Knowledge Based Health

by

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Research Report 4/2011

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Research Report 04/2011
ISSN: 0803-2610

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N-0442 Oslo
Phone: 4641 0000
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Print: Nordberg

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1 Introduction: Knowledge-based health

In this study, we assess the underlying properties of a global knowledge hub to examine the extent to which the Norwegian health industry constitutes such a hub. We begin with a general discussion of the industry before we examine the underlying properties of global knowledge hubs: cluster attractiveness, educational attractiveness, talent attractiveness, R&D and innovation attractiveness, ownership attractiveness, environmental attractiveness and cluster dynamics. We conclude by providing clear recommendations for business and public policy.

Innovation in the Health Sector

Lifecare A.S. (Ltd.) is a privately owned, independent company that focuses on the development of medical sensors to monitor blood glucose levels. The firm's headquarters are located in Bergen and R&D is carried out in Horten, Norway. In 2007, Lifecare was awarded a large grant by the Research Council in Norway for the development of its technology. The firm aims to introduce the first injectable micro-sensor as a novel tool to monitor the glucose levels of diabetes patients. Lifecare is currently completing development and testing of this technology, known as Sencell, for which it has held a registered patent since 2003.

The Lifecare Sencell project is focused on the development of an under-the-skin glucose sensor for diabetics. The current model measures just 3x7mm, and encompasses a communication antenna, a pressure sensor, pressure chambers and a processor. The Sencell sensor will be encapsulated in a biocompatible material and suitably formed for injection into the body. The placing of the sensor is a quick and simple procedure that may be carried out at the doctor's office. Therefore, there is no need for surgical intervention.
The Sencell sensor injected into the patient is teamed with a Sencell wristwatch worn by the patient. This wristwatch powers the sensor via electromagnetic impulses, allowing continuous surveillance of the patient's glucose levels. Results are calculated and sent wirelessly to the wristwatch, where they are displayed. Lifecare's slogan "Inject and forget, be watched and warned, read at need" accurately communicates the Sencell's capabilities.

The market potential for glucose-monitoring products is enormous. Diabetes is a widespread disease that affects 6.4% of the world's adult population. It is estimated that more than 220m people worldwide had diabetes in 2005 and this figure is expected to reach 366m by 2030 (WHO 2010). In addition to traditional invasive methods of measuring blood sugar levels (such as finger-pricking), Lifecare's main competition is found in the field of non-invasive blood sugar level monitoring based on nanotechnology. Such products, some of which are still not on the market, include hydrogel contact lenses and a sensor-based technology worn on the patient's finger.

Lifecare is likely to remain a "one-product company" focused on the commercialization of its Sencell technology, which provides it with access to a large, low-risk market with high growth potential. In order to commercialize its technology, Lifecare is in need of financial strength to overcome typical start-up hurdles and networks that can provide it with access to the national diabetes markets. Will Lifecare succeed in developing its product? If so, will it immediately be bought by a large foreign pharmaceutical company?

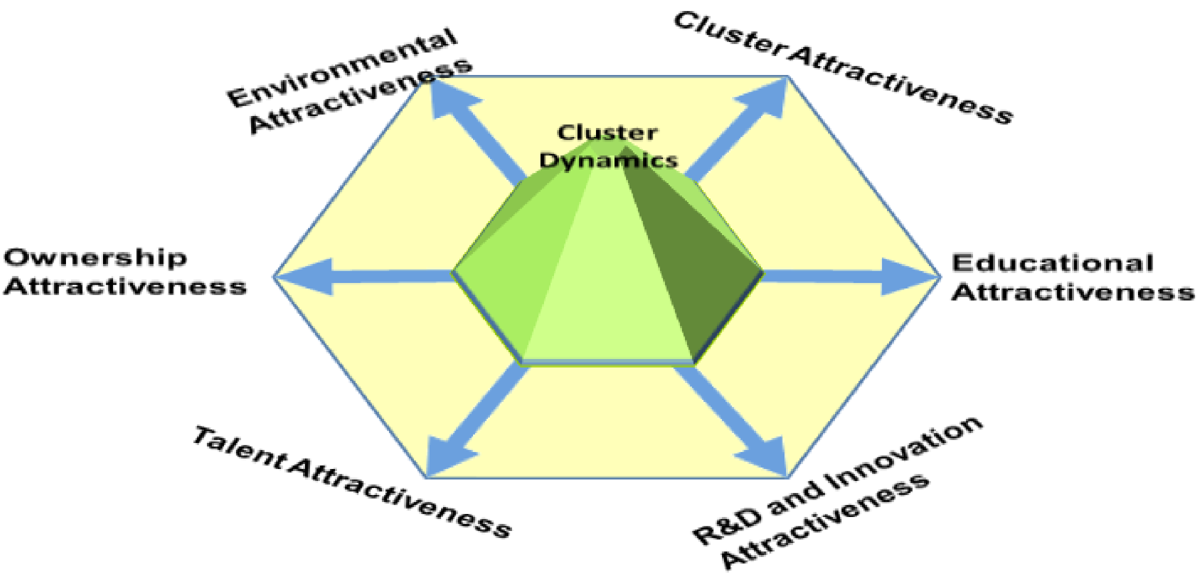
The Lifecare case illustrates the development of a novel business model to solve a growing, but well understood, medical condition. The Sencell solution combines technological development with the application of existing knowledge across multiple institutions and geographical boundaries. However, the lack of a community of customers, including large pharmaceutical firms, and the lack of competitors in the vicinity of the firm are likely to constrain the firm's strategic options. This weakens the likelihood of the formation of an industry that can build on the knowledge developed thus far to create additional value.

Global knowledge hubs

For Norway to be able to sustain its wealth in the future, an adjustment process must be initiated while oil reserves are still being exploited. Recently published innovation indexes (e.g., OECD 2010) raise concerns about the relative speed and comprehensiveness of the adjustment process in Norway. To address the shortfalls in the adjustment process, tough decisions are required on the national level. These decisions will affect Norwegian businesses and their representative organizations, as well as educational institutions and governmental agencies.

This study is based on three simple premises. For industries to be competitive and sustainable in a high-cost location like Norway, they have to compete globally, they have to be knowledge-based and they must be environmentally robust. Under such conditions, nations and regions face the challenge of attracting the best talent and the best firms. We argue that knowledge-based industrial development occurs in global knowledge hubs or superclusters characterized by a high concentration of innovative industrial actors interacting closely with advanced research institutions, venture capital firms and competent owners. Hence, firms, local authorities and national governments face the challenge of creating conditions under which knowledge-based industrial development can occur.

Figure 1-1: The Global Knowledge Hub© model



The Global Knowledge Hub© model presented in Figure 1-1 provides a framework for analyzing the attractiveness of localities. The surface of the hexagon represents the room for maneuvering available to public authorities and a decision set for firms. It conceptualizes attractiveness as six-dimensional. Localities differ in their attractiveness in accordance with their abilities to attract advanced-education institutions and departments, highly talented employees, advanced academic specialists, research and development projects, competent and willing investors and owners, the creation and implementation of environmental solutions, and a diverse and sizeable group of related firms.[1]

The effects of these dimensions on economic performance are moderated by the degree of cluster dynamics, which refers to the extent to which related firms structure their internal and external relationships. The objectives are to identify existing and emerging global knowledge hubs, and to recommend policy initiatives designed to enable the further development and competitiveness of such hubs.

The next chapter presents a brief overview of the development of the industry. We then examine the underlying attractiveness properties that affect the success and failure of industrial initiatives within the Norwegian health industry. In the concluding chapter, we discuss implications for firm strategy and public policy.

[1] In this study, we ignore the cultural dimension of attractiveness.

2 Value creation in the health industry

This chapter provides a historical overview of the health industry with specific reference to innovative products relating to treatment and diagnosis. It describes the Norwegian health industry and its sectors, and elaborates on the nature of value creation among individual health firms and within the system of health firms.

2.1 The Norwegian health industry[2]

The health industry as a whole has not historically played an important role in Norway. However, it has flourished in recent years, particularly in the fields of pharmaceuticals and biotechnology. Norway has traditionally been a net importer of pharmaceuticals and has even been referred to as having a third-rate status with no more than reproductive capabilities in the pharmaceutical industry (Ballance et al. 1992). Sogner (1993) notes that very little has been written about the Norwegian pharmaceutical industry, which might reflect perceptions of its low importance.

From the 1920s to the 1940s, four main pharmaceutical firms were based in the Oslo area, all of which focused on vitamins (A/S Farmaceutisk Industri, AL, Collett and Nycomed). Despite close collaborations between the firms and the University of Oslo and the promise of new breakthroughs in the “therapeutic revolution” of 1935, the Norwegian pharmaceutical industry did not take off. After the material and economic destruction of WWII, attention and funds were directed to more urgent activities, and the pharmaceutical industry was unable to evolve in line with its potential. In the late 1940s, Norway began to lose its competitive advantage in vitamins, as the technology became widely available and vitamins could be synthetically produced.

Nycomed had not specialized purely in vitamins and had always had a number of research projects underway that were rooted in the company’s strong research culture. In post-war times, Nycomed sold generic products on the home market but it had no products that were suitable for export. This meant that it was restricted to and dependent on the small Norwegian market for survival. In 1959, a review of its product portfolio, with the aim of product renewal, led to the discovery of a substance that could be patented as an x-ray contrast media. Although Nycomed’s move into the x-ray contrast media field was not planned, it was to become a massive success. The invention of this groundbreaking technology meant that Nycomed was able to create a new world market to serve.

Today, Norway is one of the world’s largest producers of x-ray contrast media. This is entirely due to the success of Nycomed, which was the world’s 28th largest pharmaceutical company in 2009 with turnover of EUR 3.2 billion (Nycomed 2011). In contrast, in 1975, Nycomed had only 250 employees and no profit. By 1993, there were 1,250 employees in imaging operations alone, which had become extremely profitable.

In addition, the Norwegian biotech sector is subject to increasing attention in the media. According to a survey conducted by The Research Council of Norway (2011), the majority of Norwegian managers believe that biotech will become as important in the future as the oil and

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[2] This section is based upon "Nations, Clusters and Culture: Nycomed and World Leadership in the Field of X-ray contrast Media" by Knut Sogner (1993).

gas industry is today. The same survey states that international studies indicate that 40% of the global economy will be biotech-based by 2025.

The development of the global biotech industry in the 1990s was directly linked to pharmaceuticals. Pharmaceutical firms, which are based in traditional chemistry, found themselves unable to create and foster innovative research environments, which were a prerequisite for product development. Smaller biotech firms took over in niche areas and it became more cost effective for pharmaceutical firms to obtain new product concepts and technologies through these biotech firms (Haanæs 1997).

The rapid development of the Norwegian biotech industry required an equally rapid legal and regulatory response to address novel ethical situations. The Norwegian Biotechnology Advisory Board was established in 1991 in order to provide guidance and advice. A gene technology law was passed in 1993 and a biotechnology law was passed in 1994. International developments have also affected Norwegian policy, such as the 1997 cloning of Dolly, which led to a total ban on the cloning of primates and humans in Norway (The Norwegian Biotechnology Advisory Board 2011).

In the early days of 1993, over 2,000 biotech firms were active worldwide but few had managed to show a profit (Gibson 1993). One exception was the Norwegian biotech firm Dynal. Dynal was established in 1986 as a joint venture between two large Norwegian industrial firms and boasted annual earnings growth of 35% from 1989 to 1994. From the outset, Dynal's management recognized that the Norwegian home market was too small in terms of commercialization and research but that it would serve well as a platform for successive expansion.

Initially, Dynal entered the niche market of HLA tissue typing and worked closely with the National Hospital in Oslo in order to develop magnetic, particle-based biological separation systems, known as Dynabeads®. Research applications provided an influx of cash to Dynal in 1988, which enabled the company to pursue therapeutic uses for its unique technology. In 1989, it began to focus on applications in the field of molecular biology. Rather than competing with the main players, Dynal chose to establish non-exclusive supply agreements. By 1992, the firm was confident that it had built up the cash flow, reputation and track record needed to enter the growing microbiology market (Haanæs 1997). The acquisition of Dyno Particles in 2000 allowed Dynal to gain control of the entire manufacturing chain. In 2005, Dynal was acquired by Invitrogen Corporation, US, (now Life Corporation), and changed its name a year later to Invitrogen Dynal AS.

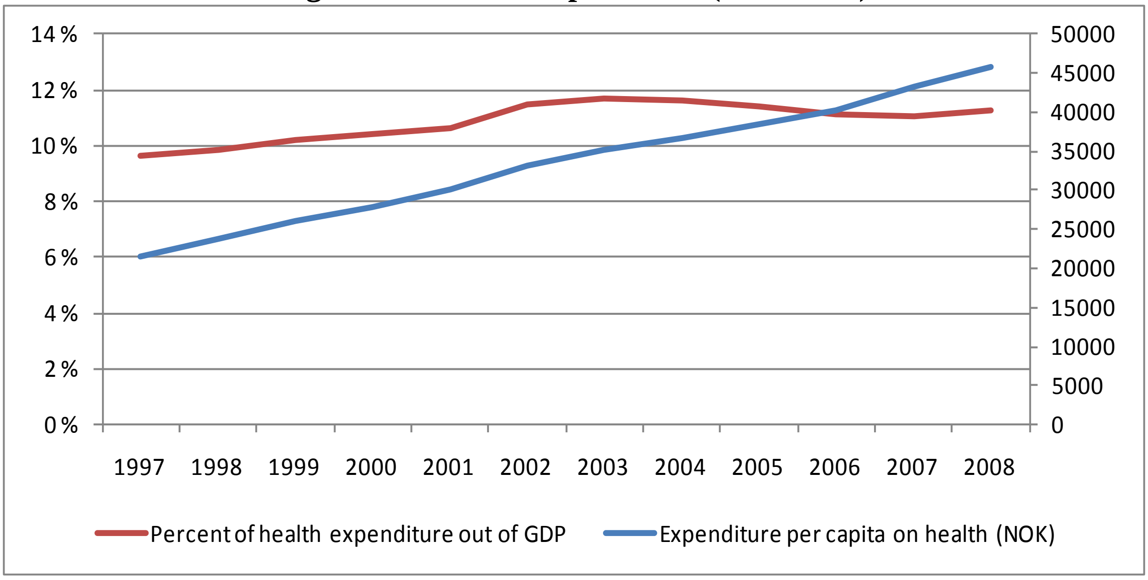
A number of Norwegian biotech firms are currently experiencing growth and exceptional value creation. In the largest deal in Norwegian biotech history to date, Algeta signed a deal with Bayer worth NOK 5 billion in September 2009. That same year, DiaGenic was hailed as Norway's most innovative firm by the Research Council of Norway; Clavis Pharma raised NOK 130m; and Photocure signed a deal for the development and commercialization of Lumacan, a photodynamic colorectal diagnostic worth NOK 500m. All of these firms are members of the Oslo Cancer Cluster (OCC), which plays an important mediating role in terms of linking clinicians, academics and biotech firms together in order to improve cancer diagnostics and treatments, and help with the commercialization of innovative developments.

A handful of success stories have induced optimism in the market with regards to the ability of Norwegian firms to create value from biotechnology. A focus on commercialization and innovation within the Norwegian biotech and pharmaceutical industries will help to ensure the development of better products and services relevant for diagnosis and treatment on a global basis. However, this focus will also be important on the national level in terms of creating value in the Norwegian economy.

Figure 2-1 describes both the expenditure on health per capita (right axis) and health expenditure as a percentage of GDP (left axis). Health expenditure per capita doubled from 1997 to 2008 (from NOK 21,401 to 45,842). Over the same period, health expenditure as a percentage of GDP increased from 9.6% to 11.3%. With the aging population, longer drug development times and related costs, more advanced diagnostic tools, and the increased focus on the consumption of health products, the trend is likely to continue.

In this respect, health problems can be viewed as opportunities for value creation. The main mental model that has determined the developmental path of the Norwegian health industry has been based on a publicly financed health sector in which health services are viewed as unavoidable costs. The industry, however, offers many opportunities for value creation on a global scale. These opportunities have attracted the attention of scientists, investors and public authorities, and have resulted in the investment of considerable resources in the pursuit of health-related innovation. In this study, we focus on the value creation potential of the Norwegian health industry.

Figure 2-1: Health expenditure (1997-2008)



Source: Statistics Norway

In this research report, the health industry is broadly defined as the range of firms active in the fields of biotechnology, medical technology and pharmaceuticals that are involved in diagnosis and treatment and support activities for both the development and commercialization of medical equipment and drugs. 6,340 firms make up the population of health-related firms. For the purpose of this project, all actors within the health sector in Norway were classified into one of seven categories. Figure 2-2 illustrates the seven sectors, their underlying definitions and examples.

Diagnosis: This sector includes firms that specialize in developing biotechnology and medical technology-based tools for the diagnosis of diseases. This is a relatively small sector with

1,625 employees in 79 firms (2008), and it includes such companies as Invitrogen Dynal AS, GE Vingmed Ultrasound and Axis-Shield ASA.

Treatment: This sector includes 5,337 employees in 305 firms. The sector includes firms that specialize in developing biotechnology-based treatments for diseases and in developing medical devices (acoustic, dental, optical, orthopedic) to treat diseases and it includes such companies as Pronova and Biotec Pharmacon.

Figure 2-2: Classification of the health industry

Sector	Definition	Examples
Diagnosis	Firms specialized in developing biotechnology and medical technology-based tools for the diagnosis of diseases	Invitrogen Dynal AS, GE Vingmed Ultrasound
Treatment	Firms specialized in developing biotechnology-based treatments for diseases and medical devices to treat diseases (e.g., acoustic, dental, optical, orthopedic)	Pronova Biopharma, Clavis Pharma
Research Institutions	Research organizations and funds for research	Radium-hospitalets Forskningsstifelse
Service	Services related to life sciences, e.g., testing, contract manufacturing, health IT, risk assessment, packaging, storage, clinical, commercial, consulting, capital solutions and maintenance of medical technology	Invent2
Wholesale and Retail	Wholesale and retail sales of health products and services	NMD, Vitusapotek
Hospitals and other care institutions	Hospitals and other care institutions, including private and public organizations	St. Olav's Hospital, Ullevål University Hospital
Human and veterinary services	General practitioners, nursing, physiotherapy and veterinary services	GPs, Pharmaq AS

Research Institutions: Research institutions serve an important function in the provision of knowledge and testing for this R&D-intensive industry. The sector includes small and large research-based institutions, as well as funds for research. This sector employs 346 people in 71 firms. Examples include Radiumhospitalets Forskningsstifelse and Stavanger helseforskning.

Service: This small sector employs 479 employees in 50 firms (2008). It includes technology transfer offices, health automatization services, patent registration and testing services. Examples include Invent2, Exova and Bevital AS.

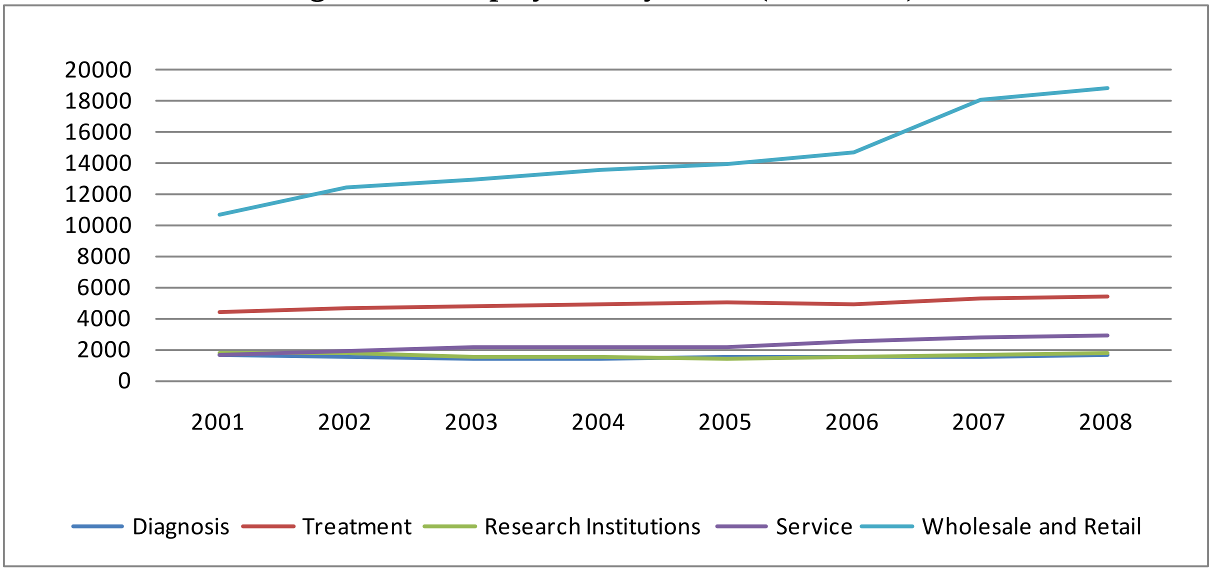
Wholesale and Retail: This is the industry's second-largest sector. It employs 18,813 people in 1,922 firms (2008). The firms in this sector include large foreign wholesalers, such as Alliance Healthcare Norge AS and Boots Norge AS, and their respective vertically integrated retailers.

Hospitals and other care institutions: This sector includes both private and public hospitals and clinics, including St. Olav's Hospital and Ullevål University Hospital. This sector is by far the largest with 106,585 employees (2008).[3]

Human and Veterinary Services: This sector includes general practitioners, nursing institutions, physiotherapy institutes and veterinary services. This sector employs 10,400 employees in 3,025 service-providing firms (2008). Henceforth, we refer to this sector as Human Services.

The main aim of this project is to assess the industry surrounding the provision of care services rather than to evaluate the value and cost of the provision of such services. As this study does not focus on the assessment of efficiency and effectiveness of hospitals and other care institutions, or on human and veterinary services, these sectors are not examined in this report.

Figure 2-3: Employment by sector (2001-2008)[4]



Sources: Statistics Norway and BI

Figure 2-3 provides an overview of the size of each sector over time measured in terms of employment. While employment in the Wholesale and Retail, and Service sectors grew (including organic growth, new establishments and M&A) from 2001 to 2008 (by 75% and 73%, respectively), employment in the Diagnosis and Research Institutions sectors remained stable whereas Treatment grew by 21%.

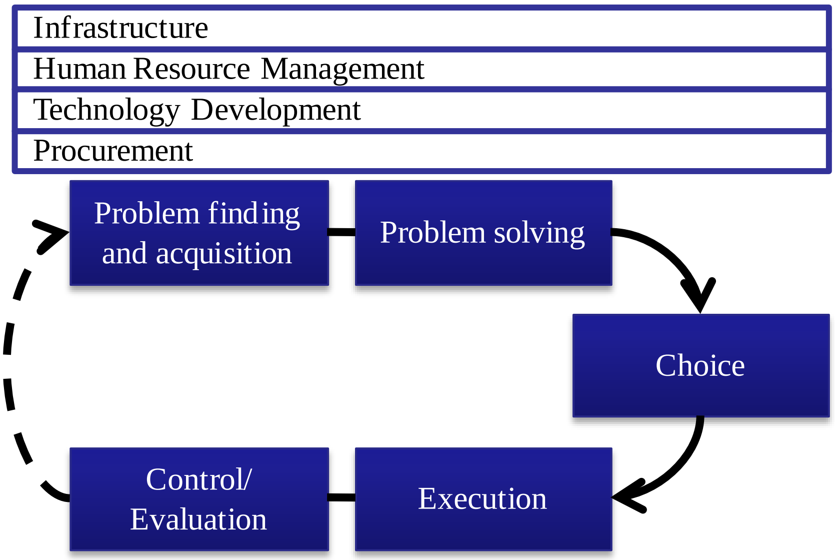
2.2 Value creation

Building on Thompson's (1967) definition of long-linked, intensive and mediating value-creating technologies, Stabell and Fjeldstad (1998) suggest that Porter's (1985) value chain is just one of three value-creation logics. They introduce the concepts of value networks and value shops. Health firms are best characterized as value shops, that is, firms that utilize the

[3] As a result of the reorganization of the health sector in 2008, a number of hospitals do not appear in the database for that year.
[4] It should be noted that because the population of health firms has been developed in recent years, it may not include firms that are no longer in existence due to mergers, acquisitions or bankruptcies.

organizational intensive technology for the creation of value. Value shops resolve customer or client problems. Their activities are both cyclically and sequentially interdependent. The most critical attribute of these activities lies in the fact that customers, who lack expert knowledge, face significantly greater information asymmetries than specialized actors. This situation prevents customers from solving problems themselves. In terms of the organization of value shop firms, it is critical to match the problem with the appropriate problem-solving resources. Value shop firms are best modeled as performing five generic primary activities, which are supported by general secondary activities (Figure 2-4).

Figure 2-4: Health firms modeled as value shops



Stabell and Fjeldstad (1998)

A value shop's generic primary activities include the following. *Problem finding and acquisition activities* are associated with the search for and identification of a problem, and acquiring the rights to solve that problem. *Problem solving activities* are associated with the generation and assessment of alternative solutions. *Choice activities* are related to the selection of a solution, while *execution activities* are related to the carrying out of the solution. *Control and evaluation activities* are related to the measurement and evaluation of the effect of the solution.

Primary activities are highly interdependent, which creates a necessity of coordination among an organization's activities. Value creation in value shop firms is characterized by the high level of knowledge intensity that is inherent in the reliance on professionals. As every problem has unique features, specialist knowledge is essential, which often leads to a referral to a more specialized expert within the problem domain. The main driver of value in value shop firms is a firm's reputation, which is determined by its ability to solve a customer's problem through its ability to access unique, specialized knowledge.

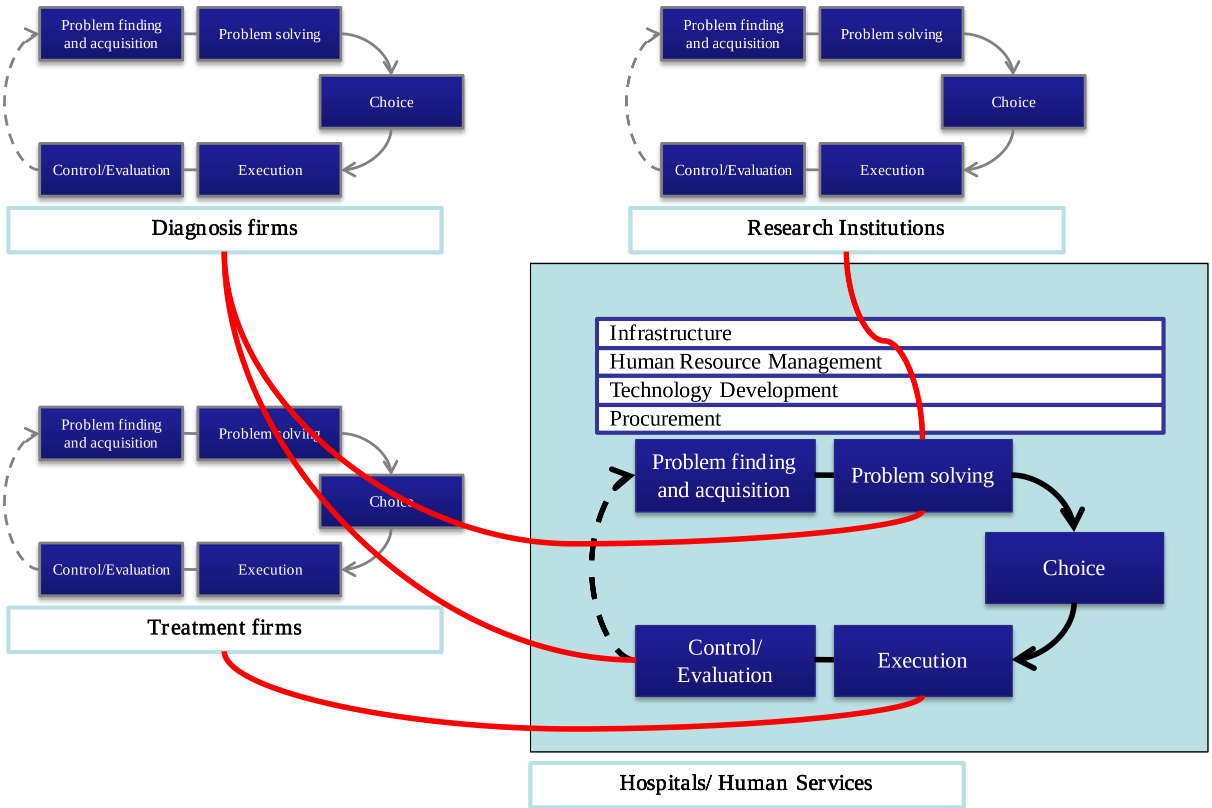
The value shop concept is best exemplified within the health sector by hospitals. For example, a patient approaches a medical service provider with a possible medical condition (problem finding and acquisition). Expert doctors (resources) are allocated to the problem on the basis of their specializations to diagnose the patient through consultation and testing (problem solving/diagnosis) or by referrals to other specialists (referral leading to problem finding and acquisition activity of the specialist). These doctors select (choice) and administer (execution) a treatment, and reassess whether the patient's problem has been resolved (control/evaluation).

