products are suggested to boost the uptake of managerial skills[465].

International knowledge base
The knowledge base is further strengthened by the international knowledge base. Access to foreign research by networks and collaborations as well as attractiveness to top foreign researchers are essential today in order to cope with the global challenge. According to GCP, the level of international interconnectedness is high in Cambridge and the sub-national region is highly active in participating and developing mechanisms that bring innovations to a global market[466]. Cambridge has been involved in several successful international collaborative research projects in the biotech field. The development of a universal database and knowledge base of protein molecules, a GBP 15 million collaborative research project initiated by the US National Institutes of Health (NIH) is one such example[467].

However, the international interconnectedness of Cambridge University and other research organisations could be questioned. As shown in figure 8.7, almost all co-authorships in life science journals with an impact factor above 6 are exclusively British. Among the international co-authorships, it is the US that dominates, as shown by figure 8.8. The US and some European countries are quite well represented, but India for instance is not visibly present on the co-authorship map. Apart from European countries and the US, there are co-authorships with Japan, Israel, China, Australia and Canada. When considering the specific organisations taking part in the co-authorships (as shown by figure 8.8) it is clear that among the international co-authorships of the University of Cambridge it is predominantly the US universities like Harvard and Stanford that have strong reputations. This is consistent with the description given by Cambridge University that international collaborations with US are highest ranked in a research career. There are no strong career incentives to take part in other international research collaborations[468]. It should be kept in mind that the maps are generated exclusively on the basis of co-authorships in journals with an impact factor >6. If there are strong co-authorships with certain countries in less highly ranked journals, this would not show on the maps. In Cambridge, it was claimed in interviews with industry representatives that the international connections are probably stronger when considering industry. This may be true if considering international connections with clients and suppliers in general, but as far as research collaborations are concerned, the industry falls short. Universities and hospitals dominate the map of organisations.

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465 East of England Development Agency, 2007, page 55.
466 PACEC, 2003,, page 40.
467 PACEC, 2003, page 39.
468 Interview, Reschner Richard, research services Division, Cambridge University, 20071018.

Research organisations in Cambridge have participated in 60 life science projects, started in 2004 or later, of the 6th European Framework Programme, FP6. Over the period 2004-2006, the number of projects started with Cambridge participating decreased. The main partner organisations outside the region are mostly in France, Germany, Great Britain and Sweden. In several joint projects, a minority of the organisations with which Cambridge collaborated are industry organisations whilst the vast majority are in academia. Collaborations with industry in other European countries are predominantly restricted to single joint projects. Overall, academia dominates. Academia also dominates when considering what type of organisations within the region take part in the FP6; 52 out of 60 projects involve a Cambridge partner from academia and 16 from Cambridge industry. The strongest thematic area in terms of number of joint partnerships is cancer[469].

[469] www.lifecompetence.eu, 20080205.

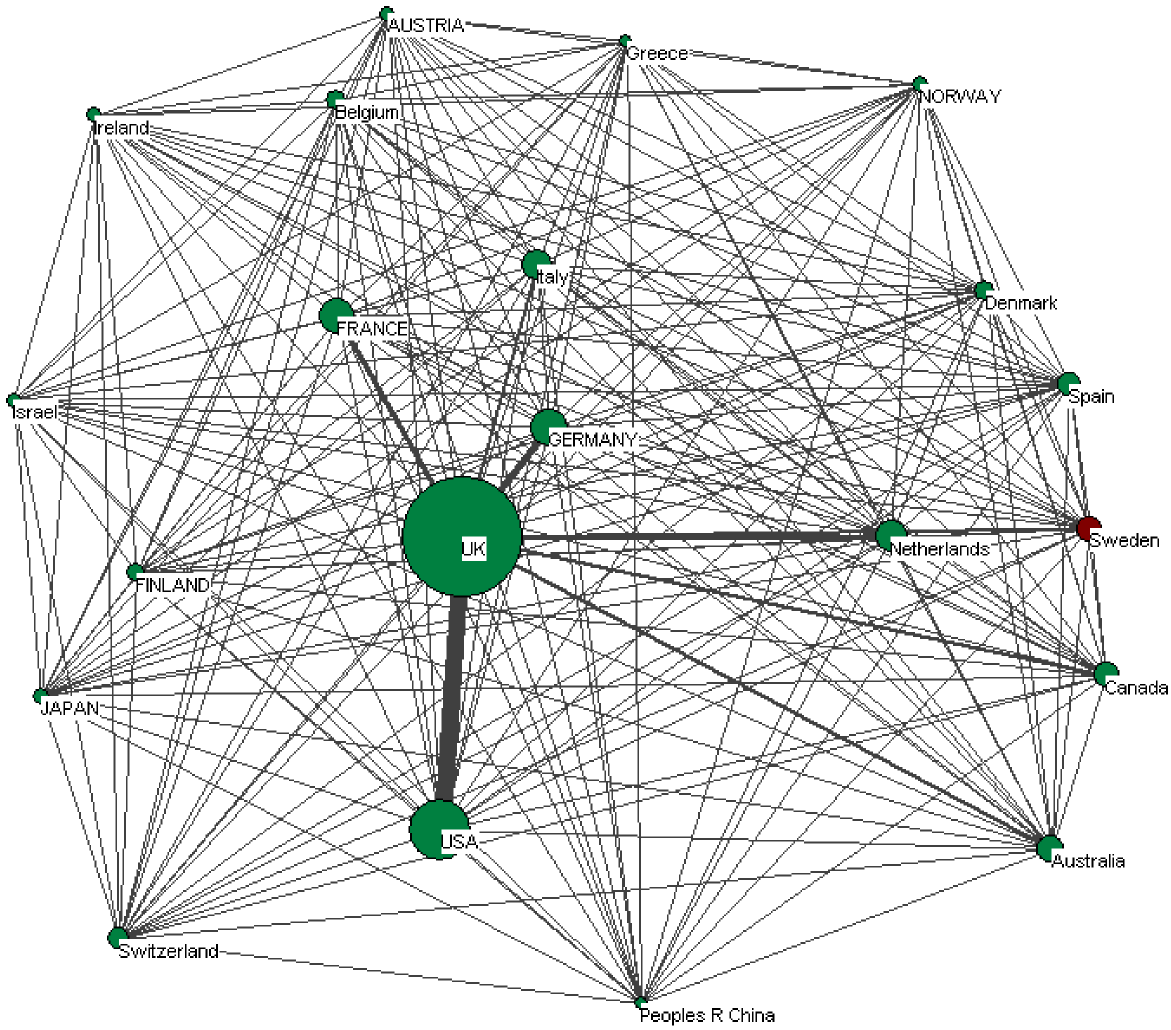

Figure 8.7. Co-authorships between organisations in Cambridge and organisations, nationality shown.

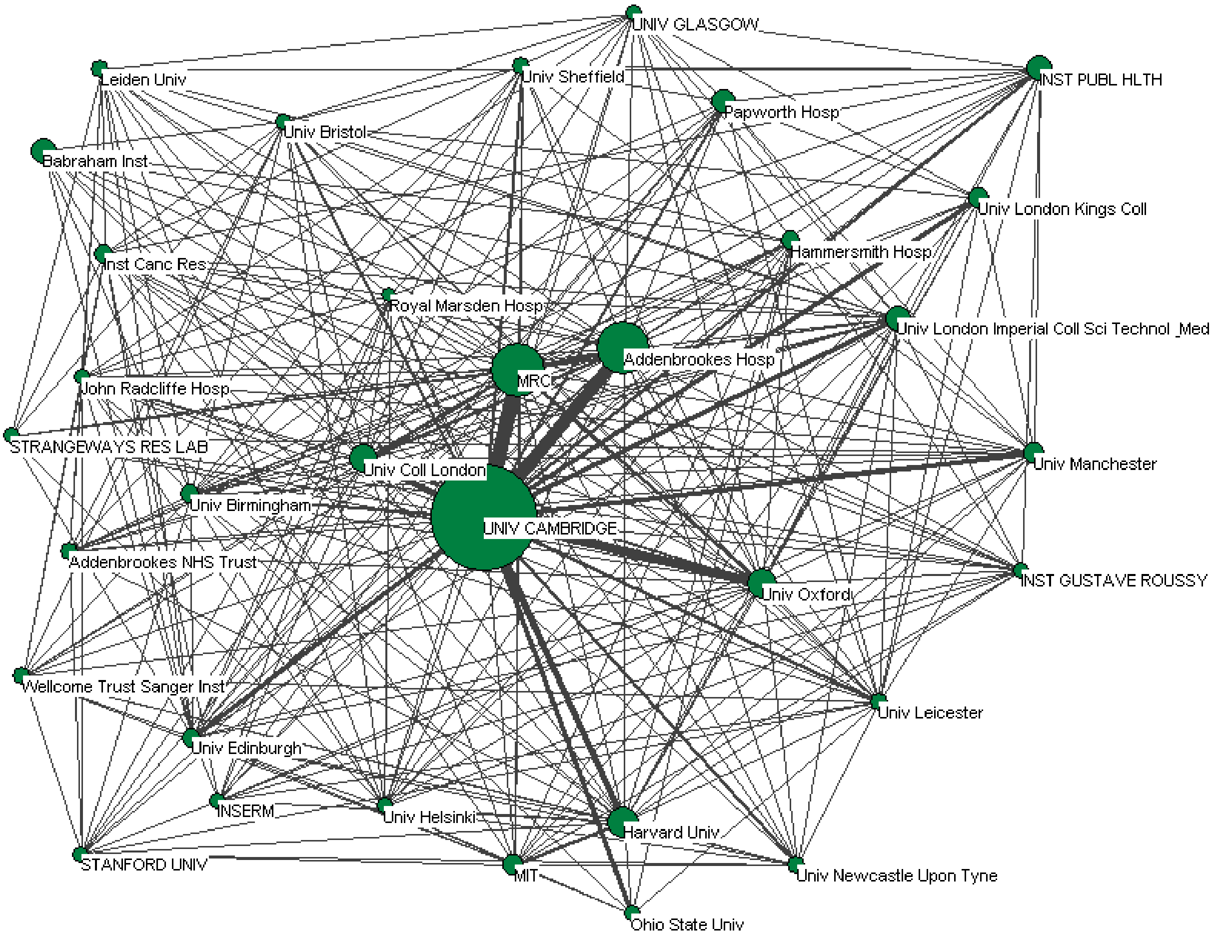

Figure 8.8. Co-authorships between organisations in Cambridge and other organisations, organisations shown.

Knowledge transfer

Commercialisation activities

According to ERBI and St John's Innovation Centre, the Cambridge Phenomenon cannot be attributed to the University of Cambridge with reference to the low extent of commercialisation efforts until a few years ago[470]. The University staff and students have founded about 50 spin-off companies based on university IP[471].

In contrast, Library House, Cambridge City Council and several others take the view that the University of Cambridge indirectly has had a profound

[470]http://www.erbi.co.uk/bfora/systems/xmlviewer/default.asp?arg=DS_ERBI_ABOUTART_51/_page.xsl/78.
[471] Library house, 2006a, page 10.

impact on the development of the Cambridge Phenomenon[472]. The economic impact of the University is recognised to a much greater extent than the St John point of view. The net return on investment for educating a Cambridge graduate is estimated at over six times the original investment according to Library House[473]. By using a model designed to enable the analysis of the impact of HEIs on economies and societies, Library House investigated not only the direct economic impact of research activities but also the knowledge generated through these activities and made available to regional, national and international business through technology licensing, faculty consulting activities, research contracts etc[474]. They conclude that the economic benefit from the University of Cambridge to the East of England Region and the Greater Cambridge sub-region is profound, both in economic and social terms, as outlined in table 8.4.

Table 8.4. Economic impact of the University of Cambridge on the region and on the nation[475].

Economic Impact of the University of Cambridge	
Number of employees directly employed by the University of Cambridge	11,700
Indirect jobs created by the University of Cambridge	77,000
Net present value added to the region	GBP 21.1 billion
Net present value added nationally	GBP 4.4 billion

Strengths and weaknesses identified in relation to the knowledge development

One of the most obvious strengths of this activity is the technological knowledge base of Cambridge. However, the volume of publications from the University of Cambridge is not increasing. This development is not highlighted by the University or the surrounding innovation system and thus presents a potential future concern in the technological research base.

The strength of the market-related knowledge base in Cambridge is debated. The general view among those interviewed is that management skills have been improved in recent years. There are a lot of management support products available, although some of the people interviewed claim that companies simply will not listen to all the advice they are given. Based on

[472] Library house, 2006a, page 58 and http://www.cambridgeshire.gov.uk/business/economic/Research+and+development.htm.
[473] Library house, 2006a, page 1.
[474] Library house, 2006a, page 23.
[475] Library house, 2006a, page 1.

the 2001 survey to representatives of high-tech firms in Cambridge in which a large share of firms and business support providers claimed management skills to be a constraint to growth[476], there has at least been major potential for improvement. It has also been claimed that there simply is not enough interest among CEOs in major business expansion. The drive is entrepreneurship itself and the profit gained when selling the business. The entrepreneurial researcher then goes off to the next project. If a lack of management skill still constitutes a weakness in the life science innovation system of Cambridge and a constraint on growth, then the constraint is probably a combined one, due in part to reluctance among local business leaders to make their company perform in a specific fashion deemed successful from outside. The individual entrepreneurs and CEOs might make a profit on their company by consultancy activity or buy-outs even if the company as a hole is not profitable or growing in terms of number of employees. The issue then is lack of incentive rather than lack of management skills. The strong presence of consultants combined with a relatively high number of business support products available, constitutes a strength if considered separately. The overall contribution to the life science innovation system of Cambridge may not be as strong as it could be with better mechanisms for translation into economic benefit for the region.

Since international collaborations and partnerships have a very high profile on the national agenda (UK strategy documents, frameworks etc), it is particularly interesting to investigate what international links there are on a sub-regional level. Based on the results of the sub-regional policy examination, the co-authorships of Cambridge University and other organisations, the decrease in the participation in FP6 and finally the interviews in Cambridge, the conclusion is that international links are not very strong in academia or industry. To claim this as a weakness, it is essential that Cambridge thereby loses out on potential benefits. A view in some interviews was that there might not be that much to gain in international collaborations. Or, simply put, “what’s in it for Cambridge?”. Although certain successful initiatives have been established, the overall interest in international partnerships is not very high. As figure 8.7 shows, the share of international co-authorships among those of Cambridge University and other organisations is low and the US is the country that receives the greatest interest from the Cambridge-based researchers. Based on interviews in Cambridge, one explanation for this is that there are no real incentives for Cambridge researchers to collaborate with international researchers. The opinion has been that the only country that would increase the qualifications of a Cambridge researcher is the US. This is not so surprising in the light of the national view that the UK comes second in the world in regard to performance in life sciences. The first country is clearly the US and this has been the motive for some partnerships.

[476] PACEC, 2003, page 58.

