Create the right conditions for innovation in the Dutch biotech cluster

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General information

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Preface

In order to finish my master Business Administration, master track Innovation and Entrepreneurship, I conducted a research on the improvement of the innovation system of the Dutch biotech cluster. The subject innovation always had my interest, and as part of an entrepreneurial family it was directly clear that I wanted to follow the track Innovation and Entrepreneurship. Therefore to finish this study on the matter of innovation within the biotech cluster in the Netherlands was great.

The objective of my research was to get a better view on the conditions needed for the Dutch red biotech cluster to improve innovation. Therefore, I first conducted a research to the current status of the biotech cluster and secondly I assessed the conditions that should be present for the development of a biotech cluster. This study also has been accompanied by quite some interaction, because I conduct interviews with policy makers, entrepreneurs, investors and academics to evaluate the cluster and its conditions. This was very informative and very enjoyable for me.

My graduation assignment has been facilitated to a large extend by my supervisor and colleagues of The Decision Group. I would like to thank them for the possibility they gave me to become part of the team and to work on several different projects. The valuable insights and creative thinking of all the people at The Decision Group helped me ending this thesis, for which many thanks.

For the University of Twente this thesis was supervised by Jeroen Kraaijenbrink, who I would like to thank for his guidance and professional approach which resulted in many valuable insights and comments. I am also very thankful to Marianne van der Steen, who kindly agreed to be my second reader and gave me useful comments and suggestions to improving the thesis.

Last but not least I want to thank several persons, who supported me during the process of writing my master thesis. First I would like to thank Monique, my girlfriend, for just being there and listening to my arguments why writing a thesis sucks. Second and last I would like to thank my parents who gave me the opportunity to study, without any compromises. They supported me during my educational career in all possible ways. I can honestly say: THANKS mom and dad, without you both this thesis had never been there.

Frans Heijs

Executive summary

The Dutch biotech industry has great economic and social potential based on the good scientific position, but The Netherlands are still lagging behind in the valorization of this solid scientific foundation. To increase usage of the economic potential of the Dutch biotech cluster, the innovation process of the valorization process needs to be improved. An improved valorization chain will contribute that more economic and social benefits can be obtained out of the excellent Dutch knowledge base. Therefore the central question of this research is; which aspects of the Dutch biotech sector innovation system can be improved to stimulate the utilization of the economic potential of the red biotech cluster? The Dutch biotech sector can be divided in different areas, this research will focus on the Human Health area in the Netherlands. The human health area refers to the use of organisms for the improvement of medical processes. The human health area is also referred to as the red biotech sector or cluster.

This above question is twofold and to answer it, it has been split into an assessment of the Dutch red biotech cluster and an analysis of the conditions necessary for the development of the innovation system of the Dutch red biotech cluster.

In order to evaluate the performance of a system, each of the actors, not primarily as single entities, but connected in the entire system need to be evaluated (Carlsson et al., 2002). A single indicator is not sufficient to capture performance, but several measures have to be combined to give an assessment of the performance of a cluster. For the assessment of the Dutch red biotech cluster six indicators have been constructed; total employment, total turnover, total number of companies, total number of products, number of public investments and the number of private investments.

For the analysis of the conditions a system approach on innovation is used. On a high level there are two different approaches using a system approach on innovation. The first approach is the concept of innovation systems introduced by Freeman, the other approach is the cluster model introduced by Porter. To examine the causes of the lack of innovation within the Dutch biotech cluster this research will use a framework that have been used for analyzing innovation in the biotechnology cluster of Singapore, based on the cluster model by Porter. By analyzing a biotechnology cluster it is important to focus on the processes of knowledge creation and diffusion. Therefore, for this research the cluster model have been modified to four distinct elements necessary

for innovation within a biotech cluster; catalysts, fuel or nourishment, supportive host environment and a high degree of interdependence.

The assessment resulted in a growing Dutch Biotech cluster, but this is however not yet reflected in the growth of capacity of the Dutch biotech cluster. Following the increase of companies and products, it was expected the total revenue of the cluster would show also a big increase, but on the contrary the increase of revenue was marginal. This means the cluster is growing in size, but this is due to a significant number of small companies that are not self-sustaining. The assessment showed that employment within the cluster showed a marginal decrease. It was expected to increase following the increase of companies and products. This outcome strengthens the idea of the fact that the cluster has a lot of young small companies. This means that in the transfer of knowledge and in the exploration of young small biotech companies great progression have been made, while this progression is not yet visible in latter stages of the innovation process.

After the assessment, the analysis of the Dutch biotech cluster has been performed. The first element of the analysis framework, catalysts, showed that basic research is the main catalyst for a biotech cluster and thereby it can be stated that the foundation for an innovative cluster is present. However the numbers of graduates are rising, which is necessary for the growth of the Dutch biotech cluster, the knowledge of the graduates is unilaterally. The analysis of the conditions necessary for the development of the innovation system showed that the cluster also needs people who combine the industry specific knowledge with business knowledge.

Investments are a main fuel for a biotech cluster, and Dutch biotech cluster has a well-developed investment organ, and there are enough financial assets within the Netherlands. The problem is that the capital is not invested within the Dutch biotech cluster. Suppliers of financial capital have difficulties in assessing future risks of new products and services and claim that many Dutch life science start-ups in The Netherlands are not able to attain notable growth in reasonable time through their product-portfolio of interesting products with future perspective.