The process is iterative in that it begins again if the control reveals that the problem has not yet been resolved.

2.3 The value system

How is value created in a system of multiple value shops? The health sector's value system follows the value shop logic, with firms and institutions contributing to different activities in the process of creating value by solving customers' problems. How, then, do industry actors relate to one another? Value creation in the health industry is characterized by referrals, subcontracting and competition. Referrals materialize when problems are passed from generalists to specialists, and from one generalist or specialist to another. Subcontracting materializes when the responsibility of the solution for a portion of the problem is delegated to another actor. Subcontracting is based on individual networks of relations and on reputation. Competition refers to firms or individuals competing for the same customer, such as the competition seen among general practitioners. These are common characteristics of industries that create value by solving customer problems. The health industry, therefore, serves as a good example of the operation of the referral, subcontracting and competition mechanisms in relationships among firms belonging to the same sector.

Figure 2-5: Value configuration on the industry level – the value system



Based upon Stabell and Fjeldstad (1998)

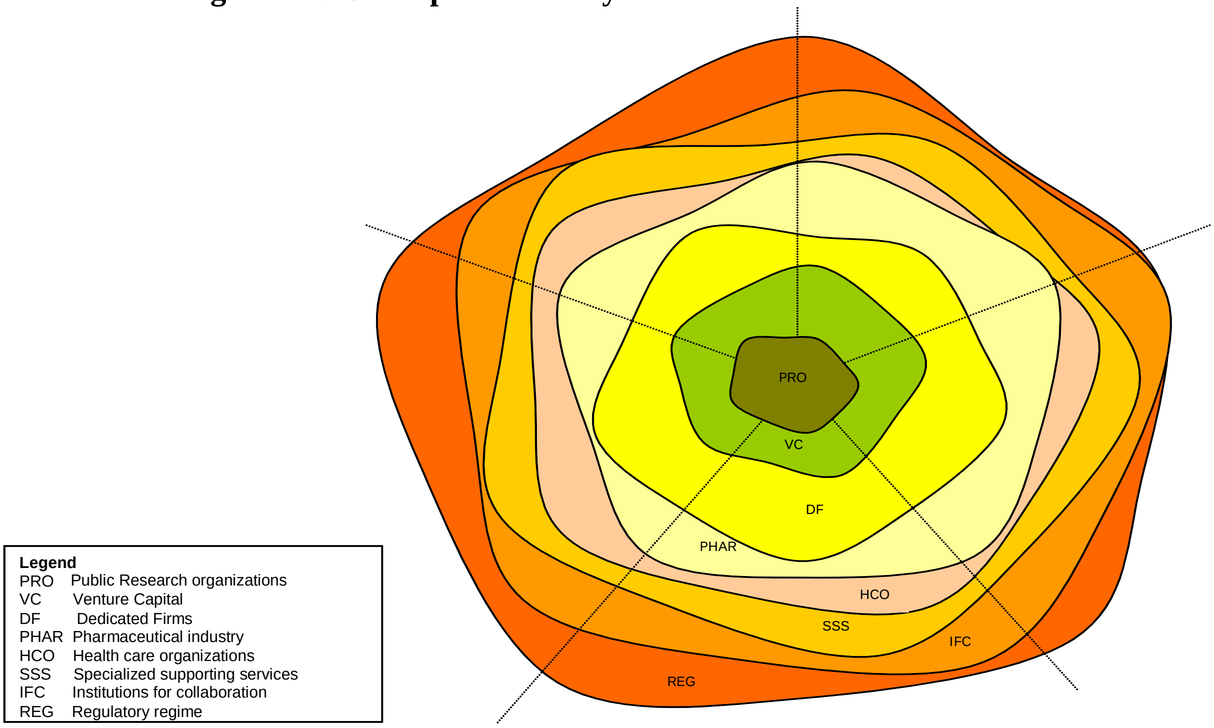
Figure 2-5 illustrates the relationships among the different sectors. Hospitals and Human Services represent individual value shops engaged in solving patient problems. However, the value system of the entire industry is also strongly influenced by a network of relations and the reputation of the different firms in the system. The referral, subcontracting and competition mechanisms among actors within the health sector result in firms and individuals being loosely connected to different activities. While firms active in diagnostics provide assistance in solving problems, Treatment firms provide their expert knowledge in the execution phase, where the outcome can be assessed in the following stage using the specific knowledge provided by Diagnostic firms.

These linkages and the dependence on access to different sources of knowledge in the problem-solving process determine how value is created. Diagnostic firms, Treatment firms and Research Institutions are value shops in their own right. They simultaneously refer to other firms of the same type, subcontract parts of the problem they face and compete within the sector.

2.4 Value and industry formation in the R&D-intensive sectors

To the extent that problems do not vary across the actors, the markets for diagnostic tools and treatments are global. The health-based nature of a range of problems has led to the development of a unique system that encompasses a range of steps, including basic research, a lengthy and regulated quality control process, and product commercialization. Figure 2-6 illustrates the creation of value in the R&D-intensive sectors of the health industry.

Figure 2-6: Value production system in R&D-intensive sectors



Source: Powell (2001)

At the very core of the industry are the public research organizations (PRO) that are engaged in basic research. The next layer includes competent owners and venture capitalists (VC). Competent capital is crucial to the transformation of academic ideas into dedicated firms (DF) and, thereafter, into commercialized products. Dedicated firms are small, R&D-intensive firms. VCs provide a commercial logic that supplements the scientific logic provided by the PROs. Competent owners are characterized by their inherent ability to identify and fund innovative ideas with large commercial potential. In relation to the Norwegian health industry, there is a clear lack of competent owners. In Norway, companies such as Algeta, Photocure and Biotec Pharmacon are examples of successful DFs that are highly innovative and have managed to attract funding to drive the move from innovation towards commercialization.

Funding for this transition is secured through an initial public offering or an acquisition by a player within the pharmaceutical industry (PHAR) with the financial means to commercialize.

A necessary requirement for the creation of value is the availability of medical laboratories, test facilities and intellectual property experts, and actors providing specialized knowledge services, such as testing, instrumentation, marketing, communication and IT services (SSS). The Norwegian health industry has a few institutions for collaboration (IFC) that perform key network functions. Such organizations provide meeting places, facilitate knowledge linkages, represent the cluster externally, manage government relationships and are active in global brand building. The Oslo Cancer Cluster is an example of such an organization. Finally, the industry works within a regulatory context (REG) that reinforces the focus on long-term knowledge development in the industry. Examples in Norway include the elaborated rules governing the use of medication, the approval process for new drugs, the regulatory context for stem cell research and the move towards the setting of common industrial standards.

2.5 Value creation: Conclusions

Total expenditure on health has been increasing in absolute terms and as a percentage of GDP. The expenditure on health per capita doubled from 1997 to 2008. Employment growth rates in sectors that have global value-creation potential have been disappointing. Specifically, the Diagnosis sector has not grown over the last decade, while the growth rate in the Treatment sector has been only moderate. Growth in the R&D-intensive sectors is far outrun by growth in the support and logistics sectors.

The Norwegian health industry imposes costs on the public as a result of the large, publicly financed health sector. However, it offers many opportunities for value creation on a global scale. These opportunities have attracted the attention of scientists, investors and public authorities, and have resulted in the investment of considerable resources in the pursuit of health-related innovations.

Value shop firms create value by solving customer problems through a process of acquiring and diagnosing problems, choosing between alternative solutions, and executing and evaluating solutions. Knowledge of the problem domains and professionalization in various domains are central characteristics of the system, which make this industry extremely knowledge intensive, as reflected in long, professionalized educational programs. The industry is not formed in isolation. A constellation of actors and institutions that invest considerable resources over a few decades is a prerequisite for the formation of an innovative diagnostic and treatment cluster.

The remaining chapters of this report provide an evaluation of health-related value creation through the development of new treatment and diagnostic products and services, and related support activities.

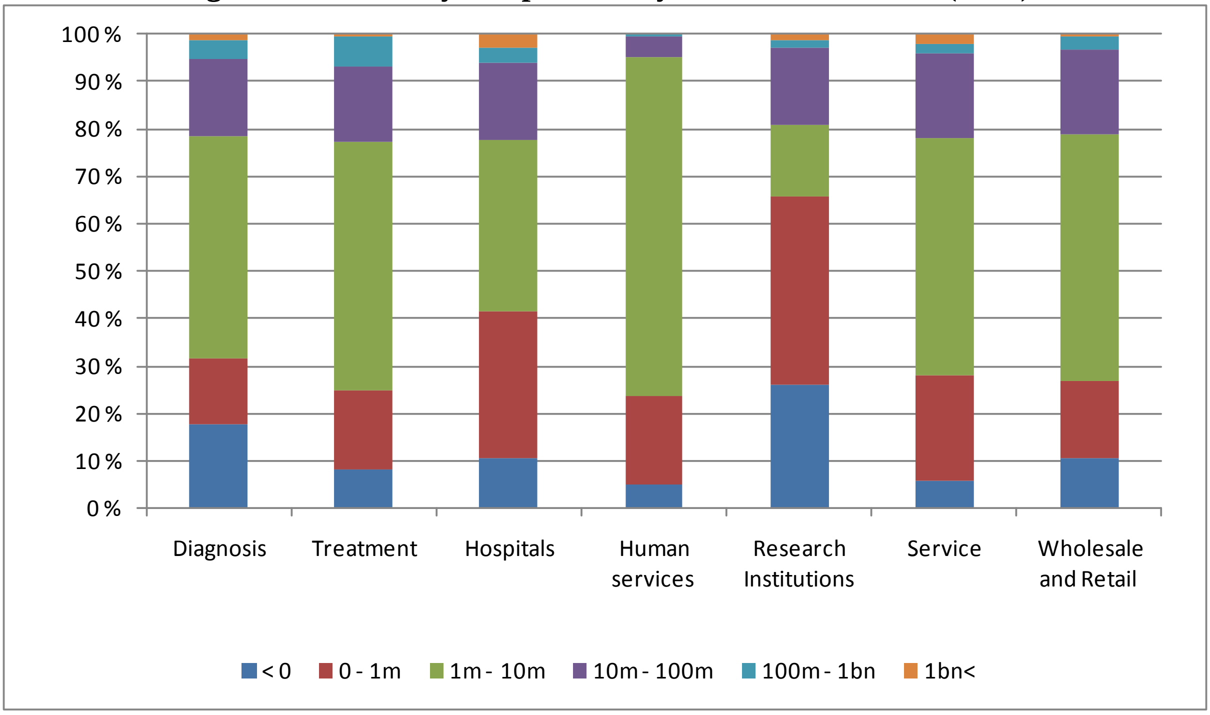
3 Cluster Attractiveness

This chapter discusses the degree to which the cluster of Norwegian health firms is attractive. In particular, we assess the degree to which the cluster contains all relevant activities (its completeness), the existence of a critical mass of firms in all parts of the industry activity system, its value creation properties and its geographical distribution.

3.1 Cluster completeness

An investigation of the completeness of the Norwegian health industry reveals the existence of economic activities across all major health-related sectors. However, in major parts of the industry, the level of activity is low, and sectors lack the requisite critical mass of competing and complementary firms to be able to reap the benefits of co-specialization.

Figure 3-1: Industry composition by revenue and sector (2008)



Sources: Brønnøysund Register Centre and BI

Figure 3-1 shows the composition of firm revenue by the sector. The industry is diverse and comprises 6,340 firms. The majority of firms are involved in the provision of general practitioner services, veterinary services (in total 3,025 firms), and wholesale and retail sales of developed products (1,922). There is also a large number of hospitals and other care institutions (885). 8% of firms are involved in the development of products and services, or in supporting activities. The industry is characterized by a large number of very small firms: 86% of firms have annual revenues of less than NOK 10m. For comparison, the corresponding figure in the oil industry is 76%.

In terms of activities related to the creation of products and services, the Wholesale and Retail sector contains the highest number of high-revenue firms. This can be attributed the to the consolidation trend seen since the deregulation of the pharmaceutical market in 2001. In Wholesale and Retail, seven firms, all of which are drugstore chains, had revenues of more than NOK 1 billion in 2008.

Industry support activities are small and largely below critical mass. The Service sector has one large firm and one medium-size firm, both of which derive much of their revenue from their involvement in other industries.

The vast majority of health-dedicated firms are very small in terms of revenue. The Research Institution sector contains one large research institution, which derives most of its income from other industries. The Research Institutions sector also contains a number of organizations (trusts) that finance research. Many of these firms have no income, which partially explains the large proportion of very small firms in this sector.

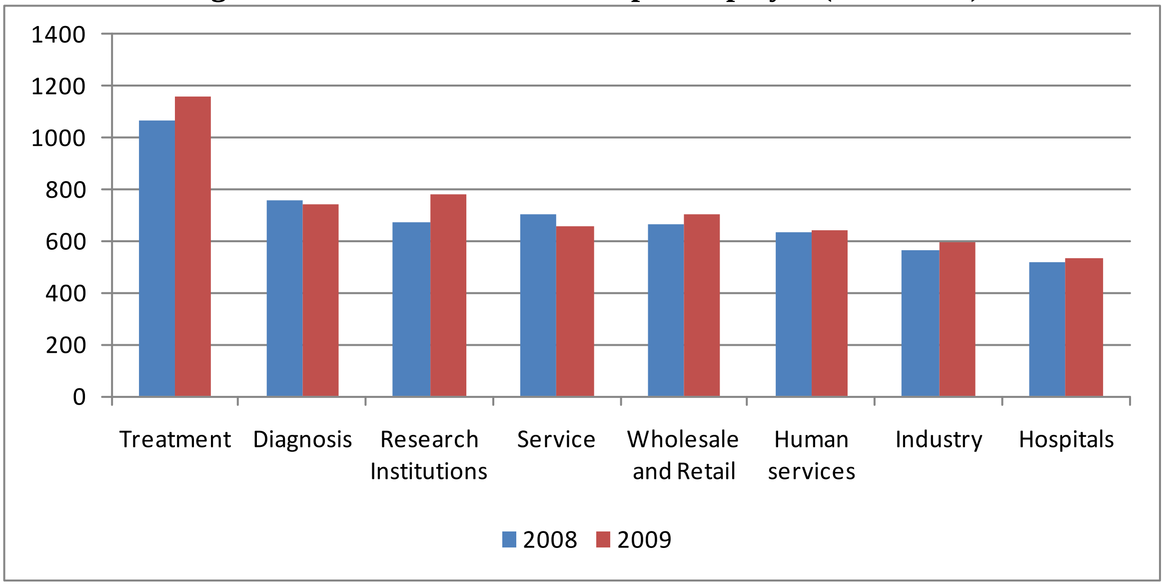
The Treatment and Diagnosis sectors are similarly distributed. 78% of firms are very small in terms of revenue (less than NOK 10m) and 16% have revenue between NOK 10m and NOK 100m. The remaining 6% have revenue of more than NOK 100m.

In summary, 8% of firms are involved in the creation of new drugs and diagnostic equipment, or the provision of ancillary services. The majority of firms in the industry are very small. The large firms in the industry (with the exception of hospitals) are foreign owned, and they are mainly involved in the distribution of foreign and domestically produced products, although there are a handful of exceptions.

3.2 Economic characteristics

Is the Norwegian health industry economically attractive? If so, are all of its parts equally attractive? The different parts of the health industry have distinct economic characteristics. All sectors create only a moderate amount of value, with the exception of fish oil products within the Treatment sector.

Figure 3-2: Gross value creation per employee (2008-2009)

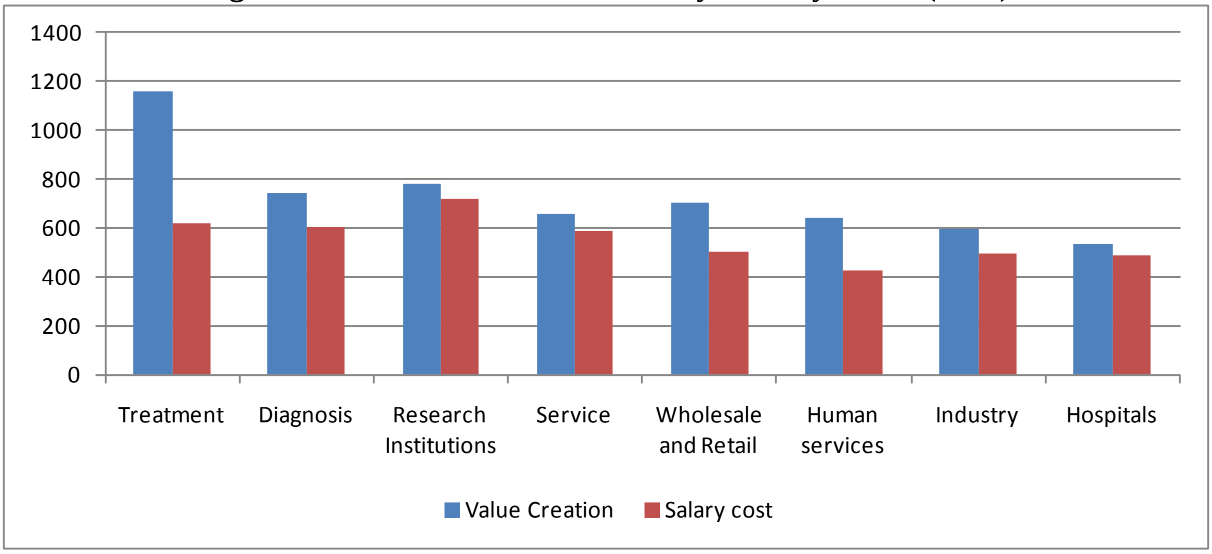


Sources: Brønnøysund Register Centre and BI

Figure 3-2 examines the economic attractiveness of different parts of the industry. It reports gross value creation per employee in thousand NOKs. Value creation in the health sector in terms of profits/losses plus salary costs and depreciation was a mere NOK 0.6m per employee in 2009. Value creation per employee in Hospitals, which is by far the largest sector, is very moderate (NOK 0.54m). The value creation in supporting services, excluding the two largest firms, that create much of their value in other industries, is NOK 0.66m for Services and NOK 0.78m for Research Institutions. Diagnostic firms generate NOK 0.74m per employee, while Treatment firms have a value creation of NOK 1.16m per employee. Treatment firms specializing in dietary supplements, especially products based on fish oil, report value creation of NOK 2.03m and NOK 1.97m per employee in 2008 and 2009, respectively. In general, value creation appeared to exhibit a positive trend in many of the sectors in 2009.

If hospitals are excluded, a clear relation between risk and return can be observed in this industry. Activities that require long-term investments provide higher value creation per employee. Activities that require more R&D (e.g., Treatment and Diagnosis) also provide higher value creation. For comparison, value creation per employee in the emerging Treatment sector of NOK 1.16m is only 17% below value creation in the Maritime industry (NOK 1.40m), which is a mature industry with a strong, extended tradition in Norway.

Figure 3-3: Value creation and salary costs by sector (2009)



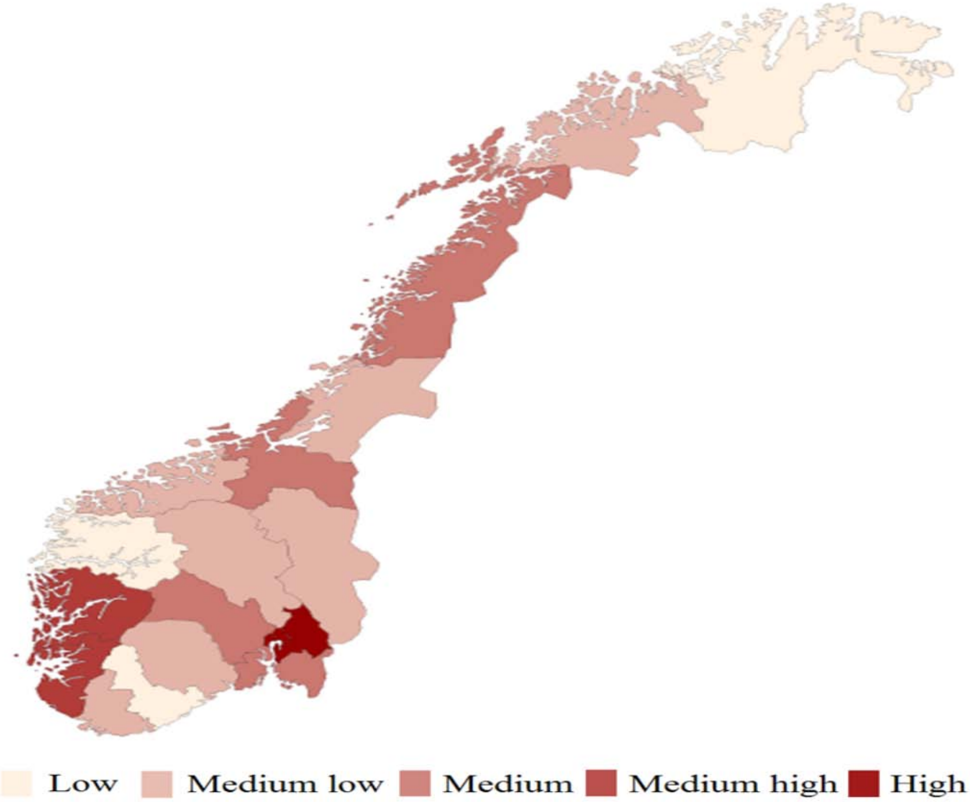
Sources: Brønnøysund Register Centre and BI

Figure 3-3 establishes that, on average, the majority of value creation (82%) can be attributed to salary costs. For the Diagnostic sector alone, the figure is 82%, while the proportions of salary costs in Human Services and in Treatment are lower (65% and 53%, respectively), as indicated by the large gap between salary costs and value creation.

3.3 Geographic concentration

An analysis of the distribution of firms by sector and size, as well as their economic performance, must be combined with an understanding of the geographic distribution of health-related economic activities. A cluster functions best when related economic activities are co-located in the vicinity of each other. In the health industry, one needs to distinguish between the provision of general health services to the public, and the creation and production of new drugs and diagnostic equipment being undertaken in sectors like Treatment and Diagnosis.

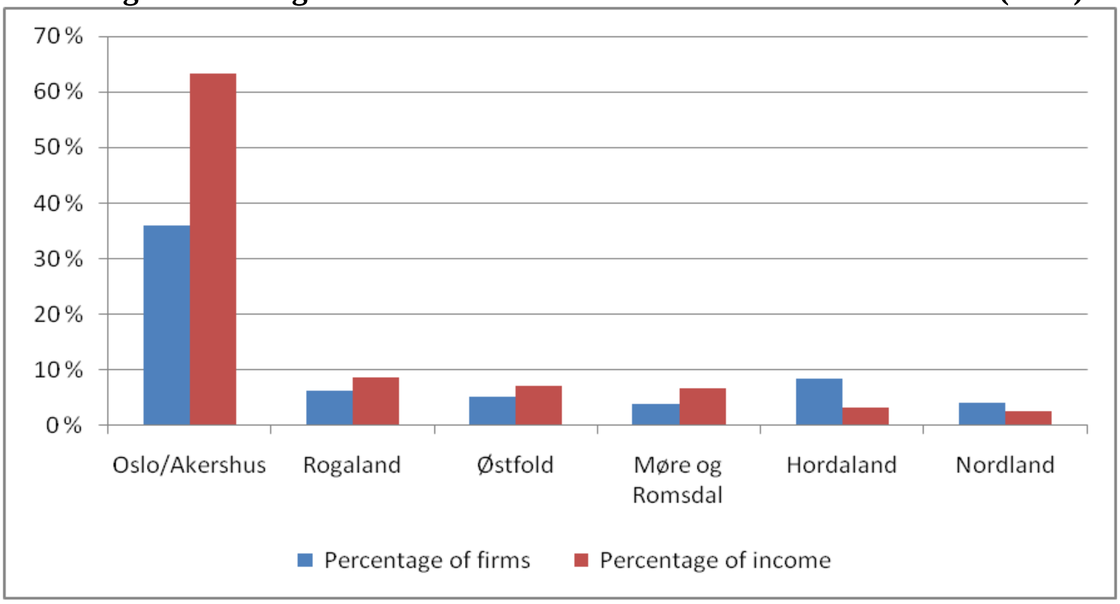
Figure 3-4: Regional distribution of health firms (2008)



Sources: Brønnøysund Register Centre and BI

To a large extent, the distribution of all health-related firms follows the regional distribution pattern of the Norwegian population. Oslo is, by far, the largest county in terms of health firm concentration with 32,000 employees, see Figure 3-4, 8% of which are scientists. A similar proportion of scientists is observed only in Sør-Trondelag (11,000 employees). The proportion of scientists in Hordaland, Rogaland, Vest-Agder and Telemark is 7%. In all other counties, the proportion of scientists is 6%, with the exception of Finnmark (4%).

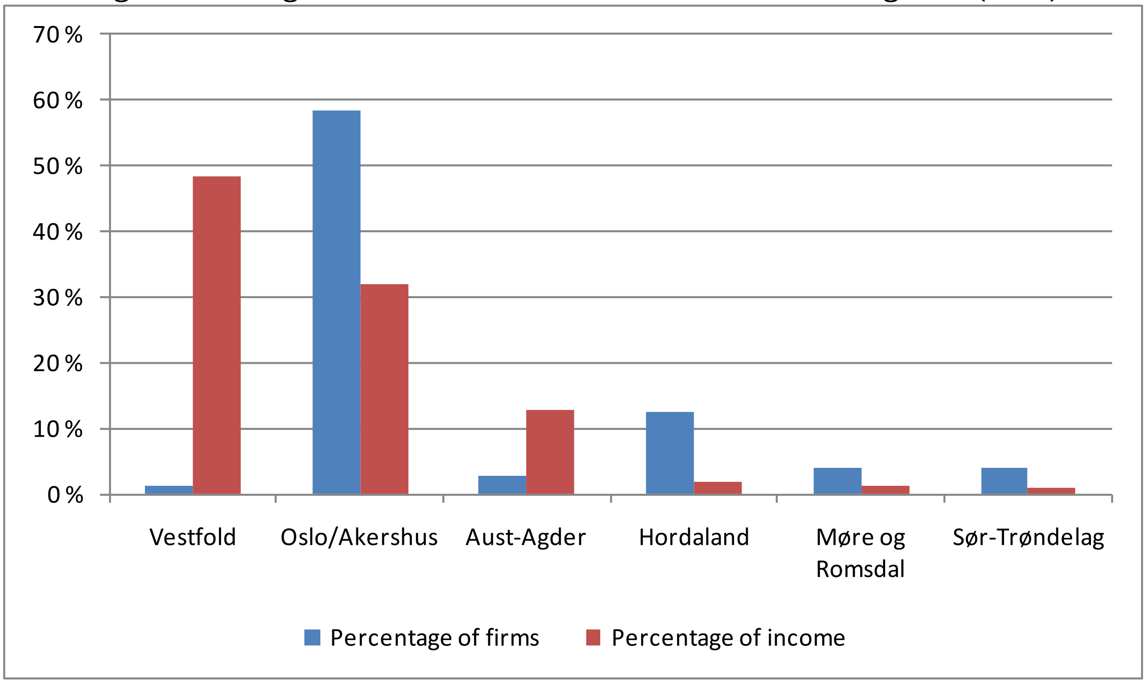
Figure 3-5: Regional distribution of firms and income: Treatment (2008)



Sources: Brønnøysund Register Centre and BI

With regards to the clustering of the creating and producing sectors, and their supporting activities, a clear picture emerges. We identify activity in most counties in Norway. However, the centrality of Oslo/Akershus for all sectors is apparent. Figure 3-5 displays both the percentage of health-related firms and the percentage of health-related income by county. The figure covers only counties with more than 1% of income generated by the health sector. 62% of all income generated by Treatment firms originates from firms located in Oslo/Akershus. One-third of all firms in Treatment are also located in these counties. Rogaland is the second-largest county in terms of income from Treatment activities, although these activities generate only 9% of total Treatment income.

Figure 3-6: Regional distribution of firms and income: Diagnosis (2008)

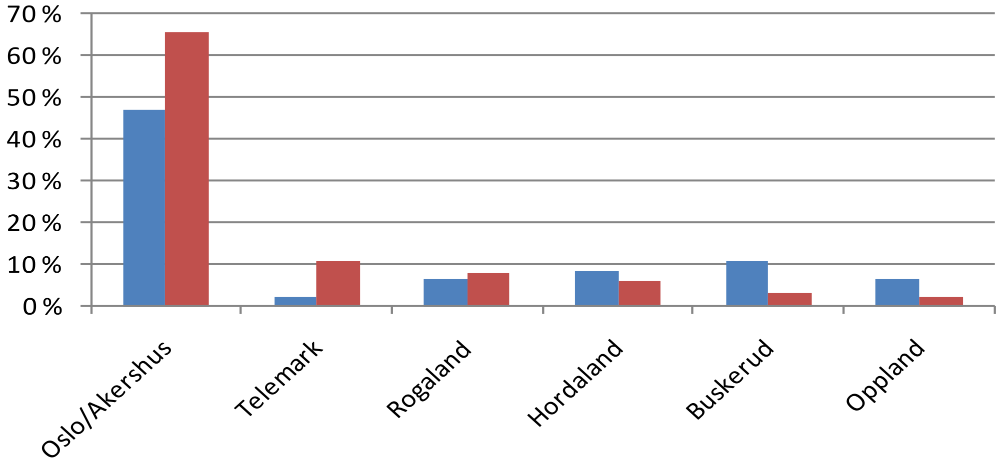


Sources: Brønnøysund Register Centre and BI

A similar picture of regional distribution emerges with respect to Diagnosis. 30% of the sector's total income arises from Oslo. The presence of GE Vingmed (48% of total income) is responsible for the large share of income originating from Vestfold. However, as is evident from the number of firms, there is no agglomeration of independent firms in Diagnosis in Vestfold.[5]

[5] We stress that there is no agglomeration in Diagnosis, which is distinct from microelectronics in general. See section 8.4 for further information.