There again, when it comes to receiving EU funding, the East of England has been fairly successful in achieving funding and there are quite active players trying to increase the awareness of EU funding and assisting in accessing available funding. The EU Frameworks and accessible funding have thereby presented incentives to build on European links. This explains the relatively high share of European collaborations among the total international co-authorships, including Cambridge. Some of the people interviewed pointed out that links between the biotech industries of Cambridge are likely to hold more international collaborations than the University. However, the FP6 participation reveals that industry is participating in quite a few research collaborations compared to academia. The reasons for the decreasing interest for participation in the framework programme should be further analysed since it could become a future weakness.

There is a brokerage service available for companies seeking international partners, IRC. However, its focus is within Europe and no corresponding brokerage player has been identified for international industry collaborations in the emerging economies of East Asia.

Knowledge transfer between academia and industry is another key issue on the national agenda. This has been in the sub-regional and regional spot-light for a longer time than the importance of international links in addressing the global challenge. This might explain the much stronger policy focus on commercialisation than global challenge among the life science networks and funding networks of East of England. Several actors claim that there have been cultural barriers preventing knowledge transfer from the University of Cambridge. However, leaving aside the hair-splitting over the relative parts played in the Cambridge Phenomenon it is clear that there has been major potential for improvement. Most of the players seem to agree there has been an improvement in attitudes and some speak of a cultural shift in the universities. The knowledge transfer from the universities to industry may have reached quite a satisfactory level, but the commercialisation of knowledge into products and profitable companies has not. As shown in the industry structure, the share of companies that have managed to put a product on the market is small and so is the share of the companies actually being profitable. Thus, knowledge transfer is not included among the weaknesses (nor among the strengths), but commercialisation into profitable products is included among the weaknesses.

8.3.2 Financial support systems for innovation

This section deals with different aspects of the financial support system and outlines general access to venture capital as well as private versus public capital in the system. In the discussion about strength and weaknesses following the activity description there is an additional focus on the question "where are the big gorillas?". This is because constraints to growth are a major topic in the Cambridge financial support system. The question was also found to be very important since the same question is on the agenda in SLIS and ULIS as well.

Access to Venture Capital

General access to venture capital

Although the South Cambridgeshire and Cambridge City accounts for less than 1% of the UK population, 7.8% of all venture capital investments are made in these districts (July 2006)[477]. According to St John's Innovation Centre, a decline in investments has been noted as well as a decline in the number of startups. However, the downturn should be put in a wider UK and European perspective, since there is a general decline in investments and startup companies[478]. Historically, the general access to venture capital has been considered good, and the relative access to venture capital in East of England and in the Cambridge and South Cambridgeshire districts is high. As shown in table 8.5, the average share of the total amount of venture capital-backed companies in the UK based in Cambridge and South Cambridgeshire was high in 2004 but saw a decline in 2005. Still, this was the overall development in the UK that year and Cambridge and South Cambridgeshire did relatively well.

Table 8.5. Average share of UK venture capital-backed companies based in Cambridge and South Cambridgeshire.

Year	Average share of UK venture capital-backed companies based in Cambridge and South Cambridgeshire
Before the 20th Century	7.7[479]%
2004	25.0[480]%
2005	20.3[481]%

Today, several sources claim a funding gap, predominantly in three stages of business development. In the Biotech sector in particular, it has been argued to be deficient seed funding for startups[482]. There is also a debated lack of 'grow-on' funding[483]. This kind of funding required is larger than the seed funding, GBP 2-5 million. Finally it has been argued that companies

[477] Herriot WJ., Minshall T., Smeets A., 2006, page 6.
[478] Herriot WJ., Minshall T., Smeets A., 2006, page 6.
[479] Library House, 2006b, page 23.
[480] Library House, 2006b, page 23.
[481] Library House, 2006c.
[482] Herriot WJ., Minshall T., Smeets A., 2006, pages 17, 21.
[483] Herriot WJ., Minshall T., Smeets A., 2006, page 21.

close to putting a viable business plan into market are prevented by a funding gap of GBP 250,000-500,000. Their unattractiveness to venture capitalists springs from the narrow market niche in which they operate and mezzanine funds have been proposed to bridge the gap. These funds should be used to offer long-term loans, with a relatively high rate of return.[484] Other sources claim that the current overall venture capital funding in the biotech cluster is strong[485]. The recovery from the global venture capital dip after the dotcom bubble has meant harder times for the companies, but at the same time requirements from investors for larger shares of the companies in return has increased the benefits to investors and their willingness to invest.[486]

Originally, business angels and investment funds did not play any major part in supporting business. However, some of the early entrepreneurs that encountered success in their business later became business angels and also created investment funds[487]. The opening of Library House, which serves as a focal point for investors, increased the interest of business angels in biotechnology. However, local banks stay out of the game because of the high-risk nature of biotech companies[488].

Public Funding

One of the reasons for so many actors claiming that the Cambridge Phenomenon has arisen via an organic, bottom-up process is that very little public funding was available for startup companies during the fast-growing years of the biotech cluster[489]. However, the Regional Economic Strategy concludes there are many publicly funded business support products in the East of England and that confusion reigns over good access. Substantial changes to public funding have taken place in recent years, aimed at simplifying and streamlining business support. The Business Link and business Support Simplification Programme are efforts to simplify the information channels about business support systems[490].

European Funding

The European Structural Fund Programmes allocates GBP 320 million to the East of England. The GO-East has a European unit handling the administration and is actively engaged in developing European Structural Fund Programmes for the East of England region for the period 2007-

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[484] Herriot WJ., Minshall T., Smeets A., 2006, pages 24, 29.
[485] The Cambridge Cluster, Chapter 3.2.1.
[486] The Cambridge Cluster, Chapter 3.2.1.
[487] Smeets A., 2006, page 16.
[488] The Cambridge Cluster, Chapter 3.2.3.
[489] The Cambridge Cluster, Chapter 3.2.3.
[490] East of England Development Agency, 2007, page 28.

2013[491] with the current programme ending in 2006. Initiatives have been taken to increase the East of England share of future European Structural Fund Programmes, including the Competitiveness and Employment European Regional Development Fund (ERDF)[492].

Strengths and weaknesses identified

The general access to venture capital is a strength of the Cambridge life science innovation system. However, matching available funding with the demands of industry compiles some weaknesses. There is a discrepancy in the size of funding needed by the relatively small Cambridge companies and the sums that venture capitalists seek to invest. Also, according to Deloitte[493], the type of funding available is not ideal and creates a ripple effect in the system. The investment horizon is too close and exits take place too early. When comparing Cambridge to strong regions in the US, the spread of investment falls short in Cambridge, with a larger share of venture capital and IPO but less licensing than in the US[494]. However, as shown in figure 4.4, licensing in the UK has increased significantly in recent years as has income from licensing. It is also a deliberate strategy from the government's side to support this development, since revenues from licensing often are higher than for spin-offs. It could be that the development of licensing has not been as strong in Cambridge as in the UK overall, or in the life science sector as other sectors (figure 4.4 shows the overall picture, not only life science). However, as will be discussed later on from a Swedish perspective and in particular compared to the industry structure of Uppsala, the large consultancy business segment was striking as was the share of companies putting licences instead of "tangible" products on the market.

Another aspect to consider in diagnosing the accessibility of capital to biotech companies in Cambridge is the reasons underlying the large share of consultancy companies. The strong consultancy sector can be attributed to the history of the Cambridge cluster and the great success of the Cambridge Consultants and a few other companies in establishing a 'consultancy tradition'. Several others followed in their footsteps and there were spin-offs from the biotech companies into consultancy. Another major factor is the increasing outsourcing of research and other activities among the drug development companies, biotech tools and supplies companies etc. Apart from these factors, the consistent view of company representatives interviewed was that the CRO business model was an alternative to funding.

491 http://www.go-east.gov.uk/goeast/european_funding/?a=42496.
492 http://www.go-east.gov.uk/goeast/european_funding/444865/?a=42496.
493 Deloitte 20071017.
494 Deloitte 20071017.

Unless they are among the best performers and receive early-stage funding, companies which consider themselves to have good commercial potential are left with contract research as a source of income. Some claimed that CROs formed a basis for researchers and entrepreneurs wanting to put a product on the market, but due to the difficulties and associated risks and the large consultancy incomes, many companies remain CROs or partial CROs. It is said that some were tempted to keep the best of the research for themselves for commercialisation into a product, but eventually gave up this idea. The picture that begins to emerge of the Cambridge Biotech cluster is an innovation system where some of the strengths also acting as obstacles in other respects. The consultancy sector has played a major part in the success of Cambridge in terms of number of startup companies and worldwide nomination. However, the lack of profitability among many companies and the low share of companies which have actually put a product on the market is a weakness. The cluster may have locked itself into a situation where consultancy is the safest way of financing and thereby withdrawn the incentives for small research companies to go for the “product on the market alternative”. Their clients are among the outsourcing companies and the trend towards outsourcing is increasing. Based in Cambridge, the CROs and consultancy sector in general, both have access to the smaller clients among the Cambridge companies and the larger ones in the London life science industry. It is important to remember that this is not necessarily a bad thing. On the contrary, it might be a development to encourage (compare to the national level of UK and government initiatives to increase licences).

Naturally, one important aspect in analysing the performance of an innovation system is what share of the economic value created is kept within the region. What mechanisms are there to channel the value into the local economy? It has been identified as a key problem that the exit routes chosen by venture capitalists often lead to business being closed down or purchased by American firms[495].

“Where are the big gorillas” or constraints on growth related to venture capital access

The equity gap in earlier stages has been attributed to a mismatch in the amount required by the startup and early-stage companies and the often fixed amount the investors are willing to invest. The restrictions to growth in small companies has been referred to as “where are the big gorillas?”[496]

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[495] Herriot WJ., Minshall T., Smeets A., 2003, page 26.
[496] Owen G., 2004, http://www.libraryhouse.net/about/press/article/136/.

in Cambridge[497], meaning why don't companies grow faster into large companies[498]? There are very few Cambridge companies with more than 250 employees[499]. Apart from the problems in accessing venture capital, one of the obstacles in growing larger businesses is arguably the constraints on the physical infrastructure of the sub-region. Poor communications to Heathrow and London make the region less accessible for UK and global markets[500]. Cultural factors constitute another constraint. There is unwillingness in the city to grow out of the "small town feeling[501]". Contentment among CEOs over the current size of their companies and an unwillingness to grow into risky business also has been noted[502]. The Deloitte diagnosis previously described might also add one explanation to the question at hand. As stated before, they claim there are not enough early exits for investors in the UK compared to the US and that the type of accessible VC also plays a part. As in the US, a larger spread in the spectrum of accessible VC would be welcome. According to Professor Walt Herriot at St John's Innovation Centre, the main reason for the absence of the gorillas is that the market for customers and the VC market are too small in the UK and companies must internationalise in a very early stage. The successful Cambridge startups are characterised by a presence in the US[503].

8.3.3 Policy evolution

This section examines the policies regarding certain issues of importance for the innovation system and development. These issues are the importance of addressing the global challenge, increasing the collaboration between funding bodies and other actors in the innovation system, identifying key technologies of strategic importance and retaining economic value in the nation/region. The policy study takes its point of reference in the strategies and visions of the public authorities. However, on all spatial levels of the British innovation system, the industry plays an important role in affecting the agenda for the public authorities. As mentioned in the system structure analysis, the East of England Development Agency is responsible for the Regional Economic Strategy for the East of England. This strategy sets the framework for the public authorities, like GO-East, county councils and the local city councils. Not only are there non-public bodies implementing the policies of public authorities, there are also public authorities implementing the policies of non-public bodies. Delimiting the policy study spatially to a sub-regional level also creates a problem since the regional and national

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[497] For instance, the title of the Cambridge Enterprise Conference 2007 was "Growing big gorillas – turning promising startups to major corporations": http://www.cambridgeenterpriseconference.co.uk/documents/PR01CEC.pdf, page 1.
[498] http://www.libraryhouse.net/about/press/article/136/.
[499] The Cambridge Cluster, Chapter 3.2.1.
[500] Herriot WJ., Minshall T., Smeets A., 2006, page 19.
[501] Interviews in Cambridge.
[502] Herriot WJ., Minshall T., Smeets A., 2006, page 16 and interviews in Cambridge.
[503] http://www.cambridgeenterpriseconference.co.uk/documents/PR01CEC.pdf.

actors are the predominant policy-makers. Therefore, the policy study has been conducted on a regional as well as a sub-regional level. Consequently, each of the issues initially mentioned is discussed with a point of reference in the policies of the different actors, ranging from regional to sub-regional or even sub-sub-regional level. Generally, the most explicit policies, most tangible strategies and clearest devotion were found on the regional level, predominantly in the Regional Economic Strategy (RES) and on the sub-sub regional level constituted by Cambridge City Council.

In an attempt to quantify the focus on the issues mentioned initially, all the networks and funding networks in East of England, public and non-public, were examined in regard to their focus on the issues chosen. This was described in the system structure analysis and the results are given in tables 3 and 4. The priorities of the networks and funding networks are interesting from a policy point of view since they show how the national and regional strategies and visions are actually implemented throughout the innovation system. The study of the funding networks in particular give a hint on the extent to which accessible capital in the system is spent on these issues. The results will be discussed under the corresponding heading in this chapter.

Collaboration

Collaboration in funding

The aim at all levels of the UK funding system is streamlining. The Business Support Simplification Programme reduced the number of schemes and established a single access point for funding, the Business Link. In the local labour market for Cambridge, the Business Link East constitutes the regionalised access point for business support and innovation programmes to enable collaboration in funding[504].

Collaboration in the triple helix

The RES states that “close collaboration between universities and research institutes, businesses and government is a key feature of successful regional innovation systems”. The importance of collaboration within the triple helix is mainly justified by the benefits it brings to the commercialisation of research and by the diffusion of new technologies to the regional economy it creates. It is recognised that in order to increase collaboration within the triple helix, the public sector must play a major role and use funding and planning systems in such a way as to facilitate collaboration[505].

Explicit funding and initiatives to support collaboration

As previously mentioned, since July 2007 the EEDA has been responsible for a single regional economic strategy. The EEDA is thus taking on a stronger role in bringing key actors like local government, business and

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[504] East of England Development Agency, 2007, page 37 and 28.
[505] East of England Development Agency, 2007, page 36.

voluntary organisations together. A recently established regional minister will further add to the collaboration within the region[506].

One of the four key areas of the EEDA is enterprise creation. In the year 2005-2006, a total of GBP 12.959 billion was spent on enterprise hubs, of which business growth networks were given support of GBP 1.775 billion and hub centres GBP 2.468 billion. The Bio Park Hertfordshire and Papworth biotechnology incubator are two of the projects supported[507].

The aim of East of England International is to bring together the advisory services of the former DTI with EEDA-funded advisory services in a streamlined support to business wishing to go international and foreign companies interested in the region.