The third element of the framework formulated by Finegold states that there should be a supportive host environment. Analyzing the Dutch environment showed that the Dutch regime for animal testing is strict and counterworking entrepreneurs in the biotech cluster. Companies are moving their testing processes abroad. However the

Netherlands invests a lot in their infrastructure and facilities for the biotech cluster, there are still some thresholds to be taken.

The fourth and last element showed that in the transfer of knowledge and in the exploration of young small biotech companies have been made great progression the last years, while this progression is not yet visible in latter stages of the innovation process. Improvement of the latter stages of the innovation process can be found in three several directions and will improve the total valorization process.

Although this research yields interesting results, they should be considered against several limitations. First the latest data available for this research dated from 2005. To give a more specific and accurate assessment of the Dutch biotech cluster the data-set needs to be updated. Secondly, the insights gained by the analysis are to a large extent based on the interviews held. Third, the conclusions of the analysis are based on a limited set of interviewees with experts, who may have a subjective view on the cluster.

During the research process concessions have been made concerning the interview list. However the list has been composed carefully, due to time limitations and availability some interviewees had to be substituted or dismissed from the list.

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1. Introduction to the problem

In 1980 the American patent bureau assigned a patent to General Electric for a bacterium modified digest oil, because it was manmade and therefore an invention. Around this time, the hype around biotechnology began (Van Kasteren, 2001), what led to a wider and broader application of biotechnology.

In the mid-nineties the European commission described biotechnology as one of the most promising sectors for durable development. Time called the 20th century as the era of knowledge and technology, while Business Week called the 21th century the "Biotech century". Nobel Prize winner for chemicals Robert Curl predicted that biotechnology would be the number one science for the 21th century.

The potential of the bio-economy to spur economic growth and create wealth, through enhancing industrial productivity, is unprecedented (Sasson, 2004). Now for several decades biotechnology has attracted an enormous interest of scientist and policy makers for a number of reasons. The first reason, although biotechnology appears a rather narrow field, its applications are so wide in health, agro-food, energy and environmental sectors that it is becoming a core competence across a substantial portion of our modern economic activities (Cooke 2004). Second, biotech industry differs from conventional one since not the engineering but scientific knowledge constitutes an important base of the industry (Henderson et al. 1999).

In the late 1990s, the European Commission introduced the concept of the "European Innovation Paradox" (Wright et al., 2007). According to this concept, the European Union (EU) plays a leading role in top-level scientific output but lags in terms of its ability to transform this strength into wealth-generating innovation. In other words, "Europe performs well in science but badly in innovation" (Wright et al., 2007).

The lack of ability of Europe to turn scientific strength into innovative and commercially viable applications has been reported in many European policy studies (Enzing et al., 2004). The European biotech industry also faces this phenomenon, according to Reis et al. (2004) the overall picture on European performance in biotechnology emerging from various studies presents Europe as a very diverse area with strong research activities in some life sciences fields and weaknesses related to the exploitation of the biotechnology research base.

The Netherlands is having problems similar to the European paradox, see figure 1. According to the High Profile Group (2008) the Dutch life sciences have high-level scientific participation, but not done in a way which gives rise to enough business activity.

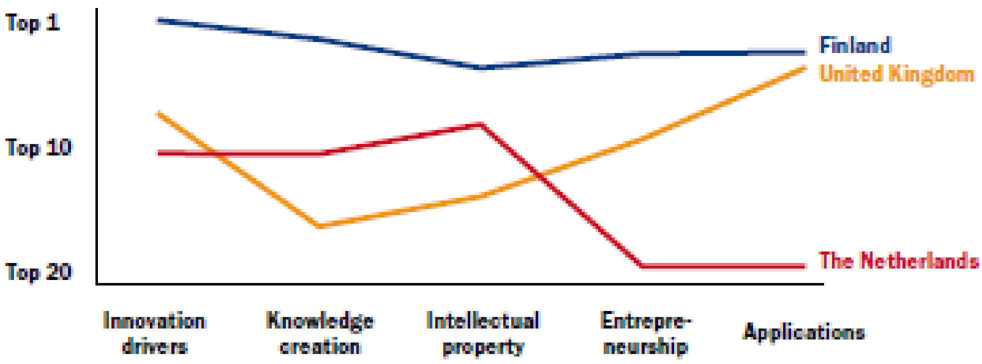


Figure 1: The Dutch paradox (source: European Innovation Scoreboard 2006)

Traditionally, the Netherlands excels in life sciences research, because the knowledge on-hand reaches the highest levels. The Netherlands has a good reputation on education in the life sciences, given the fact that Dutch universities are well represented in the list of top 100 best European universities in life sciences and biomedicines.

The Netherlands is home to world-class companies like DSM, Philips and Schering-Plough. In European context the Netherlands holds a fifth position (table 1), and in a global context the eighth position, based on a combination of scientific paper citations and the share of global biotechnology patents.

The Netherlands is leading in research, has an above average number of starting biotech companies and an above average number of patent requests, nevertheless, there are too few innovations of Dutch design in the life sciences. In terms of valorization of knowledge The Netherlands is performing very badly or like the Gezondheidsraad in 2007 noticed: the economic potential of the Dutch biotech sector is underused.