Figure 3-7: Regional distribution of firms and income: Service (2008)



Sources: Brønnøysund Register Centre and BI

Oslo/Akershus generates the majority of income related to Services. 66% of all income and 45% of all Service firms are located in the region. There is no obvious agglomeration of Services in any other county (Figure 3-7).

Medinor

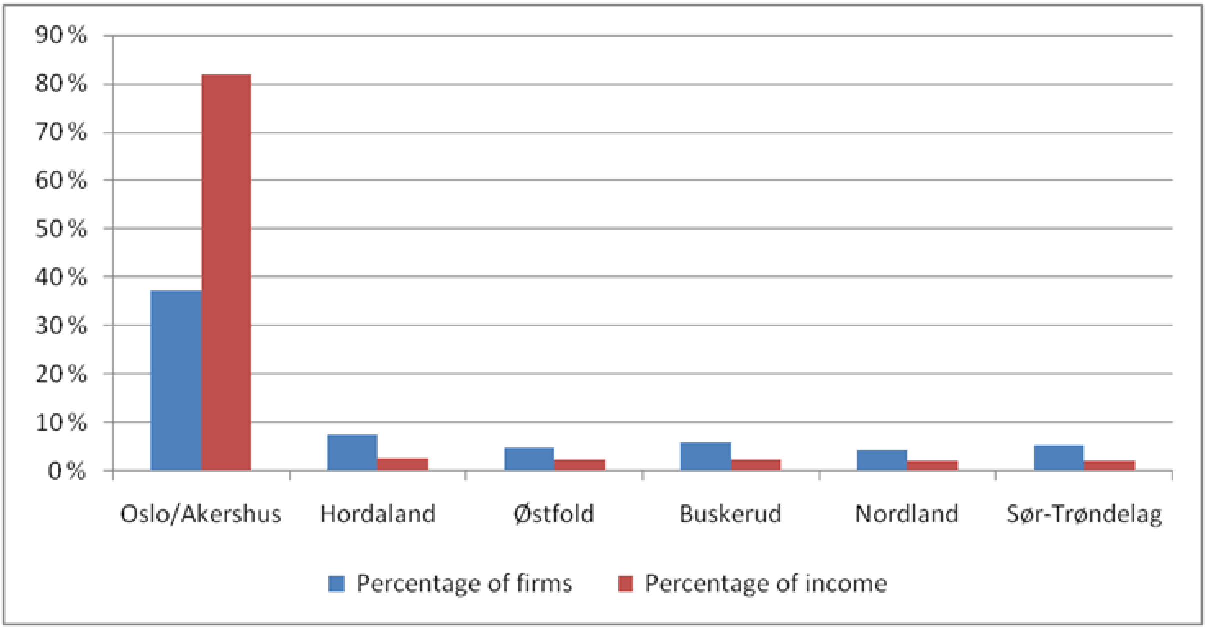
Medinor, a member of the Axis-Shield Group, has over 100 years of sales and marketing experience within the health industry. The company actively seeks to collaborate with the world's leading suppliers within its line of business. In return, Medinor offers access to its strong presence in the Nordic market. Since 2000, Medinor has considerably enlarged its portfolio of third-party products. Medinor's experience has provided it with both the position and the organization necessary to successfully introduce new products into the market. The company aims to provide superior solutions for analysis, diagnosis and treatment through highly competent staff and quality products. A strong customer orientation acts as the basis for Medinor's plans and activities.

Financial Performance

Axis-Shield Direct Distribution, including Medinor:

GBP 1,000	2005	2006	2007	2008	2009
Total operating income	27,125	29,483	32,125	40,000	43,092
Total income growth		*8.7%*	*9.0%*	*24.5%*	*7.7%*
Operating profit/loss	1,578	1,854	2,079	2,700	2,551
Operating profit/loss growth		*17.5%*	*12.1%*	*29.9%*	*-5.5%*

Figure 3-8: Regional distribution of firms and income: Wholesale and Retail (2008)



Sources: Brønnøysund Register Centre and BI

Even in the more functional sector of Wholesale and Retail, Oslo/Akershus is responsible for 81% of all income. 37% of all health-related wholesalers and retailers are located in the region (Figure 3-8).

In summary, health activity (excluding hospitals, care institutions, and human and veterinary services) is centered in Oslo/Akershus. The centrality of Oslo/Akershus is even more obvious with respect to income distribution, which indicates that large firms are located in the region. Activity outside this region is marginal. A few isolated firms exist (e.g. Leardal. GE Healthcare Lindesnes). However, with the exception of GE Vingmed's location within the micro-electronics milieu, these firms are not part of an agglomeration of health-related or any other technology-related or industry-related activities.

3.4 Internationalization

Has the Norwegian health industry internationalized, or is it a home industry that focuses on the provision of services and the development of products for the benefit of the local market? An industry is attractive to the extent to which firms have internationalized their operations. Firms that are exposed to international competition in foreign markets must outperform other firms to survive. In Norway, 47% of sales within health are exports. Interestingly in the health industry, the level of exports is high (82%). The various sectors of the industry differ substantially in terms of the degree to which they have internationalized their operations.

Figure 3-9 provides data on the average proportion of foreign sales to total sales by sector, controlling for firm size. Wholesale and Retail is clearly a home-country activity, as 99% of products and services are sold to local customers. 13% of sales originating from Research Institutions are made to foreign customers, indicating that this sector is mostly directed towards the home market. This raises the issue of the extent to which Research Institutions hold world-leading competences, as leading Research Institutions should provide advanced services to firms outside their own home market. 21% of Service sales are to foreign customers. The percentages of foreign sales in Research Institutions and Services may have implications for the level of support that the developing firms in Treatment and Diagnosis receive from local suppliers.

Figure 3-9: Foreign sales per activity (2010)

Sector	Foreign sales
Diagnosis	83%
Treatment	62%
Service	21%
Research Institutions	13%
Wholesale and Retail	1%

Source: BI Survey

The Treatment sector is in the process of internationalizing, although many of the firms in Treatment have yet to register significant sales or any sales at all. The current level of exports (62%) is high and this figure is expected to increase. Diagnostic firms have internationalized their operations and 83% of sales originate from foreign customers.

3.5 Other health clusters

What can we learn from other established and emerging health-related clusters? The key success factors are similar across such agglomerations. In this report, we highlight those success factors in relation to the Boston-Cambridge (Massachusetts, US), Medicon Valley (Denmark/Sweden), Research Triangle Park (North Carolina, US) and Cancer BioSanté (France) clusters. Although these clusters emerged and developed at different paces and along different paths, they share many common elements.

Boston-Cambridge, Massachusetts[6]

The Boston biotechnology cluster is perhaps the best known in the world. It ranks as the top life-science cluster in the US and the region receives the highest amount of governmental funding (*Top 100 NIH Cities 2004* 2011). The region is located on the northeast coast of the US and comprises the metropolitan areas of Boston, Cambridge and Worcester.

The Boston region is home to over 240 biotechnology companies and the top five National Institutes of Health (NIH) funded hospitals in the US. In addition, there are 122 colleges and universities in the greater Massachusetts area, of which over 40 offer advanced degrees in the life sciences. Many of these institutions are world-leading research universities. In 2005, these colleges and universities awarded over 4,500 degrees in fields of study related to biotechnology. Furthermore, the state ranks first in the US in terms of the percentage of residents with a bachelor's degree or higher. Boston is also well known for being one of the world's premier financial centers and for hosting a substantial community of venture capital firms. All of these factors contribute to making the region attractive for R&D.

As a whole, the state of Massachusetts is home to more than 480 biotechnology companies, of which 277 are involved in the development of therapeutic drugs. In 2009, 46,553 people in Massachusetts were employed in the biotechnology industry (MassBio 2011). Notable names in the life sciences industry that have chosen to locate in the Massachusetts biotechnology cluster include Genzyme, Merck, Biogen Idec, Vertex, Novartis and Sanofi Aventis.

[6] This section is based upon information from the Massachusetts Biotechnology Council (MassBio 2011)

The Massachusetts bio/pharma industry has witnessed 60% growth in employment since 2000. Employment reached an all-time high in 2009 (29,046 in 2000; 46,553 in 2009). In terms of employment, 2003 was the year of greatest growth in the industry (17.3%), while 2004 was the only year in the last decade during which the industry constricted (-1.6%). The cluster has grown at a faster rate than the Massachusetts economy as a whole in terms of employment growth. Between 2000 and 2004, the cluster's growth rate was 28.6% compared to a decrease of 3.4% in overall employment in Massachusetts. Furthermore, between 2005 and 2009, the cluster's growth rate was 19.7% compared to a growth rate of 5% for Massachusetts in general.

Massachusetts was the biopharma-manufacturing state with the second-highest percentage growth in terms of industry concentration between 2001 and 2009 (24.5%). Maryland had the highest growth in the same period (32.9%). Massachusetts had location quotients[7] of 1.06 in 2000 and 1.34 in 2009, which indicate that the bio/pharma industry in the region is growing well in strength and concentration.

Employment in "Biotechnology Research and Development" specifically (North American Industry Code (NAICS) 541711) is dominant in Massachusetts relative to other states, and it is growing at a higher rate. From 2007 to 2009, employment in biotechnology R&D in Massachusetts grew by 2,435 employees from 24,565 to 27,000 (compared to growth of 2,203 from 19,134 to 21,337 in second-place California).

Massachusetts also holds a dominant position in terms of industry concentration in "Biotechnology Research and Development" compared to other states. The broader industry classification NAICS 54171 "Research and Development in the physical, engineering, and life sciences" includes employment in biotech R&D as well as in related fields such as chemistry, physics, computers, electronics and aerospace. In this respect, California is the largest employer, but Massachusetts has grown faster than all other states over the last decade with growth of 102.1%.

Massachusetts was home to five of the top eight National Institutes of Health (NIH) funded hospitals in 2009, and to seven of the top sixteen. Preliminary figures for 2010 indicate that Massachusetts-based organizations received 12% of total NIH funding for basic research at a per capita rate far above that of other NIH-recipient states (first place: Massachusetts at USD 345.78 per capita; second place: Maryland at USD 148.81 per capita). Although Massachusetts still trails behind California in terms of absolute NIH funding, the general decline in funds has not been felt as strongly in Massachusetts as in all other states, which reflects the fact that the NIH sees growth potential in the region and that it is focusing its limited funding in Massachusetts.

Venture capital (VC) investments in Massachusetts-based biotech companies reached an all-time high in the first two quarters of 2010. VC investments in the region have fluctuated over the last decade, with investments notably lower in 2003 and 2005 than in other years. Overall, VC investments grew from USD 177m in the first half of 2000 to USD 548m in the first half of 2010. Massachusetts received 26% of all VC biotech investments in the US in the first half of 2010.

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[7]A measure of industry strength and concentration in a region versus the nation as a whole, where a value of 1.0 or more means that the industry has a greater concentration than the nation as a whole.

The Massachusetts Institute of Technology (MIT) is located in the immediate vicinity of the Boston biotechnology cluster. Many of MIT's support structures for spin-off formation are provided by the regional infrastructure of the Cambridge-Boston region (Breznitz, O'Shea, and Allen 2008). MIT has a strong entrepreneurial culture and has made a notable contribution to the creation of a vibrant biotechnology cluster in the Boston region.

The industry is of steadily increasing importance as a source of job growth and economic revenue. However, local low-skilled and semi-skilled workers have only limited job opportunities and are unable to reap the benefits of the industry to the same degree as highly skilled workers that move to the region (Sable 2007).

The success of the biotechnology industry in the Boston region is largely due to the efforts and innovativeness of talented individuals who move to the region. A natural result of this success is a focus on future generations of researchers and to foster scientific interest amongst high school children from the immediate area. In this respect, the CityLab program (see section 4.1) was set up in 1992 in order to provide access to advanced scientific equipment and teaching for all high school students in the greater Boston area (DeRosa and Phillips 1999). This occurs either at the University of Boston or in a mobile lab that drives around the region. The aim of the CityLab program is to provide high school students with early exposure to careers in medicine and to promote careers in biomedicine.

Harvey (2009) argues that most of the two largest groups of foreign scientists, namely Indian and British scientists, working in the pharmaceutical and biotechnology sector in Boston are likely to remain in the US, and that they have a long-term perspective on working in the region. He highlights the fact that professional opportunities are the main reason for highly skilled migrants to return to their home countries. As long as Boston's biotechnology sector continues to provide migrant workers with high levels of social, cultural and professional security, these highly skilled employees are likely to remain in the region, and to continue to contribute to regional innovation and value creation.

As of August 2010, the Massachusetts drug-development pipeline included: 362 projects in preclinical phases, 170 drugs in phase I, 277 drugs in phase II, 66 drugs in Phase III and 20 drugs awaiting approval. Therefore, a total of 895 drugs were in development in Massachusetts. This figure does not include drugs being developed in Massachusetts by companies headquartered outside the state. Massachusetts-based companies account for 11% of the US and 5.5% of the global drug development pipelines, and companies headquartered in Massachusetts have thus far commercialized 141 drug products for the treatment of 90 different medical conditions.

Medicon Valley, Denmark/Southern Sweden[8]

The Medicon Valley life-science cluster links academic institutions, hospitals and companies in the Øresund region of Denmark and Skåne in Sweden, i.e., it is a cross-border cluster. The region covers Copenhagen and surrounding towns in Denmark as well as the southern part of Sweden, (Figure 3-10).

[8] This section is based upon information from the Medicon Valley homepage (MVA 2011)

Figure 3-10: Medicon Valley

Source: Medicon Valley Alliance (2011)

Medicon Valley houses 10 science parks, 8 universities and 75 hospitals (including 4 university hospitals). There are 42,000 employees in the life-science industry in the region, which is composed of over 180 core biotechnology firms and more than 200 core medical technology firms. These firms focus mainly on Treatment (60.4%) and Diagnosis (28.2%). Approximately 4,000 employees are academic researchers. The region has a strong knowledge base that originates from the University of Copenhagen and the University of Lund, and from the presence of five major players in the pharmaceutical industry (Novozymes, Novo Nordisk, LEO Pharma, H. Lundbeck and Nycomed).

The region, which has experienced great success, has hosted numerous research projects over the years (Scupola, Steinfield, and Lopez-Nicolas 2010). Today, Medicon Valley accounts for more than 20% of the total GDP of Denmark and Sweden combined. There are a number of large pharmaceutical firms with production facilities in Denmark (Biogen Idec, Alpharma, Bavarian Nordic, Statens Serum Institute, CMC, Novozymes, LEO Pharma, Nycomed, Ferring, Fertin and Ferrosan). Most notably, Medicon Valley is home to the world-leading Novo Nordisk, which holds 50% of the world market for insulin.

Medicon Valley is considered to be especially competent in the biotechnology research areas of neurological disorders, inflammatory diseases, cancer and diabetes. It is the leading biotech cluster in Europe in terms of biotech patents relative to the number of total patents. In addition, the region rates as number two in Europe on the Best Performance Index of the Biotechnology Innovation Scoreboard (Van Beuzekom and Arundel 2006).

The presence of a comprehensive drug development pipeline makes the region particularly attractive to R&D-intensive firms. The regional setup helps to speed up the development of drugs from the preclinical trial stage to testing and onto final production, which in turn means a quicker time to market and that firms may begin to recoup their R&D investments quicker than in other areas. In fact, the Medicon Valley pipeline is the second-largest commercial drug development pipeline in Europe (Ernst&Young 2008). The region receives governmental support through "Invest in Denmark" promotions that are specifically focused on the life-science cluster. The region is marketed globally to biotech firms that may wish to locate in Europe.

Research Triangle Park, North Carolina[9]

The Research Triangle in North Carolina is one of the few southern US locations that has any prominence in biotechnology and it appears set to follow the same path in nanotechnology (Youtie and Shapira 2008). North Carolina is the third-largest biotechnology state in the US and Research Triangle Park is located at the heart of the Raleigh-Cary and Durham metropolitan areas. North Carolina has a strong base in manufacturing and contract research organization (CRO; 91 CRO firms in the state) but a limited R&D infrastructure. Biotechnology companies in North Carolina are generally smaller in size and scale than in other clusters.

Research Triangle Park is home to 450 life-science companies employing approximately 55,000 workers. Governmental funding, supplied through the National Institutes of Health, totaled USD 931m in 2007. VC funding averages USD 154m per year. The region has significantly lower costs than competing US clusters, such as those in California and Massachusetts, which is positive in terms of attracting investors and firms. However, VC presence and investments are limited compared to the other US biotechnology clusters, as is the availability of commercial talent.

The high concentration of nationally ranked medical schools – two of which (Duke University and the University of North Carolina at Chapel Hill) are advanced research institutions – creates a strong academic bioscience research presence in the region. However, the universities do not have prominent connections to the dominant, leading national institutions such as those based in the state of Boston, and the region therefore struggles to compete with other national biotechnology clusters. This has led to the Research Triangle lagging behind in terms of issued patents and license income.

Cancer BioSanté, Toulouse, France[10]

In 2005, it was announced that Europe's largest centre for cancer research, Cancer BioSanté, was to be built on the site of a major chemical explosion in Toulouse, France (Abbott 2005). The blast, which had occurred on September 21, 2001 at the AZF fertilizer production plant owned by Total, was one of the worst industrial accidents to ever occur in Europe. 30 people were killed and thousands were injured. The site of the blast was cleaned up by Total and sold to the Cancéropôle project for the token sum of "one franc".

Planned public investments in plants and equipment for the cancer research site were set at approximately EURO 600m. The authorities' vision was that the cancer centre would form the heart of a regional network of cancer research and care. Many cancer research groups and institutions scattered throughout the region could now be located together and be able to benefit from the presence of shared facilities. In a positive response to the initiative, two major French pharmaceutical companies (Sanofi-Aventis and Pierre Fabre) announced that they would move to the new site and planned to build labs to develop new drugs based on the cancer research that would be taking place there.

[9] This section is based upon information from the Research Triangle Park homepage (RTP 2011)
[10] This section is based upon Abbott (2005)

This cancer center is just one part of the so-called Cancer-Bio-Health Cluster in Toulouse. The region is host to a strong industry network. Its main strengths lie in prevention, nutrition, therapeutic compounds and home-care relating to cancer.

The R&D environment is critical for the continued growth and development of the region. There are currently 2,000 public sector researchers and 1,650 private-sector researchers working in the area. The Midi-Pyrénées region, where Toulouse is located, is home to France's second-largest university cluster. There are 611 life-science research professors distributed throughout the four universities in the region. This provides a strong knowledge base and continued interest in further R&D at the affiliated universities.

There are currently 68 organizations in the cluster, including 21 major companies, such as Sanofi-Aventis. Ten international corporations (including Glaxo-SmithKline, IBM, Siemens and Lallemand) have also chosen to locate at the centre. The greater area is home to 99 small and media-size enterprises (SMEs) and 20 centers of excellence, and is supported by 10 local authorities.

The region received EURO 16m in state aid, which has been supplemented by private sector donations in the form of financial foundations and support for start-ups. This relatively young cluster is still growing and shows good signs of progress. Companies in the cluster filed a total of four patents in 2007. The Toulouse life-science cluster has a strong international outlook with a clear focus on international cooperation with foreign clusters, involvement in international projects and participation in European programs. This focus improves the cluster's benefits and leads to inter-cluster information sharing to support the common goal of advancements in cancer diagnosis and treatment.

Figure 3-11: Clusters and mechanisms

	Boston	Medicon	Research Triangle	Cancer BioSanté
Institutional R&D	+++	++	++	++
Firm R&D	+++	++	+	+
Scientific scope	+++	++	++	+
Venture capital	+++	++	+	+
Public institutions support	+++	++	++	+++
Critical mass	+++	++	++	+
Completeness	+++	++	+	+
Patenting	+++	+++	+	+

In summary, these clusters share a common focus on R&D, and are all characterized by private and public institutions that support such activities. They differ in the quality of their institutions, the availability of VC funding, the size and diversity of cluster members, and their scientific portfolios. Outputs also differ greatly. The OECD (2010) examined patenting activities between 2004-2006 in three of the four clusters and found that the Massachusetts cluster controls 5.2% of all biotech-related patents (1,422 patents), while Medicon valley controls 1.7% (454 patents) and North Carolina controls 1.2% (336 patents).

3.6 Cluster attractiveness: Conclusions

Economic activity in the health-related sectors is highly concentrated in the Oslo region. However, many of those sectors have yet to reach critical mass. This situation is further explored in chapter 8, where competition is discussed. There is only one emerging health cluster in Norway, namely in the Oslo region. Isolated activities in Hordaland, Sør-Trondelag and Tromsø are likely to remain as stand-alone projects, as a critical mass of firms working on related projects is unlikely. The same pattern is evident in terms of the distribution of some of the largest health firms, like Laerdal.

Value creation in the health sector is moderate with average value creation of NOK 0.6m per employee. Treatment is, by far, the highest value-creating sector (NOK 1.1m). Salary costs are very high in the health industry and constitute 82% of total value creation. Treatment is the sector in which salary costs are lowest as a proportion of value creation per employee (53%). Diagnosis has a very large portion of foreign sales (83%), as does Treatment (62%). Advanced services are also internationally oriented, as are some parts of research-based services. Retail and Wholesale is a home-market sector.

Biotech clusters around the world share common characteristics. Cross-cluster comparisons indicate that a focus on the underlying mechanisms of value creation and industry formation are of the utmost importance. Such comparative studies may allow for a greater understanding of what allows certain biotech clusters to flourish and evolve where others fail.

4 Educational Attractiveness

The ability of an industry to successfully compete in its relevant market is increasingly dependent on investments in human capital. Clusters are specialists in translating generic education into productive use. While educational programs in various disciplines are found around the globe, there are generally only a few clusters for each discipline and these are located in just a few countries. The distribution of commercial activity based upon the knowledge of a specific discipline is spiky. This is even more apparent when the combination of knowledge of a number of disciplines is required. In other words, such commercial activity is not uniformly distributed across countries or regions.

Clusters can only excel in productively channeling knowledge if the human capital existing in educational institutions has the necessary basic knowledge and if that knowledge is increasing. Investments in human capital are first made by educational institutions outside the scope of control of industrial actors. Such investments enable the creation of industries. If they are lacking, they contribute to the disappearance of industrial activities (for example, the required knowledge about constructing hydropower stations no longer resides within the human capital of the younger generation of Norwegians as a result of political factors, educational factors and a substantial reduction in the activity level). All else equal, if an industry is to be attractive over an extended period of time, it must be able to attract the best human capital into educational programs that provide the prerequisite knowledge upon which firms can build further. Therefore, in this chapter we focus on the investments made by educational institutions, while we focus on competence development programs initiated by the firms themselves in chapter 9.

Specialized Education Programs: OCC, Radium Hospital and Ullern High School

The Oslo Cancer Cluster (OCC) and Radium Hospital are working in close collaboration with Ullern High School to foster the next generation of researchers and entrepreneurs in biotechnology and oncology. Construction has already begun on OCC Innovation Park, which is due to open in August 2013. It is hoped that the Innovation Park will serve as Norway's leading environment for education, research and industry within life sciences, while also shortening the time that it takes to develop new diagnostic tools and treatments against cancer. The OCC Innovation Park is the first of its kind to integrate a high school with research institutions and leading biotechnology companies within the field of cancer R&D.

The academic partnership between Ullern High School and OCC has already begun in the form of Innovation and Creativity Camps, guest lectures at the school, and biology projects based on the latest research in the field. This unique project aims to bring clinical cancer research and biotechnology together with Ullern High School, locating them in close proximity to each other and actively promoting cooperation between actors in the OCC Innovation Park. The aim of this project is to ensure and strengthen recruitment to life science fields, and to support research by improving the quality of education in math and science and nurturing a keen interest in the field (OCC 2011; UVS 2011).

Human resources generally receive advanced, subject-specific education through public education systems. As the OECD comments, "…almost every aspect of R&D and innovation requires the input of skilled people" (OECD 2010, : 41). On a country level, Norway as a whole has performed worse than the vast majority of OECD countries with regards to education. The proportion of graduates with science and engineering degrees increased slightly from 1998 to 2007. Norway educated approximately 7.5% of its graduates in engineering and an equivalent percentage in science, which places Norway in sixth-last place among the OECD countries (OECD 2010). There are even greater grounds for concern when the shares of degrees awarded to women are examined. With only 28% of science and engineering degrees awarded to women, Norway exhibits lower levels of gender equality than other OECD countries, including the traditionally male-dominated societies of Italy (38%) and Spain (37%), and lower levels than in other Scandinavian countries (Finland 29%, Sweden 34%, Denmark 34%). Therefore, it is pertinent to examine the extent to which Norway educates future generations in subjects pertaining to the health industry.

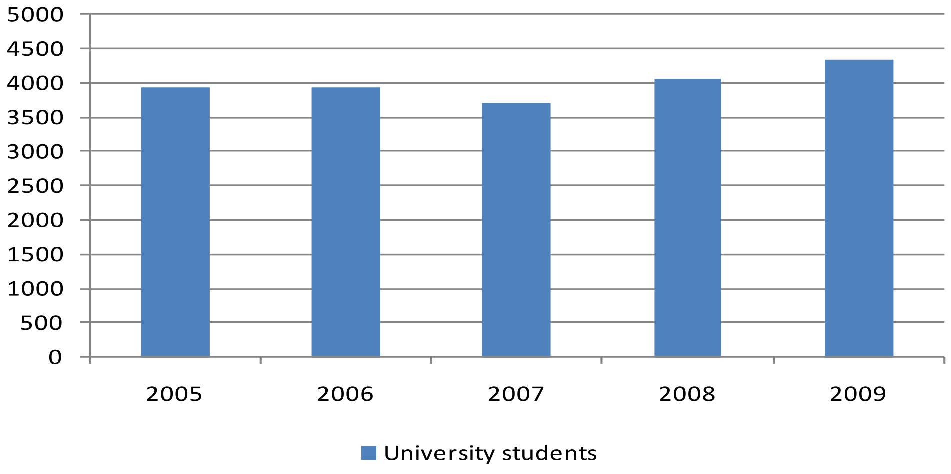
An attractive education program should lead to increasing interest in the program in absolute and relative terms. Absolute terms concern the availability of qualified personnel in the future, while relative terms concern the relative attractiveness of the subject to the general student population. All else equal, lower figures in relative terms will lead to the relevant industry representing a lower share of GDP in the future because a growing number of graduates will find employment in firms engaged in other activities.

In this study, “educational attractiveness” is operationalized in the following manner:

- Level and growth of university students studying in health-related fields,
- Share of university students studying in health-related fields,
- Level and growth of students studying in health-related fields by educational level

A distinction is made between the Bachelor, Master and PhD levels. University students are therefore specifically categorized as Bachelor, Master or PhD students in health-related subject areas. To account for the lack of data on PhD students before 2002 and the impact of the Step I implementation of the Amendments to the University Acts in 2002,[11] which followed the Bologna process on higher education, the analysis is conducted using annual figures for the period from 2005 to 2008.

Figure 4-1: University students in health-related fields (2005-2009)

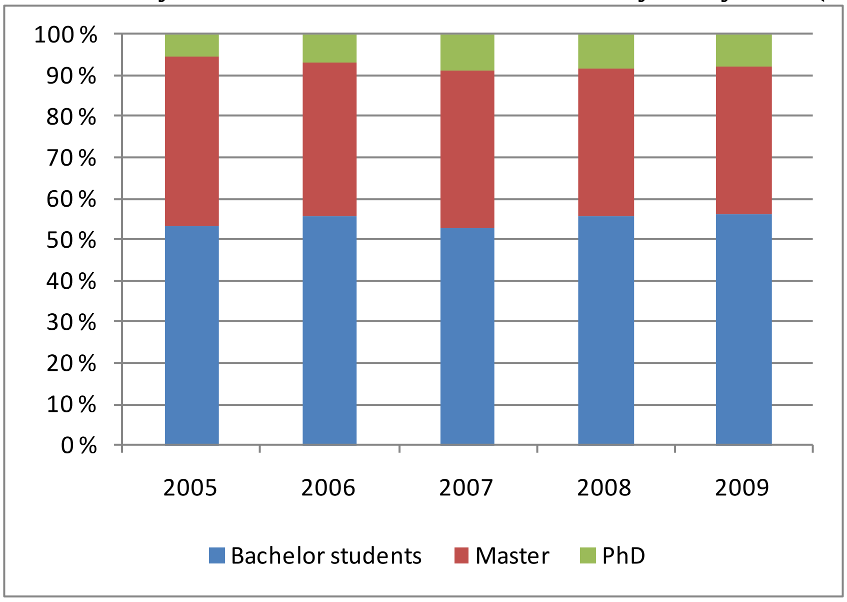


Sources: NSD and BI

[11] The amendments made in response to pursuance the EU harmonization of educational programs (Bachelor, Master and PhD).