Key technologies

The East of England is set to continue developing a specialised economy, referring to the need to focus on the areas of highest growth potential and capture global market shares. A concentration of business support products on the major economic centres is justified by building on the essential critical mass needed for business, people and infrastructure. Clusters of national and international importance have been selected for efforts to overcome their constraints on growth[508]. Co-ordination and intensive business support is available for manufacturing and startups within key sectors[509].

However, apart from the East of England regional level, the selection of key technologies seems limited. As will be discussed later, the networks and funding networks did not focus on identifying or prioritising key technologies.

Global challenge

In the RES, it is recognised that the global challenge will increase significantly with a shift of global economic mass to the E7 (China, India, Brazil, Russia, Mexico, Taiwan and South Korea)[510]. The development towards knowledge-based economies and a highly skilled work-force among the E7 sharpens the competition and crucially, the East of England must rise to the challenge and find ways of benefiting from the emerging markets[511]. Increasing regional benefits from international trade and investment and a strengthened position for the East of England within the network of leading global innovation regions are the major issues of concern

[506] http://www.eeda.org.uk/929_2836.asp.
[507] East of England Development Agency, 2006, page 21.
[508] East of England Development Agency, 2007, EEDA, page 24.
[509] East of England Development Agency, 2007, page 116.
[510] East of England Development Agency, 2007, page 17.
[511] East of England Development Agency, 2007, page 17.

in regard to the global challenge according to the RES[512]. The RES lists priorities and corresponding (suggested) actions and table 8.6 gives a summary of the priorities and corresponding actions based on their relevance for addressing the global challenge.

[512] East of England Development Agency, 2007, pages 115 and 120.

Priorities	Impact of actions	Actions, examples
Increasing regional benefits from international trade and investment	Increased foreign direct investment in the region	Promote the region as an attractive inward investment destination in a co-ordinated and consistent manner.
		An enhanced investor development programme
	Increased share of region's firms engaging in international trade	Targeted support, such as Passport to Export, to enable businesses to access international markets
		Expand capacity of business networks in the region focused on international trade and investment
A strengthened position for the East of England within the network of leading global innovation regions	Strengthened position of Greater South East as a global centre of innovation with increased impact on economic growth	Undertake a Greater South East (GSE) international promotional programme (e.g. Shanghai expo)
		Develop a global network of international ambassadors
	The East of England as international partner of choice for international collaboration and outsourced R&D	Develop international partnerships with well-matched regions
		Promote the Cambridge brand as a leading global centre of learning and research
		Increase business and higher education involvement in international innovation networks
		Enable regional businesses to partner internationally through the Innovation Relay Centre and Selecting and Managing Overseas Partners (SMOP) programme

Table 8.6. A summary of the priorities and corresponding suggested actions concerning the global challenge in the Regional Economic Strategy for the East of England.[513]

Cambridge City Council recognises that the strong brand of Cambridge cannot be solely relied upon as global competition increases. The attractiveness of Cambridge is threatened by European and global alternatives and the situation requires a more proactive approach to inward investment. According to Cambridge City Council, joint marketing of the

[513] East of England Development Agency, 2007, pages 115 and 120.

Cambridge Area, rather than the former individual marketing of the City of Cambridge and other cities in the region is crucial[514].

Explicit funding and initiatives addressing the global challenge
In 2005-2006, GBP 2.704 million was allocated by EEDA to international business support, with a total of 140 businesses supported. One of the key projects of the year was East of England International, the international business support agency of the region, which was allocated GBP 2.6 million out of the GBP 2.704. The entire EEDA expenditure over 2005-2006 to business support was GBP 27 million[515].

The formation of the East of England European Partnership (EEEP) and a Brussels Office is considered a strategic move by EERA in assessing the global challenge. As described above, the EEEP contributes a horizon-scanning activity to the European development of the East of England innovation system and promotes the strong scientific base of the region to create strategic partnerships. An important aim of the Brussels office is the ability to move quickly and meet needs as they occur[516].

Relative strengths of focus areas

This section describes the outcome of the attempt to quantify relative strengths of potential policies. Tables 2 and 3 in the system structure section show how many networks and funding networks of the total population are defined by UK Directory[517] as focusing on key technology areas, commercialisation, applicable research/economic benefit to society, collaboration and/or the global challenge. The focus areas were chosen according to studies of the main policy documents on a national level, i.e. the Science and Technology Investment Framework 2004-2014, the Science and Technology Investment Framework 2004-2014: Next Steps, the Technology Strategy, the Innovation Report etc. The aim was to study the extent to which regional actors relevant to the life science industry are focusing on those issues deemed to be in focus on a national level as well as how strong the focus areas turned out to be relative each other.

Apparently, commercialisation was the focus area that came out strongest in the comparison, scoring 12 out of 22 funding networks and 19 out of 31 networks. Some of the networks and funding networks are private companies seeking to make a profit on the business they support. It is not so surprising that commercialisation is in their interest since some of them require a return. However, the focus area was defined as knowledge transfer from research environment to business and the result is probably an

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514 Cambridge City Council, 2004, page 20.
515 East of England Development Agency, 2006, page 15.
516 http://www.eera.gov.uk/Text.asp?id=SX87A5-A77F5251&cat=43.
517 http://www.entrepreneurs.gov.uk/directorySearch.cfm.

adequate indicator that the knowledge transfer aims of national policy-makers have had an impact among actors in East of England.

Sixteen out of 31 networks focus on the global challenge. Of the 22 funding networks, the rate was much lower, only four held the global challenge as a priority area. The difference between networks and funding networks on that issue may indicate a higher extent of international networking activities in the former. Needs-driven research and benefit to the region was a focus area of 13 of the networks and six of the funding networks.

Collaboration, in terms of collaboration between funding networks and/or networks, has been highly stressed in several national policy documents, which is reflected in the 12 out of 31 networks focusing on collaboration. The funding networks show a lower relative share of collaboration focus, seven out of 22. The lowest relative focus lies on key technologies. Only one of the networks, Cambridge City Council, stresses the focus on key technologies as highly important. This is somewhat surprising since supporting selected emerging technologies and key technologies is the current policy of TSB, the former DTI, the Chief Scientific Adviser and several other major policy-makers on a national level.

In the EEDA budget for 2005-2006, business support products were allocated a total of GBP 27,805,000 as shown in figure 8.9. The relative distribution to different support areas is outlined below. In the EEDA allocation, business support IDB is allocated the highest amount. IDB stands for Information, Diagnostics and Brokerage and means that Business Links are to help businesses in diagnosing their support needs[518]. Clearly, public actors are thought to have an important role in diagnosing the obstacles facing the industry, whereas providing grants to enterprises is relatively restrictive compared to other business support products. The industry criticises the fact that the money RDAs receive for business support does not really go to business support if their task is to diagnose and act as broker for accessible business support[519]. The real-term allocations to international business support and selective finance for investment in England on the other hand gives a hint as to how strongly the policies of “focus on the global challenge” and “focus on economic benefits to the region” are stressed.

[518] http://www.the-guild.co.uk/article.php?recordID=8.
[519] http://www.the-guild.co.uk/article.php?recordID=8.

Business Support	Capital £000	Current £000
Business Support IDB		16,061
Specialist Business Support	58	2,627
International Business Support	222	2,482
Skills development package	351	2,783
Best Business Practice (SIBBP)		607
Selective finance for investment in England	2,571	3
Enterprise grants	40	
Total Business Support	**3,242**	**24,563**

Figure 8.9. Distribution of business support allocations by EEDA in 2005-2006[520].

Strengths and weaknesses identified in relation to policy evolution

The global challenge is strongly addressed by a few actors on a sub-regional level. The actions that need to be undertaken and what they aim to achieve have been analysed and are clearly stated on a regional level. It is recognised by EEDA that the international links of Cambridge University could be improved and that this is a policy matter where change might be on the way, with a time delay compared to regional and national efforts[521].

As will be described in the section "interconnectedness between sub-regional, regional and national level", some of the policies strongly addressed by actors on a national level are not in focus in Cambridge.

The public actors take on a major responsibility to increase collaboration within the triple helix. There are several public actors taking the role of brokering business support, advice or partnerships. The major share of the EEDA business support budget allocated to information, diagnosis and brokerage further strengthens this picture. It is interesting to note that the basis for the commitment to increased collaboration is the economic benefit of the region. Based on the organisational rearrangements that have occurred the aim of increasing collaboration seems very high.

The industry criticises that the public actors do not satisfactorily take on the role of business supporters. The idea of Business Link is that industry will have to solve this more independently. However, it is claimed that "business will never pay for business support"[522]. This development is interesting to follow, since the there is a corresponding discussion in Sweden.

[520] East of England Development Agency, 2006, page 15.
[521] Interview with East of England Development Agency.
[522] http://www.the-guild.co.uk/article.php?recordID=8.

9 Uppsala Life Science Innovation System

9.1 Industry structure Uppsala

The figures of the industry structure of Sweden shown in the SLIS section also hold information about the life science industry structure of Uppsala. The following section, comments on information from these figures taking a point of reference in ULIS. The figures commented upon appear in section 3.1.

There are a total of 71 life science companies in Uppsala, comprising approximately 4,400 employees (marketing and sales excluded). Uppsala has several of the country's biotech tools and supplies companies, largely due to Pharmacia's previous activity in that region. The medium-sized and large companies include GE Healthcare Biosciences and Biacore within biotech tools and supplies, Phadia within diagnostics and Advanced Medical Optics within ophthalmic devices. There are also many very small companies. The business segment of drug discovery is not at all as large as in Stockholm; there are only a few drug discovery companies in Uppsala and these are very small. Among the companies conducting broad R&D, all but one have a product on the market. Overall, there are few R&D companies that have not reached the market with a product. Within biotech tools and supplies for instance, all companies have put a product on the market. On the other hand, half the drug discovery companies do not have a product on the market. Within the activity of production development, there are no biotech tools companies. The major presence of biotech tools and supplies companies is found predominantly within exploratory research.

In Uppsala, the companies with foreign ownership are almost exclusively large. This is consistent with the overall picture of foreign ownership in the Swedish life science industry. The largest biotech tools and supplies companies as well as the largest diagnostics companies are foreign-owned. A couple of exceptions to this phenomenon are among the foreign-owned CRO companies in Uppsala. It is also interesting to note, although not too surprising, that the foreign-owned R&D companies all have a product on the market. A majority of the Uppsala companies have positive results. However, among the very small companies many show negative results.

9.2 System Structure Uppsala

The actors of the innovation system of Uppsala are presented in this section. As for the system structure of CLIS, the chosen actors were selected because they constitute the most vital bricks of the system. These are the companies, the public authorities, the industry associations and partnerships, the innovation centres and science parks. The system structure analysis also presents the most vital networks and funding networks. The networks and funding networks accessible in ULIS have been notably identified by the Uppsala search tool Företagsfrämjande Organisationer i Samverkan (FFO) [Business-promoting Organisations Together]. FFO is a website for all business support organisations in Uppsala[523]. The networks have also been identified from many other websites, such as the City Council website[524]. All the networks and funding networks, public and private, were studied taking their focus on certain key issues as a point of reference. The results are assembled in table 9.1 and analysed in the policy evolution activity section.

9.2.1 Public authorities

The County of Uppsala is led by the Municipal Council. There is a business unit at the Municipal Council responsible for the business climate in Uppsala. Their remit includes helping finding the right networks, providing contacts with investors and offering advice on company startup[525]. Specific advice for life science and IT is also available[526]. Apart from the Municipal Council, there is also a county administrative board with particular responsibility for planning infrastructure and increasing economic growth within the county[527]. No sector-specific activity within life science has been noted apart from the 2007 Carl von Linné celebration. The County Administrative Board and the Municipal Council collaborated with the Universities in Uppsala and the Linné Society to promote and celebrate Linné and his scientific work [528]. Uppsala is also home of the Medical Products Agency and National Food Administration.

9.2.2 Industry associations and partnerships

Uppsala Bio

Uppsala Bio is an initiative of the local biotech industry in Uppsala and was created by representatives of the life science industry, the universities and the City of Uppsala[529]. The initiative was made possible by financial support from VINNOVA in the form of the VinnVäxt programme. Some steps towards joint work with Stockholm Business region and the Strängnäs cluster have been taken. Uppsala Bio markets the bioregion internationally and provides various kinds of business support products[530].

[523] http://ffo.biz/.
[524] http://www.uppsala.se/uppsala/templates/StandardPage____3113.aspx.
[525] http://www.uppsala.se/uppsala/templates/Level2Page____3006.aspx.
[526] http://www.uppsala.se/uppsala/templates/StandardPage____3161.aspx.
[527] http://www.c.lst.se/templates/versamhetstart.aspx?id=565.
[528] http://www.c.lst.se/templates/versamhetstart.aspx?id=566.
[529] http://www.uppsalabio.com/DynPage.aspx?id=4719&mn1=1223.
[530] http://www.uppsalabio.se/DynPage.aspx?id=4715.

9.2.3 Innovation centres, science parks and incubators

Uppsala Innovation Centre (UIC)

Uppsala Innovation Centre is a company incubator that provides advice and business support to companies within the Uppsala region. It also aims to attract new companies to the region[531]. UIC has five different programmes in the incubator; business start, business lab, business accelerator, alumni and growth. The growth programme is available to existing companies. The aim of the programmes is for companies to put a product on the market or have gained access to long-term financing[532].

Uppsala Science Park

The Park is dominated by biotechnology, materials science, medicine and IT. There are a total of 140 companies and organisations within the area, including service providers within legal matters, capital brokerage, marketing and export. There are also clinics within the area, which is located in close proximity to the University Hospital and the two universities[533].

Uppsala Business Park

Uppsala Business Park, former Fyrislund, is home to several life science companies in Uppsala, notably Phadia. When Pfizer left Uppsala, a long-term vision was developed by local actors in concordance with Pfizer and VINNOVA to develop a science park which would be characterised by entrepreneurship and life science. There are hopes that a Swedish facility for production of vaccines could be established within the area[534].

Uppsala University AB (UUAB)

Uppsala University AB is the University holding company and functions as an incubator. The prime function is as a partner in different types of companies, including service companies, joint ventures and project companies[535].

9.2.4 Research Institutions and Universities

Jointly, the University of Uppsala and the Swedish Agricultural University, SLU, have 35,000 students[536]. Biotechnology is one of the profile areas of Uppsala University and according to the University, its research in biosciences is world leading and characterised by an interscientific

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531 http://www.uic.se/.
532 http://www.uic.se/.
533 http://www.uppsalasciencepark.se/Templates/PageWide.aspx?id=695.
534 http://www.stuns.se/stuns_projekt.html.
535 http://www.uuab.uu.se/menu2.php?id=1.
536 http://www.akademiska.se/templates/page____11023.aspx.

approach[537]. The faculties of medicine and technology and science are the major faculties within life science at Uppsala University. In addition, there are several research centres more or less connected to the University; the centres for Bioethics, Bioinformatics, Surface Biotechnology, Mass Spectrometry, the Ludwig institute for Cancer Research and the Svedberg Laboratory. There are also research campuses like EBC, the Rudbeck Laboratory and BMC[538]. The research conducted at SLU ranges from biological natural resources and functional genomics. Within the responsibility areas of food, forest, land and city, SLU combines its strong basic research with applied research[539]. Uppsala University Hospital conducts clinical research in close collaboration with the medical faculty of the University of Uppsala. The Uppsala Clinical Research Centre forms an independent unit at both Uppsala University and the University Hospital. The PET Centre, Positron Emission Tomography, is another example of a university/hospital research collaboration[540].