Country	Scientific paper citation		Share of global biotechnology patents	
	Value	Rank	Value	Rank
UK	7565	1	5.3	2
Germany	7497	2	9.6	1
France	5172	3	3.6	3
Italy	3363	4	1	9
Netherlands	2665	5	1.7	5
Switzerland	2168	6	1.4	6
Spain	2042	7	0.8	10
Sweden	1960	8	1.2	7
Belgium	1206	9	1.1	8
Denmark	1052	10	1.8	4
Finland	893	11	0.2	11

Table 1: Scientific competiveness (Ernst & Young 2007)

1.1 The problem in the valorization chain

The strategic and economic importance of scientific knowledge has been recognized for a long time (Teece 1981). Alongside the recognition of the importance of scientific knowledge, the valorization of scientific knowledge is becoming more important nowadays. The valorization of knowledge is the formal transfer of knowledge resulting from basic and applied research in universities and research institutes, as well as from applied research and development in companies, to (other parties in) the commercial sector for economic benefit (Goorden, et al., 2008). The valorization of knowledge can be understood as the broad process of capturing the value of new knowledge through commercial use in the economy (Van Geenhuizen, 2008). Using a process perspective on the valorization of knowledge a distinction can be made between the origin of knowledge (including start-up of the company) and the next stages of exploration, examination and exploitation of knowledge (Cooke 2004, 2005), see figure 3.

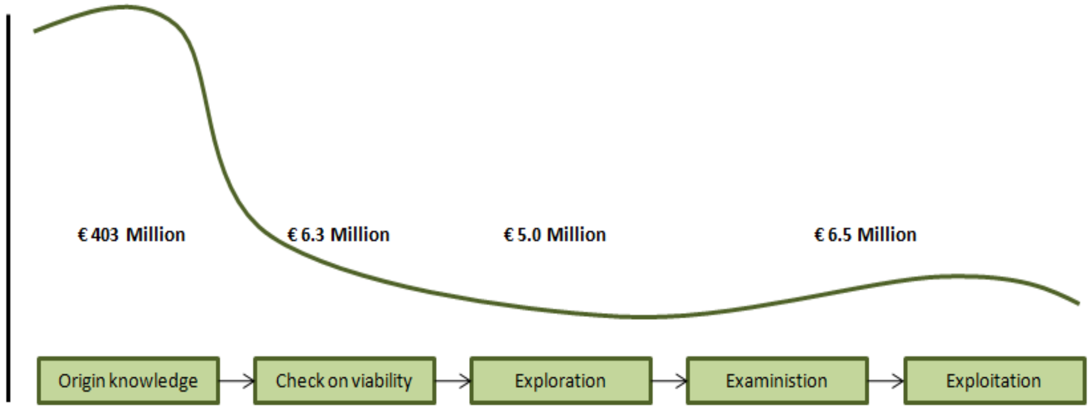


Figure 2: Money spent in the Netherlands on instruments for creating knowledge and valorization (Based on Cooke, 2004, 2005 and Partners in de Polder, 2009)

The point where companies attempt to gain viability and profitability, with the scientific knowledge from universities or other research institutes as commercial basis is the exploration phase. This is also the point where the attention for the valorization process is decreasing in the Netherlands, while many programs were pointed to stimulate the origin and check on viability of scientific knowledge. Programs like Master classes in Biobusiness, Technopartner and the rise of the Public Private Partnerships are aimed to originate useful scientific knowledge. As can be seen in figure 2, most of the money available for instruments for creating knowledge and valorization is pointed to the first two stages of the valorization process. These programs and money invested have shown good results, this research aims to help ensure that these results are continued in the second part of the valorization chain.

Following the High Profile Group, who divided the valuation process also in an invention and innovation phase, this research will do the same. The origin of the knowledge and the check on viability will be noted as the invention phase. The next stages of exploration, examination and exploitation of knowledge, the emphasis of the research, will be considered as the innovation phase.

Because the invention phase is showing good results and is gaining on attention, this research will mainly focus on the innovation phase of the valorization process.

1.2 Defining the biotech industry

Scholars of all disciplines were very interested in analyzing the biotech industry. While analyzing the biotechnological industry the wide variety in definitions created difficulties. Therefore in 1992 a standard definition of biotechnology had been set during the Convention on Biological Diversity. According to Sasson (2004) this definition was agreed by 168 member nations and was also accepted by the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organisation (WHO). The standard definition is: 'Any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products and processes for specific use'.

Biotechnology is a very broad concept and covers many different areas, the industry has already become increasingly essential to many different areas of modern life, of which a broad range of bio-industries have risen after the commercializing and industrialization of biotechnology. Biotechnology has applications in four major industrial areas: AgBio/Agro-food, Environment, Human Healthcare and General biotechnology, specified in table 2. These four sectors are closely associated with the economic impact of human-induced change to biological systems (Graff and Newcomb, 2003), but in this research will only be focused at one sector: the Human Health sector.

The area Human Health in the Netherlands, from this point forward referred to as "the red biotech" sector refers to the use of organisms for the improvement of medical processes. It includes the designing of organisms to manufacture pharmaceutical products like antibiotics and vaccines, the engineering of genetic cures through genomic manipulation, and its use in forensics through DNA profiling

AgBio/Agro-Food	Veterinary healthcare, bio-pesticides, plant agriculture, food technology, bio-cleaning, bioremediation, water treatment, waste recycling, white biotech, green biotech.
Environment / Biodiagnostics	Environmental diagnostics, industrial diagnostics, healthcare diagnostics, bio-chemicals, equipment, instrument, and miscellaneous.
Human healthcare	Biomaterials, drug delivery, drug discovery, gene therapy or healthcare cell therapy, genomics, vaccines, red biotech.
Service concerns / General biotechnology	Bio-processing, chemicals, contract research, contract manufacturing; bioinformatics, functional genomics, high throughput screening.