As Figure 4-1 illustrates, the number of graduate students enrolled in health-related subjects has fluctuated. The 6% decline in 2007 was caused by a decline in the number of Bachelor students (11%) and in the number of Master students (3%). The average annual growth rate for graduate students in health-related subjects is 2.6%, indicating that health-related subjects are attracting more students and, as a result, the education sector is producing a growing number of qualified workers. In particular, we observe significant growth in the core subjects of chemistry (54% on the Bachelor level and 11% on the Master level) and biotechnology (78% on Bachelor level and 128% on Master level). Average growth in all related fields is the same level a the national growth rate for graduate students (3.1% per annum on average in the same period).

Figure 4-2: University students in health-related fields by study level (2005-2009)

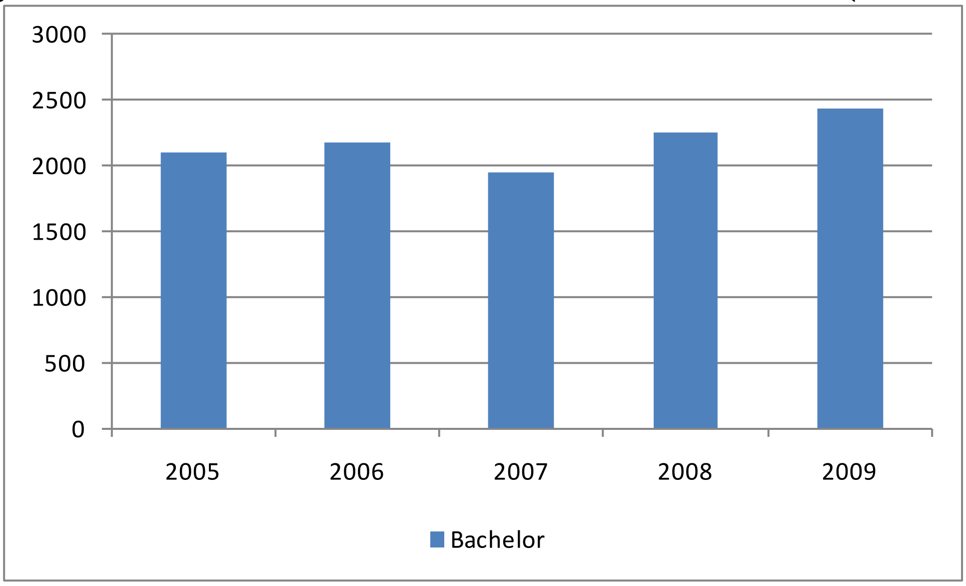


Sources: NSD and BI

Figure 4-2 illustrates how the different levels of higher education are distributed over time. The share of Bachelor students is increasing slightly, while the share of Master students is decreasing. The share of PhD students increased from 5.6% in 2005 to 7.8% in 2009, indicating that this educational level is supplying an increasing share of talent to the health sector. The percentile composition of students in health-related subjects is relatively constant over time with the exception of PhD students which is growing. However when examining each educational level more closely, a different picture emerges.

4.1 The attractiveness of various health-related education levels

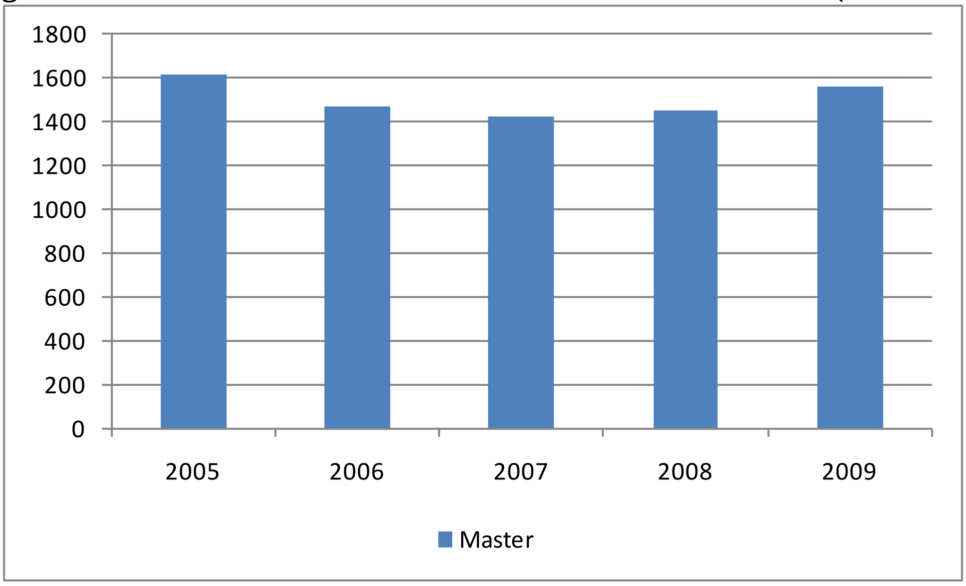
Figure 4-3: Number of Bachelor students in health-related fields (2005-2009)



Sources: NSD and BI

The number of bachelor students in subject areas related to health has been increasing at an average annual rate of 5% (Figure 4-3). This growth is in line with the average growth rate for all Bachelor level students in Norway (4% in the reference period). This indicates that health-related fields of study do not attract more Bachelor students than the average field of study.

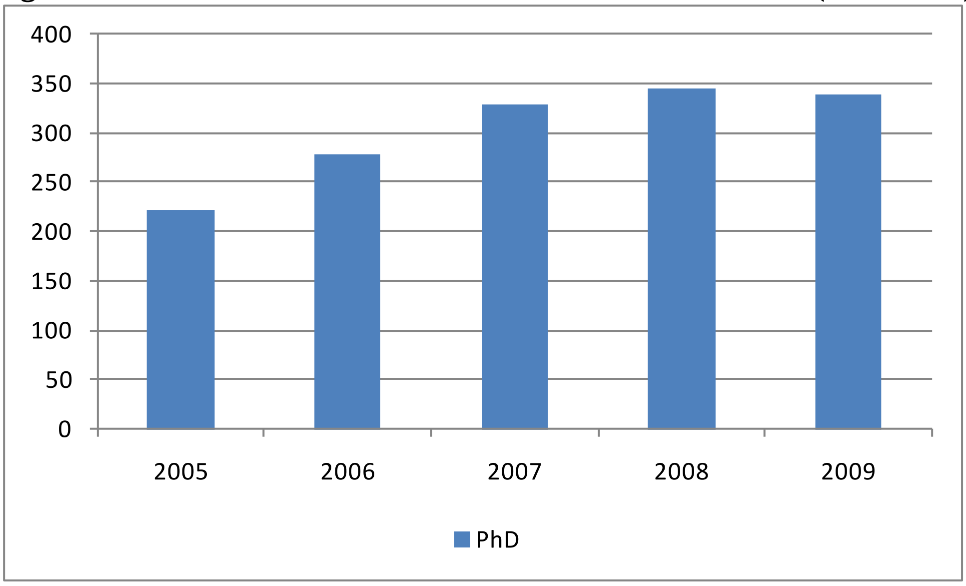
Figure 4-4: Number of Master students in health-related fields (2005-2009)



Sources: NSD and BI

Figure 4-4 illustrates the development of Master-level students in health-related subjects. The graph indicates a *negative* linear trend in the level of Master students in subject areas related to the health industry. The average annual decline amounts to 1% (2005-2009). Although the decline in 2007 was partially offset in 2008 and 2009, the trend is negative. This is a source of great concern. First, although this rate is negative, there is a positive growth rate for the total number of Master students nationally. Second, Master students hold important positions in this knowledge-intensive industry. A 10% decline in the number of Master students means that firms have a smaller pool of talented graduates from which they can choose future employees and that fewer graduates have the possibility to undertake doctoral studies, which are much needed in this industry.

Figure 4-5: Number of PhD students in health-related fields (2005-2009)

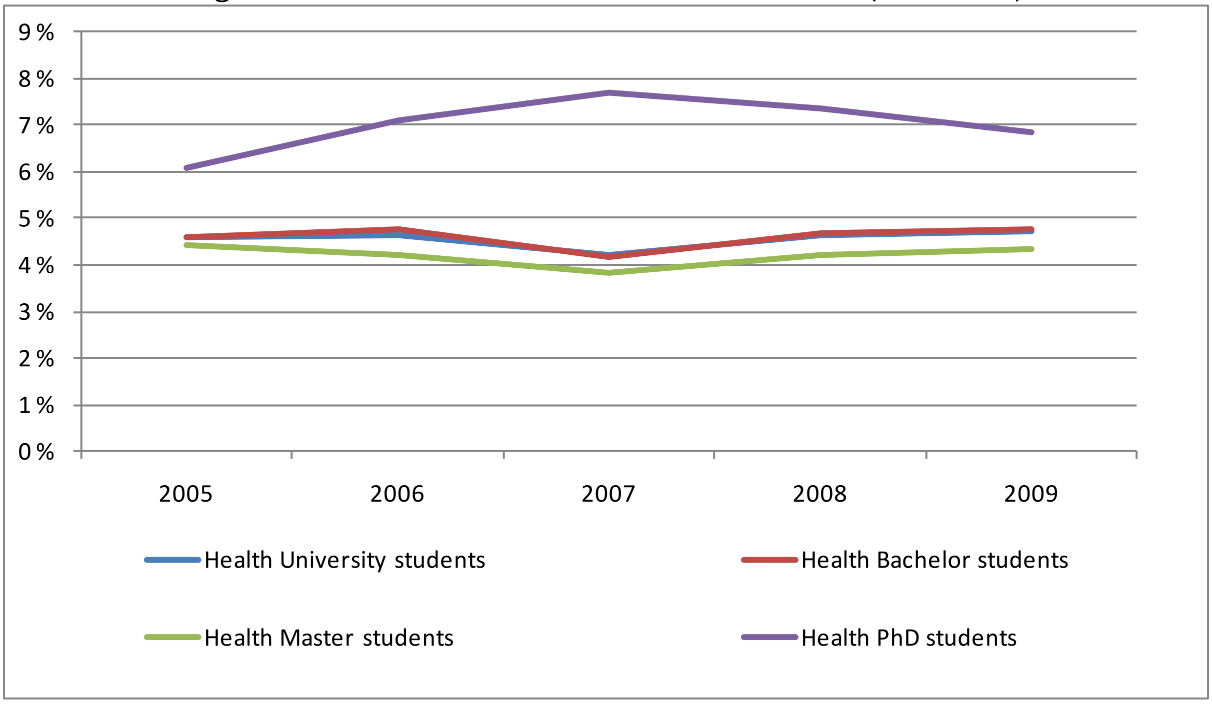


Sources: NSD and BI

As the positive slope of the trend line in Figure 4-5 indicates, the number of PhD students in health-related subjects is growing. While the growth rate of PhD students in all subjects was 10% from 2005 to 2009, the growth rate in the number of PhD students in health-related subjects was 52% over the same period. This positive trend indicates the growing importance of PhD students in the health sector. It also indicates a positive outlook, as the supply of PhD graduates may meet the growing demands for such graduates in the sector. However, this trend should be considered in conjunction with two other factors. First, national investments in biotechnology, especially Norwegian Research Council (NFR) investments, partially finance this increase in the number of PhD students. For instance, the NFR's FUGE program financed 80 of the 339 doctoral positions in 2009. Second, the pool of students who are eligible to undertake doctoral studies, is shrinking, which may jeopardize the return on investments in PhD studies.

Figure 4-6 gives an indication of the centrality of health-related subjects relative to the national development in the total population of students at each level. If health-related fields are gaining in popularity among the student population, the proportion of students taking health-related subjects should increase. In this regard, a comparison of the development of the number of students in health-related subject areas relative to all subject areas in Norway shows that the shares for Bachelor and Master students remain stable at 4-5%. However, the share of PhD students is considerably higher (Figure 4-6). It has shown a positive trend between 2005 and 2007. While this can be partially attributed to the nature of the health sector and to the recent national focus on biotechnology investments, it also highlights the importance of PhD graduates to the health sector compared to other industries. We however observe the declining relative attractiveness of doctoral studies in health-related fields in 2008 and 2009.

Figure 4-6: Attractiveness of health-related fields (2005-2009)



Sources: NSD and BI

Specialized Education Programs: Boston CityLab

Boston University has established a bioscience education program, known as CityLab, which specifically targets Boston-area students in grades 7 through 12. The goal of the CityLab program is twofold: to provide equal educational opportunities within biotechnology and medical sciences for all students in the greater Boston area, and to develop their confidence and ability so that they are able to consider careers within the field.

A lack of funding for education means that many schools in the region can only provide very basic scientific equipment for their students. These schools typically rely on theoretical explanations rather than practical demonstrations in the classroom. Without exposure to rich learning experiences, students are unlikely to develop a passion for science and research.

The CityLab program focuses on providing participants with meaningful, hands-on laboratory experience either at the Boston University School of Medicine or in a mobile laboratory bus. The two laboratories can accommodate 200 students per week and approximately 3,000 students participate each year. Sessions are well structured, with teachers closely involved at every step. In addition to regular class visits, students are encouraged to participate in the CityLab Biotechnology Club, the summer Biotechnology Camp and independent science fairs.

4.2 Educational attractiveness: Conclusions

Doctoral educational programs are developing in both absolute and relative terms. However, the source of this increased popularity is unclear. On the one hand, there may be a real demand for an increasing number of doctoral graduates in the market. On the other hand, such programs may be flourishing as a result of public-sector investments (e.g., FUGE), which may cease in the near future or following a change in government. We revisit these possibilities in chapter 5.

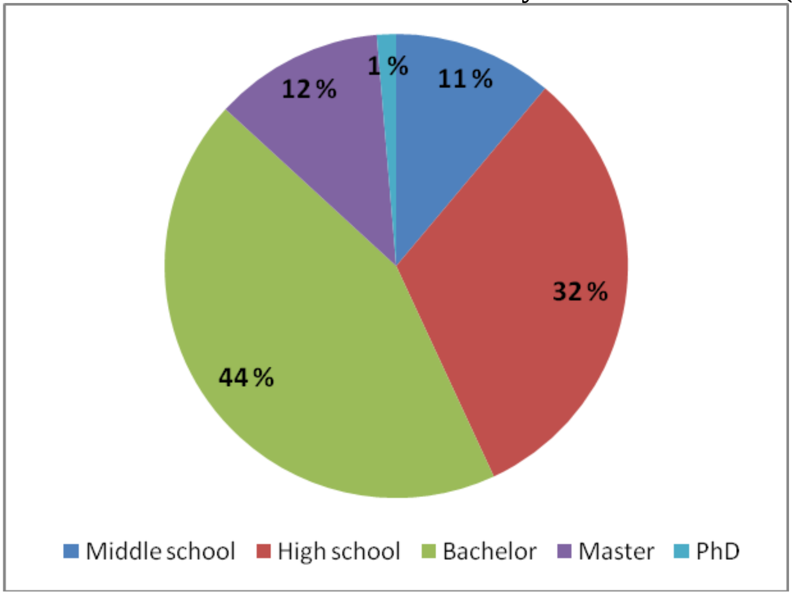
Another reason for concern is the variability and the moderate negative trend with regards to the number of Master students. This shrinks the pool of Master students who can accept employment in Treatment and Diagnostic firms, or proceed to doctoral studies, which are of central importance in this industry. The industry is not increasing its attractiveness for Bachelor or Master students and its attractiveness for doctoral candidates is on the decline after a period of growth from 2005 to 2007. The proportion of students engaged in health-related studies has remained constant. An introduction to health-related and biotechnology-related subjects is not part of the Norwegian early education system. An experimental project (Ullern High School) is on the way but it represents an exception to the rule rather than the modus operandi.

5 Talent Attractiveness

Educational institutions produce one kind of unique resource: knowledge workers. Industries and firms compete in labor markets to attract the most talented individuals within the workforce. To the extent that an industry can attract talented individuals, it is better positioned than an industry that cannot. Hence, the output of initial investments by educational institutions has to be attracted to specific industries. For an industry to be competitive over an extended period, it must be able to attract highly competent human capital before it can commit resources to new technologies and competence development.

In this chapter, we focus on the degree to which the health industry is successful in recruiting and retaining highly developed human capital. In chapter 8, we focus on competence development programs initiated by the firms themselves.

Figure 5-1: Distribution of the labor force by educational level (2008)



Sources: Statistics Norway and BI

Figure 5-1 displays the educational level of employees working in the Norwegian health industry. This division of human capital is unique among Norwegian industries. On the national level, 15% of all employees in the private sector have had only a secondary school education, compared to 11% in the Norwegian health industry. The largest differences are observed in the proportion of employees with high school and Bachelor educations. These figures are 52% and 20%, respectively, on the national level. In the health sector alone, however, 32% of the workforce has only a high school education, while 44% has a Bachelor education. The percentages of employees holding Master and PhD degrees in the health industry are similar to the national averages (11% and 1%, respectively).

If we further examine the proportion of the workforce with a university education and the proportion without a university education, a similar picture of the professionalism of the industry appears. Nationally, 32% of the workforce in the private sector has a university degree. In the health industry, 57% of the workforce has a university degree, of which 13% are postgraduate degrees (Master or PhD). On the one hand, the high percentage of employees with a Bachelor degree indicates the professionalism of the health industry. On the other hand, the extremely high knowledge intensity of this industry, especially in the Treatment and

Diagnosis product development sectors, is not reflected in the distribution of the workforce with advanced human capital. The fact that the distribution of employees with Master and PhD degrees mirrors the overall distribution in the Norwegian private sector indicates that the industry is under-invested relative to the human capital that is required in order to be globally attractive.

Figure 5-2: Distribution of employees by educational level (2000-2008)

Sources: Statistics Norway and BI

Figure 5-2, which indicates the distribution of employees among five educational levels over time, allows for inferences about major shifts in the industry with respect to professionalization. If we distinguish between the lower educational levels (middle and high school) and the higher education levels (Bachelor, Master and PhD), a shift is observed over time. In 2000, 40% of the workforce had a university degree, while the corresponding figure in 2008 was 57%.

At the same time, the share of the workforce in the industry with a Bachelor-level education increased from 26% in 2000 to 44% in 2008. A rising trend is also observed for employees with a Master-level education (from 9% in 2000 to 12% in 2008). The percentage of employees holding a PhD degree, however, remained constant at 1%. Despite the increase in the number of doctoral students evident in Figure 4-5, those investments have only had a marginal impact on the professionalization of the industry as a whole. Most of the increase over the period can be attributed to the professionalization of health care services rather than to further professionalization of advanced, research-based economic activities.

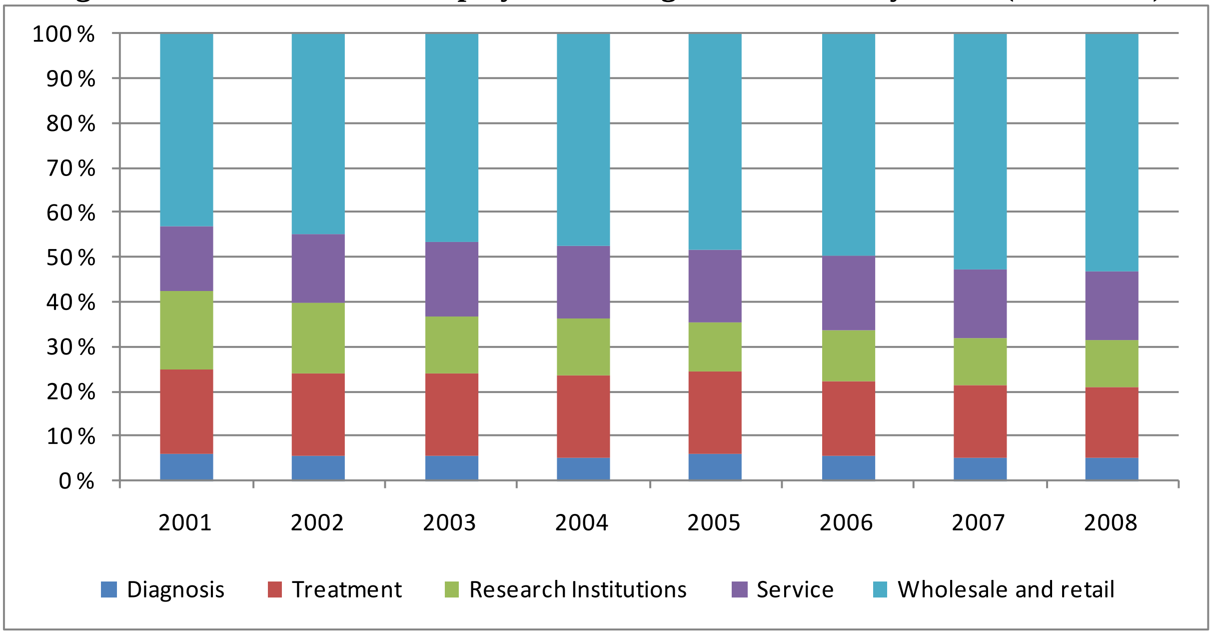
5.1 Talent and activity

As discussed in chapter 2, the health industry is composed of various problem-solving firms that conduct similar activities and are interdependent on one another. The main differences between these firms lie in the role of knowledge in the generation of value and the respective markets. Treatment and Diagnosis activities are based on the exploration of new knowledge, or the combination of old and new knowledge in order to create new products and services, or to provide production capacity for previously developed products and services. To the extent to which the problems do not vary, these markets are global. In sharp contrast, hospitals and general practitioners (including veterinarians) focus mainly on applying developed knowledge to expected and unexpected health-related problems. Their markets are mostly local.

Hence, the talent-related findings discussed above should be examined in light of the distribution of talent and the growth of that talent in each sector. We therefore examine the distribution of workers by sector before we analyze the attractiveness of each individual sector.

Figure 5-3 displays the distribution of employees with higher education in five sectors of the Norwegian health industry (Hospitals, and Human services are excluded). Wholesale and Retail is the largest sector in the early stages of the investigated period and its relative share increases steadily over time. In 2008, 62% of employees were employed in the Retail and Wholesale sector. In comparison, only 5% of employees worked for Diagnostic firms in 2008.

Figure 5-3: Distribution of employees with higher education by sector (2000-2008)



Sources: Statistics Norway and BI

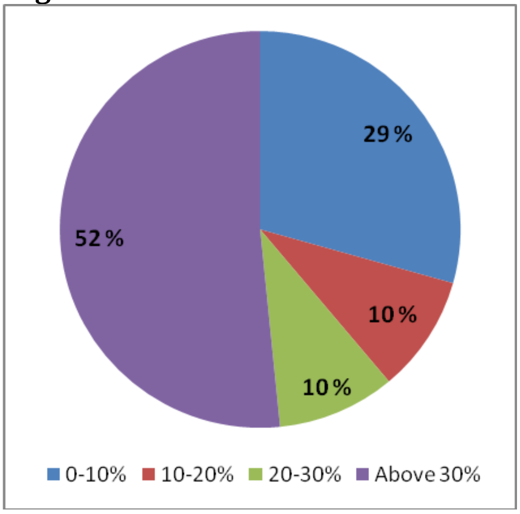
An examination of the growth rates for the different sectors reveals that the major driving force behind growth is wholesale and retail sales of multinational drug and medical equipment products in Norway. Wholesale and Retail has experienced the highest growth in university educated labor, with a growth rate of 25% over seven years. This can be partially attributed to the large-scale deregulation of pharmaceutical trading, which began in 2001 and the trend is unlikely to continue at the same pace given that the sector is simultaneously experiencing stagnation on the demand side and margin cuts on the regulatory side.

The remaining sectors have experienced declines in the proportion of employees with university education over the same period. Diagnosis and Treatment have experienced a decline of 10-20%, while Research Institutions experienced the largest relative decline of 39%.

These findings have important implications. Although the industry is growing, growth is highest in the distribution of health-related products. Its vast majority of its products are imports. In particular, the two sectors that have received specific government investments, Treatment and Diagnosis, have declined in terms of their relative share of university educated employees in the health industry.

A related data source provides further support for this observation. The main focus of the majority of firms operating in the health industry is on sales, marketing and customer relations. Figure 5-4 details the distribution of firms in accordance with their focus on commercialization. 52% of firms have more than 30% of their workforce conducting sales, marketing and customer relationship activities. In comparison, only 29% of firms operating in the oil and gas industry have more than 30% of their workforce focused on such activities. Is the industry mostly characterized by retail and wholesale activities – and the related administrative and economics-educated workforce – or is it a true knowledge-intensive industry?

Figure 5-4: Percentage of workforce in commercialization activities (2010)



Source: BI Survey

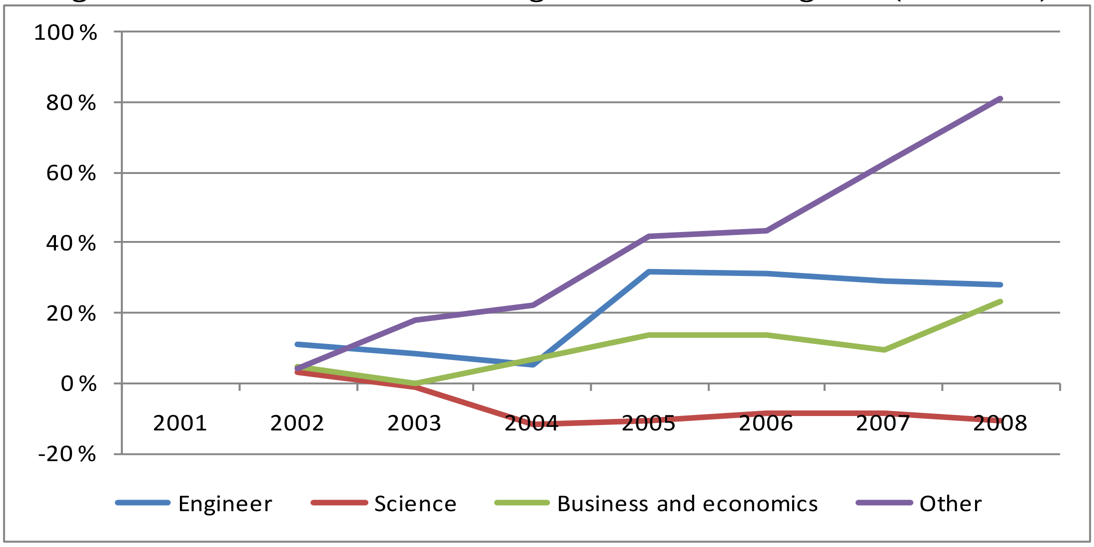
We now turn our attention to the traits of each sector within the health industry. As stated above, we exclude Hospitals, and Human services from the analysis, and we examine talent attractiveness in Diagnosis, Treatment, Research Institutions, Service, and Wholesale and Retail. The main focus is on the composition of each sector in terms of the higher-education backgrounds of engineering, science, business and economics employees, as well as a general category of other higher-education backgrounds, and on the growth levels of these employees. In addition, the commercialization focus in each sector will be examined.

Diagnosis

The Diagnosis sector is a relatively small sector in terms of employment but it has a much higher proportion of engineers than the industry as a whole. The share of engineers and scientists, the two knowledge-intensive employment groups that support the development side of this industry, declined during the observation period. The share of engineers fell from 48% in 2002 to 44% in 2008 and the share of scientists fell from 19% to 13%. The decline was offset by an increase in the number of employees educated in the social sciences. The absolute number of engineers actually grew during the period. Hence, the decline can be partially explained by the professionalization of support activities. However, a crucial finding is that the absolute number of scientists has declined and the increase in the number of engineers is moderate during the period (Figure 5-5).

This sector is slightly less focused on commercialization than the other sectors. The distribution of firms (as a percentage of the workforce) that conduct sales, marketing and customer relations activities is similar to the industry as a whole. However, only 44% of firms have 30% or more of their workforce conducting such activities, as opposed to the industry average of 52%.

Figure 5-5: Growth of labor with higher education: Diagnosis (2000-2008)



Source: Statistics Norway and BI

DiaGenic

DiaGenic ASA is a Norwegian biotechnology company active in in-vitro diagnostics based on peripheral gene expression profiling. The company develops patient-friendly diagnostic tests that identify disease-specific gene expression signatures enabling the early detection of such diseases as Alzheimer's, Parkinson's or breast cancer, which require early intervention for successful treatment. The company is the market leader in the identification and development of diagnostic tests. DiaGenic develops and markets its products through collaborations with partners in order to lower costs and improve success rates. In order to account for market peculiarities, regulatory requirements and different reimbursement schemes, the company envisages a gradual market entry process and is currently establishing a distribution network. DiaGenic is about to commercialize its first two products: ADtect® and BCtect® used to diagnose Alzheimer's disease and breast cancer respectively. Both have received regulatory approval in Europe and the company is also targeting FDA approval in order to enter the US market.