9.2.5 Networks and funding networks

Seventeen networks were found in ULIS. Some would classify as funding networks but, unlike Cambridge, this terminology is not used in UKLIS. No such classification has therefore been done in Uppsala. The webpages of all the networks and funding networks listed in table 9.1 were examined in regard to their focus on certain policy issues. If one or more of these are formulated as key goals, key objectives, and key priority or in any other way described as an issue of major concern for the network or funding network, then it has been considered a focus. The entire table forming the basis of table 9.1 below appears in appendix 5.

[537] http://info.uu.se/fakta.nsf/sidor/bioteknik.id0E.html.
[538] http://info.uu.se/fakta.nsf/sidor/fakulteter.id83.html.
[539] http://www.slu.se/?ID=3.
[540] http://www.akademiska.se/templates/page____11023.aspx.

Table 9.1. Networks and funding networks of ULIS.

Name of network/funding network	Key Technology Areas	Commercialisation	Needs-driven research/economic benefit to the regional society	Collaboration	Global Challenge
UppsalaBio	X	X	X	X	X
Stuns		X	X	X	X
UIC		X	X	X	X
Innovationsbron Ua		X		X	X
UUAB		X	X		
Handelskammaren Ua			X	X	X
Nyföretagarcentrum			X	X	
Drivhuset		X			
Stockholm-Uppsala universitetsnätverk SUUN			X	X	X
Connect Uppsala		X	X	X	X
CEF (Centrum för entreprenörskap och företagsutveckling i Uppsala)		X		X	
Regionförbundet i Uppsala län			X	X	X
Uppsala Universitets Näringslivskontakt		X		X	
Forskarpatent i Uppsala	X	X		X	
Företagarna Uppland				X	X
Invest in Uppsala			X	X	X
Almi företagspartner i Uppsala		X	X	X	X
SLU holding AB		X	X		X

9.3 Activities

9.3.1 Knowledge development

This section describes the generation of knowledge elements in terms of factors affecting the direction of research and what funding is available from different sources. There is a description of access to technological, market-related and international knowledge elements and finally a description of how knowledge is disseminated in the system, with particular focus on the knowledge transfer between academia and industry.

Generation of knowledge elements

Factors affecting the direction of research
The generation of knowledge in the Uppsala innovation system is highly influenced by the University of Uppsala and the Swedish University of Agricultural Sciences (SLU). Nobel Prize-winners such as The Svedberg and Arne Tiselius have played an important role in the development of the research environment. These researchers initiated relations with the industry, notably with Pharmacia and Amersham biosciences that have been favourable for knowledge generation[541]. Several sources claim that the structure of the current biotech industry of Uppsala has been substantially formed by this initial collaboration[542]. Apart from the Nobel Prize-winners, certain discoveries have influenced the development such as the contribution of the IgE antibody which played a vital role in the origins of Pharmacia. The industry has functioned as a nursery for researchers during the growth of the biotech sector. When Pharmacia moved out of the innovation system, the knowledge base that had developed remained in the system and spread to new industries[543].

Public research funding
The total income to medical research at Uppsala University in 2005 is shown in figure 9.1. The figure shows the universities and institutes with the largest R&D income for medical research in Sweden and Uppsala University comes fourth[544]. It should be noted that in 2005, there was additional pharmaceutical research income at Uppsala University of SEK 88 million. The other universities listed in the figure did not have specific research income to this scientific area. Unlike all other universities, the Swedish University of Agricultural Science had an income for veterinary research in 2005 of SEK 150 million[545]. Even when taking other life science-related research fields into account such as veterinary research and

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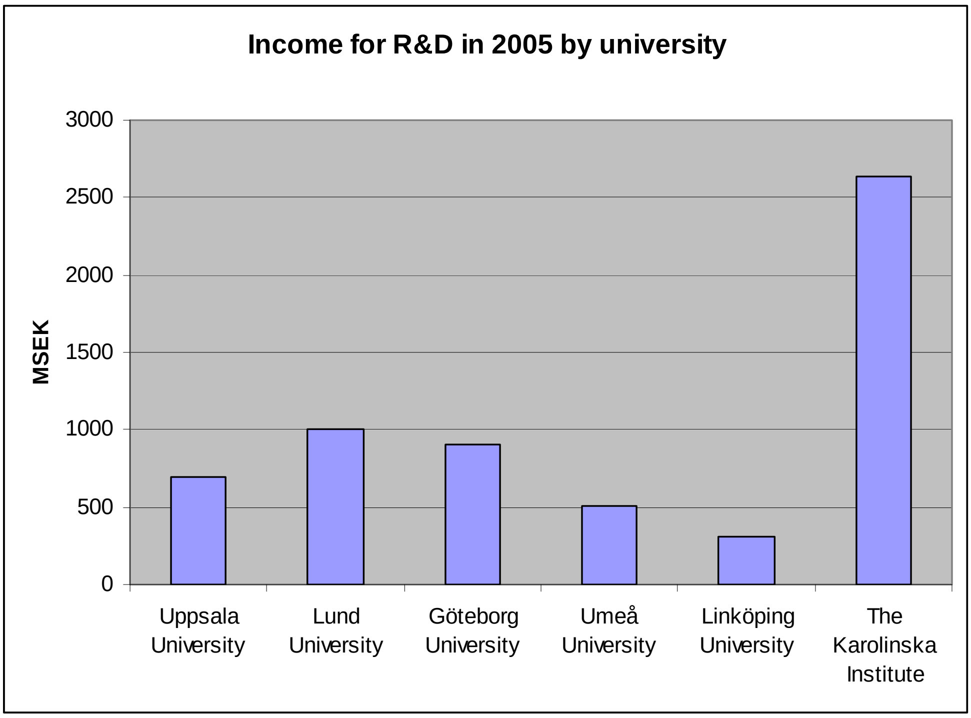
541 Waxell A., 2005, pages 54-56.
542 Waxell A., 2005, page 66.
543 Waxell A., 2005, pages 54-56.
544 Statistics Sweden, 2007, pages 29-30.
545 Statistics Sweden, 2007, pages 29-30.

pharmaceutical research, Karolinska Institutet stands out as by far the largest life science research organisation in terms of research income.



Industrial R&D expenditure and other sources of private funding
Sources of external funding at Uppsala University includes research councils, foundations, EC, companies etc. and most often have to be applied for by the researchers themselves. The income from interest is distributed among institutions according to the consortium[546]. External funding makes up 52 % of the total research funding at Uppsala University. The majority of this is allocated through peer review. Tax reductions for private donations to research were very welcome by the University's fundraising unit as public financing has decreased and there is a major need for external financing. A development office will be established to further increase the contact with external partners[547]. The industrial R&D expenditure to medical research conducted at Uppsala University increased strongly over the 1995-2001 period, as shown in figure 9.3[548]. Over the same period, the share of medical R&D expenditure from Swedish companies out of the total industrial medical R&D expenditure fell drastically, as shown in figure 9.4[549].

[546]http://info.uu.se/uadm/dokument.nsf/sidor/E9343B7D08A843E5C1256EDF00643E8C?OpenDocument.
[547] Forskning och Medicin 2007:3. http://forskningochmedicin.vr.se/knappar/tidigarenummer/innehallnr32007/enkatstortbehovavexternfinansiering.4.5d7d40fd1154283906d80003700.html.
[548] Hällsten M., Sandström U., 2003, page 11.
[549] Hällsten M., Sandström U., 2003, page 11.

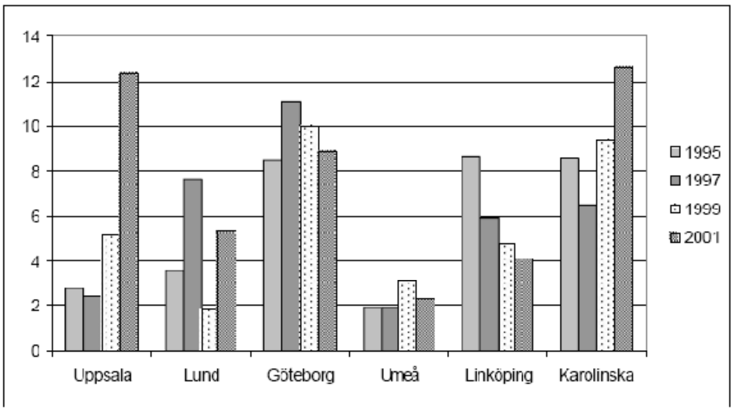


Figure 9.3. Share of industrial R&D expenditure to universities[550]

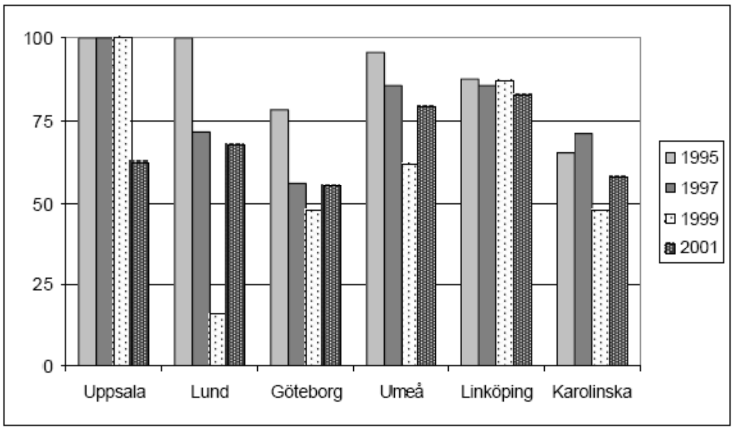


Figure 9.4. Share of Swedish industrial R&D expenditure to universities out of total industrial R&D expenditure to universities.[551]

Access to knowledge elements

Technological knowledge base

According to the University, the profile areas of Uppsala University include biodiversity and evolutionary biology, biotechnology, national diseases, genomics/functional genomics, drug discovery, neuro-degeneration and neuro-regeneration, health and bioethics[552]. The only pharmaceutical faculty in Sweden is at Uppsala University[553]. Biotechnology holds a strong technological knowledge base in Uppsala, both at the universities and within the industry. The development of methods, models and tools for biotech research are particularly characteristic of Uppsala[554]. Also among the areas

[550] Företagens finansiering av universitetsforskning – en översikt i mars 2003, U. Sandström, M. Hällsten (SISTER), page 11.
[551] Företagens finansiering av universitetsforskning – en översikt i mars 2003, U. Sandström, M. Hällsten (SISTER), page 11.
[552] http://info.uu.se/fakta.nsf/sidor/profilomraden.id8C.html.
[553] Uppsala Universitet, 2003, page 12.
[554] Uppsala universitet, 2003, page 19.

of expertise are diagnostics and pharmaceuticals[555]. One large initiative that will affect the technological knowledge base of Uppsala is a particle therapy centre for cancer treatment. The establishment means a unique competence in radiation treatment for Sweden as well as in Europe will be developed in Uppsala[556]. The patient capacity of the establishment is set at 2,500 patients. Seven county councils are funding the SEK 800 million establishment[557].

The biotechnology cluster's own perception of the Stockholm/Uppsala Bioregion's international ranking is shown in figure 9.5. In 2004, 7% of the respondents put the Stockholm/Uppsala Biotech cluster among the five most competitive biotech clusters in the world. In 2006, this perception was represented by 4% of the respondents. In this particular ranking, Cambridge is ahead of Stockholm/Uppsala and has strengthened its position since 2004[558]. The industry generally was less convinced that the region is among the top five bioregions in the world[559].

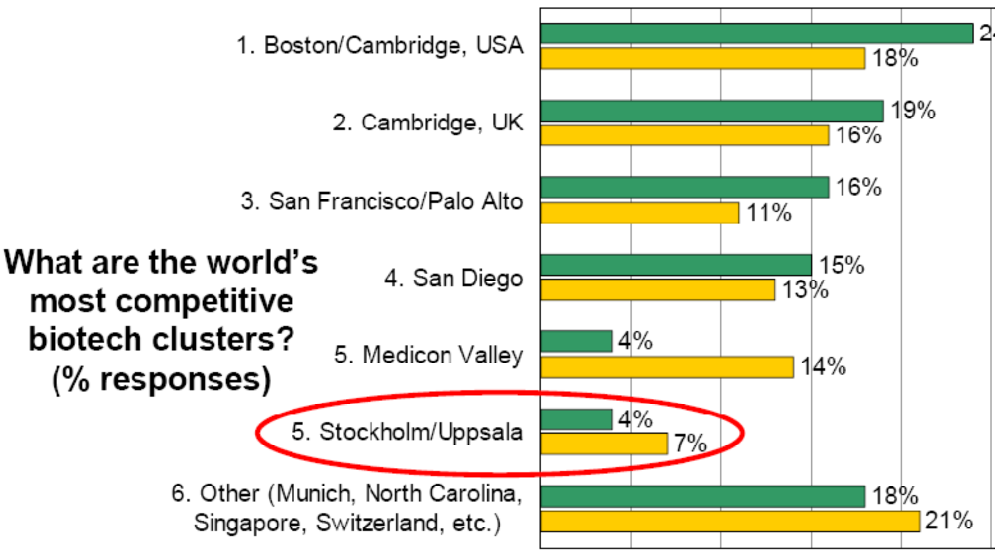


Figure 9.5. Ranking of the world's most competitive biotech clusters by respondents from the Uppsala Biotech cluster, including respondents from industry, government, academia. [560]

International knowledge base

According to the respondents to the 2006 Uppsala Biotech Cluster Survey, access to foreign skills is perceived as bad and constitutes a cluster

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555 http://www.uppsalabio.se/DynPage.aspx?id=4706&mn1=1224.
556 http://www.stuns.se/.
557 http://www.cancerfonden.se/templates/Article____1778.aspx?full=1&skip=3.
558 http://www.uppsalabio.com/graphics/8494.pdf, page 11.
559 http://www.uppsalabio.com/graphics/8494.pdf, page 12.
560 http://www.uppsalabio.com/graphics/8494.pdf, page 11.

weakness[561]. Moreover, the respondents are more keen to disagree than agree with the statement that “in the last two years, there has been an increase in skilled labour for Uppsala”[562]. In that perspective, it is interesting that Uppsala University stated in its strategy for the period 2005-2008 that international research collaborations are crucial. The perception of the University was that its international research collaborations are extensive and well-developed, particularly with Europe and the US[563].