Table 2: The four major industrial areas of biotechnology (Life science monitor, 2005)

1.3 The problem Statement

The Dutch biotech industry has great economic and social potential based on the good scientific position, but The Netherlands are still lagging behind in the valorization of this solid scientific foundation. Given figure 2 there is a lot attention for the invention phase, which resulted in an increase of Dutch biotech companies, Fuchs (2003) stated that in the Dutch biotech market, almost the entire turnover and employment is generated by the large (multinational) companies, e.g. Unilever, DSM, AKZO-Nobel.

To increase usage of the economic potential of the Dutch biotech cluster, the innovation process of the valorization process needs to be improved. Improving the innovation system, will result in an improvement of the last phase of the valorization chain. Improving the second half of the valorization process will contribute to a shift of the total valorization process.

An improved valorization chain will contribute that more economic and social benefits can be obtained out of the excellent Dutch knowledge base. Therefore the central question of this research will be:

Which aspects of the Dutch red biotechs' innovation system can be improved to stimulate the utilization of the economic potential of the red biotech cluster?

To answer this research question sub questions have to be formulated. Before the research elaborates on what aspects of the innovation system can be improved, it will assess the current situation of the Dutch biotech systems. By assessing the status of the Dutch biotech industry, the premises for this research will be validated. The first goal of this research will be to give more insight in the systems current status of the Dutch red biotech cluster. Therefore the first sub question will be:

What is the current status of the Dutch red biotech industry?

By answering the first question it will come clear how the cluster performs on several indicators that mirror the economic utilization and when combined will give a good overview of the current status of innovation within the cluster. This will be used as basis for eventual recommendations for improvement of the innovation system of the cluster.

To figure out how the current status can be improved in the future, this research will analyze the conditions necessary for the development of the cluster. By analyzing the conditions necessary for development, it will come clear where the Dutch biotech cluster has shortcomings and where it needs to improve or even change. The second sub question will therefore be:

Which conditions necessary for the development of the innovation system of the Dutch red biotech cluster, need to be improved?

By answering this second question it will become clear where the system needs to be improved to stimulate innovation in the Dutch red biotech cluster*, b*y answering this last question and the results of the previous question the research will answer the central question of this thesis.

1.4 Research approach

In order to create a defined base, first a theoretical framework for both sub questions is created. The theoretical framework exist of two parts, a framework for the assessment of the Dutch red biotech cluster and a framework for the analysis of the development of the innovation system of the Dutch red biotech cluster.

The theoretical framework for the assessment of the Dutch red biotech cluster will result in 6 indicators, which combined give an overview of the current status of the Dutch red biotech cluster. The data needed for these indicators is obtained by desk research. The second sub question has been tested using desk research and interviews. Based on the outcomes of the assessment and analysis of the Dutch red biotech sector, conclusions and recommendation are prepared.

2. A Framework for assessment and analysis

An assessment and an analysis of the Dutch red biotech cluster will be conducted in this research. In this chapter the frameworks for both parts will be explained. First the framework of the assessment will be explained, the second part of this chapter elaborates on the analysis framework.

2.1 A framework for the assessment of the Dutch biotech cluster

In order to evaluate the performance of a system, each of the actors, not primarily as single entities, but connected in the entire system need to be evaluated (Carlsson et al., 2002). A single indicator is not sufficient to capture performance, but several measures have to be combined to give an assessment of the performance of a cluster. It is important to determine whether cluster performance should be assessed in terms of improvement in rate or quality of innovation, revenue growth, market shares, value added, or some composite latent dependent variable such as "competitiveness" (Davis, 2008).

Although no common used assessment exists of the biotech industry, most assessments used by scholars show a number of similar indicators. For example The European commission developed a ´Biotechnology Innovation Scoreboard´ (BIS), which functions as a standard exercise across Europe (table 3).

The Biotechnology Innovation Scoreboard has being criticized on the fact that the publicly available indicators are different among countries, what causes an inconsistent measurement of the R&D levels, employment and outputs (European Commission Enterprise, 2003).

The OECD agrees to several indicators of the BIS of the European Commission for the assessment of a biotech industry; total expenditures on biotechnology R&D by biotechnology-active firms and by public sector, total number of biotech firms, number of biotech firms, number of biotech start-ups, people employed, sales, granted patents and application patents (OECD, 2005).

To evaluate the selected indicators of the OECD for the assessment of innovation, the use of patents and research and development (R&D) as indicators could be questionable. The level of the expenditure on research and development does not guarantee a certain level of performance. In contrary a high expenditure of R&D could also simply implicate an inefficient R&D process. Therefore patents are not the best indicator to assess the economic potential of the innovation. For example a biotech company could have twenty patents with very low profits, while a biotech company with only two patents could making an enormous profit.

Indicators	EU leaders	NL position
PhD graduates in life sciences per capita	France, Ireland	-
Government biotechnology R&D expenditures as a percentage of GDP	Belgium, UK	8
Biotechnology publications per capita	Sweden, Denmark	5
Citations per publication in biotechnology	UK, Germany	3
Biotechnology EPO patent applications per capita	The Netherlands, Denmark	1
Biotechnology USPTO patents granted per capita	Denmark, Finland	6
Dedicated biotechnology firms per capita	Sweden, Ireland	10
Biotechnology venture capital as a percentage of gross domestic product	Belgium, Germany	9
Drug approvals per capita	Denmark, Ireland	4
Field trials in GMO crops per billion GDP in agriculture	Belgium, Sweden	10
Public understanding of biotechnology	Sweden, The Netherlands	2

Table 3: Biotechnology Innovation Scoreboard of the European Commission

Rickne (2001) developed indicators of performance of an innovation system in terms of knowledge generation and knowledge diffusion. These indicators of Rickne (2001) are summarized in table 4. Contrary to the OECD and the European Commission, Rickne (2001) also composed the indicator financial assets, which is a very important asset for a biotechnology cluster.