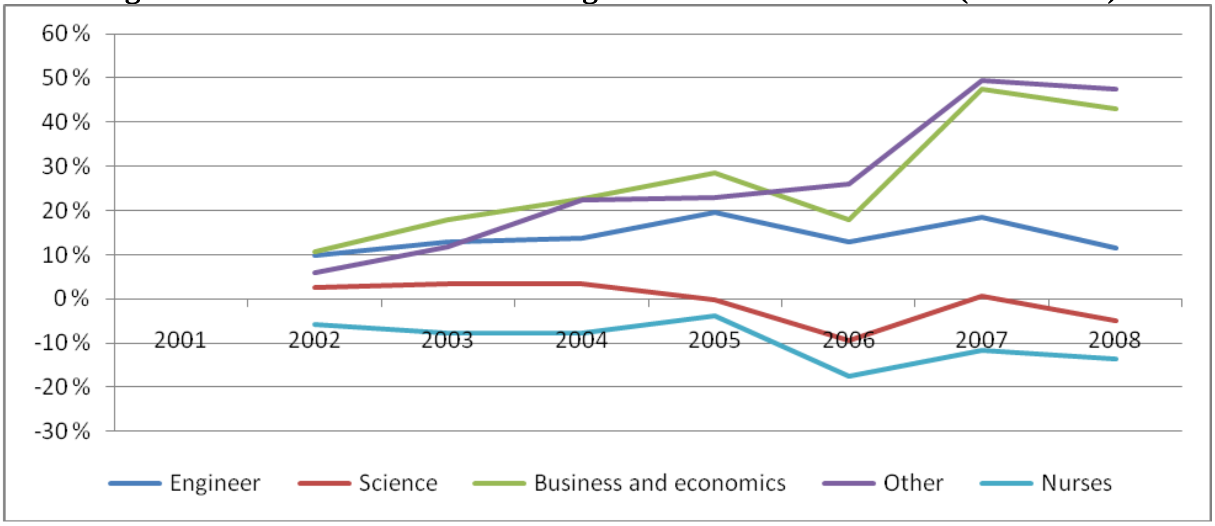
Financial Performance

NOK 1 000	2005	2006	2007	2008	2009
Total operating income	105	60	56	0	131
Total income growth		*-42.6 %*	*-6.7 %*	*-100.0 %*	*n/a*
R&D expenditure	(11,910)	(11,984)	(17,833)	(19,844)	(16,639)
R&D expenditure growth		*0.6 %*	*48.8 %*	*11.3 %*	*-16.2 %*
Operating profit/loss	(25,551)	(23,313)	(29,017)	(36,384)	(39,856)
Operating profit/loss growth		*-8.8 %*	*24.5 %*	*25.4 %*	*9.5 %*

Treatment

Treatment is another small, R&D-intensive sector. It has a large share of scientists (16%) and engineers (29%) working on drug development activities. Furthermore, it has the smallest share of employees with social science degrees. As previously mentioned, the Treatment workforce has grown by 21%. However, as in Diagnosis, the highest growth rates are found among employees with other backgrounds (47%) and among those with business and economics backgrounds (45%) (Figure 5-6). At the same time, the absolute number of engineers working in this sector has grown by a mere 10%. The lack of an increase in the number of employees with a scientific background and the marginal increase in the number of employees with an engineering background runs contrary to the general belief of fast-growing economic activities within this sector.

Figure 5-6: Growth of labor with higher education: Treatment (2000-2008)



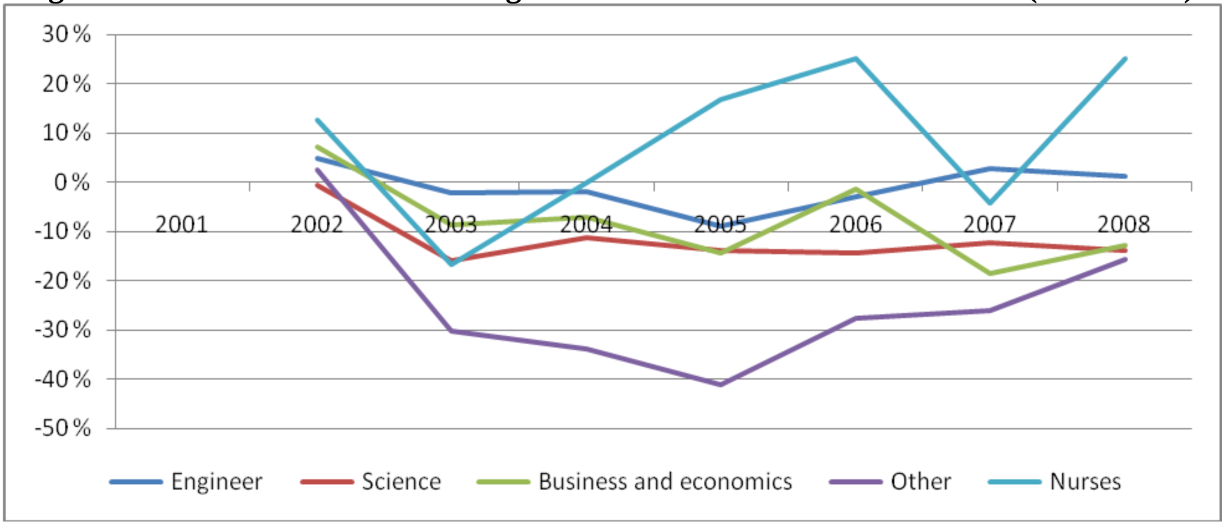
Source: Statistics Norway and BI

Another indicator of the development in this sector is the proportion of the workforce that is focused on commercialization. 39% of firms report that more than 30% of their workforce conducts sales, marketing and customer relations activities. The industry average is 52%. The difference can be traced to the high proportion of firms reporting that 0-10% of their workforce conduct such activities. These firms constitute 45% of Treatment firms compared to the industry average of 29%.

Research Institutions

The Research Institutions sector generally remained stable throughout the period in terms of the relative share of professions. If nurses, who represent only 2% of the workforce, are excluded, the proportion of engineers has remained constant, while the utilization of scientists, economists and employees with backgrounds in other social sciences has declined. The most alarming finding is the lack of growth among engineers and scientists (Figure 5-7). If the industry had become more R&D intensive, growth should have been observed in specialist research institutions that conduct both basic research and testing.

Figure 5-7: Growth of labor with higher education: Research Institutions (2000- 2008)



Source: Statistics Norway and BI

Service

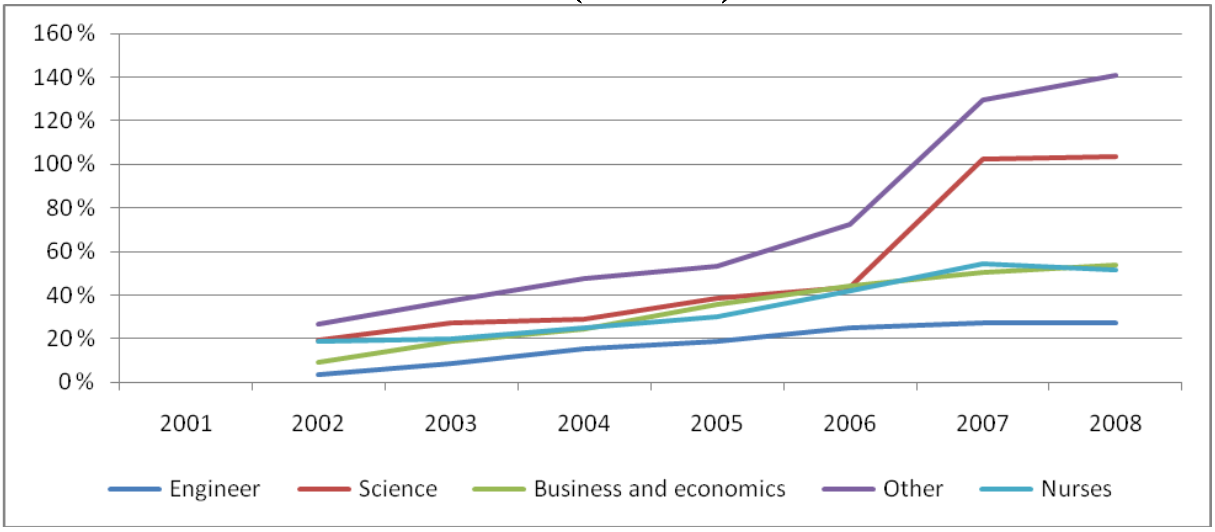
Service has a high presence of engineers (34% in 2008), and the proportions of employees with science, and business and economics backgrounds (18% and 11%, respectively) are higher than in the industry as a whole. Thus, the group of employees with other backgrounds (31%) is significantly smaller than in the overall industry. In the period 2000 to 2008, growth in other backgrounds (2%), and in business and economics backgrounds (3%) has reduced the percentage of engineers. Given the small number of employees in this sector, annual growth rates are more volatile than in other sectors. Over the period 2000 to 2008, the number of engineers and the number of economists doubled, while the number of scientists increased by 42%.

Wholesale and Retail

A large proportion of Wholesale and Retail employees have other social science backgrounds (47%). This group of employees also experienced the highest level of growth over the period, which was closely followed by the growth rate among scientists. Business and economics employees have grown more moderately at 40% over the period, while engineers experienced 23% growth. The growth among those with a scientific background is the most noteworthy trend in this sector and runs contrary to the trends observed in other sectors (Figure 5-8).

Wholesale and Retail is primarily focused on sales, marketing and customer relations. 82% of firms have more than 30% of labor focused on these activities. Only 9% of firms report having 0-10% of the workforce conducting sales, marketing and customer relations activities.

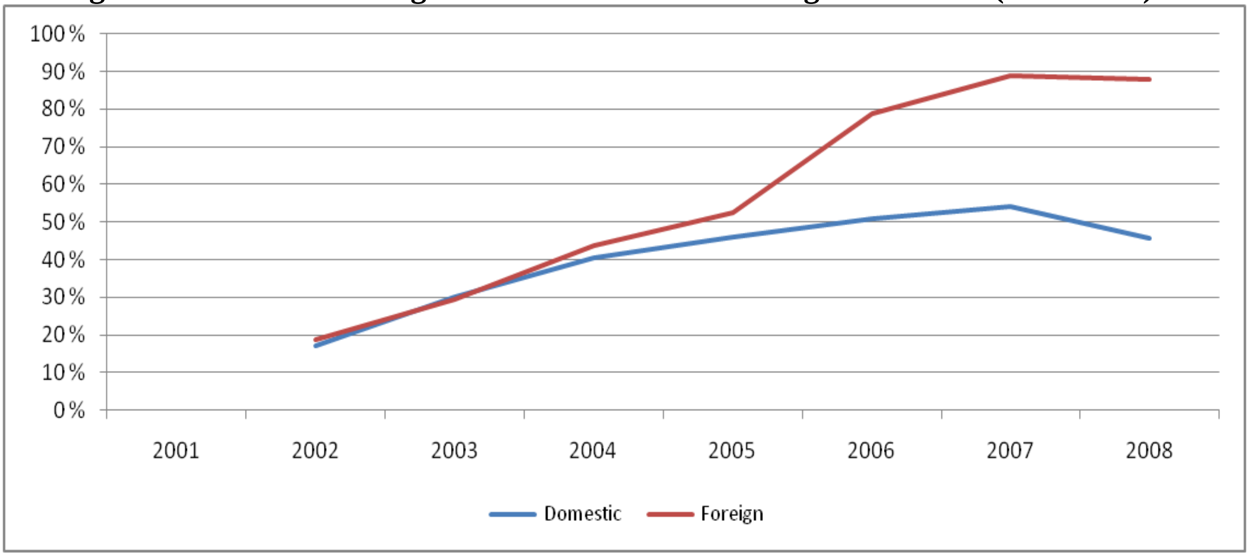
Figure 5-8: Growth of labor with higher education by background: Wholesale and Retail (2000-2008)



Source: Statistics Norway and BI

5.2 Foreign employment

Figure 5-9: Accumulated growth of domestic and foreign workforce (2000-2008)



Sources: Statistics Norway and BI

An attractive industry is a magnet for foreign talent. Not only has the number of foreign workers within the health sector increased five-fold within the nine-year period (Figure 5-9), but foreigners' relative share of total employment has also increased by 1.3% from 5.1% to 6.4%. An analysis of growth per type of origin allows for further inferences with respect to shifts in the distribution over time. As Figure 5-9 demonstrates, the growth rate of foreign employees is much higher than the growth rate of domestic employees. While growth rates for the two groups were similar until 2004, growth rates for foreign employees have since been much higher. The number of employees from Russia, Iraq, Thailand, Pakistan and the Philippines has grown by 7 to 19 times over the period 2000 to 2008. The growth rates among employees originally from advanced economies, like Sweden, the US, the UK or Germany, are much more moderate over the same period.

If we examine the attractiveness of foreign talent irrespective of county of origin, we conclude that the influx of foreign labor has resulted in a lower percentage of highly educated foreign-workforce. In 2000, foreign workers holding a university degree accounted for 0.024% of the workforce in the health industry. By 2008, this percentage had shrunk to 0.019%. The decline in the share of the foreign-educated workforce is evident on all educational levels. The health industry has managed to attract foreign workers but it has not managed to attract advanced foreign talent.

5.3 Talent attractiveness: Conclusions

The division of human capital in the health industry is unique among Norwegian industries. The health industry is highly professionalized – 44% of employees have a Bachelor education compared to 20% nationally. The proportions of employees holding Master or PhD degrees are similar to the national averages (11% and 1%, respectively). The industry is dominated by the Wholesale and Retail sector (when hospitals, other care institutions and private clinics are excluded). In 2008, 62% of all employees worked in this sector. In relative terms, all other sectors are shrinking.

One of the most important findings is that the number of employees with science and engineering backgrounds is either not increasing or only moderately increasing in the Diagnosis and Treatment sectors. If these sectors were growing as one would expect based on the media coverage of these sectors, we should observe an increase in the number of people with relevant scientific and engineering backgrounds. We observe declines or only moderate growth rates throughout the investigation period. The situation in the advanced supporting activities is similar. The size of the Research Institution sector remained constant from 2000 to 2008. As in Diagnosis and Treatment, we do not observe growth in the number of engineers or scientists working for Research Institutions. The industry has attracted a large number of foreign workers. However, the human capital of the average foreign worker joining the Norwegian health industry is lower than the human capital of the average domestic employee.

6 R&D and Innovation Attractiveness

Research and innovation play central roles in economic progress and in shaping the trajectory of societal development. In this regard, a debate fueled by Norway's low percentage of gross expenditure on R&D (1.6%) relative to total Norwegian GDP has been underway for some time. On the one hand, some argue that Norway spends as much on R&D as New Zealand, another country rich in natural resources, and hence its R&D expenditure is in line with its industrial structure. On the other hand, some argue that Norway is failing to utilize its resource richness to invest in future innovation that would provide continued funding for the high standard of living and the relatively expensive social welfare system.

In this chapter we provide evidence that the health industry is substantially more research-intensive and innovative than other Norwegian industries. Furthermore, we discuss the extent to which the health industry is attractive for R&D-related investments as well as its capacity to develop innovative outputs. In the conceptualization of R&D and innovation attractiveness, we examine R&D intensity, the structure of R&D investments, the properties of institutional R&D, the properties of firm R&D, financing innovation, innovative output, obstacles to innovation and the protection of investments in innovation.

6.1 The Norwegian health innovation system

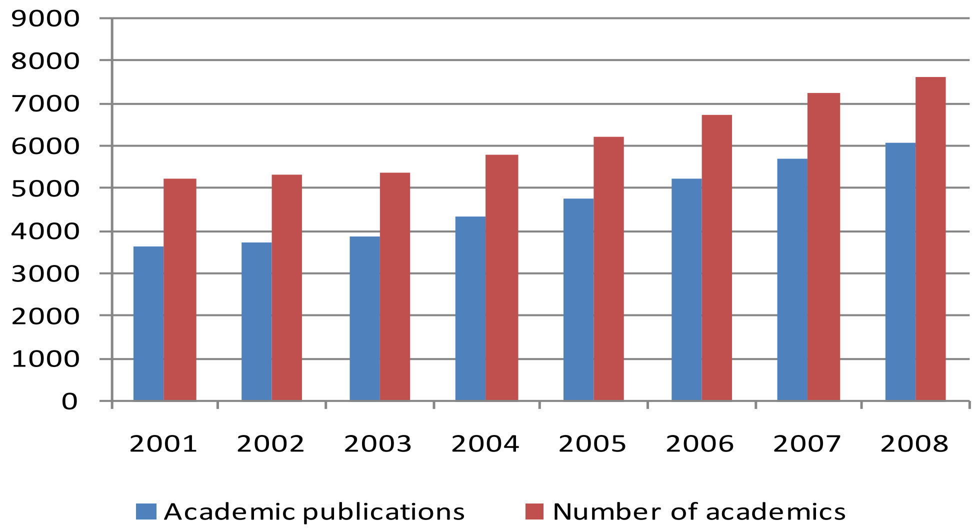
The Norwegian health innovation system consists of advanced academic R&D, various intensities of firm R&D and numerous collaboration constellations, including strong links to funding agencies. In this chapter, we review the performance of academic and firm-specific R&D, while collaboration is discussed in Chapter 8.

6.1.1 Academic R&D

How productive are the resources available in the health sector? In order to investigate the productivity of industry resources, we examine the development of the number of publications, the number of academics in related fields working in academic institutions and the productivity of these academics in terms of publication activity. The OECD uses a similar measure – the number of scientific publications per million population – as a measure of R&D investment outputs. All else equal, the number of publications is a good proxy for the return on investment in the educational sector. Academic publications constitute a platform upon which commercialized innovation can occur. However, as scientific output is not a commercialized invention or innovation, we view it as an input to the two major objectives of economic progress and the shaping of society in the future, rather than as an output (commercialized activity).

As Figure 6-1 illustrates, the number of academics and the level of academic publications in the health sector have been increasing over the period 2001 to 2008. While the academic research community grew by 5.6% on average over the period, the number of academic publications grew slightly faster at an average of 6.9% per year. The field of oncology represents the largest subject area for academic publications, representing up to 10% of all health-related publications.

Figure 6-1: Academic staff and publications (2001-2008)



Sources: ISI Web of Science, NSD and BI

Clavis Pharma

Clavis Pharma ASA is an Oslo-based oncology company focused on the clinical stage. The company is engaged in the development of cancer treatment medicines based on lipid vector technology (LVT), with the aim of improving the survival of cancer patients. Clavis Pharma's vision is to build a high-growth oncology company that has a strong pipeline of proprietary new and improved cancer drugs.

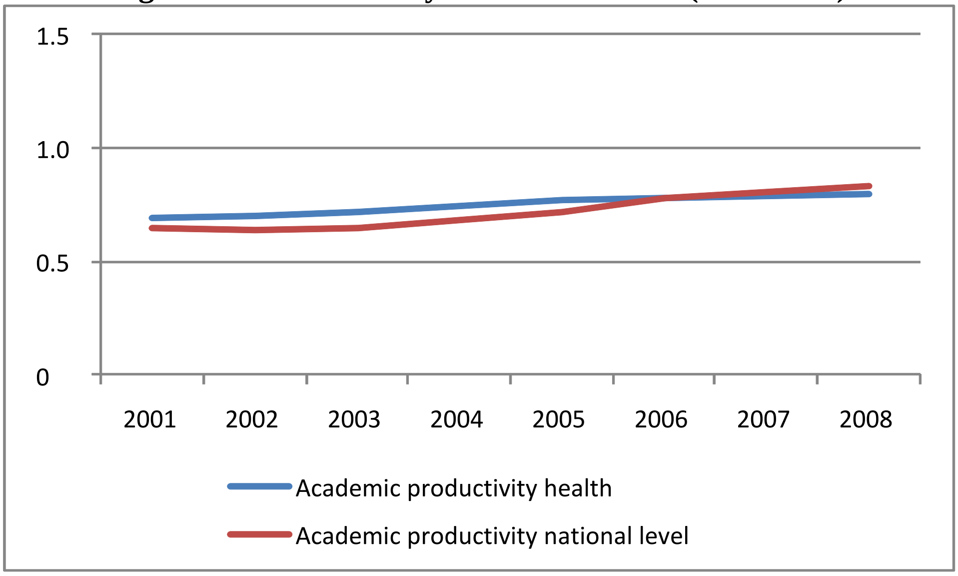
In 2006, Clavis Pharma was listed on the Oslo Stock Exchange. In 2008, it entered into a USD 380 million partnership with Clovis Oncology Inc. to develop and commercialize the anti-cancer agent CP 4126 in the Americas and Europe. The company operates a global network of research, development and manufacturing subcontractors focused on the development of potential drugs through clinical phases I and II.

LVT creates a chemical link between lipid vectors and pharmaceutical agents, thereby creating a "New Chemical Entity" (NCE) that has strong patent protection. LVT serves as the basis for a broad therapeutic window with expansion opportunities into potential niche-busting drugs. Clavis Pharma has a promising pipeline of improved cancer drugs, including a patented cytotoxic drug for solid tumors. The company has not yet commercialized any drug and, therefore, R&D expenditure is a better proxy of firm prospects than income.

Financial Performance

NOK 1 000	2005	2006	2007	2008	2009
Total operating income	3,161	3,378	4,719	2,047	7,550
Total income growth		*6.9 %*	*39.7 %*	*-56.6 %*	*268.8 %*
R&D expenditure	(14,796)	(28,583)	(37,074)	(47,853)	(40,916)
R&D expenditure growth		*93.2 %*	*29.7 %*	*29.1 %*	*-14.5 %*
Operating profit/loss	(31,012)	(53,829)	(65,229)	(89,200)	(82,750)
Operating profit/loss growth		*73.6 %*	*21.2 %*	*36.7 %*	*-7.2 %*

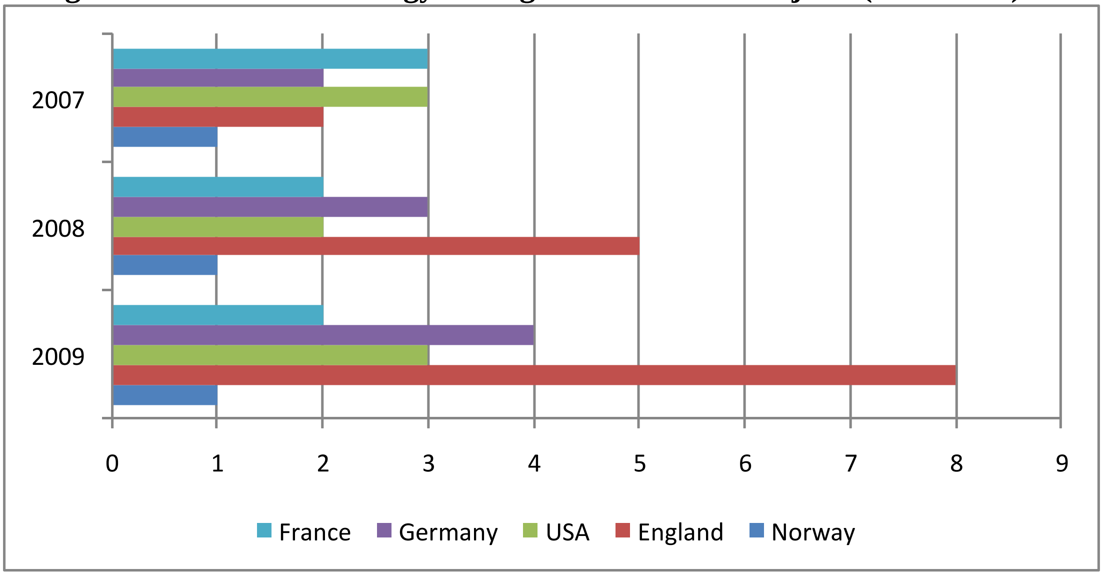
Figure 6-2: Productivity of academic staff (2000-2008)



Sources: ISI Web of Science, NSD and BI

As illustrated in Figure 6-2, health-related productivity shows an increasing trend over the time period. However, academic publication productivity within health has shifted from slightly outperforming national productivity prior to 2005 to slightly underperforming national productivity. Academics publishing articles on health are as productive as their colleagues in other departments in Norwegian universities.

Figure 6-3: Rank of oncology among health-related subjects (2007-2009)



Source: ISI Web of Science

The average number of scientific article publications per academic working on health-related topics is 0.8 articles per year. Oncology is the field with the largest number of publications in Norway. If we examine the ranking by number of publications per country in medical-related fields (Figure 6-3), oncology in Norway has been the most widely published field. In comparison, German scientists focus on other medical fields, so that the oncology focus in Germany dropped in rank from second to fourth between 2007 and 2009. The same trend is evident in England. France has productive scientific and commercialized communities in oncology. Its oncology research rank increased from third in 2007 to second in 2008 and 2009. In percentage terms, 7.1% and 7.4% of all health-related scientific publications in Norway in 2009 and 2008, respectively, centered on oncology. In France, the corresponding figures were 7.1% and 5.9%.

6.1.2 Firm R&D

To what extent can firms tap into the knowledge base residing within dedicated R&D institutions? We analyze the ratio of R&D investments to sales before we examine firm investments in R&D personnel. The former measure is commonly used as an indicator of R&D intensity (March 1991). The higher the share of R&D relative to sales, the more likely a firm is to explore new territories. Lower R&D as a percentage of sales indicates a focus on the exploitation and incremental amendment of already developed solutions.

Axis Shield

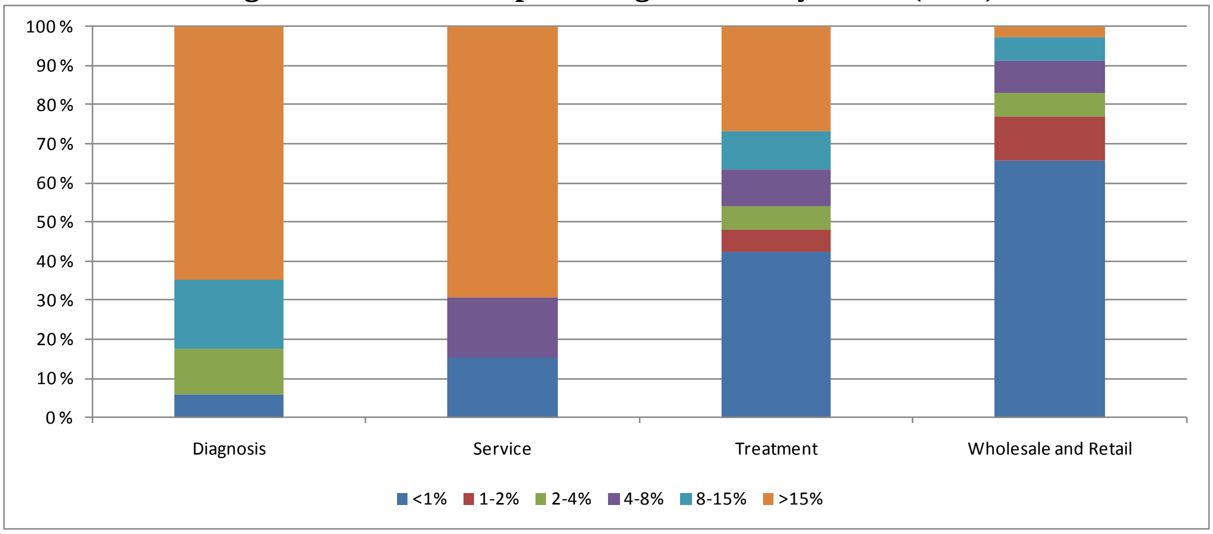
Axis-Shield is focused on the development and manufacturing of important in-vitro diagnostic (IVD) tests for use in clinical laboratories and at points of care (PoC) within the fields of cardiovascular disease, diabetes, infectious diseases and alcohol-related diseases. With more than 40 years experience, Axis-Shield's vision is to improve healthcare as a global provider of innovative IVD products. Axis-Shield PoC develops and produces a wide range of diagnostic products targeted at doctors' offices and clinics, where quick and accurate diagnoses are required.

Collaboration with scientific institutions and companies throughout the world has brought several unique products to the market, including Thrombotest™, Lymphoprep™, NycoCard™ and Afinion™. The company has a strong market position. Heavy investments in R&D over the years have given Axis-Shield a new and unique multi-parameter PoC platform: The Afinion™ AS100 Analyzer. The Afinion™ concept received a Norwegian Innovation Award in 2003 and was acknowledged as a Medical Design Excellence Award Winner in 2006.