As shown by figure 9.6, the main countries with which organisations located in Uppsala conduct research collaborations (in terms of co-authorships in life science-related journals with an impact factor above 6) are mainly European countries. Apart from Europe, the US is quite well-represented. China, Japan, Israel, New Zealand and Australia are also on the map, although not strongly represented. As shown by figure 9.7, the vast majority of Uppsala co-authorship organisations and other co-authorship organisations are either universities or hospitals. One exception however is Pharmacia Diagnostics.

The Uppsala participation in FP6 includes 45 projects started in 2004 or after. The vast majority of the organisations with which Uppsala organisations has collaborated in more than one project are academic organisations. Collaborations with industry are predominantly single joint projects. Among the Uppsala organisations taking part in FP6, 41 are academic organisations whereas only seven companies participated. The counterpart countries were mostly France, Sweden, Great Britain and Germany and the main subject area was cancer[564].

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[561] http://www.uppsalabio.com/graphics/8494.pdf page 14.
[562] http://www.uppsalabio.com/graphics/8494.pdf page 14.
[563] Uppsala Universitet, 2003, pages 24-25.
[564] www.lifecompetence.eu, Data generated from the Cordis database.

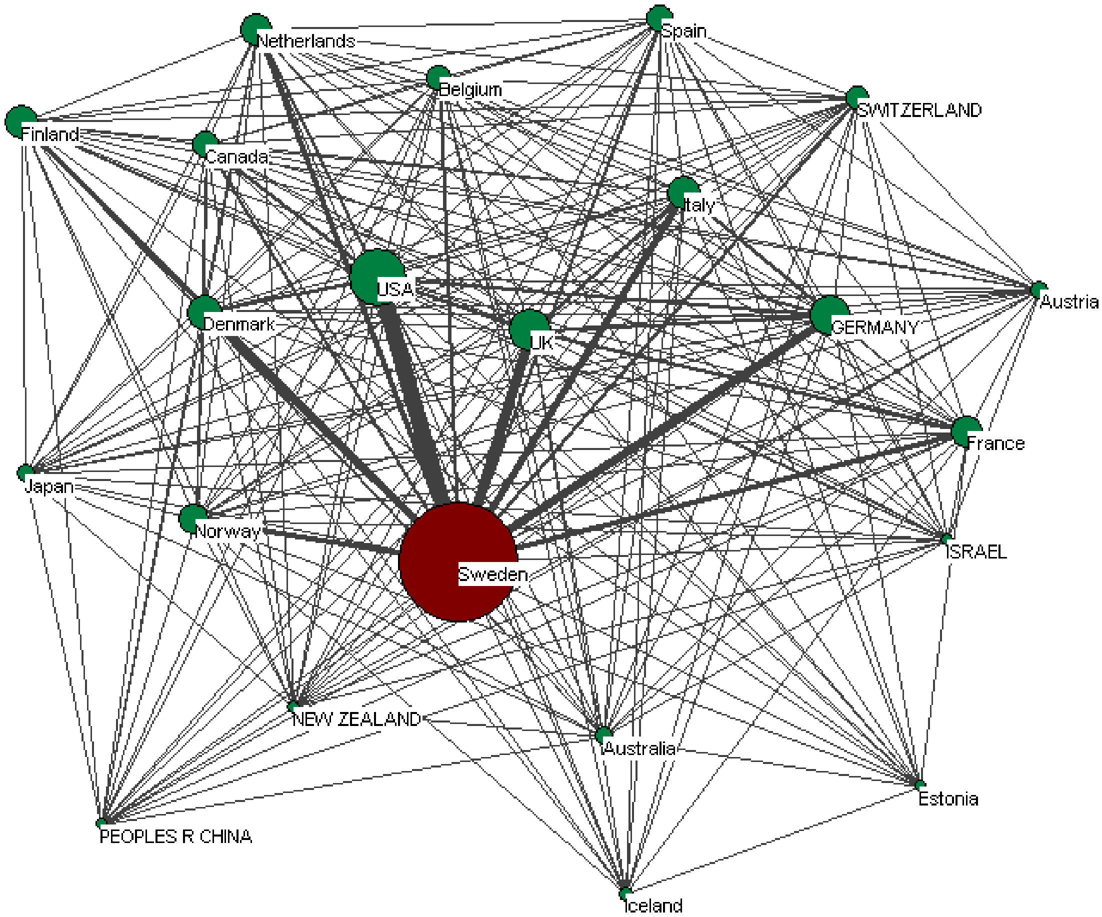

Figure 9.6. Co-authorships between organisations in Uppsala and other organisations, nationality shown.

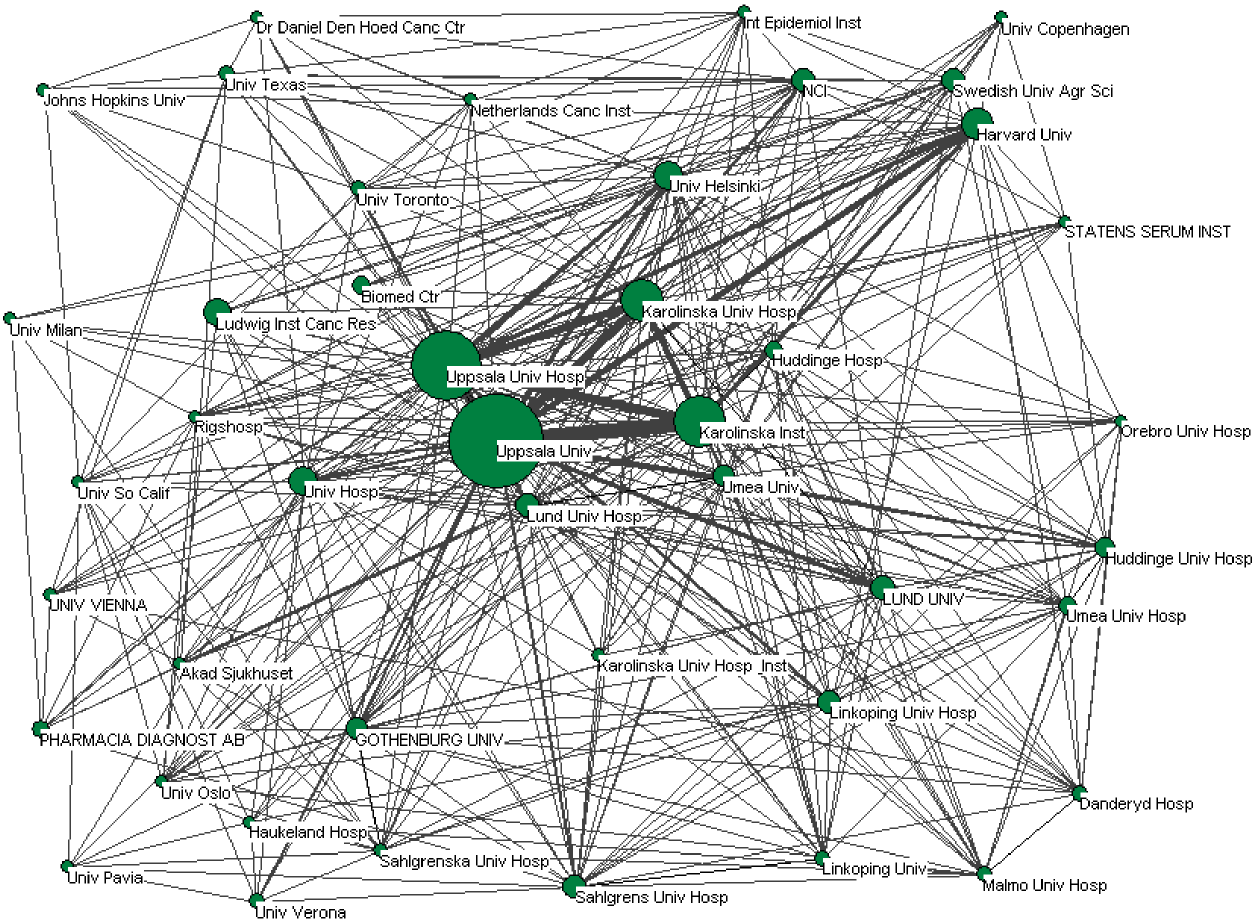

Figure 9.7. Co-authorships between organisations in Uppsala and other organisations, organisations shown.

Market-related knowledge base

A number of organisations in Uppsala provide support to researchers and companies in order to increase their market-related knowledge base. The Uppsala Bio innovation programme focuses on such things as business coaching, commercialisation, advise on patent strategies, mentorship and access to external networks of advisers and financers[565]. The perception is generally that there has been an increase in commercialisation of research[566]. In 2003, the main challenges identified by Uppsala Bio included “securing a steady, long-term flow of people with competencies in science and management skills”[567]. This challenge still remained in 2006[568]. It is

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565 http://www.uppsalabio.com/DynPage.aspx?id=4645&mn1=1223&mn2=1232.
566 http://www.uppsalabio.com/graphics/8494.pdf, page 16.
567 Uppsala Bio, 2006a, page 5.

claimed that the management skills are fairly good but there is major potential for improvement, particularly in regard to SMEs and international markets[569].

It should be noted though that not only market-related skills constitute a constraint to entrepreneurship. Some also claim that the IP ownership rules for university teachers, the so-called teacher's exception, constitute one. A researcher needs major resources and legal support in applying for patents and particularly in defending patents against powerful companies. Some advocate that it would be harder for large companies to overrule researchers if the university owned the patent[570].

Knowledge transfer

According to the University of Uppsala, local relations between academia and industry are strong and have historically been very important. The knowledge transfer builds on both formal and informal relations and many biotechnology companies conduct collaborations with public research environments[571]. This picture is also attested by other sources. The development of the life science industry in Uppsala was greatly affected by interactions between certain research groups and companies, such as The Svedberg, Arne Tiselius and Pharmacia[572]. There again, others claim the impact of the basic research of the universities on the biotech industry has been overestimated[573]. There seems to be a debate similar to the one in Cambridge about the reasons for the Cambridge Phenomena.

Current situation and initiatives

Uppsala Bio identified a gap in the border between industry and academia and has worked quite successfully to bridge it[574]. Research commercialisation is one of Uppsala Bio's primary objectives and according to the respondents of the 2006 Uppsala Biotech Cluster Survey, Uppsala Bio has contributed to an increase in research commercialisation over the 2004-2006 period[575]. Their 2007-2010 strategy states that there is still a gap between basic research and product development[576].

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568 Uppsala Bio, 2006a, page 5.
569 Stuns, 2006, page 6.
570 http://info.uu.se/fakta.nsf/sidor/studenter.och.id1C.html.
571 http://info.uu.se/fakta.nsf/sidor/samarbete.forskning.id87.html.
572 Waxell, A, 2005, pages 55-56.
573 Waxell, A, 2005, page 84.
574 Uppsala Bio, 2006.
575 Uppsala Bio, 2006a, page 22.
576 Uppsala Bio, 2006b, page 5.

Uppsala Bio-X is a programme supporting interdisciplinary research by providing complementary financing. The research is intended to be collaborative and include both academia and industry[577]. Upside is another initiative within technology, science, medicine and pharmacy aiming to translate research conducted at Uppsala University into commercial products. Uppsala Bio is supported by VINNOVA with SEK 25/4 million a year for eight years[578], and complements a UUAB programme entitled Bridge. Bridge focuses on the commercialisation of research within nanomedicine, and particularly regenerative medicine. The programme has been selected to lead one of four EC commissions to increase knowledge of the triple helix at EC level. The project will build on experiences from European partnerships. The selection of Uppsala University for this task is thought to have strategic importance for localisation decisions of future large EC initiatives[579].

The university unit UU Innovation was launched in order to strengthen the collaborations between Uppsala University and industry. This unit is intended to lead the strategic work of the University in regard to relations to industry and also execute strategies to some extent. The commercialisation responsibility primarily falls on the holding company UUAB[580].

Strengths and weaknesses identified related to knowledge development

As shown in the section on the generation of knowledge elements, the relative access to funding for pharmaceutical research at Uppsala University is high compared to other universities. In that perspective, it is interesting that the industry structure shows relatively few pharmaceutical companies compared to Stockholm. An area for future research could be the knowledge transfer between the University's pharmaceutical research and the local industry as well as what spin-off/licensing activity there is from the pharmaceutical research. It could be that the pharmaceutical university research is part of knowledge transfer with the biotech industry rather than the pharmaceutical industry. In 2001, a large share of total research income stems from private sources and the share of university income from foreign companies increased drastically over a few years. There are both positive and negative sides to this, as will be discussed in "factors affecting the direction of research" in SLIS.

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[577] http://www.uppsalabio.se/DynPage.aspx?id=4715.
[578] http://www.uuab.uu.se/news.php?id=80.
[579] http://www.newsdesk.se/pressroom/uu/pressrelease/view/uppsala-universitet-i-europeisk-storsatsning-paa-tillvaext-186658.
[580] http://info.uu.se/fakta.nsf/sidor/uu.innovation.id6B.html.

The industry structure gives information about the profile of the research competence among the life science companies in Uppsala. Biotech-tools and supplies is the largest individual business segment in terms of both number of employees and number of companies. This may imply that the research competence also is relatively strong within scientific fields related to biotech-tools and supplies. It should be noted that this business field has a rather wide definition. Still, it is clear that the life science industry of Uppsala is strong in biotechnology and less oriented towards pharmaceutical business segments than that of Stockholm.

The technological knowledge base does not appear as strong in an international comparison as was anticipated in the goals set out in strategies a few years ago. Among actors within the cluster, there is a discrepancy between previous aims and the perception of the international ranking of Stockholm-Uppsala's biotech cluster. Moreover, the perception of the international ranking of the Uppsala-Stockholm Biotech cluster has decreased since 2004. There is also a discrepancy in the perception of the international knowledge base and the goals set out in 2005. Considering the goals set out and the dominance of *intra*national collaborations (in terms of co-authorships) as shown by figure 9.6, the international knowledge base of Uppsala could be stronger. In particular, co-authorships with Asian countries fall short. (It could be argued that life sciences in these countries are not developed enough to motivate extensive collaborations. On the other hand these countries present markets that could be vital to the life science companies in Sweden and knowledge about these markets is important.) The FP6 participation data also shows that industry is infrequently involved in joint projects. This could become a future weakness. Still, some initiatives focusing on Asia on behalf of the life science industry of ULIS have recently been launched by Stuns (see section 9.3.3, global challenge).

The market-related skills were not found to be debated nor addressed in many explicit initiatives in ULIS, unlike in Cambridge where this still is a major issue. This is somewhat surprising since there have been extensive efforts to improve market-related skills in Cambridge. Although management skills in ULIS are still perceived as a challenge by some[581], it might be that the particular history of the industry structure in Uppsala has affected management skills in a significantly positive way. The human resources that were channelled to companies established in the wake of Pharmacia has probably played an important part in building on a market-related knowledge base. As shown in figure 9.8, there have also been several extensive spin-offs from Pharmacia[582].