Indicators of generation of knowledge	Indicators of the diffusion of knowledge	Indicators of the use of knowledge
Number of patents	Timing/ the stage of development	Employment
Number of engineers or scientist	Regulatory acceptance	Turnover
Mobility of professionals	Number of partners/number of distribution licenses	Growth
Technology diversity, e.g. number of technological fields		Financial assets

Table 4: Examples of performance indicators for an innovation system (Rickne, 2001)

2.1.1 Indicators for assessing the Dutch biotech cluster

Comparing the variables of the two representative institutions, the OECD and the European Commission, gives the following corresponding indicators:

1. the total number of companies
2. number of startups
3. people employed and sales
4. expenditure on research and development
5. the number of granted patents and application of patents

The indicators ‘expenditure on research and development’ and ‘the number of granted patents and application patents’ will not be part of the assessment, as they are questionable as written above.

To ensure a representative outcome of the assessment and since the three remaining indicators (1-3) are an addition on the indicators formulated by Rickne (2001), the assessment of the Dutch red biotech cluster will based on six indicators.

1. total employment;
2. total turnover;
3. total number of companies distributed by the number of employees;
4. the total number of products;
5. the number of public investments;
6. and the number of private investments.

2.2 A system approach on innovation for the analysis of the Dutch biotech sector

In the research question of this research is stated, that a system approach on innovation will be used. The system approach on innovation is contrary to the belief in a linear innovation mechanism, in which innovation is the result of a highly organized and systematic process. The linear model on innovation starts with basic research, continued by applied research and development and ends with production and diffusion (Godin, 2005).

The traditional linear innovation theory considers science as the driver of innovation. The traditional theory has been believed to fail in explaining the real innovation processes. According to Smits and Kuhlman (2004) the thought of innovation being a linear process has changed the last four decades, and nowadays it is believed innovation takes place in a system perspective. In the system approach on innovation, "the strategic behavior and alliances of firms, as well as the interaction and knowledge exchange between firms, research institutes, universities and other institutions, are at the heart of the analysis of innovation processes" (Roelandt, 1997).

2.3 The concept of Innovation System

The concept of innovation systems was introduced by Freeman (1987). There is no exact definition of the concept of Innovation System and the concept is still emerging. Different scholars use different definitions, but they all include at least the following elements (Vandeberg et al., 2006):

- A network of stakeholders
- Interactions between the stakeholders in which knowledge and information is transferred
- Institutions (i.e. rules)

- A purpose of the innovation system (i.e. innovation success, reduction of uncertainty, economic growth and welfare)

Although Freeman introduced the concept of the innovation system, other scholars classified different approaches of the system. The innovation system concept can be applied in several forms based on criteria of classification: national, spatial, technological, industrial or sectoral.

In the national innovation system approach, a set of actors and their role in innovation is analyzed within the geographical boundaries of a given innovation system.

The sectoral system of innovation was introduced by Malerba (2002). The sectoral system is a multidimensional, integrated and dynamic view of sectors. The sectoral system of innovation is a set of products and a set of agents, individuals and institutions at different levels of aggregation making market and non-market interactions for the creation, production and commercialization of those products. The interactions are through processes of communication, exchange, co-operation, competition and command. The interactions are shaped by institutions.

Complementing existing approaches on national innovation systems and sectoral innovation systems, the spatial innovation systems approach incorporates a focus on the path-dependent evolution of specific technologies as components of technological systems and the intermingling of their technological paths among various locations through time (Oinas and Malecki, 2002). The spatial innovation system concept emphasizes the external relations of actors as key elements that transcend all existing systems of innovation. The integrating role of these relations remains inadequately understood to date (Oinas and Malecki, 2002).

The principle of the technological innovation system was developed in the beginning of the nineties (Carlson and Stankiewitz, 1991). Industrial innovation systems are based on the idea that different sectors and industries operate under different technological regimes which are characterized by particular combinations of opportunity and appropriability condition, degrees of cumulativeness of technological knowledge, and characteristics of the relevant knowledge base (Malerba, 2002). Malerba (2002) points out that the industrial innovation system has a specific knowledge base, technologies, inputs and demand. The agents of the industrial innovation system, including individuals and organizations at various levels of aggregation, interact through processes of communication, exchange, co-operation, competition and command. An industrial innovation system undergoes change and transformation through the co-evolution of its various elements.

All different forms of the innovation concept can be reduced to the first concept introduced by Freeman; the System of Innovation approach.

At the time Freeman introduced the System of Innovation approach another innovation system model was developed. In 1990, Michael Porter ended his extensive empirical studies of different nations and different sectors. These empirical findings were articulated in terms of a simple and highly influential model named as the Diamond Model or cluster model. This model argues that if all the conditions go hand in hand in a proper dynamism, there will be a positive loop that grows sectors productivity and innovation and thereby competiveness (Mehrizi and Pakneiat, 2006).

According to Freeman (1995) the networks of relationships are necessary for any firm to innovate. The influence of the national institutions like the education system, scientific institutions or government policies is fundamental, however external network connections and relationships are of growing importance within the innovation system.

Porter also sees the importance of networks and relationships, the combination of these relationships are called a cluster in his theory. The incentives for such clustering are even greater, when a new technology is just emerging, as the knowledge associated with it is predominantly tacit, and thus difficult to transmit to those not directly involved in its creation (Finegold, 1999)

The possibilities of doing an integrated and consistent analysis in the interrelated features is still very limited (Malerba et al., 2002). It is difficult to understand the working and transformation of the features or to compare different sectors with respect to several dimensions, like the role of agents, the structure and dynamics of production or the rate of innovation, and the effects of these dimensions on the performance of firms in the system (Malerba et al., 2002).