Financial Performance

£ 1 000	2006	2007	2008	2009
Total operating income	12,450	15,967	23,011	30,184
Total income growth	*5.7 %*	*28.2 %*	*44.1 %*	*31.2 %*
R&D expenditure	-3,430	-4,727	-9,032	-5,426
R&D expenditure growth	*-10.6 %*	*37.8 %*	*91.1 %*	*-39.9 %*
Operating profit/loss	-2,585	-2,669	-6,858	-971
Operating profit/loss growth	*48.5 %*	*3.2 %*	*157.0 %*	*-85.8 %*

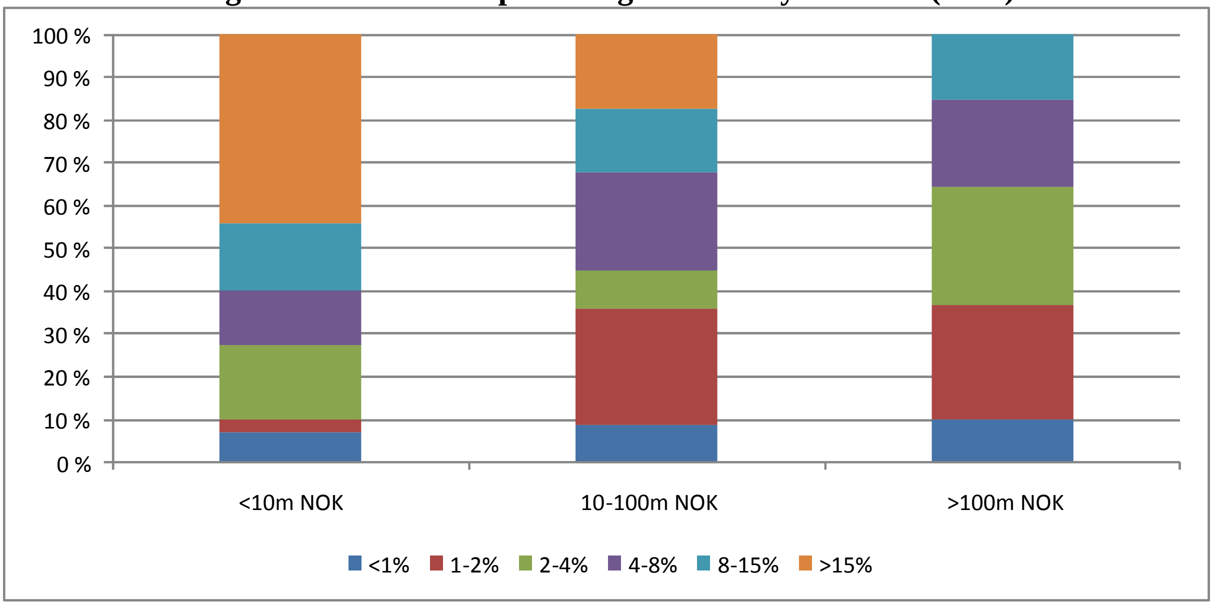
Figure 6-4: R&D as a percentage of sales by sector (2010)



Sources: Statistics Norway and BI

Figure 6-4 summarizes the survey answers regarding R&D intensity. An analysis of the survey answers by sector reveals significant differences in R&D investments. In Wholesale and Retail, 65% of respondents invested less than 1% of their 2009 sales in R&D. The Diagnosis and Service sectors show a different picture, as more than 60% of respondents allocated more than 15% of their annual sales to R&D activities in 2009. Treatment lies between the two extremes – 40% of Treatment firms belong to the lowest R&D-intensive group (R&D costs are less than 1% of sales), while 30% are found in the highest R&D-intensive group (R&D costs are more than 15% of sales). Nevertheless, as some firms have not reached the commercialization phase and do not, therefore, generate revenues, this measure might be misleading for all sectors except for Service, and Wholesale and Retail.

Figure 6-5: R&D as a percentage of sales by firm size (2010)

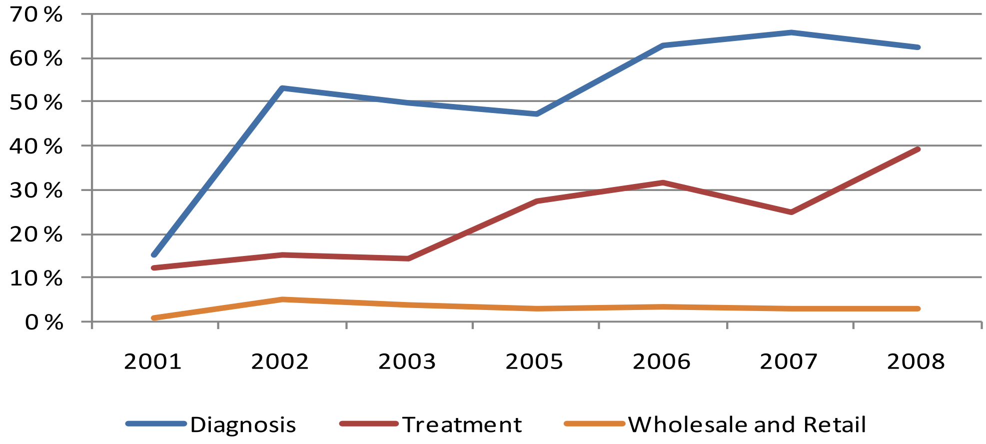


Sources: Statistics Norway and BI

R&D-intensive firms are generally very small. Figure 6-5 presents the distribution of R&D intensity by firm size. 45% of firms with income below NOK 10m allocate more than 15% of sales to R&D activities. In contrast, 17% of firms with income between NOK 10m and NOK

100m do the same, while none of the largest firms with income above NOK 100m allocate at least 15% of sales R&D activities.

Figure 6-6: R&D costs as a percentage of sales (2001-2008)



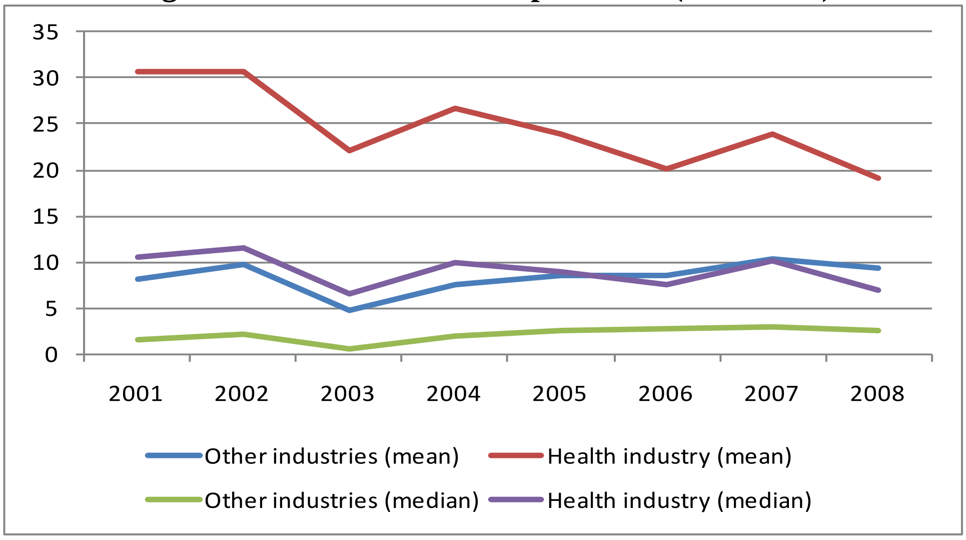
Sources: Statistics Norway and BI

Figure 6-6 shows the percentage of own R&D costs relative to total turnover. The figure shows that there has been a significant increase in spending among Diagnosis and Treatment firms. Firms in these sectors allocate a high percentage (40% and 60% on average, respectively) of their annual turnover to R&D. In comparison, R&D costs as a percentage of sales in oil industry sectors vary between 2% and 25%. R&D investments lie at the core of the operations of Diagnostic and Treatment firms, which explains why these sectors dedicate relatively more financial resources to R&D.

Another indicator of the capacity for innovation and execution of R&D projects is the total number of R&D personnel and researchers (OECD 2010, : 44). Figure 6-7 shows the median number of domestic personnel employed in R&D in firms in the health industry and in all other industries. The figure shows how the levels of R&D personnel changed between 2001 and 2008. The median firm in the health sector employs just less than eight R&D personnel, while the median firm in all other industries employs just more than two R&D personnel. The ratio between the median number of R&D personnel in the health industry and other industries decreased from 5.0 in 2001 to 3.5 in 2008.

Figure 6-8 shows the share of foreign and domestic R&D personnel by activity. Diagnostic firms employ the greatest number of employees in R&D at slightly more than 51% of their total workforce. Approximately one-third of total R&D personnel in Diagnosis are foreign. Treatment employs fewer people within R&D, which is in line with the findings regarding R&D investments and R&D costs, as the level of R&D employment should be correlated with R&D costs. 20% of R&D personnel in the Treatment sector are foreign. It should be noted that foreign personnel constitute merely 6.4% of the health industry workforce, while the median Norwegian firm, not including health-related firms, employs no foreign R&D personnel.

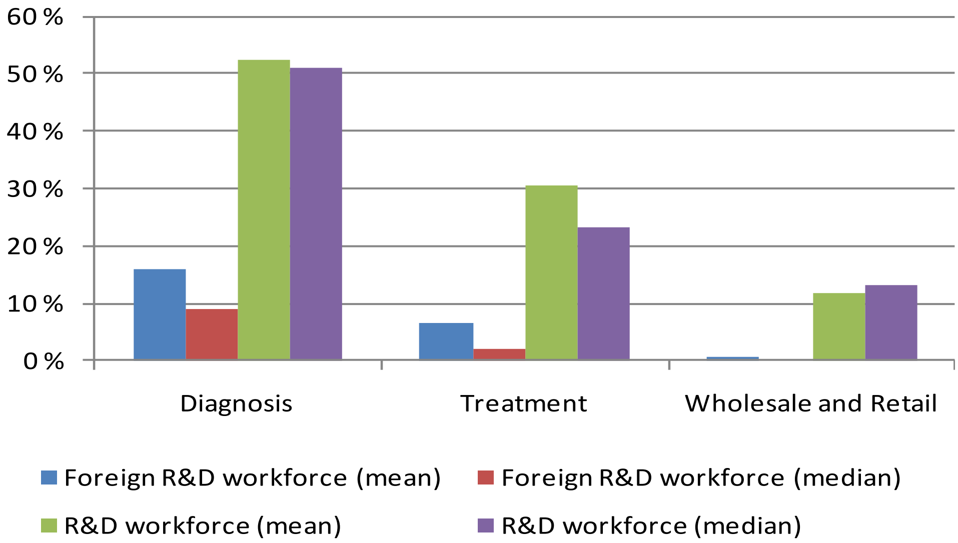
Figure 6-7: Number of R&D personnel (2001-2008)



Sources: Statistics Norway and BI

In summary, the average level of R&D personnel per firm in the health industry is high but is decreasing. At the same time, the health sector appears to employ more foreign R&D personnel than other industries, indicating a certain level of talent attractiveness within the health sector.

Figure 6-8: Share of R&D personnel by sector (2008)

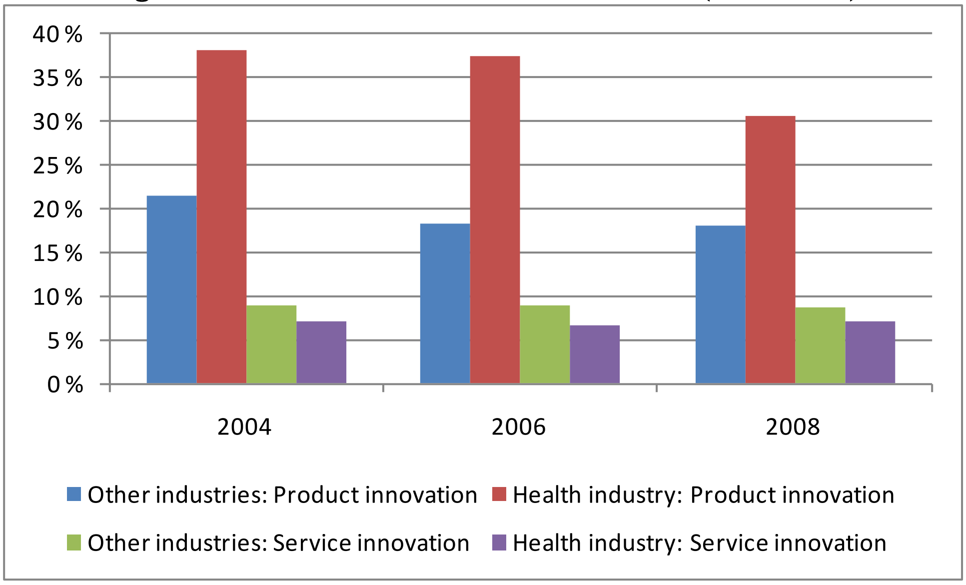


Sources: Statistics Norway and BI

6.2 Current innovative capacity

An industry is attractive to the extent to which the firms operating in it can document a track record of innovative output. The nature of the relevant innovation – whether it is a product, service or organizational innovation – depends on industry-specific characteristics. The various parts of the health industry exhibit different success rates with regards to innovation. The industry as a whole is one of the most innovative industries in terms of product innovation but not in terms of service innovation.

Figure 6-9: Product and service innovation (2004-2008)



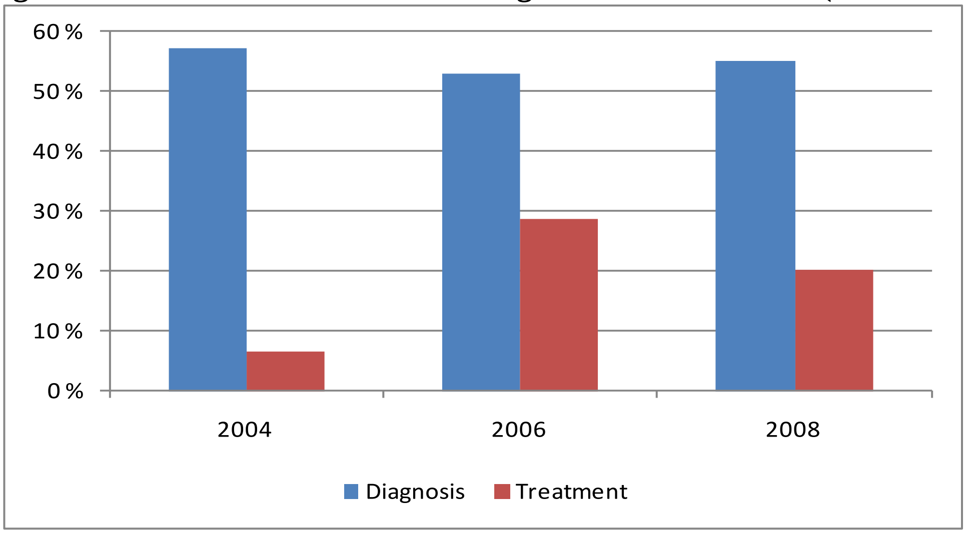
Sources: Statistics Norway and BI

Figure 6-9 shows the percentage of firms that innovated in the form of new or significantly improved goods and services in the three years preceding the date of data collection. Product innovations are at the heart of Diagnosis and Treatment activities. The proportion of health firms that introduce new or significantly improved products is about twice the national average. However, the percentage of firms that introduce new or significantly improved products in the health sector is gradually declining. 38% of firms in the health sector reported new product innovations in 2004, while the corresponding figure for 2008 was only 30%.

In the health industry, one should observe product innovation figures over an extended period of time in order to account for the long developmental process that characterizes the industry into account. However, the apparent reduction in product innovation is worrying and may indicate a lack of projects in the pipeline. Such projects are of the utmost importance if the industry is to move from relying on a few success stories that may migrate to foreign clusters at any point in time into a self-reinforcing cluster that attracts both ideas and investments.

Firms in the health sector provide less service innovation than the rest of Norwegian industry. Notably, the percentage of firms introducing service innovations in health and other sectors is generally constant. When the large proportion of firms operating in the Wholesale and Retail sector is taken into consideration, the low rate of service innovation may indicate that this activity is focused on delivering existing products, and that services innovation occurs outside Norway.

Figure 6-10: Product innovation in Diagnosis and Treatment (2004-2008)



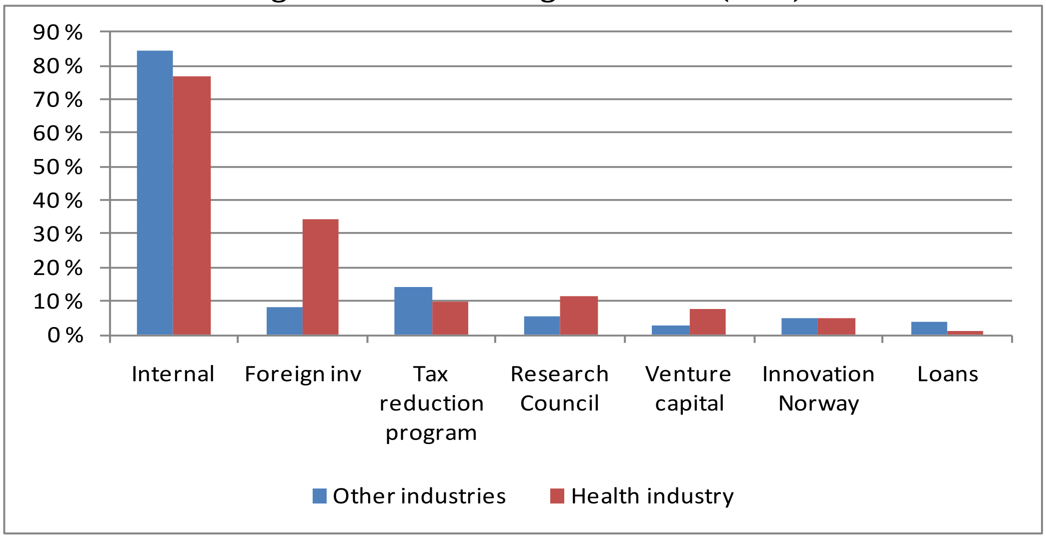
Sources: Statistics Norway and BI

Figure 6-10 covers product innovation in the Diagnostic and Treatment sectors. Diagnostic firms maintained a stable amount of product innovation over the period. 55% of Diagnostic firms reported that they had introduced new or significantly improved products in the three years preceding the date of data collection. In contrast to Diagnosis but in line with the R&D investment findings, the proportion of firms within Treatment that introduced product innovation fluctuated from less than 10% to 30% between 2004 and 2008. While the large increase between 2004 and 2006 may be explained by the maturation of the flagship firms, such as Algeta and Clavis, the decline in 2008 may indicate a lack of followers in this sector.

6.2.1 Financing R&D

In order to understand the extent to which firms are able to maintain and enhance the level of innovation, we need to understand the principal factors that prevent firms from innovating. Given the challenging nature of financing risky projects over a long period of time, we focus on the financing of innovative activities.

Figure 6-11: Financing innovation (2008)



Sources: Statistics Norway and BI

Figure 6-11 shows the proportion of different financing resources for R&D relative to total financing in 2008. The figure compares the mean values for the health industry to those for all other industries. Other financing sources have also been analyzed but they have proven to be insignificant. The primary source of finance is internal funds, which contribute 75% of total financing. Internal financing in the health industry is almost 10% lower than in other industries.

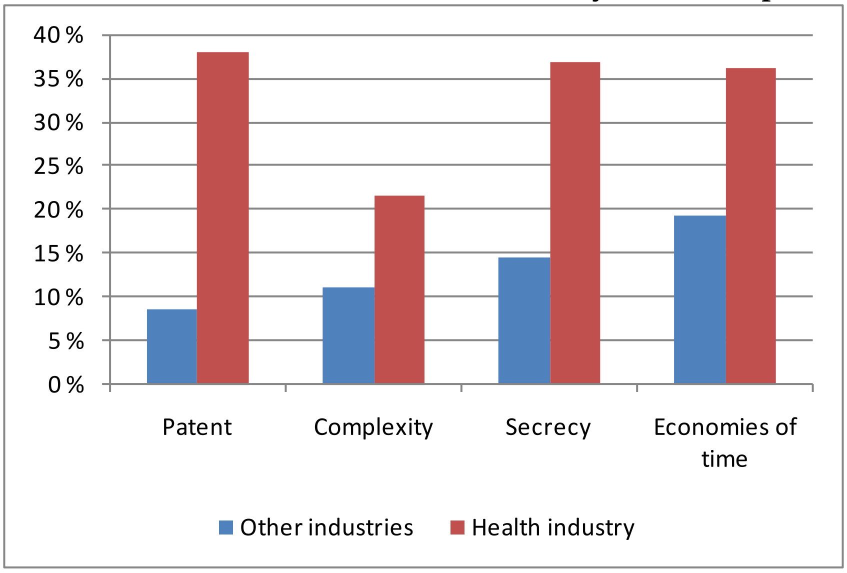
Debt markets are almost non-existent and non-functional in terms of financing Norwegian R&D in general and, even more so, in terms of financing Norwegian health-related R&D. The health industry, however, seems to be more attractive to venture capitalists than other industries, as more financing comes from this source. Many start-ups and small firms in the health industry rely on venture capital in order to survive the early years of trial and error in which they have only marginal levels of income. This is particularly true for R&D in the Treatment and Diagnostic sectors, where many years of product development are typically required, often followed by clinical trials before product certification and launch can even be considered. For venture capitalists that have invested in such firms, the risk is high but the potential payoff from a successful product may be huge. This may explain why venture capitalists are willing to invest relatively more in health R&D than in other industries. However, their involvement is still relatively marginal.

A large difference between Norwegian industries in general and the Norwegian health sector can be found in the percentage of R&D financing that originates from abroad. Funding from foreign investors is the second-largest source of financing in the Norwegian health industry. This reflects the global nature of the health industry. Investors are aware of the fact that successful products can be sold on a global basis. As such, they are willing to invest in the R&D behind any promising innovations, regardless of their geographic location. This reliance on foreign investors may reflect the lack of availability of capital on a national basis. We return to this point in our discussion of ownership attractiveness in chapter 7.

6.2.2 Protecting investments in innovation

The initiation of innovative activity is also dependent on the extent to which the proceeds of such investments can be shielded from imitation by competitors (Barney 1991; Peteraf 1993). Figure 6-12 shows the percentage of respondents that have chosen to protect their inventions and innovations according to the protection method used. As the health industry is knowledge intensive, intellectual property is commonly protected through patents. Firms in the health sector utilize patents five times more often than firms in other industries. Furthermore, there is far more protection of inventions and innovations in the health industry than in other industries. Once a formula for a particular patented drug becomes freely available, any producer may make generic copies and sell them at a much lower price, thus introducing competition into the market and reducing returns for the original producer of a drug. Interestingly, in an industry renowned for its protection of intellectual property rights through the patenting system, secrecy and economies of time are utilized to the same extent as patenting in Norway.

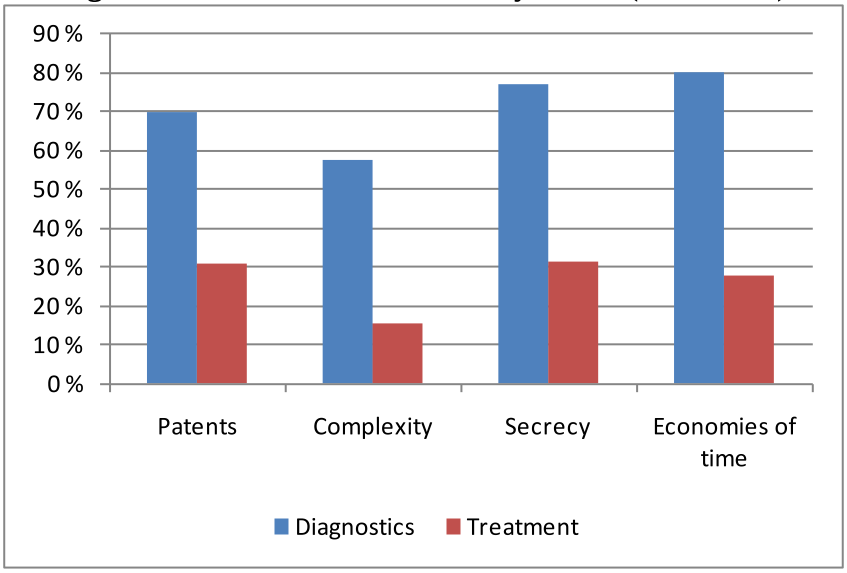
Figure 6-12: Protection of inventions and innovation by method of protection (2008)



Sources: Statistics Norway and BI

Figure 6-13 shows the percentage of respondents in the Diagnostic and Treatment sectors that protect their inventions and innovations, and the methods by which they do so. The numbers shown in the figure are obtained by averaging the percentage of respondents that answered positively in 2006 and 2008. A substantial divergence is apparent between Diagnostic and Treatment firms. About 70% of all Diagnostic firms utilize patenting, secrecy or economies of time to protect their innovations. Only 30% or less of Treatment firms do the same.

Figure 6-13: Protection method by sector (2006-2008)



Sources: Statistics Norway and BI

6.3 R&D and innovation attractiveness: Conclusions

Norwegian academics are not over-productive in terms of publishing academic work on health-related topics. However, Norway has an overrepresentation of cancer-related research output in terms of ranking and in terms of the proportion of cancer-related publications out of all health-related publications.

Diagnostic and Treatment firms are extremely R&D intensive in terms of investments and number of R&D personnel. The industry as a whole is innovative in terms of products but not in terms of services. Diagnostic firms are highly innovative with more than 50% of firms reporting product innovation. Product innovation for the industry is high but there are signs of a declining trend. Firms in Diagnosis maintain a very high rate of product innovation. Treatment firms exhibit a positive trend in terms of product innovation.

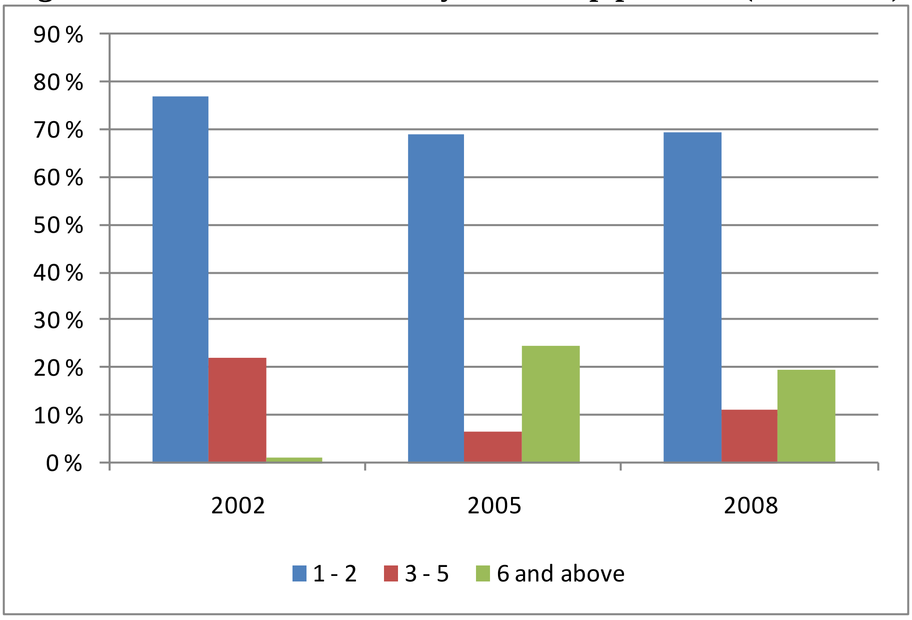
R&D is mostly financed by internal funds. The second-largest source of financing is foreign investors. This highlights both the global nature of the industry, where knowledgeable investors are scanning the global market for investment opportunities, and the lack of a local, knowledgeable investor milieu. A health firm is five times more likely to use patenting to protect its innovations than a firm outside the health industry. Substantial differences also exist in the use of protection through secrecy and economies of time.

7 Ownership attractiveness

An industry's ownership attractiveness is the extent to which it manages to attract competent capital, either national or foreign, to finance its activities. Emerging industries, such as biotechnology applications within the health sector in Norway, typically suffer from a lack of competent owners who can competently evaluate new projects. In more mature industries, competent capital is crucial for the financing of innovative and novel projects, and for the injection of fresh capital in existing, growing firms. All else equal, a community of competent owners that enjoy the benefits of narrow search for investment targets, easier selection and foresight into the operation of the industry should assist the growth and sustainability of an industry. In this chapter, we discuss the extent to which the Norwegian health industry manages to attract competent capital.

With the exception of hospitals, the majority of the health industry is foreign owned. In 2008, 60% of income generated by health firms originated from firms in which the largest owner was foreign. This proportion has remained relatively constant since 2002 (57% in 2002; 60% in 2005). Foreign ownership per se is not detrimental. It may even indicate the competitiveness of a national industry. For example, the motivations for foreign ownership in the oil supplying industry are not only participation in the national oil industry but also the opportunity to tap into the local knowledge base. Therefore, the issue is whether there are corresponding national owners in the Norwegian health industry.