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[581] UppsalaBio, 2006, page 5.
[582] Sandström A., Bergqvist H., Dolk.T, 2007.

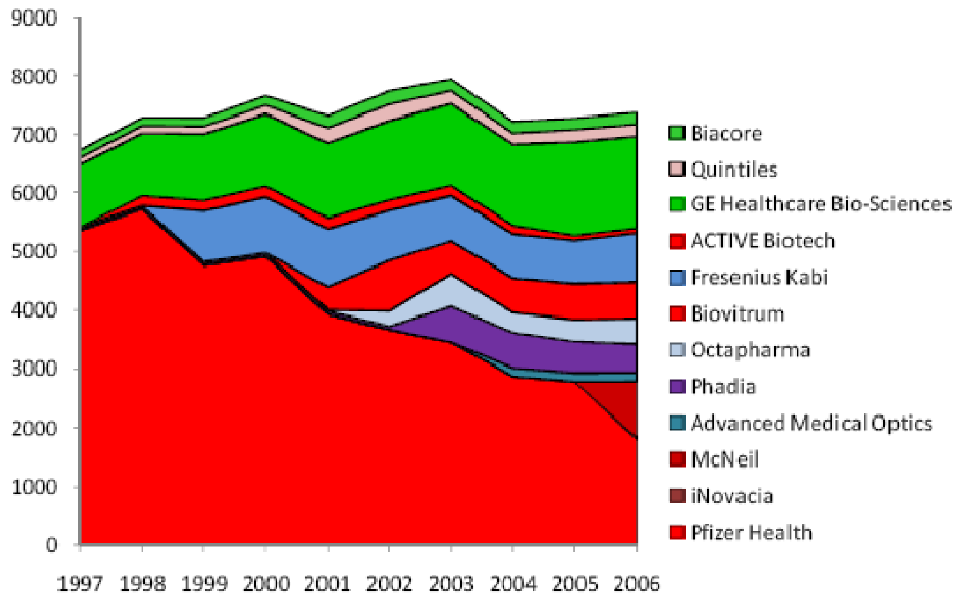

Figure 9.8. Spin-offs from Pharmacia.[583]

The gap between academia and industry was identified several years ago as an important weakness to address and explains the consistent view among actors in ULIS. This will be further discussed in the policy section. The weakness might still exist in the system but has improved, according to Uppsala Bio[584].

Just as with CLIS, the industry structure reveals a large share of small and non-profitable companies. There are also many companies that have not managed to put a product on the market. Therefore, the verdict is like the case of CLIS that the development of commercialisation activities represents a strength, whereas a weakness is identified in regard to actually making a commercialisation profit for the individual company. This weakness could be discussed in the context of how to provide efficient business support products as well as in what stage these efforts are most vital.

9.3.2 Financial support systems

Access to venture capital

General access to venture capital
The access to capital is generally good in Sweden. However, as far as the biotechnology sector is concerned it is claimed that there is "relatively poor

[583] Bergqvist H., Dolk T., Sandström A., 2007.
[584] Interview, Rhiannon Sanders, 200705.

availability of local and foreign capital” and this is perceived by some as a cluster weakness[585]. The biggest barrier to starting new companies is claimed to be a lack of financial support[586] and the biggest threat to the Uppsala Biotech Cluster is claimed to be insufficient financing, as shown in figure 9.9[587]. According to several respondents, the most important task is requesting an actor to take on the responsibility of attracting venture capital inflow to the region[588]. Uppsala Bio is not perceived as increasing the inflow of investments over the period 2004-2006, however it should be remembered that this is not their primary objective[589]. Financing is also said to be a problem for the more mature companies that have already shown promising development. It has been suggested that difficulties in raising new growth capital/venture capital could be overcome by more collaboration with investment companies listed on the stock market. That way, the inflow of capital does not necessarily have to come from the same sector or geographical region[590].

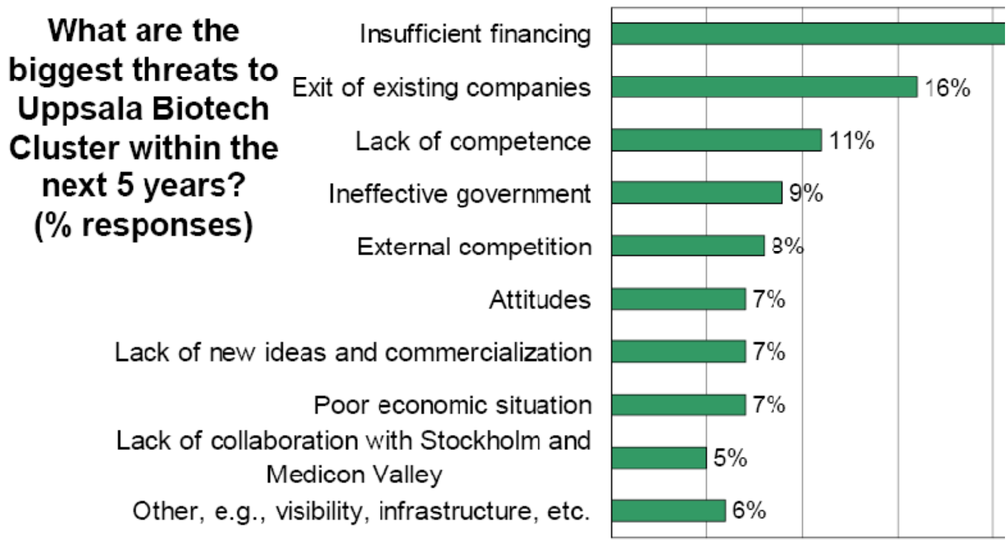

Figure 9.9. Responses from the Uppsala biotech cluster regarding major threats to the cluster.[591]

Public funding

The public investments in the UIC incubator have had high returns. In 2006 the public return on investment, ROI, was 7.9% and the UIC incubator invested SEK 93 million[592]. Co-financing is often required among the public

585 http://www.uppsalabio.com/graphics/8494.pdf page 14.
586 http://www.uppsalabio.com/graphics/8494.pdf page 33.
587 http://www.uppsalabio.com/graphics/8494.pdf page 32.
588 http://www.uppsalabio.com/graphics/8494.pdf page 34.
589 http://www.uppsalabio.com/graphics/8494.pdf page 22.
590 Stuns, 2006, page 6.
591 http://www.uppsalabio.com/graphics/8494.pdf page 32
592 UIC, 2007a.

financiers. Almi Uppsala is a public financer that offers loans to existing companies as well as startups. To receive a loan, funding must have been denied from other sources. Almi then acts as a complementary financer[593]. Public funding often also requires there to be collaborative research between academia and industry, like Uppsala Bio's research support product Bio-X for instance. Uppsala Bio has been allocated SEK 10 million per year over ten years from VINNOVA and an additional SEK 4 million from regional partners and SEK 6 million per year from regional partners in the form of work. The largest share has been allocated to the research support product, Bio-X[594]. According to Uppsala University, such requirements for collaboration between industry, universities and the public sector must often be fulfilled in order to receive funding to specific projects at the University. Uppsala University has been successful in receiving such earmarked funding from the Swedish Foundation for Strategic Research[595]. Another source of public funding is Innovationsbron, which provides financial support and advice in the very early stages of research commercialisation [596].

A recent initiative is Uppsala Seed Capital, which will provide funding to very early-stage growth companies to enable them to develop prototypes, file a patent etc. The fund holds an estimated capital of SEK 15-30 million and there is a 50/50 distribution between public and private funding[597].

Strengths and weaknesses related to the financial support system

Although access to venture capital is generally good in Sweden today[598], this activity demonstrates a perception within the Uppsala biotech cluster of a lack of financing being the biggest barrier to starting new companies and the largest threat to the cluster. There is also the claim that the most important task of business support organisations should be to attract capital to the cluster. It is interesting then to consider why the generally good access to VC is not available to some companies. A mismatch between the needs of the companies and the amount investors are willing to invest has been pointed out on a national level[599] and may apply to ULIS as well. Another interpretation could be that there is no lack of capital but that many companies are not growing organically due to other shortcomings. Another claim is that startups are being based on ideas that are not commercially viable[600] and thus have a hard time accessing VC. The industry structure of

[593] http://uppsala.almi.se/finansiering.html.
[594] Mail conversation with Stuns, 200801.
[595] Uppsala Universitet, 2003, page 23.
[596] http://www.Innovationsbron.se/Bazment/926.aspx.
[597] UIC, 2007b.
[598] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[599] Interview, Williams Ylva, Invest in Sweden Agency, 200705.
[600] Interview, Rhiannon Sanders, Uppsala Bio, 200705.

ULIS shows a large amount of small companies that are not profitable. The restrictions to growth for these companies could be that many should not have passed through proof of concept[601]. However, the return on investment of public funding in UIC has been high. It could also be argued that even for commercially viable companies there are obstacles to growth that should be addressed as well as problems occurring at a later stage than supported by publicly-funded business support products. According to Uppsala Bio, potential obstacles are better approached through a stimulating approach than a business funding one[602].

This activity has identified a possible gap in the innovation system concerning business support directed to the growth of established but very small companies. It is not necessarily an equity gap; there could be structures on a national level that should be improved and have positive effects for small companies with constraints to growth. According to Uppsala Bio, innovation in procurement could be very important to companies such as these small ones.

The current public actors in ULIS were found to be predominantly focusing on early-stage business support and their problems in accessing funding. If there actually is a mismatch between the presumably good access to funding from investors and the size of investment usually requested from Swedish life science companies, then it seems there is a Catch-22 situation: The small companies do not grow in terms of employees, profitability and product/patent portfolio because they have difficulties in accessing venture capital, whereas the investors are unwilling to invest in companies that are small (in terms of patent and product portfolio etc.[603]) whilst the issue lies beyond the scope of what the publicly funded business support actors reason that they could or should address. Apart from an obvious need for critical evaluation of how public capital should be used in selective support of industry, such publicly funded support may actually restrict initiatives emerging from industry by competing with them and the specialist business support consultancy sector[604]. Uppsala Bio highlights the importance of stimulating organic growth in the industry[605]. These questions and dilemmas have also been identified on a national level in SLIS.

Another dimension could be added to this discussion. In Cambridge, many companies that already have developed a technological platform still chose to secure their financing by conducting contract research instead of putting a

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[601] Interview, Sandström Anna; VINNOVA, 20080116 and Interview, Williams Ylva, ISA, 200705.
[602] Intervew with Uppsala Bio 20080205.
[603] Interview, Williams Ylva, ISA, 200705.
[604] Interview, Sandström Anna; VINNOVA, 20080116.
[605] Interview, Neil Madeleine and Åström Jonas, Uppsala Bio 20080205.

product on the market. There are several reasons for this, as described in the Cambridge chapter, but the most cited in the interviews was a lack of financing. Consulting offers a more profitable and secure financing opportunity than developing a product. Based on a combination of this Cambridge result and a potential funding lock in ULIS, it is plausible that the industry structure of Uppsala will become more similar to that of Cambridge with a very large consulting sector including many CRO companies. According to the Department for Commerce and Industry at Uppsala City Council, the consulting sector is currently expanding within life science. For the individual company consuming the services and products of a CRO for instance, this could have the benefit of access to knowledge without employment[606]. It might be interesting to analyse this potential development in connection with the development of employment in the sector.

9.3.3 Policy evolution

Collaboration

Collaboration within the triple helix

Uppsala Bio describes relations with local politicians as strong and their knowledge about life science as fairly good. Uppsala Bio recognises the importance of maintaining such relations and also pinpoints a need to strengthen relations to politicians on a national and regional level[607]. The aim is to have a close operational collaboration with other bioregions as well as with national organisations with strong lobbying activity[608]. It is perceived that the organisational collaboration within the Uppsala biotech cluster has improved over the period 2004-2006[609]. However, many people claim that an increased collaboration between Uppsala and Stockholm is necessary[610]. Also the Community Council wishes to see increased collaboration between the regions, particularly within top research fields[611].

Explicit initiatives or programmes to strengthen collaboration within the triple helix

The association of Stockholm-Uppsala Bioregion is an example of an initiative to strengthen collaboration. This collaboration is intended to increase visibility on the global arena and is further described in the global challenge section[612]. From a national level, there are several programmes aiming to strengthen the links between academia and industry, such as

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[606] Mail Interview with Department for commerce and industry at Uppsala City Council, 200801.
[607] UppsalaBio, 2006b, page 5.
[608] UppsalaBio, 2006b, pages 6-7.
[609] http://www.uppsalabio.com/graphics/8494.pdf, page 16.
[610] UppsalaBio, 2006b, page 37.
[611] Uppsala City Council, 2007, page 7.
[612] Stockholm Business Region, 2007.

Sambio and Sampost[613]. The Community Council supports increased collaboration between Uppsala and Stockholm and supports Stockholm Business Alliance and the Stockholm – Uppsala Bioregion[614].

The Centre for Surface Biotechnology constitutes a small but enlightening example of collaboration between students, academia and industry that aims to make the most out of small resources. Industry gains access to the faculties' competence, international networks and a recruitment base composed of participating students. The institution and students gains access to the expensive industrial equipment and financing from many companies[615].

International collaboration

According to Uppsala Bio, collaboration on a European level is growing more and more important. They recognise the importance of maximising European research resources to the region and affecting the content of the new European research programmes so that they better match the strengths of the region[616]. The Community Council wishes to expand the collaboration within the Baltic Sea area[617] and there are life science collaborations in place with Minneapolis and Heidelberg[618]. Uppsala Bio was active in establishing the Council of European Biotech Regions and aims to build upon the Council and strengthen collaboration with other European regions. It also assists in contacts with the EC administration and Europe Bio[619].

Collaboration in funding

As stated in the public funding section, some financers require co-financing from other sources in order to accept funding applications, like Almi for instance[620]. According to Uppsala University, accessible funding from research foundations and the European programmes has increased since the 90s and, accordingly, requirements for co-financing with industry[621].

A regional collaborative project between eight incubators in Mälardalen and Östergötland has been initiated with a budget of SEK 60 million. Stuns and Uppsala are responsible for establishing an expansion capital company that aims to increase industrial growth. This is a co-funded project, with Uppsala

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613 http://www.VINNOVA.se/Finansiering/Utlysningar---forteckning/Pagaende-utlysningar/SAMBIO-2007/, http://www.VINNOVA.se/Finansiering/Utlysningar---forteckning/Pagaende-utlysningar/SAMPOST-2007-2/.
614 Mail interview Uppsala City Council, 200801.
615 http://info.uu.se/fakta.nsf/sidor/studenter.och.id1C.html.
616 UppsalaBio, 2006b, pages 6-7.
617 Uppsala Kommuns Näringslivsprogram, page 7.
618 Mail interview Uppsala City Council, 200801.
619 UppsalaBio, 2006b, pages 6-7.
620 http://uppsala.almi.se/finansiering.html.
621 Uppsala universitet, 2004, pages 5 and 19.

contributing SEK 7 million over three years. The EC is defraying a third of the budget and another third is being allocated by Stuns and UIC[622]. Another example of collaboration in funding is the establishment of Atlas Antibodies. KTH and Uppsala University will access the profits of the company through a foundation, which in turn has an ownership in the company. According to the principals of the Royal Institute of Technology and Uppsala University, this kind of ownership solution may increase the resources accessible to Swedish research and also facilitate commercialisation of research[623].