Innovation is no longer the outcome of sequential processes but is perceived as the result of complex relations between a large number of factors in a network.

On a high level there are two different approaches using a system approach on innovation. The first approach is the concept of innovation systems introduced by

Freeman, the other approach is the cluster model introduced by Porter. In the next paragraph the cluster model will be addressed as the leading approach.

2.4 Analyzing the innovation system of a biotechnology cluster

To examine the causes of the lack of innovation within the Dutch biotech cluster this research will use a framework that has been used for analyzing innovation in the biotechnology cluster of Singapore. This framework has been chosen for this research because it has already proven its effectiveness. This framework has been used successfully to analyze the Singapore cluster and therefore it is assumed to be complete and applicable to other biotechnology clusters in the world.

The framework analyses the conditions necessary to create self-sustaining biotechnology clusters (Finegold.1999). It consist of four distinct elements that are common to the development of biotechnology clusters (Finegold et al., 2004), and draws on related research on industrial districts of Piore and Sabel (1984), cluster theory of Porter (1990), collective learning of Teubal (1997) combined with the distinctive requirements of the biotechnology industry (Cooke, 2003).

The basic framework was developed by Finegold for analyzing so called High-Skill Ecosystems (HSE). A HSE is defined as a geographic cluster of organizations (both firms and research institutions) employing staff with advanced, specialized skills in a particular industry and/or technology (Finegold, 1999). Like the definition of Finegold suggests, the core of the HSE is based on the cluster theory of Michael Porter (1990) amplified with collective learning idea of Teubal (1997).

The remainder of this chapter will elaborate on both facets. First the cluster theory will be treated, starting with the cluster diamond, secondly the characteristics of a cluster and last the link between clusters and innovation will be explained.

The added value of the collective learning principle will be explained with Chesbrough's principle of open innovation. First the principle of open innovation will be explained and secondly the thesis will elaborate on the contribution of the open innovation principle for the biotechnology cluster to end the last paragraph with the model of Finegold.

2.5 The cluster diamond

Porter developed his theory to explain the characteristics of the environment that shapes the rate of private sector innovations in an industrial cluster. For explaining these characteristics Porter recognizes the dynamics of innovations and the dynamics of interactions, between clusters and specific institutions. For this interaction he created four key drivers as shown in figure 3. Central for this interaction is the group of companies in a sector.

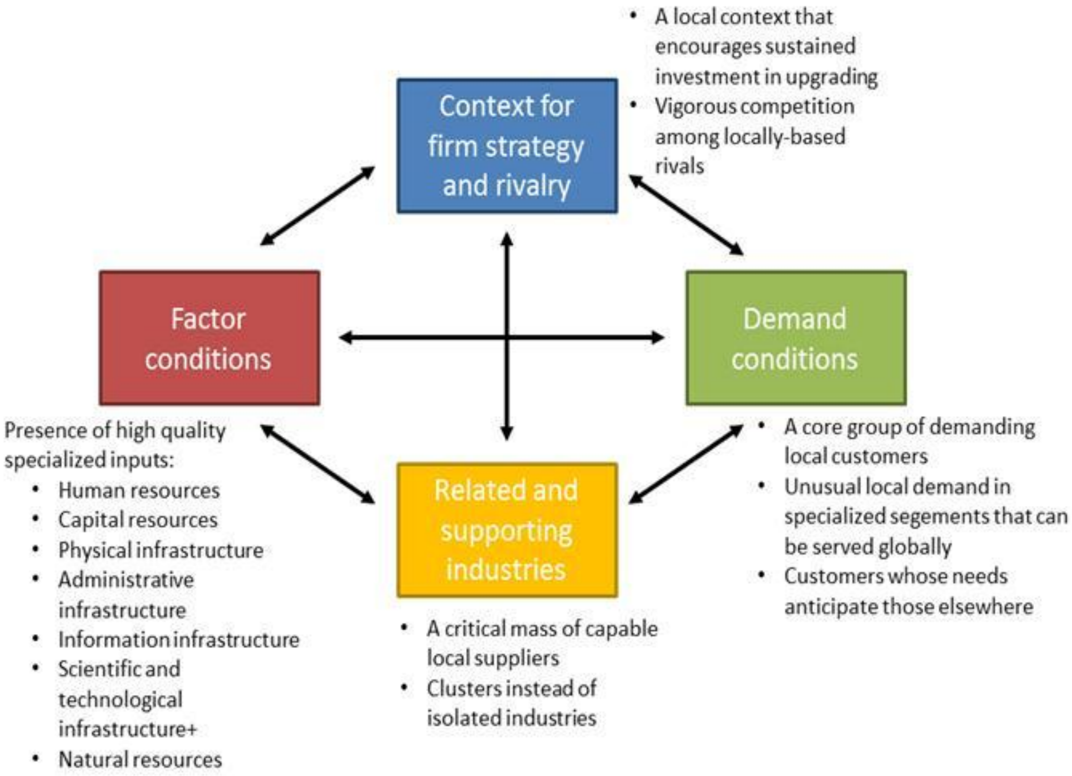


Figure 3: Porter diamond model (porter 1998)

2.5.1 Four key drivers

The diamond theory of Porter (1990) highlighted four key drivers of national competitive advantage, factor conditions, demand conditions, related and supporting industries and firm strategy, structure and rivalry.