Figure 7-1: Percent of income by ownership portfolio (2002-2008)

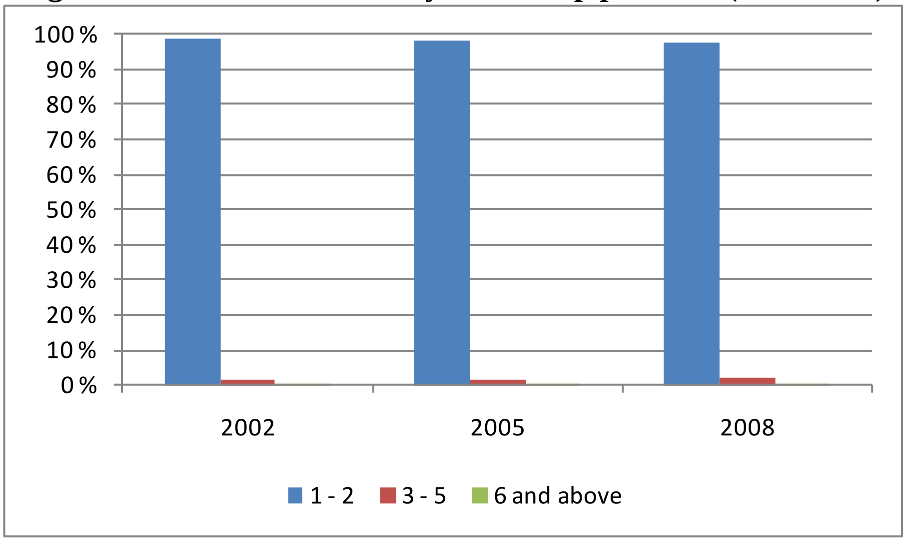


Sources: Brønnøysund Register Centre and BI

We first examine the existence of serial owners who leverage their experiences and knowledge from one firm for the benefit of other firms in the same industry. As groups of firms enjoy taxation incentives, the largest owners of one or two firms were grouped together. Figure 7-1 shows the distribution of income by the number of firms that an ultimate largest owner holds. The figure shows that the control of serial owners that are assumed to leverage their experiences and knowledge over many investment projects is increasing. However, the level of control of such owners is very low (20%). For comparison, in the oil industry (not including operators like Statoil), 60% of all income is controlled by such serial owners.

Our qualitative interviews support this finding. One investor who has invested heavily in this sector stated: “There is clearly a shortfall in terms of competent investors. Some argue that we can count them on one or two hands. Competent investors have either had a dual education covering the life sciences and economics, or they have personally invested in studying and developing advanced competences in the line of study that they did not have during university”.

Figure 7-2: Percent of firms by ownership portfolio (2002-2008)

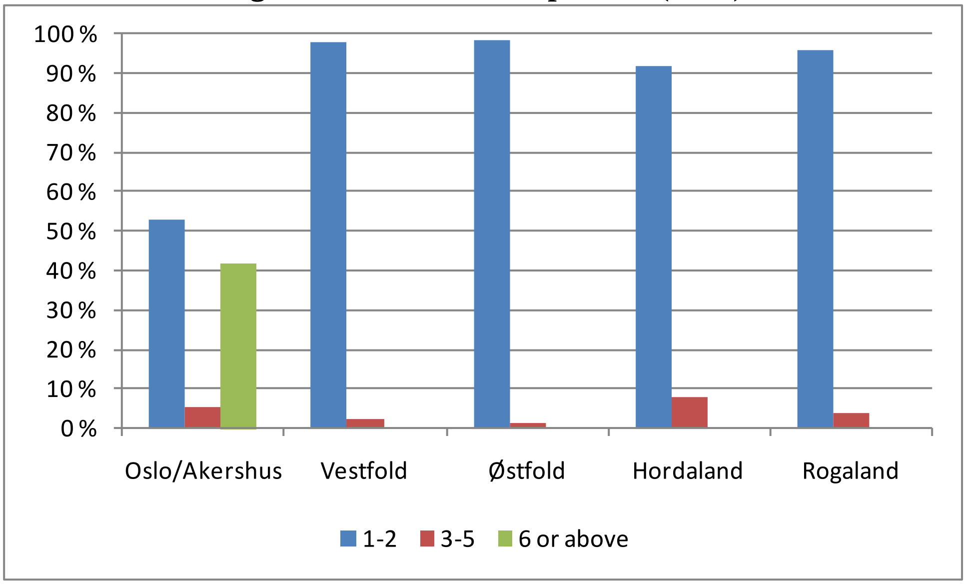


Sources: Brønnøysund Register Centre and BI

When we further examine the number of firms that such serial owners control relative to the population of firms (Figure 7-2), a similar picture emerges. 99% of firms are owned by owners who control only one or two firms. Of the few serial owners that exist, the vast majority are domestic and foreign owners operating in the Wholesale and Retail sector. The two notable exceptions are Axis-Shield PLC (an Anglo-Norwegian in-vitro diagnosis group with a large, varied investment portfolio in Norway and the UK) and FSN Capital (a private equity investment firm that supports private health services and staffing in Norway but is not involved in treatment or diagnosis projects).

Venture capital firms play a central role in the financing of drug development and diagnostic products, as shown in chapter 2. Such firms control multiple health-related firms. The fact that retail chains are the serial owners rather than the venture capital firms indicates a lack of health-related risk capital. One investor stated: “There is a small community of venture capital firms. However, it is too small in terms of financing and in terms of the magnitude of projects that can be financed.”

Figure 7-3: Cluster competence (2008)



Sources: Brønnøysund Register Centre and BI

We also examine the degree to which serial ownership is distributed across the country (Figure 7-3). The findings support our argument that activity is chiefly centered in Oslo/Akershus. 42% of income generated in Oslo/Akershus is controlled by serial cluster specialist owners. No other counties report the existence of serial cluster specialist owners.

In conclusion, while capital is generally available in Norway, it is not readily invested in long-term, health-related projects that are perceived as very risky. Norway has few competent capitalists who are able to evaluate advanced biotechnological treatment projects and willing to invest in such projects. Competent owners found in many of the well-established industries in Norway do not migrate from these industries to the health industry, especially not to the riskier health-related projects. Competent owners control about 20% of total sales in the health industry by controlling a very small number of firms. Most of these firms are retail chains, not technology developers. To the extent that competent ownership exists in the health industry, it is concentrated in the Oslo region.[12]

[12] Environmental issues in the health sector result from the production (chemical accidents and spills), sale (packaging), distribution (transportation), and disposal (recycling) of health products. As these issues refer primarily to manufacturing and trading concerns, and do not allow for an analysis of health-specific implications with respect to attractiveness, this dimension of the hub is not investigated further.

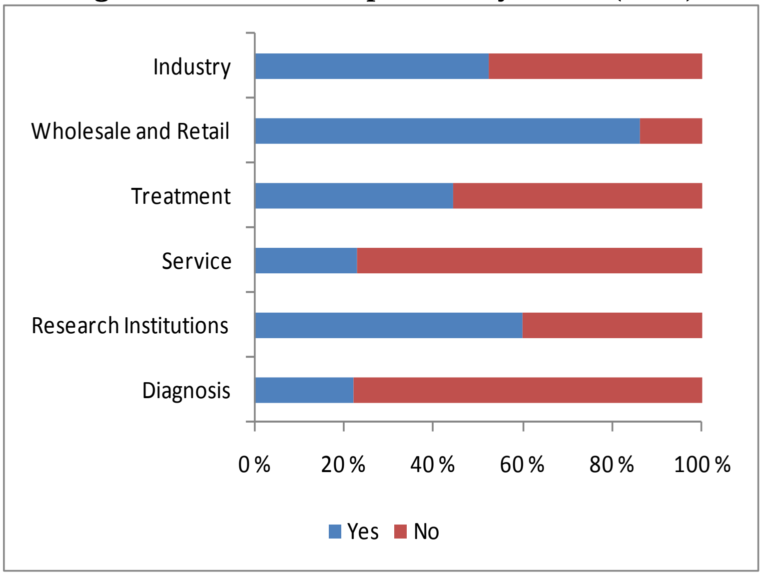
8 Cluster Dynamics

The dimensions reviewed in chapters 3 to 7 describe the conditions under which firms can excel. Whether firms can utilize those dimensions to their benefit depends greatly upon the extent to which they succeed in creating a dynamic environment. Previous literature (Reve and Jakobsen 2001) identifies four upgrading mechanisms that can increase innovation and productivity among clustered firms: innovation pressure arising from closeness to demanding customers, technologically leading suppliers and internal competition; critical mass (chapter 3); knowledge externalities, mainly in the form of labor mobility and strong business linkages; and transaction cost reductions achieved through the establishment of long-term relations. Dynamism is, therefore, a function of competitive and cooperative linkages, the degree of intra-industry labor mobility (which proxies for the extent of knowledge spillovers) and the degree of overlap between various industries. These linkages are examined in this chapter.

8.1 Competitive linkages

Local competition has been theorized to drive firms to excel (Porter 1990; Burt 1992). Competing firms that locate in the same vicinity have been repeatedly observed to have an incentive to remain “on top of things” by continuously innovating, and seeking new technologies and customers. 52% of firms in the Norwegian health industry report having at least one direct competitor in the local region. This is in line with other industries in Norway, such as the oil industry (56%). Such local competition may help to increase the level of innovation, as firms use this pressure to try to stay one step ahead of the competition. The importance of local competition varies among the different health industry sectors.

Figure 8-1: Local competition by sector (2010)

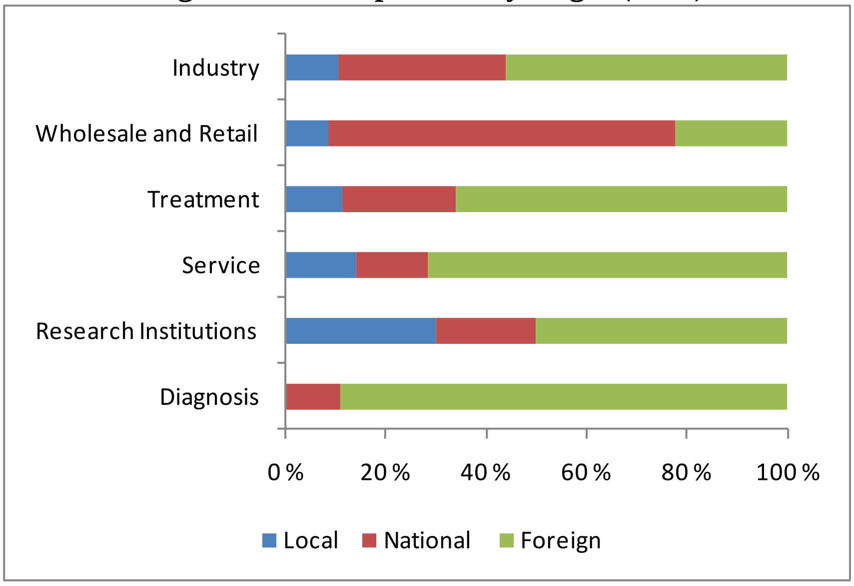


Sources: BI Survey

Figure 8-1 shows that 86% of wholesalers and retailers have local competitors. This reflects the fact the retail segment includes many small pharmacies, which are usually located in shopping centers or on main streets with other competing pharmacy chains nearby. It also reflects the centrality of the Oslo region with regard to wholesalers. This finding is supported by the fact that wholesalers and retailers report that they experience the toughest competition on the national level (Figure 8-2).

Service and Diagnosis have the lowest levels of local competition (23% and 22%, respectively). The lack of local competition in these sectors implies a shortage of local competitive driving forces, which are required for the promotion of innovation and development. This, in turn, means that the vast majority of Diagnostic firms and specialized Service firms in Norway may function as stand-alone operations in relative competitive isolation. Cluster theory implies that such isolation is likely to be detrimental to innovative output, which is an essential feature of Diagnostic firms in particular. In addition, only 50% of Treatment firms have a direct competitor nearby. Given the extreme geographical concentration of this sector and of the Diagnosis sector (see chapter 2), Treatment and Diagnostic firms work in parallel. That is, they work on seemingly unrelated projects with respect to the final customers, which effectively reduces the strength of the local competition mechanism that supports innovation and improvements.

Figure 8-2: Competition by origin (2010)



Sources: BI Survey

Figure 8-2 demonstrates that, on the industry level, health firms meet the *toughest* competition for customers on the international level. National competitors are the toughest competition in only one-third of all cases, whereas local competitors are of comparatively little significance. These findings highlight the global nature of the health industry and act as a reminder of the global market that successful Norwegian health firms can serve.

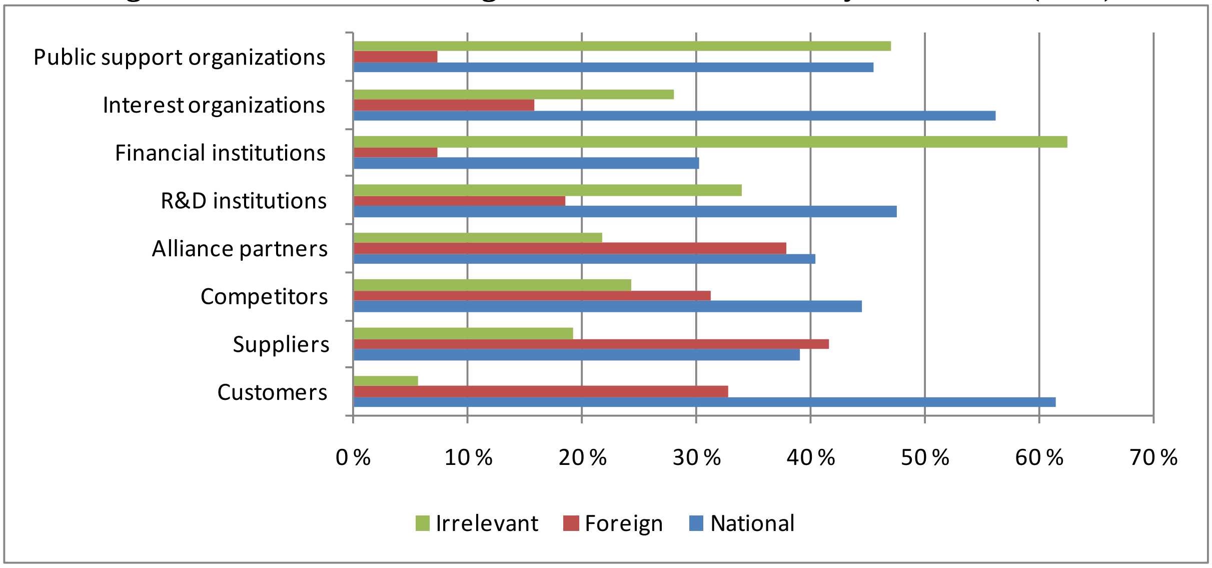
On the sector level, we observe several deviations from the general industry trends. One striking result in Figure 8-2 is the fact that Diagnostic firms experience the highest level of competition from international firms. This may be explained by the fact that firms involved in diagnostic activities generally produce products that have a global market. It should be noted that the Diagnosis sector includes a wide range of firms, from high-tech equipment developers to low-tech medical technological applications, e.g., orthopedic inlays. If there were more globally competitive Diagnostic firms present in Norway, then these statistics would be quite different. Diagnostic firms tend to specialize within a medical niche focused on a particular disease or condition. There is typically no community of firms competing within any one niche, particularly on the local and national levels.

Treatment and Service firms also experience the most competition for customers from international firms. This again reflects the global nature of the industry and the lack of competition on a national basis, the latter of which is important for driving innovative ideas and increasing knowledge. The fact that Wholesale and Retailers operate on a local and national level to sell their goods greatly reduces the overall significance of international firms, and explains why firms in this sector report that their toughest competition is on the national level.

8.2 Collaborative linkages

Innovations occur less and less in isolation and R&D is increasingly more interconnected and globalized. Innovative linkages across firm and country boundaries allow for higher returns originating from the sharing of cross-boundary knowledge, the joining of complementary resources and the transferring of effective governance of work and innovation processes (Dyer and Singh 1998). With the increasing globalization of economic activities, cross-border linkages are of increasing importance (OECD 2010). Norway as a whole underperforms in this regard. Only 5% of firms report involvement in international collaborations on innovation. In comparison, 17% of Finnish and 8% of Danish firms report that they are involved in such collaborations.

Figure 8-3: Innovative linkages across firm and country boundaries (2010)



Source: BI Survey

Collaborations in the health industry take many forms, such as vertical relationships between customers and suppliers, horizontal relationships between companies on the same level in the supply chain, or relationships between a company and a governmental agency, an R&D institution or a finance institution. For the industry as a whole, relations among certain actors are more significant in the development of new ideas, processes or products.

Figure 8-3 depicts firms' innovative linkages across firm boundaries to national and foreign actors. Finance institutions are largely irrelevant – 63% of respondents view them as irrelevant for their own innovation. Relationships with customers and personal networks are of key importance on all geographic levels. In contrast to more mature industries, interest organizations play a central role in innovation in the health industry. Many firms are very small and, hence, organizations like OCC play a central role in reducing search costs for partners, customers and suppliers. They also reduce transfer costs by creating arenas for information and knowledge transfer. R&D institutions are at the heart of this innovation system. Every second firm indicates that relations with R&D institutions affect their own innovative output. In comparison, in the technology-based oil industry, only 35% of firms indicate that national R&D institutions affect their innovative output.

PCI Biotech

PCI Biotech ASA is an oncology based company that has developed a technology for localized cancer treatment based on photochemical internalisation (PCI). PCI Biotech aims to extend its unique PCI into a patented platform technology with a large range of application areas and multiproduct opportunities. The company has been granted approximately 80 patents in all core markets.

PCI Biotech ASA was founded in 2000 as a subsidiary of the Norwegian company Photocure ASA. PCI Biotech is engaged in a partnership with the Institute of Cancer Research at the Norwegian Radium Hospital, where PCI technology was originally developed and where its development will continue.

The company's lead potential drug is the proprietary photosensitiser Amphinex®. A clinical study shows that all treated tumours disappeared within a few weeks of treatment without serious side effects. PCI has the potential to be applicable to over 20% of the cancer drugs in the market with enhancing therapeutic effects. The company has not yet commercialized any drugs based on PCI technology but R&D expenditures are increasing.

Financial Performance

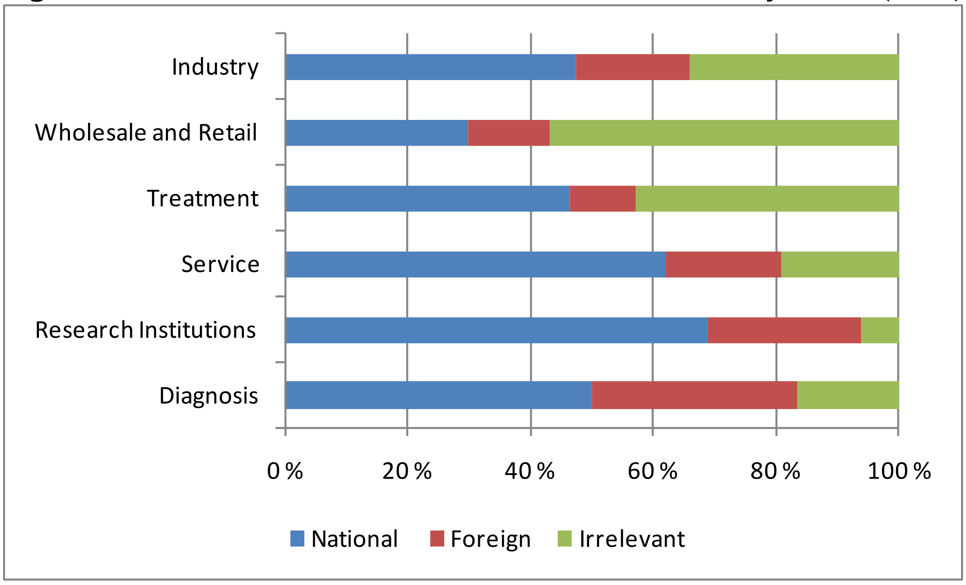
NOK 1 000	2007	2008	2009
Total operating income	5,867	7,367	8,612
Total income growth		*25.6 %*	*16.9 %*
R&D expenditure	(14,732)	(14,323)	(19,319)
R&D expenditure growth		*-2.8 %*	*34.9 %*
Operating profit/loss	(10,136)	(12,139)	(17,686)
Operating profit/loss growth		*19.8 %*	*45.7 %*

Governmental agencies also play an important role. 46% of firms report that governmental agencies affect their innovative output, while 47% view them as irrelevant. The wide variety of firms in this industry, from retailers to advanced drug developers, highlights the importance of funding agencies such as the Research Council, while programs like FUGE will directly affect the likelihood that this industry will evolve further.

8.2.1 Collaborations with R&D institutions, governmental agencies and suppliers

In order to better understand these trends, we compare the industry results with the sector-specific results. We first examine the role of R&D institutions and governmental agencies, as they are rated as irrelevant by 34% and 47% of the industry players, respectively. We also examine the role of suppliers given their centrality in cluster theory as agents of adaptation and innovation.

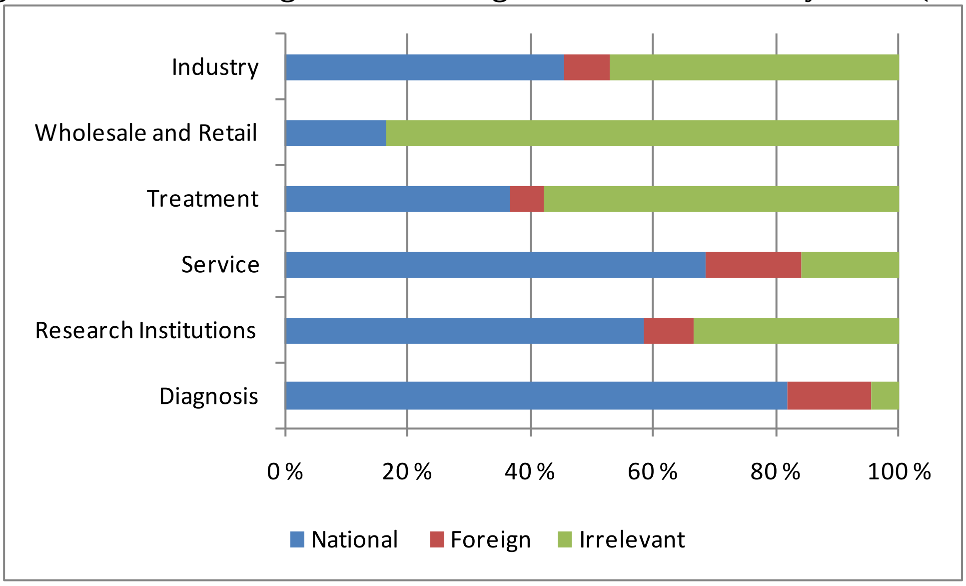
Figure 8-4: The role of R&D institutions in innovation by sector (2010)



Source: BI Survey

The role of R&D institutions varies across all health sectors, with national R&D institutions being consistently of greater significance than international R&D institutions. For Diagnostic firms and specialized Service firms, this finding highlights the importance of *national* R&D institutions in enabling Norwegian firms to innovate in the global marketplace. Not surprisingly, R&D institutions play an important role in research activities, where again the national level dominates. In each of these three sectors, the development of unique and innovative products is the key. This helps to explain why R&D institutions are of relevance, and have an important role to play in providing inspiration, backing, expertise and experience for the firms in question. When discussing the role of R&D institutions, one may think in terms of researchers pelting out brilliant ideas that are then seized upon to create successful companies. However, one should also assess the importance of laboratories and test centers made available to the industry, such as those supported by the University of Oslo (UiO) and SINTEF.

Figure 8-5: The role of governmental agencies in innovation by sector (2010)

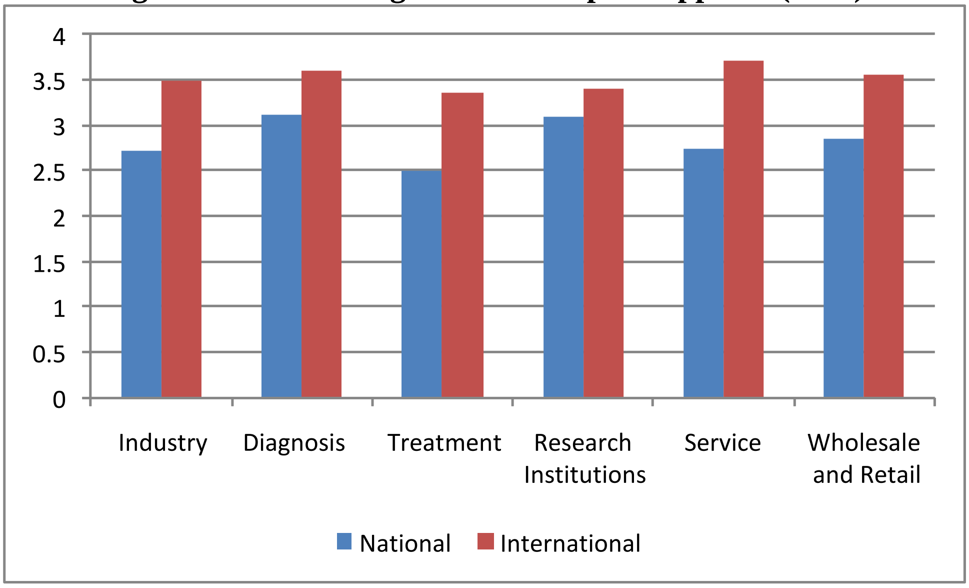


Source: BI Survey

Governmental agencies (such as SIVA and NFR) provide financial support, advice and networks of relations for firms. The Service, Diagnostic and Research Institution sectors do not follow the industry trend of rating governmental agencies as highly irrelevant. Such agencies, particularly *nationally* based governmental agencies are vital for these firms. These national agencies are of critical importance for the development of ideas, processes and products in Diagnostic firms. Diagnostic firms are heavily involved in R&D and it may take many years for an initial idea to be thoroughly researched, developed, run through clinical trials and launched. Throughout this process, products do not generate any revenue and there is no promise of success. Many costly ideas for diagnostic tools or products are worked on for years before being cast aside without having generated any revenue at all. In order to reduce risk and minimize losses from such projects, Diagnostic firms rely on the expertise and support of governmental agencies. A similar pattern is observed in Research Institutions and Services.

Notably, firms involved in the development and production of treatments rate governmental agencies as largely irrelevant to the development of new ideas, processes and products. The focus of governmental agencies has been on supporting drug development and not on those parts of the Treatment sector that relate to vitamins and related products, although these products contribute more to value creation than the potentially global drug firms.

Figure 8-6: Technological leadership of suppliers (2010)



Source: BI Survey

Finally, foreign suppliers are mentioned as frequently as national suppliers as a source of innovation. Health firms in all sectors perceive their international suppliers as more technologically advanced than national suppliers (Figure 8-6). This clearly indicates the lack of competitiveness of national suppliers to all sectors, which renders Norwegian firms even less able to innovate and outperform rivals. National suppliers to the Wholesale and Retail, Service and Treatment sectors are viewed as substantially less technologically advanced than their foreign counterparts.

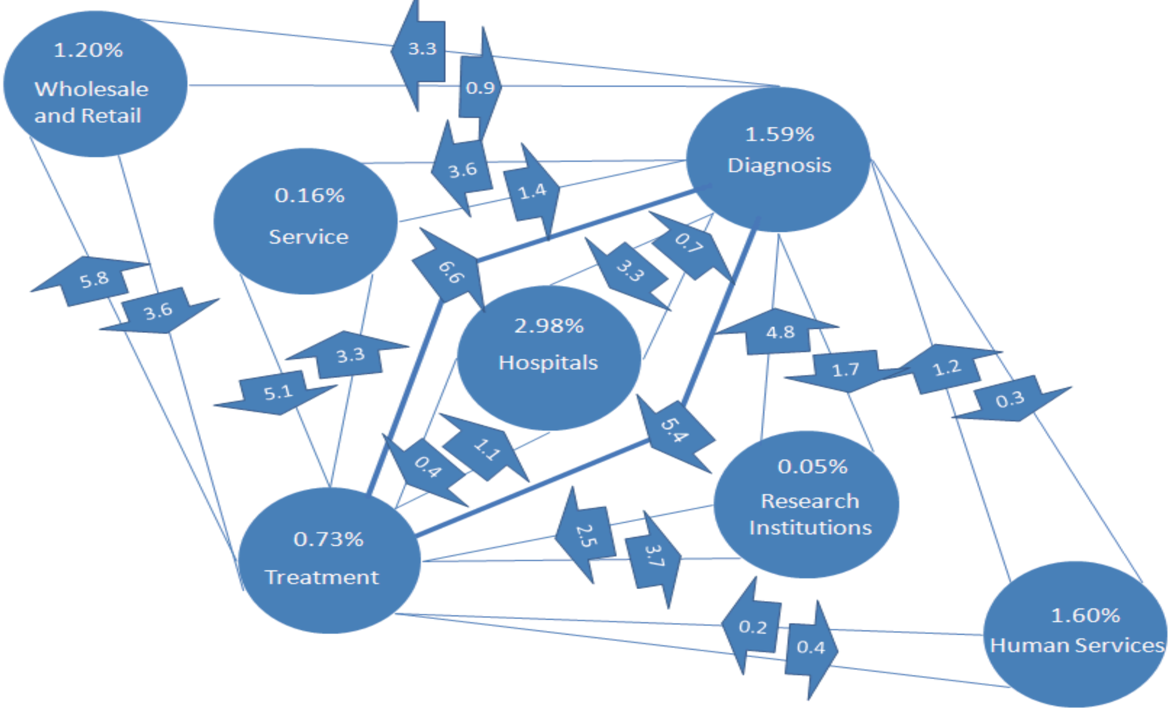
8.3 Labor dynamics

Another source of industry dynamics is the labor market. Spillover effects have been identified as one of the three major mechanisms by which cluster advantages materialize (Marshall 1920; Almeida and Kogut 1999; Jaffe, Trajtenberg, and Henderson 1993). Spillover in labor markets happens through the transfer of employees across firm boundaries.