Key technologies

The selection of key technologies does not seem to be as present in the local debate as it is on a national level. Nor is it highlighted in policy documents of local actors. Several actors claim that life science already has the status of a priority industry[624] and that these industry priorities were made in the Uppsala innovation system even before the debate started on a national level[625]. According to the City Council, there is a consensus among political parties within the Council that the life science industry is a priority industry due to its local strengths and that it has to be further built on in a long-term perspective[626]. However the more specific selection of prioritised key technologies is regarded with more scepticism[627]. The University of Uppsala has chosen biotechnology as a priority area though[628] and STUNS states that drug delivery, proton therapy and veterinary research are local strengths particularly well suited to further build upon by establishing cross-regional collaborations. These areas present a depth and a breadth that is unique in Scandinavia[629].

Organisations within the Uppsala life science innovation system do pinpoint the necessity of prioritising between activities and focusing on certain key activity areas such as communicating cluster strengths to the outside world. STUNS states that they aim to stick to strategic initiatives in prioritised areas[630], Uppsala Bio regrets that certain activities, like attracting investment to the region, have not quite been fulfilled since they exceed the focus activities of the organisation. This kind of prioritising is linked to collaboration and identifying gaps in the distribution of roles in the local innovation system.

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622 http://www.uic.se/.
623 http://info.uu.se/notiser.nsf/pm/unik.agarlosning.id96.html.
624 http://www.stuns.se/ and Mail interview Uppsala City Council.
625 Mail interview Uppsala City Council.
626 Mail interview Uppsala City Council.
627 Mail interview Uppsala City Council.
628 http://info.uu.se/fakta.nsf/sidor/bioteknik.id0E.html.
629 Stuns verksamhetsberättelse 2006, page 7.
630 Stuns verksamhetsberättelse 2006 page 2.

Global Challenge

The biotech industry of Uppsala is described as a local system, but there are important connections to the regional system of Mälardalen and the global market. The international dimension is particularly strong in regard to customers and suppliers[631]. One of the four function areas of Uppsala Bio is "to communicate the strengths of the life science sector in Uppsala to the rest of the world"[632]. The vision stated in the Uppsala Bio strategy is that "within five years time Uppsala-Stockholm will be recognised as one of the leading biotech regions in the world with a growing competitive industry, world-class research and education and a climate where industry, academia and people thrive. Within this region, Uppsala's emphasis is on methods, models and tools for biotech research"[633]. This strategy is backed up by academia, industry and the public sector of Uppsala[634]. The City Council aims to provide an internationally competitive business climate and addresses the global challenge primarily by marketing Uppsala's strengths and the knowledge base at hand[635]. The annual allocation from Uppsala City Council to strengthen the Uppsala brand is SEK 1.2 million[636]. Uppsala Bio requests a political consensus to further build on the strengths within life science in the long-term perspective and attract strategic investments to Uppsala. Investment decisions need to be more strongly supported[637].

Explicit initiatives or programmes to address the global challenge
In order to be able to compete on the global arena, the association Stockholm-Uppsala Bioregion was launched in May 2007 by the Foundation Biotechvalley.nu in Strängnäs, Stockholm Business Region and Uppsala BIO/STUNS. This is a step towards putting more strength into marketing the region internationally and becoming more visible. Hopefully, the new platform will attract more foreign skills and capital as well as adding possibilities of cross-sectional collaboration within the Stockholm-Uppsala life science community[638]. The aforementioned collaboration between incubators in different regions is also an initiative aiming at addressing the global challenge. The need for growth companies to reach the international market at an early stage of their company development has been recognised within the project[639]. The Uppsala life science industry has access to the network of business advisers of the Minnesota life science industry. This is due to a memorandum of understanding between Uppsala Bio/STUNS and the Bio Business Alliance of Minnesota. The aim is to

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631 http://info.uu.se/fakta.nsf/sidor/ett.kluster.idB7.html.
632 http://www.uppsalabio.com/DynPage.aspx?id=4719&mn1=1223.
633 Uppsala Bio, 2006a, page 9.
634 Uppsala Bio, 2006a page 3.
635 Uppsala Kommuns Näringslivsprogram, pages 3 and 7.
636 Mail-interview with Uppsala City Council.
637 Mail-interview with Uppsala City Council.
638 Stockholm Business Region, 2007.
639 http://www.uic.se/.

facilitate corporate establishments in Europe and in the US[640]. Initiatives focusing on the Chinese market have been found at STUNS and Invest in Uppsala. Invest in Uppsala aims to increase inward investment from China[641].

Relative strength of policy areas

Only one network identified a key technology as the focus of their activity. On the other hand, networks like Uppsala Bio have been established since biotechnology in Uppsala was identified as an area of strength to build upon. In that sense, their existence could be viewed as an identified key technology.

Among the other policy issues examined in table 9.1, all were highly anticipated in the sub-regional innovation system. Commercialisation of research, addressing the global challenge and needs-driven research/economic benefit to society was the focus for 12 out of 17 networks/funding networks. Increasing the collaboration between actors was the focus for 17 networks/funding networks.

Weaknesses and strengths related to policy evolution

There is currently a strong objective to increase collaboration between actors, particularly between Uppsala and Stockholm. Clearly, the incentive is the critical mass needed in order to gain visibility on the global arena. Initiatives are under way to strengthen the profile and ensure the objective is taken seriously. This is a strength, but it seems the collaboration between Uppsala and Stockholm will be mainly restricted to joint marketing activities. Some actors are requesting even more ambitious steps towards collaboration. Uppsala Bio has stated its willingness to take on the responsibility of achieving this. It is difficult to assess whether there are weaknesses in the process towards increased collaboration and where they might be situated. To conclude, it seems there is a potential to take the collaboration even further and the current situation provides an opportunity for increased strength.

There are international collaborations and initiatives to address the global challenge, but due to limited resources they are mainly restricted to the marketing of Uppsala biotech cluster or the marketing of the City of Uppsala. There are few specific life science initiatives, but there is a consensus among many actors of the importance of the life science industry which is reflected in general initiatives. For instance, Stuns and Invest in Uppsala have taken steps to attract capital to the region and facilitate market

[640] UIC, 2007c.
[641] http://www.stuns.se/projekt/index.html.

entry on Chinese markets. The life science industry is represented in these initiatives.

Due to limited resources, the actors of ULIS were found to prioritise strongly between their activities. Some actors regret this since some important activities were also left outside the primary focus. This bears upon the issue of addressing the global challenge. It is also interesting that prioritising between technologies has been found to occur to a small extent in Uppsala.

Since there are limited resources and important activities falling outside the primary focus of many actors, it is even more important to have a well-functioning collaboration. It is also important that national actors take into account the knowledge of local actors in how national programmes and initiatives are best implemented to have a positive effect on the local industry. According to Uppsala Bio, increased collaboration and communication about the needs of the local system would be beneficial to ULIS in optimising the impact of the programmes[642].

[642] Interview, Neil Madeleine and Åström Jonas, Uppsala Bio 20080205.

10 Micro-level Innovation System Comparison

Industry structure comparison
In both Uppsala and Cambridge, there are many biotech tools and supplies companies in the life science industry structure. In Uppsala, there are some larger companies among these whereas in Cambridge they tend to be rather small but generally more numerous. Another difference is that the structure of the Uppsala life science industry holds few drug discovery companies whereas in Cambridge, drug discovery and development make up 25% of the industry structure in terms of employees. Both industries have many small companies with no product yet on the market. Overall, the share of companies that lack a product on the market is larger in Cambridge. One of the most striking results of a comparison is the large share of consultancy companies in Cambridge, predominantly CROs. These are not only more numerous in Cambridge, they are also larger. This result was given extra attention. An examination of the biotech tools and supply companies in Uppsala showed that they often have a technological platform similar to that of the CRO-classified companies in Cambridge. The difference lies in the activity built upon the research and technological platform. The Uppsala companies strive to put a product on the market based on their technological platform and the result is often a physically tangible product. In Cambridge on the other hand, the same kind of technological platform is often transformed into consultancy services or licences. The basis of the CRO company is formed from know-how in the specific research field in which the company specialises.

System structure comparison
The system structure of CLIS comprises more actors than ULIS. There are more networks, more funding networks, more science parks and more research institutes etc. This should be taken into consideration since it affects the comparability of the innovation systems. It could also be seen as a result in itself. The specific terminology of funding networks does not appear in ULIS, but there are some actors that fill the function in ULIS. There are no Regional Development Agencies in Sweden, and no corresponding EEDA for Uppsala, nor has any equivalence to the East of England European Partnership been found. Overall, there seem to be fewer overarching regional bodies. On the other hand, there are departments at Uppsala City Council for instance that partly fulfil the functions of Regional Development Agencies together with actors like Invest in Uppsala, Stuns etc. The smaller size of Sweden might explain for part of this difference.

Comparison of strengths and weaknesses identified in the activities

There are differences in the generation of knowledge elements in ULIS and CLIS. In ULIS, the factors affecting the direction of research have been the industry and the connection between certain research groups and industry. Naturally, Pharmacia has put its stamp on the research community and contributed to areas of strength by functioning as a nursery for researchers. The importance academia has played in the development of the industry and technological knowledge base is debated in both systems, but more accepted in Uppsala than in Cambridge. The share of private funding to university research is higher at Cambridge University than Uppsala University.

The technological knowledge base is stronger in CLIS than in ULIS and the research fields differ somewhat, which is also reflected in the industry structure and business areas. Both Uppsala and Cambridge hold strong technological knowledge bases compared to other innovation systems within the nation. Internationally however, Cambridge is ranked higher, also by the Uppsala Biotech Cluster. Actually, Cambridge holds the place that Uppsala was aiming for a few years ago in local strategy documents, fourth in the world. When it comes to the international knowledge base, the Cambridge brand is very strong internationally and attracts top researchers. However, the international links of Cambridge University in terms of co-authorships are weak. That is, the attractiveness of Cambridge to foreign researchers is high whereas, with the exception of the US, the interest of academia in international research collaborations is limited. In Uppsala, the situation is somewhat reversed. The access to foreign researchers is perceived as limited in the Uppsala Biotech Cluster whereas according to the bibliometric data the international co-authorships are stronger. The market-related knowledge base in both CLIS and ULIS has been identified as a challenge to the systems, but has improved in Uppsala where it does not seem to constitute as great an obstacle as it has in Cambridge, at least not with the climate of discussion. The historical and current alleged strong connections and knowledge transfer between academia and industry may have played a part in the relatively strong market-related knowledge base in ULIS.

The overall result of the innovation system study conducted on the life science innovation system of Uppsala is that this is a well-functioning innovation system, even compared to that of Cambridge. Overall, the actors cover the different activities needed. The access to financing is also generally good in both systems. There may be a gap in regard to the financial support system in terms of business support and funding to companies that are in the growth stage. The growth of existing companies and attracting capital to the local industry is the focus of just a few of the actors within the Uppsala financial support system. It is not evident whose role this is to take. Some claim this responsibility should not be taken by publicly funded actors. This would leave the industry and privately funded actors within the financial support system with an important task. However, analysing the potential gap and how to best overcome it should be in the interest of both publicly funded and private actors, since deficient financial support systems for growth companies could be linked to the alarming employment development. There is ongoing debate on this matter in the UK. The former small business support scheme has been replaced by Business Link which provides industry with a brokerage service of how to access business support. It is in the interests of Sweden to observe how this arrangement works out and if business will take the role of business supporter, as has been questioned by some[643].

Both in Cambridge and in Uppsala, an equity gap is claimed by some and rejected by some. A mismatch between the size of investment required by companies and the size provided by investors is recognised in both systems. In Cambridge, the discussion about constraints to growth focuses on the equity gap, the early exit of investors, the infrastructure and the need to go international at an early stage due to the small customers' market and small VC market. The constraints on growth for life science companies has been in the spotlight in several conferences and is known as the issue of "where are the big gorillas?"[644]. The importance of access to the international market for small biotech companies is also stated for ULIS[645] and has been addressed with a focus on China by some business support providers. However, it is not certain whether these efforts have yet affected any life science companies[646].

The topics are very much the same in the policy discussions within the two innovation systems and seem to be equally mature in regard to the policies selected for further investigation in this study[647].

In both ULIS and CLIS, selecting key technologies is not a strong policy issue among the actors. A comparison of table 8.1 and table 9.1 shows this focus area to be more frequent in Cambridge than in Uppsala.

Commercialisation of research and knowledge transfer between academia and industry has been a number one topic for several years in both CLIS and ULIS and has been addressed in many ways and by almost all major actors. In Uppsala, the perception is that the development has improved in recent years and that attitudes have changed all the way. It may be that attitudes and initiatives towards commercialisation of research have had an effect on

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643 http://www.the-guild.co.uk/article.php?recordID=8.
644 http://www.cambridgeenterpriseconference.co.uk/documents/PR01CEC.pdf.
645 Waxell A., 2005, page 73.
646 Mail Interview with Stuns.
647 In the comparison, it should be noted that the networks and funding networks discussed in CLIS were identified on a regional basis, whereas the networks in ULIS were identified to a larger extent on a sub-regional basis.

the larger share of “product on the market” companies in Uppsala than in Cambridge

A larger share of the networks in Uppsala, focus on the global challenge. In Uppsala, the global challenge is addressed predominantly by an increased effort to market Uppsala to the rest of the world and increase international collaborations. Increased collaboration between actors in the local system has also been linked to the task of addressing the global challenge, in the sense that this is needed in order to achieve critical mass and become more “visible”. Compared to Cambridge, the differences lie mostly in the various offices established in order to address the global challenge in Cambridge, like East of England International, East of England European Partnership and a Brussels office. The allocation from Uppsala City Council for international marketing of Uppsala, and from EEDA to international business support, are not actually comparable since EEDA covers a larger region and the two bodies have different functions. Nevertheless, the allocations are SEK 1.2 million and GBP 2.704 million respectively.

Collaboration seems to be more emphasised in Uppsala than in Cambridge. It is recognised in both systems that more joint marketing with other sub-regions is necessary in the global competition. Needs-driven research and economic benefit to society was a more frequent focus area of the ULIS networks.