The role of factors to a cluster's competitiveness depends on the efficient and effective deployment of them. In the dynamic and interacting diamond system, factors can be upgraded or may be declined. Disadvantage in some factors may spur the improvement of other factors through innovation and strategy planning and thus help the industry to achieve competitive success (Porter, 1990).

With demand conditions the home demand of an industry's product or service is emphasized. Despite the globalization trend, local firms closer to home buyers are more able to respond and cater to customers need in a faster and less costly way, and be more innovative under pressures from nearby.

Related industries are those in which firms can coordinate or share activities in the value chain when competing, or those which involve products that are complementary (Porter, 1990). Information exchange and technical interchange are among the benefits gained from the presence of competitive related industries.

The last key driver is the dimension "firm strategy, structure, and rivalry". Porter emphasized the importance of domestic competition in creating and sustaining competitiveness advantage. He believed that the most advantage management practices and organizational modes are those that fit the industry and favored by national environment.

The four drivers interact and work as a dynamic system to determine a clusters competitiveness advantage. Besides these drivers, Porter also identified two additional variables that could affect the national competitiveness system. These two variables are chance and government.

According to Porter, government exerts its impact on national competitive advantage through its influence on the four drivers. Government's influence on national advantage can be positive or negative. What's more, its effect is partial. Government can only influence the national competitive advantage but not control it (Porter, 1990).

2.5.2 The characteristics of a cluster

Porter in his study of national competitive advantage found that clustering tended to occur in a nation's competitive industries because of the systematic character of the diamond. Geographic proximity heightens the common support of each determinant. What is more important for geographic proximity is that it affects an industry's innovation and improvement, which are crucial to competitiveness. Thus "successful industries are usually linked through vertical (buyer/supplier) or horizontal (common customers, technology, channels, etc.) relationships" (Porter, 1990).

In viewing different definitions of clusters, one can see that they mostly derived from Porter's definition. Most of them also contain what are regarded as general features of a cluster.

The first is geographic proximity, the geographic proximity in a cluster should be close enough to facilitate meeting and networking, or even personal contact to encourage information flow. Size and range is an important element to consider in cluster mapping.

The second is systematic interconnection and interaction between actors, both from industry and from other institutions. It encompasses both the horizontal relations between competitors and the vertical relations from suppliers to downstream users. Other actors such as public sector organizations and brokers etc. also play an important role. Thus a cluster is a systematic network.

Clustering also helps the industry reach external economies of scale, meaning, "firms are economies that depend not on the size of the firm, but upon the size of the industry" (DeVol et al, 2004). It further paves the way for specialization. This process enables the allocation of cost and increases in production efficiency, in turn profit the whole cluster.

2.6 Cluster and innovation

According to Porter (1998) clusters affect competition in three ways, first by increasing productivity, second by driving the direction and pace of innovation, and third by stimulating the formation of new business. He sets innovation at the core of improving productivity and thus the competitive advantage of clusters. The innovation advantage of clusters is especially important, since innovation is the main driver for biotechnology companies. Biotechnology companies are mostly working with new technologies, and exploring is a large part of their operations. The OECD (1996) recognized the crucial role of innovation in the advancing of knowledge based economies, while in literature, there have been studies aiming at reveal the close linkage between innovation and cluster development.

Firms acting within a cluster often have a better sense on what customers want. Cluster firms have the ability to discover new trends in an early stage. Thus, they have the ability to detect changes in customer needs in an early stage and change their product and/ or service accordingly. Cluster firms profit from the close relations to their customers, the high demands of their customers, the close proximity of similar and related firms and company branches (Porter, 1999).

Besides the feeling with the customers, acting within a cluster also enhances the ability to get in touch with new technologies and processes. Actors get in touch with technological developments, availability of new machines and/ or components and new service- and marketing concepts.

The large amount of formal and informal contacts with firms, customers and related institutions creates a great trust factor within a cluster. Acting in a cluster, the large number of formal and informal contacts within the cluster makes direct observation of one's competitors possible, what means that access to new information is created with low costs.

Mentioned above, a cluster makes it possible to discover in an early stage new opportunities and trends, but at least as important is the fact that acting in a cluster enables flexibility and gives actors the capacity to react on new opportunities and trends. Local suppliers and partners participate or are often directly involved in the innovative process, which makes it possible to stimulate the innovation process. New and specialized personnel can be screened and hired at lower costs than usual, to stimulate the innovative process (Porter, 1999).

Besides the contacts and enabling of flexibility and capacity to react on new opportunities, pressure is another advantage of clusters that stimulates innovation. In geographical concentrated clusters the pressure to change is large. The pressure is created by other cluster members and the continuous ability to compare oneself to each other. Equal basic circumstances in combination of the presence of competitor's, forces firms to be creative and to distinguish themselves (Porter, 1999). For a firm it is often difficult to keep their advantage, while this is not the case for firms acting in a cluster.

Innovation is at the core as a main driver for economic performance and competitive advantage. It has also been widely acknowledged that clusters promote innovation and competitiveness, while innovation performs better in a clustering environment. Thus cluster is closely linked with innovation, which is important to economic development. Since 1990s, cluster as a phenomenon has caused much world attention, clustering has also been used as a means to foster innovation and further enhance competitiveness and economic performance.

2.7 Clusters and open Innovation

Many industries, including biotechnology are currently transitioning from closed to open innovation (Chesbrough, 2003). Biotechnology companies are more and more using the principle of open innovation for a high value-added services and a highly skilled people team. Companies need to connect and derive added value from collaboration and collective learning.