Labor dynamics in the health industry vary greatly. Figure 8-7 displays the degree of inter-sector labor flow of each sector in the health industry as a percentage of total employment in the sector (reported in percent within the circles). It should be noted that the figures exaggerate the actual number of moves because they include moves that are due to mergers and acquisitions, and moves caused by group-level restructuring (although there are no effects of organizational restructuring). Hospitals and other care institutions display a significantly higher degree of intra-sector labor mobility than other sectors. The developing and producing sectors of Diagnosis and Treatment exhibit only moderate intra-sector labor mobility, which implies low labor movement between similar firms. People employed in the Diagnostic sector are more than twice as likely to change jobs as people employed in the Treatment sector.

Figure 8-7 also presents a Ballassa index of labor mobility among the sectors (indicated within the arrows). A value of one signifies that the expected number of workers move from one sector to another in accordance with the relative size of the sector in the health industry. A value of less than one signifies that fewer workers move than expected, while a value of more than one signifies that more than a higher than expected number of workers changed sectors. From the figure, it is evident that flow between Treatment and Diagnosis contributes far more than expected (the largest numbers observed: 6.6 and 5.4).

Figure 8-7: Inter-sector labor mobility (2008)



Sources: Statistics Norway and BI

Hospitals play the role of receivers of employees. The flow from Hospitals to Diagnostic firms and, especially, to Treatment firms is substantially lower than expected. We observe, however, the establishment of strong ties through labor mobility between Diagnosis and Treatment, and the related activities conducted by Service, Wholesale and Retail, and Research Institutions. The labor mobility to and from Diagnosis and Treatment to these sectors is above the expected magnitude, with the exception of movement from Wholesale and Retail to Diagnosis, which is at the expected level.

8.4 Overlapping networks

Clusters thrive in the presence of related clusters in the economy from which the formers can draw upon (Porter 1990, 1998). Is the health industry a stand-alone industry or does it have related clusters and, hence, complementary sources of competences and ideas to utilize in its operations?

In Norway, the health industry is isolated. Its professionalization and the lack of industrial customers outside Norway are the driving mechanisms of this isolation. Figure 8-8 depicts the flow of personnel between industries in Norway during 2008. A similar pattern is also observed in earlier years. The health industry received more employees than expected from the Tourism, and Wholesale and Retail industries in 2008, while it did not provide more employees than expected to any other industry. If we examine the flow of employees with a university education, the health industry does not send or receive more employees than expected from any other industry. This clearly indicates the industry's relative isolation in the Norwegian industrial structure.

GE Vingmed Ultrasound

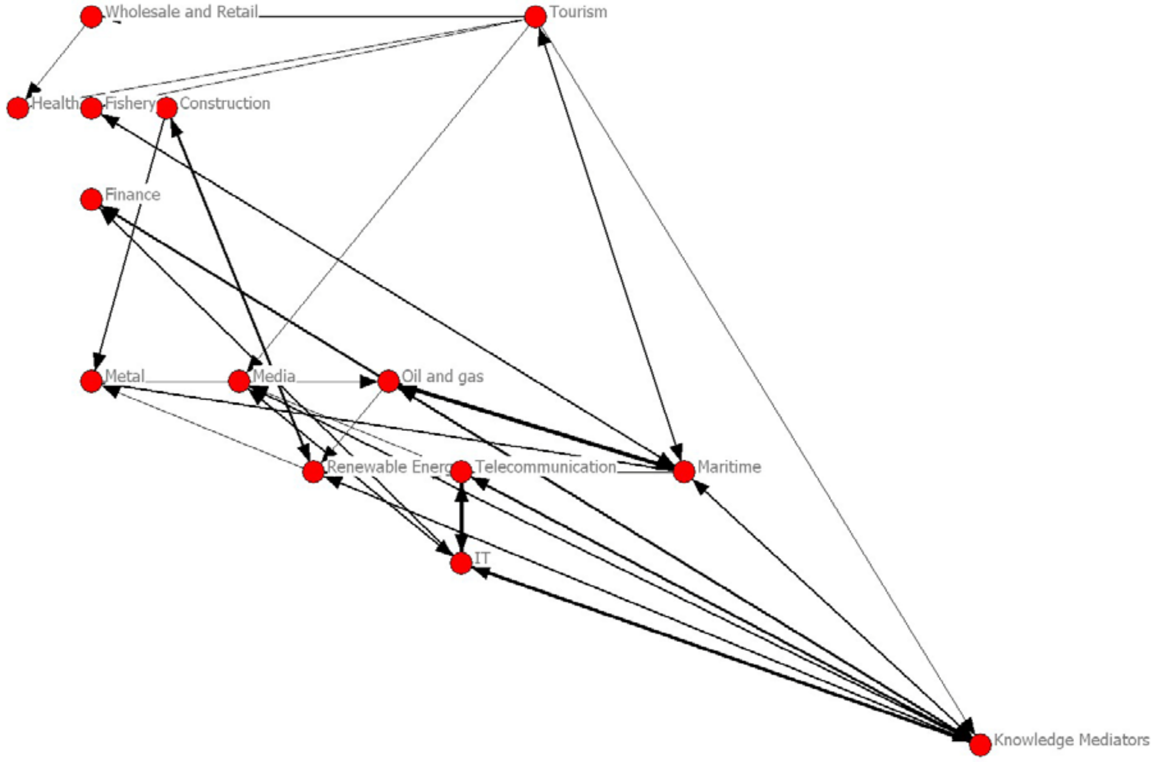
Vingmed is owned by GE Healthcare and is one of the company's Centers of Excellence for the development, design and production of advanced cardiovascular ultrasound equipment. The company supplies a wide range of ultrasound equipment. Although these products are developed and produced all over the world, the most advanced cardiology ultrasound equipment is developed and produced in Norway. Vingmed is a world leader in the development of 3D and 4D cardiovascular ultrasound imaging. Its handheld Vscan device was honored as one of *Time Magazine*'s 50 "Best Inventions of 2009" (Time 2009).

The company is based in Horten, Norway and has close ties to the medical technology cluster in Trondheim, where the founders were active. Vingmed operates in relative isolation outside of any potential medtech cluster but relies heavily on informal networks as sources of knowledge linkages and innovation, as well as access to global markets.

Financial Performance

mNOK	2005	2006	2007	2008	2009
Total operating income	848	992	1000	913	951
Total income growth		*17.0%*	*0.8%*	*-8.7%*	*4.2%*
Operating profit (loss)	238	170	126	71	121
Operating profit (loss) growth		*-28.6%*	*-25.9%*	*-43.7%*	*70.4%*

Figure 8-8: Overlapping Networks (2008)



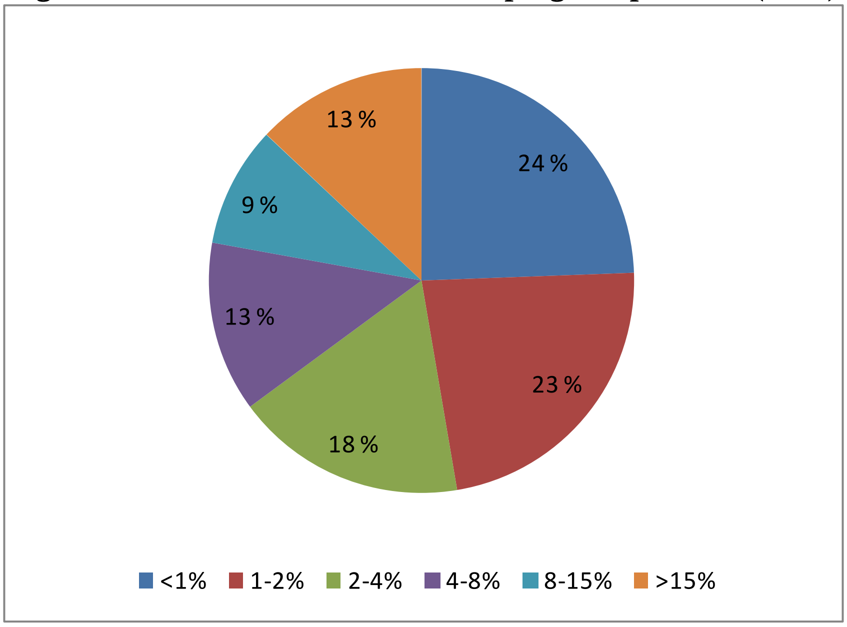
Sources: Statistics Norway and BI

8.5 Indirect linkages: Competence development

Firms can supplement investments made by educational institutions as well as individual employment choices and spillovers from already acquired industrial knowledge by investing in employee competence development (Figure 8-9). We examine this factor because investments in employee competence are semi-public goods. There is no guarantee that employees will remain with a particular firm and, hence, the benefits of investments in competence may be captured by other firms.

47% of health firms invest less than 2% of turnover in developing employee competence. This figure is identical to the investments made in the oil industry. A striking difference between these two industries, however, is observable at the high end. Whereas only 7% of oil and gas firms invest over 15% of turnover on competence development, 13% of health firms spend the same amount. This reflects the high level of knowledge intensity in the health industry as well as its rapid rate of innovation and development. Employees must stay abreast of the latest medical developments in order to produce better therapeutic drugs and diagnostic equipment. In turn, there is an ongoing need for employees in hospitals and health centers that are trained to use new equipment and correctly administer new drugs.

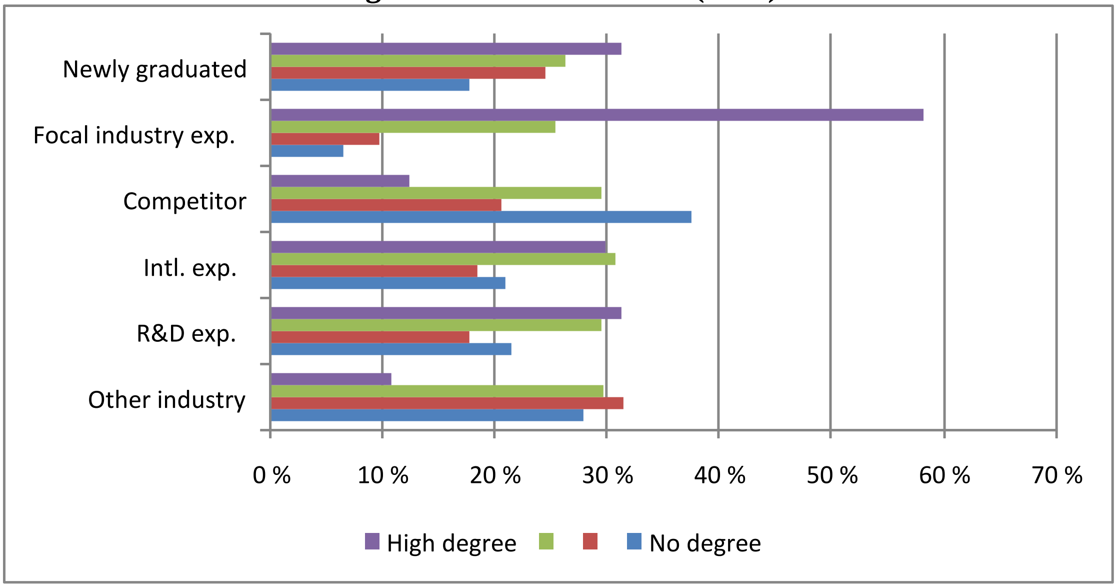
Figure 8-9: Revenues used on developing competences (2010)



Source: BI Survey

An examination of recruitment highlights a single factor deemed to be the most important (Figure 8-10). The recruitment of employees with focal industry experience is regarded as contributing knowledge to a *high degree* by 58% of firms in the survey. 83% of firms indicate that recruitment of employees with focal industry experience is at least of *above-average* importance as a source of knowledge and competence. The recruitment of new graduates, workers with international experience and workers with R&D experience rank equally as sources of knowledge. Over 58% of firms rate all of these fields as being of above-average importance in this respect. This reflects the global nature of the industry, and the demand for talented individuals within R&D and for bright minds that may be able to contribute from other perspectives.

Figure 8-10: Recruitment (2010)



Source: BI Survey

8.6 Cluster dynamics: Conclusions

Local competition is comparable to that in the oil industry (52% and 56% respectively). However, its main driving force is competition among retailers and wholesales. Treatment and Diagnostic firms work on seemingly unrelated projects with respect to the final customers effectively reducing the strength of the local competition mechanism to generate innovation and improvements.

The hardest competition is experienced from foreign competitors. Diagnostic firms, for example, experience the hardest level of competition almost entirely from international firms. As advanced in chapter 3, many of these firms work in isolation without local or national competitors. Norwegian suppliers are technologically backwards relative to their foreign counterparts. This renders the health industry firms less able to innovate and outperform rivals.

Innovations happen less and less in isolation. The industry is, as it should be, customer-centric with regards to sources of innovation. In addition, R&D institutions are at the heart of this innovation system. Every second firm perceives relations to R&D institutions to affect their own innovative output. Unlike more mature industries, interest organizations play a central role in innovation. Many firms are very small and, hence, organizations like OCC have a central role to play in reducing search costs for partners, customers and suppliers as well as reducing transfer costs by creating arenas for information and knowledge transfer. Governmental agencies, like NFR and Innovation Norway, have an important role to play in all parts of the industry but for Wholesale and Retail.

Hospitals take the role of receivers and not providers of employees. The flow from hospitals to Diagnostic firms and especially to Treatment firms is substantially lower than expected. We observe, however, the establishment of strong ties through labor mobility between Diagnosis and Treatment and the related activities conducted by Service, Wholesale and Retail and Research institutions. These may be early signs of the formation of an innovation system.

Clusters thrive in the presence of related clusters in the economy from which the formers can draw upon (Porter 1990, 1998). The health sector is relatively isolated. It has weak ties to the tourism and wholesale and retail industries. These ties are receiving ties. The industry does not reciprocate in terms of sending qualified labor to other industries. This is corroborated by a single source, people with industry experience, which is deemed to be the most important by far for recruitment of new employees. The industry creates the conditions for future success by investing greatly in competence development. 13% of firms invest more than 15% of their income in competence development.

9 Summary of findings, firm strategies and public policy recommendations

In this concluding chapter, we summarize the major findings of the study and provide recommendations for business strategy and public policy. The health sector has enjoyed relative success with firms like Algeta, Clavis and Photocure. But was this wave of success a "one off" event? How can the industry develop from intermittent success stories to a self-reinforcing set of firms that excel?

9.1 Summary of findings

This report focuses on the current status and emerging trends within the six dimensions of the Norwegian health industry as a global knowledge hub: cluster attractiveness, educational attractiveness, talent attractiveness, R&D and innovation attractiveness, ownership attractiveness and cluster dynamics. The main results are summarized below.

9.1.1 The health industry at a glance

Total expenditure on health has been increasing in absolute terms and as a percentage of GDP. The expenditure on health per capita doubled from 1997 to 2008. Employment growth rates in sectors that have global value-creation potential have been disappointing. Specifically, the Diagnosis sector has not grown over the last decade, while the growth rate in the Treatment sector has been only moderate. Growth in the R&D-intensive sectors is far outrun by growth in the support and logistics sectors.

The Norwegian health industry imposes costs on the public as a result of the large, publicly financed health sector. However, it offers many opportunities for value creation on a global scale. These opportunities have attracted the attention of scientists, investors and public authorities, and have resulted in the investment of considerable resources in the pursuit of health-related innovations.

Value shop firms create value by solving customer problems through a process of acquiring and diagnosing problems, choosing between alternative solutions, and executing and evaluating solutions. Knowledge of the problem domains and professionalization in various domains are central characteristics of the system, which make this industry extremely knowledge intensive, as reflected in long, professionalized educational programs. The industry is not formed in isolation. A constellation of actors and institutions that invest considerable resources over a few decades is a prerequisite for the formation of an innovative diagnostic and treatment cluster.

9.1.2 Cluster attractiveness

Economic activity in the health-related sectors is highly concentrated in the Oslo region. However, many of those sectors have yet to reach critical mass. There is only one emerging health cluster in Norway, namely in the Oslo region. Isolated activities in Hordaland, Sør-Trondelag and Tromsø are likely to remain as stand-alone projects, as a critical mass of firms working on related projects is unlikely. The same pattern is evident in terms of the distribution of some of the largest health firms, like Laerdal.

Value creation in the health sector is moderate with average value creation of NOK 0.6m per employee. Treatment is, by far, the highest value-creating sector (NOK 1.1m). Salary costs are very high in the health industry and constitute 82% of total value creation. Treatment is the sector in which salary costs are lowest as a proportion of value creation per employee (53%). Diagnosis has a very large portion of foreign sales (83%), as does Treatment (62%). Advanced services are also internationally oriented, as are some parts of research-based services. Retail and Wholesale is a home-market sector. Biotech clusters around the world share common characteristics. Cross-cluster comparisons indicate that a focus on the underlying mechanisms of value creation and industry formation are of the utmost importance.

9.1.3 Educational attractiveness

Doctoral educational programs are developing in both absolute and relative terms. However, the source of this increased popularity is unclear. On the one hand, there may be a real demand for an increasing number of doctoral graduates in the market. On the other hand, such programs may be flourishing as a result of public-sector investments (e.g., FUGE), which may cease in the near future or following a change in government.

Another reason for concern is the variability and the moderate negative trend with regards to the number of Master students. This shrinks the pool of Master students who can accept employment in Treatment and Diagnostic firms, or proceed to doctoral studies, which are of central importance in this industry. The industry is not increasing its attractiveness for Bachelor or Master students and its attractiveness for doctoral candidates is on the decline after a period of growth from 2005 to 2007. The proportion of students engaged in health-related studies has remained constant. An introduction to health-related and biotechnology-related subjects is not part of the Norwegian early education system. An experimental project (Ullern High School) is on the way but it represents an exception to the rule rather than the modus operandi.

9.1.4 Talent attractiveness

The division of human capital in the health industry is unique among Norwegian industries. The health industry is highly professionalized – 44% of employees have a Bachelor education compared to 20% nationally. The proportions of employees holding Master or PhD degrees are similar to the national averages (11% and 1%, respectively). The industry is dominated by the Wholesale and Retail sector (when hospitals, other care institutions and private clinics are excluded). In 2008, 62% of all employees worked in this sector. In relative terms, all other sectors are shrinking.

One of the most important findings is that the number of employees with science and engineering backgrounds is either not increasing or only moderately increasing in the Diagnosis and Treatment sectors. If these sectors were growing as one would expect based on the media coverage of these sectors, we should observe an increase in the number of people with relevant scientific and engineering backgrounds. We observe declines or only moderate growth rates throughout the investigation period. The situation in the advanced supporting activities is similar. The size of the Research Institution sector remained constant from 2000 to 2008. As in Diagnosis and Treatment, we do not observe growth in the number of engineers or scientists working for Research Institutions. The industry has attracted a large number of foreign workers. However, the human capital of the average foreign worker joining the Norwegian health industry is lower than the human capital of the average domestic employee.

9.1.5 R&D and innovation attractiveness

Norwegian academics are not over-productive in terms of publishing academic work on health-related topics. However, Norway has an overrepresentation of cancer-related research output in terms of ranking and in terms of the proportion of cancer-related publications out of all health-related publications.

Diagnostic and Treatment firms are extremely R&D intensive in terms of investments and number of R&D personnel. The industry as a whole is innovative in terms of products but not in terms of services. Diagnostic firms are highly innovative with more than 50% of firms reporting product innovation. Product innovation for the industry is high but there are signs of a declining trend. Firms in Diagnosis maintain a very high rate of product innovation. Treatment firms exhibit a positive trend in terms of product innovation.

R&D is mostly financed by internal funds. The second-largest source of financing is foreign investors. This highlights both the global nature of the industry, where knowledgeable investors are scanning the global market for investment opportunities, and the lack of a local, knowledgeable investor milieu. A health firm is five times more likely to use patenting to protect its innovations than a firm outside the health industry. Substantial differences also exist in the use of protection through secrecy and economies of time.

9.1.6 Ownership attractiveness

While capital is generally available in Norway, it is not readily invested in long-term, health-related projects that are perceived as very risky. Norway has few competent capitalists who are able to evaluate advanced biotechnological treatment projects and willing to invest in such projects. Competent owners found in many of the well-established industries in Norway do not migrate from these industries to the health industry, especially not to the riskier health-related projects. Competent owners control about 20% of total sales in the health industry by controlling a very small number of firms. Most of these firms are retail chains, not technology developers. To the extent that competent ownership exists in the health industry, it is concentrated in the Oslo region.

9.1.7 Cluster dynamics

Local competition is comparable to that in the oil industry (52% and 56% respectively). However, its main driving force is competition among retailers and wholesales. Treatment and Diagnostic firms work on seemingly unrelated projects with respect to the final customers effectively reducing the strength of the local competition mechanism to generate innovation and improvements.

The hardest competition is experienced from foreign competitors. Diagnostic firms, for example, experience the hardest level of competition almost entirely from international firms. As advanced in chapter 3, many of these firms work in isolation without local or national competitors. Norwegian suppliers are technologically backwards relative to their foreign counterparts. This renders the health industry firms less able to innovate and outperform rivals.

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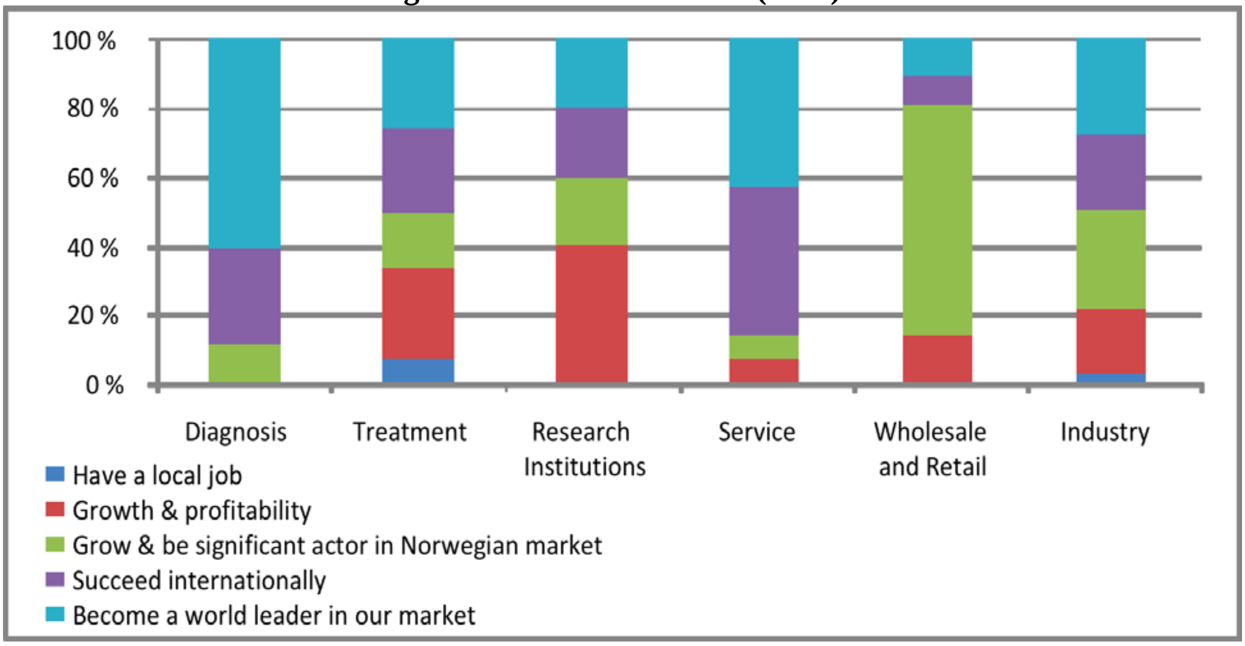
9.2 Firm strategies

Figure 9-1 describes the ambitions of firms operating within the Norwegian health industry. Assessing the industry as a whole we see that 50% of all firms have international ambitions. They desire to succeed internationally or become world leaders in their respective markets. Differences arise when we look at the different industry sectors. 90% of Diagnostic firms and 85% of Service firms have similar high international ambitions.

Figure 9-1: Firm ambitions (2010)



Source: BI survey

The Treatment sector is split between national and international ambitions with 50% of Treatment firms being focused on growth and profitability on a national and local level. However, all the biotechnology-based firms within the Treatment sector have global aspirations. Wholesale and Retail firms have very low levels of international ambitions. This section recommends general firm strategies for current and future firms with international ambitions.

Invest in unique technologies. An investment in an incremental change – moving a known technology one step further along its development curve – is unlikely to attract the attention of foreign investors or foreign pharmaceutical firms. Given the above findings, especially the lack of a well-developed cluster, a local investment milieu and large, local pharmaceutical firms, incremental projects are less likely to gain support. Many current (potential) success stories within the Treatment and Diagnosis sectors are (will be) the result of investments in new technologies (e.g., Photocure) that have the potential to penetrate the global market, and to be applied across a range of diseases and, in some cases, a number of different industries (e.g., Pronova).

Invest in blue oceans rather than crowded streets. Activities focused solely on narrow, competitive fields are likely to hamper the success of local firms. In a field populated by many firms, in which the primary success criteria is "first to patent", Norwegian firms lack advanced patent-registration services and an advanced venture capital milieu. They are likely to be both outspent and outrun by non-Norwegian firms. Given the industry's state of development, time-to-market is longer. At least in the near future, projects that focus on fields where there is a lack of direct competition allow for slightly more flexibility and have a better chance of success.

Allow for the combination of technologies and substances. While the problems to be solved currently experienced by the medical profession are public knowledge, the solution and its potential global reach are the driving forces behind the industry. One area that has provided and is likely to continue providing cross-fertilization is the application of known technologies from non-medical fields in the quest to solve medical problems. GE Vingmed serves as an illustration of the applicability of this strategy. Cardiovascular ultrasound imaging is based on a technology with a long history in the Norwegian technological environment (e.g., NTNU's original work on the technology and its ensuring application to oil exploration). The application of the technologies of which Norway has advanced knowledge to medical problems has proven successful. A similar argument can be used to explain the blockbuster status of Pronova's innovations.

Disrupt the business model. Business model innovations have been central for the development of many global firms across a wide range of industries, such as IKEA. In the health sector, business model innovations have transformed the provision of health services, and the methods by which conditions are diagnosed and subsequently treated (Christensen, Grossman, and Hwang 2009). Creative problem solving, combined with the application of technologies, can provide a fruitful avenue for successful projects, as illustrated by the Nycomed case.

9.3 Public policy recommendations

The industry is slowly evolving. It suffers from the inherent problems summarized in section 9.1, which are likely to substantially restrict its evolution. This reveals the main challenges to the formation of a health industry that provides substantial value creation in Norway: the lack of venture capital and the lack of pharmaceutical actors. By their very nature, these factors would provide the conditions under which R&D-intensive activities could be developed into innovative products and services, and commercialized thereafter.

Create a synchronized strategic direction. Governmental cycles are short relative to the cycles evident in the health industry. Investors, talented individuals and future students are likely to choose a different industry unless it is not made absolutely clear that the underlying technologies of the health industry, such as biotechnology, are nationally prioritized. This prioritization must evident from an early stage. Biotechnology, for example, is mentioned in the current government's initiation document. However, a comprehensive implementation strategy (that includes pupils, students, talented workers, existing firms and investors) and addresses primarily cluster attractiveness, educational attractiveness, talent attractiveness, R&D and innovation attractiveness, ownership attractiveness and cluster dynamics for the prioritization of biotechnology is lacking.

Establish a broad competence base. Education in core technologies and the encouragement of a desire to solve medical problems must start at an early age. Investments in biotechnology education, for example, have to increase exponentially in order to secure the development of talented researchers and practitioners. This aspect also entails the creation of incentives for the import of foreign employees with technological and commercialization knowledge. Furthermore, large investments are required in the development of the knowledge infrastructure. This requires the extension of investments in programs such as FUGE, as well as other initiatives. However, it is important to *avoid the fragmentation of limited resources*. Norway is a small country. Its involvement in drug development and diagnostic equipment is extremely centralized in the greater Oslo region. Health-related activities in other parts of the country are sporadic and, in most cases, lack critical mass. There is no room for district politics regarding the distribution of these very limited resources (widely known as governmental R&D), although this will be an unpopular strategy in Norway.

Build up risk capital (*taxation and knowledge)*. The current taxation system does little in terms of providing incentives to invest in risky drug development and disease diagnostics, which are likely to produce negative income streams over a period of at least ten years. In the oil industry, the government's pledge to refund the total tax value (78%) of investments for operators not in a tax-paying position provides a strong incentive for investments, exploration and R&D, *and* levels the playing field between existing and new operators. The health industry enjoys no such preferential taxation arrangement and investors therefore bear the risk in full over an extended period of time. A revision of the tax system to allow for an alternative risk-sharing arrangement is necessary. Such a revision is also likely to stimulate the transfer of capital from real estate (where a clear tax incentive exists) to more productive uses of capital (investments in knowledge that can be applied multiple times over a range of business activities).

In conclusion an investor commented that: "It will take a few more years to get some answers with regards to the developing biotech projects (e.g., Algeta and Clavis). Positive answers may generate not just an industry but also an enthusiasm for future research projects and ease the difficulty of gaining access to funds". Our immediate task is to create the conditions under which such an evolution may occur.

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