11 Interconnectedness of sub-regional, regional and national level

As described in the theoretical framework, although the main purpose of this report is to make an innovation system comparison and evaluate the competitiveness of the SLIS, there is also a spatial dimension within this work. With Sweden's population being so much smaller than that of the UK Innovation systems on different levels have been studied in Sweden and the UK in order to make an extensive and fair comparison of them. In the following section, the interconnectedness of these innovation systems on different spatial levels will be used as a dimension/activity to compare in itself.

The starting point of the interconnectedness evaluation is the policies and how they are implemented. For example, the geographical spread of knowledge and links between regional and national capital have not been dealt with in this report. It was considered important for the evaluation and comparison of the innovation systems to see what goes on in the national policy discussions and how this is actually received or implemented on a regional and sub-regional level. As an instrument to examine this interconnectedness, the focus on policies has been extensive in the different innovation system descriptions. On a national level, descriptions of the policies in regard to certain policy areas have been presented. Explicit examples of how these policies and strategies have actually been implemented are also provided in order to give a perspective on the extent to which policies are transformed into budgets and actions. This has also been described on the sub-regional and regional levels represented by CLIS, ULIS and ScLSIS. In addition, a systematic policy examination regarding largely the same policy issues has been conducted on these levels. By using search tools, an exhaustive population of networks and funding networks has been generated and thoroughly examined. The results of these examinations, in combination with the overall policy description in each regional/sub-regional innovation system, will be used to draw conclusions about the interconnectedness.

11.1.1 Interconnectedness between UKLIS and CLIS

In Cambridge, a discrepancy was identified between the policies, or focus areas, on a national and sub-regional level. This was based on the outcome of the focus area quantification, budget allocations and local initiatives compared to the national policy documents, homepages, strategies and initiatives. There is also a discrepancy in what is emphasised by the regional EEDA actor and what is emphasised by the sub-regional actors. The interviews indicated that there seem to be a delayed consensus in the policy evolution. The importance of commercialisation of research and knowledge transfer between academia and industry has been discussed and emphasised for many years among policy-makers on a national level and is now greatly emphasised by regional as well as sub-regional actors[648]. The need to address the global challenge and the selection of key technologies is stressed among national policy-makers and is being emphasised on a regional level, but not strongly on a sub-regional level. This has been noted only as an interesting phenomenon and will not be discussed in terms of strengths and weaknesses. Naturally, there might be risks connected to a rapid development of consensus among actors in the innovation system. It could also be that the selection of key technologies is difficult to translate from policy to concrete action and thus explains the discrepancy between national consensus and sub-regional actors.

11.1.2 Interconnectedness between ULIS and SLIS

In ULIS, prioritising is thought of as absolutely necessary due to limited resources in regard to choosing between the activities aiming to support the innovation system; the tools in the toolbox, so to speak. It is also embraced at an industry level. Life science is considered an obvious industry of strength among a wide range of actors and it is viewed as a natural consequence that is the focus of many efforts. Focusing efforts on specific key technologies was not found to be a strong policy issue among the actors in ULIS. As shown in table 9.1, almost none of the networks and funding networks highlights the key technology issue. On a national level on the other hand, discussions about the importance of prioritising focus more on key technology areas. Both levels emphasise the need to prioritise in order to achieve critical mass but in different ways. The sub-regional level perceives that, due to limited resources, they need to focus on certain activities. On the national level, there are no evident priorities made among the support activities; the tools in the toolbox, so to speak. At the same time, it has been identified on the national level that business support is thinly spread compared to other countries and it has been claimed by several that larger projects are needed. The need to prioritise (in general) in order to achieve critical mass is said to have been highlighted in Uppsala before it occurred on a national level.

It is not within the remit of this report to analyse what characterises the best approach in this matter. An explanation for the difference between the local

[648] Interviews in Cambridge and in London.

and national level probably lies in the highly organic approach towards industry growth and development in ULIS and the more long-term strategies and top-down priorities of the national level. The approaches could probably co-exist more efficiently with a more initial communication in the launch and creation of programmes/initiatives from both parts.

In ULIS, just like SLIS, there is major focus on collaboration, commercialisation of research, addressing the global challenge and needs-driven research/economic benefit to society. These focus areas are also currently addressed in various ways, as shown by the explicit examples. However, it has been identified that an even higher level of collaboration is required by some actors. Also, the effect of some initiatives addressing the global challenge is uncertain, particularly on life science, since their focus spans several industries. This makes the efforts difficult to evaluate and compare to the national level. The commercialisation of research seems to have had a breakthrough in Uppsala, whereas it is still perceived as a problem on the national level.

12 Overall competitiveness of the Swedish life science innovation system in relation to the British one

Initially, four questions were asked. The first was "what is the overall structure and development of the Swedish Life Science Industry?". This has been answered in the industry survey and to summarise, overall the employment development has stagnated in recent years whereas productivity has improved. Between 1997 and 2003 the industry grew impressively, due predominantly to research-intensive companies. The second question was "how do the British and Swedish life Science innovation systems appear and function in regard to certain activities?". The activities focused on policies and funding and the results are given in the five different innovation systems described: the UK, Sweden, Scotland, Uppsala and Cambridge. To answer the third question, "what is the performance of the Swedish and British Life Science innovation systems?", the innovation systems were compared in a macro-level and micro-level benchmarking, based on the strengths and weaknesses of the innovation systems. The comparison showed interesting differences in government policies, industry involvement and funding systems. On the micro-level, the differences in industry structure between Cambridge and Uppsala were given special attention, in particular the large share of consulting companies in Cambridge. The future development of the Uppsala life science cluster will be interesting to follow.

This section aims to answer the fourth and final question regarding the competitiveness of the Swedish Life Science innovation system, "what can we learn from the British innovation system?".

It is important that international benchmarking does not result in copying the mistakes of others. It is difficult to draw conclusions about what impact different polices and strategies have had on overall performance. It may also be too soon to evaluate the impacts. The fourth question will therefore be answered in a modest way.

There are high ambitions among Swedish policy-makers and decision-makers regarding the competitiveness of the life science research and life science industry. However, the ambitions could be more strongly reflected in actions and budgets, although an increase is on the way. There may be a concern about the levels of public funding in Sweden, particularly considering the vulnerability inflicted by the large share of funding stemming from a few private sources. In Scotland and in the UK overall, a larger share of industry funding is more actively sought than in Sweden.

When discussing the share of industrial funding of R&D out of the total R&D-investment, it is important to consider the industry structure. In Sweden, AstraZeneca is a giant which contributes a large share of the industrial research funding. Even though major industrial funding of research would be welcomed to help achieve the 3% target, it would be a less risky situation if the industrial contribution stemmed from multiple sources instead of one single dominant contributor. There are no guarantees that the main industrial contributors will remain tied to Sweden. There are lessons to learn from the UK and Scotland regarding industry involvement, but due to differences in industry structure the policies cannot be “cut and pasted” into the Swedish innovation system. Still, the concern expressed in Cambridge regarding the industry structure could just as well apply to Sweden. As has been shown, there are many very small life science companies in Sweden and a large share of companies that show negative results. It has also been shown that the employment has stagnated in later years. Therefore, the debate referred to as “Where are the big Gorillas” in Cambridge should be held and attribuated lots of attention also in Sweden.

The Scottish top down approach to build a life science industry might not be suitable to apply to the different circumstances at hand in Sweden, but there are lessons to learn on how determination and collaboration amongst key actors of the private and public sector can make things happen, not least when it comes to foreign direct investments.

In addition, there might be lessons to learn from the way public funding is allocated in the UK. For instance, the initiatives undertaken in the UK to increase governmental collaboration regarding research and innovation should be further evaluated from a Swedish point of view. Bringing the responsibilities for science and universities closer to the responsibility for innovation in the new departmental structure, with the launch of DIUS, may turn out to be a clever way to deal with business, innovation and university issues. Coordination might still be a problem in the UK innovation system but it seems stronger actions are being undertaken at departmental level in the British innovation system than in the Swedish one. Measures are being undertaken on the highest possible level. On the other hand, British governmental infrastructure is very complex and still includes a very large number of actors. It could be questioned whether a system with numerous amounts of committees, sub-committes and even sub-sub-committes is well suited to deal with innovation. Issues related to innovation are owned by many different actors. This presents both pros and cons. It might be as a consequence of the very complex structure of public authorities dealing with innovation that the drastic actions to increase intra-governmental collaboration have taken place.

In the UK, the industry has been attributed increased responsibility and impact on governmental policies through the establishment of the Technology Strategy Board in the UK. This change in the British innovation system may need to be taken into greater consideration in the Swedish debate. There is no actor in Sweden corresponding to the Technology Strategy Board and sadly, this has not been recognised in the current (spring 2008) debate regarding the organisational structure of funding bodies.

A larger co-ordinating role could also be taken on by public funders in Sweden in regard to getting the act together with relevant actors in a given project or research field. Increased project management from national public authorities is on the wish list from both companies and regional actors. Pooling of funding might be something that the funders should work harder to achieve.

Sweden should keep an eye on the life science innovation system of Scotland in particular and how the selection of key technologies turns out. Scotland is a small country and although circumstances related to critical mass differ compared to Sweden, not least due to the proximity to the rest of the UK, there are similarities that make Scotland a very interesting case from a Swedish perspective. In particular, the Scottish aim of focusing on key areas in order to achieve critical mass might possibly be an important source of inspiration for Swedish policies. The Scottish approach has already resulted in larger inflows of foreign direct investment. There is no evidence that the Scottish approach will increase the economic benefits to society in the long-term perspective. On the other hand, the actions undertaken show a commitment to stick to the high ambitions.

It has been easier to find "lessons to learn" for Sweden on the macro-level than on the micro-level. Access to international markets and funds to address the equity gap might be areas where actors in the Uppsala life science innovation system could learn from Cambridge. If a corresponding "where are the big gorillas" discussion were to take place in Uppsala it would be most welcome. It is also important that it includes macro as well as micro-level actors. In regard to the interconnectedness between the various levels in Sweden, it seems like there are differences in how actors reason about achieving critical mass. On both levels it is emphasised that priorities are needed in order to achieve critical mass. However, the choice of priorities differs. The increased collaboration between Stockholm and Uppsala is welcomed on both micro and macro levels.

To summarise, the study of Cambridge has primarily added insight on what can be expected in a life science innovation system where the industry structure is composed of many small companies, by various reasons reluctant to grow. The Scotland analysis has provided lessons to learn on how determination and cross-border collaboration of the public and private sector really can make things happen, also in a very small country. Although the Scottish life science industry is relatively young, it has already had wake up calls regarding the market-related knowledge base that should be learnt from also in Sweden. On a macro-level, actions have been undertaken in order to improve how the government address innovation. Some of these actions might turn out successful and others not. Still, the overall take home message would be the importance of ambitions and power to act on the highest possible level.

13 Appendices

Appendix 1. Important policy documents

Important policy documents				
actor	Name of document	Aim of establishing the document	Publishing dates	follow-up documents
DTI	Innovation report 'Competing in the global economy: the innovation challenge'	This report sets out the next steps we are taking in turning the UK into a key knowledge hub in the global economy	2003	
DTI, H&M Treasury, DfES. Now overtaken by DIUS	Science and Innovation Investment Framework: 2004-2014	This framework sets out how Britain will grasp the opportunities of the global challenge and how to turn strengths in the UK science base into greater economic advantage by building on the culture change in our universities, by promoting engagement and collaboration between businesses and the science base, and by promoting innovation in companies directly.	2004	Science and Innovation Investment Framework: 2004-2014 Next Steps (DTI) + annual reports on both documents (DIUS nowadays).
DTI, H&M Treasury, DfES. Now overtaken by DIUS	Science and Innovation Investment Framework: 2004-2014 next Steps	Against the background of increasing global competition for knowledge intensive business activity, this paper presents next steps on five key policy areas: maximising the impact of public investment in science on the economy through increasing innovation; increasing Research Councils' effectiveness; supporting excellence in university research; supporting world-class health research; and increasing the supply of STEM skills	2006	Annual reports on both documents (DIUS nowadays)
TSB	Technology Strategy	Address the Global Competition by focusing on those areas where the UK has the greatest capacity to develop and exploit technology.	Annual reports since 2005	Annual reports since 2005
GSIF	Strategy for International Engagement	The overarching objective of the GSIF strategy is for the UK to be the partner of choice for global business looking to locate Research and Development (R&D) activities overseas, and for foreign universities seeking overseas collaboration.	2006	

Some of the policy documents forming the basis of sections in this report dealing with UK policies.

Appendix 2. Initiatives and programmes aiming to address the equity gap

The Early Growth Fund

This fund aims to increase availability of smaller amounts of venture capital by encouraging risk funding for startups and growth firms. The size of the grant averages GBP 50,000 and no more than GBP 100,000. Startups, university spin-offs, innovative and knowledge intensive companies, smaller manufacturers with new opportunities and early growth companies are the main targets for the funding. The funds are operated by a fund manager[649].

Regional Venture Capital Funds

The explicit aim of this programme is to address "the equity gap at the lower end of the market"[650]. In the long run, the aim is to realise growth potential of SMEs by increasing access to venture capital and promoting investment by demonstrating the positive returns that are possible. It is also stated that this intervention of the government is intended to "be the minimum necessary to stimulate private sector investors to provide small-scale risk finance"[651] The programme is available for SMEs in England (one commercial fund in each of the nine English regions) and provides venture capital up to GBP 500,000 to companies that show good growth potential[652].

Enterprise Venture Capital Funds

The equity gap for SMEs is further addressed by the Enterprise Capital Funds that are intended to provide government funding alongside private sector funds. Available to companies with high potential of commercial return the investments are up to GBP 2 million[653].

Small Firms Loan Guarantee

It has been recognised that among SMEs there is an unmet need for loans in order to realise business plans. Conventional loans might be hard to access due to lack of resources that could be used as security. This is where the Small Firms Loan Guarantee comes in; BERR in a joint venture with

[649] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/early-growth-funds/page37491.html.
[650] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/regional-venture-capital-funds/page37596.html.
[651] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/regional-venture-capital-funds/page37596.html.
[652] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/regional-venture-capital-funds/page37596.html.
[653] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/enterprise-capital-funds/page37667.html.

participating lenders offers a guarantee to the lender that covers 75% of the loan, at a cost of 2% per year. The size of the loan is maximum GBP 250,000 and is available to firms with a maximum annual turnover of GBP 5.6 million per year[654].

Community Investment Tax Relief

Individuals and corporate bodies wishing to invest in accredited Community Development Finance Institutions (CDFI), that is …, can access a tax relief of 5% per year of the amount invested in CDFI. The funding provided to CDFIs is used to support qualifying profit-distributing enterprises and social enterprises[655].

[654] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/sflg/page37607.html.
[655] http://www.berr.gov.uk/bbf/enterprise-smes/info-business-owners/access-to-finance/CITR/page37528.html.

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and developing effective innovation systems

VERKET FÖR INNOVATIONSSYSTEM – SWEDISH GOVERNMENTAL AGENCY FOR INNOVATION SYSTEMS

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