The landscape of the Dutch biotech cluster is changing. Until recently, large companies housed the entire innovation process, from idea till production for the market, within their own walls. This approach, however, is unsustainable, partly due to increasing multidisciplinary requirements for knowledge, the high costs involved and the major risks that development entails. For example, in recent years, fewer new drugs have emerged from the pipelines of large pharmaceutical companies. These are actually being developed at smaller biotech companies, often with entrepreneurial scientists at the helms, and are frequently brought to the market through partnerships with or acquisition by large companies.

The market is becoming more dynamic. Specialization is the credo. Companies seek more and more activities outside their own walls. The single company with all the specialties in-house is replaced by separate private companies focusing on one of the successive steps in the innovation chain. This specialization makes way for the concept of open innovation, where players work together in the development of new products and services. A more open approach to innovation means working together with people within and outside of the traditional company. National borders are no longer barriers, making the playing field even more international.

For example Genzyme, Genzyme has achieved its success by licensing technology in from outside the company and then developing that technology further within the company. It has developed these external ideas into an array of novel therapies that deliver important cures for previously untreatable, rare diseases. It has also built a record of impressive sales and profits in an industry where profits have been hard to obtain (Chesbrough, 2006)

As the sources of future development increasingly derive from open innovation, attention must be paid to non-traditional sources that have the potential to become the basis for construction of new business and social models as well as the renovation of old ones. Innovation systems are the set of relationships in which these new or renovated models could be developed. Last years a growing attention has been devoted to the concept of “Open Innovation”. Henry Chesbrough, the founder of the concept of open innovation describes in his book how organizations have shifted from closed innovation processes to more open innovation processes (Chesbrough, 2003).

Traditionally new business development took place within the boundaries of the company, figure 4. Nowadays the open innovation model is assumed very relevant for all innovations. This is due to several factors that have led to the shift from closed innovation to open innovation.

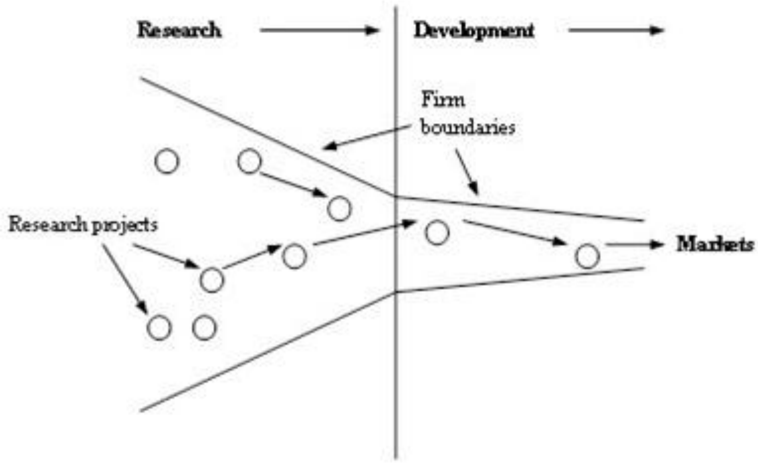


Figure 4: Closed innovation paradigm (Chesbrough 2003)

The first factor is the increase of the mobility and the availability of highly educated people over years. This results in a large pool of knowledge outside the research and development laboratories of large companies. In addition the knowledge available in the laboratories is interchangeable, because of the flow of employees. The second factor is the availability of venture capital, which makes it possible to further develop promising ideas outside the organization. In addition the possibilities to further develop promising ideas and technologies outside the organization are growing, for example spin-offs or licensing agreements. Finally, other companies in the supply chain play an increasingly important role in the innovation process.

Open Innovation can be described as: combining internal and external ideas as well as internal and external paths to market to advance the development of new technologies (Figure 5).

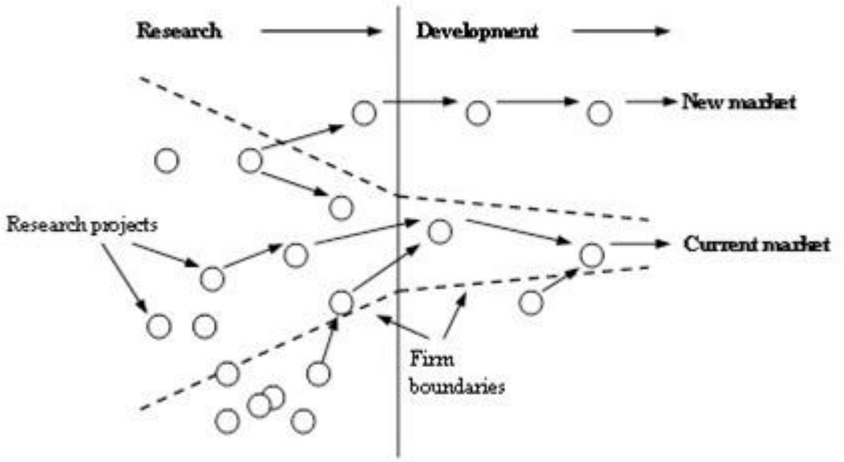


Figure 5: Open innovation paradigm (Chesbrough 2003).

The shift from closed innovation towards open innovation means that biotechnology companies needs to become aware of the increasing importance of open innovation dynamics. Not all good ideas are developed within the company, and not all good ideas have to be developed within the company. Chesbroughs open innovation theory is a good addition for the biotechnology companies within the clusters, while Chesborough said himself that clusters are well aligned with the modern approach of open innovation.

2.8 Combining clustering and collective learning

Porter (1990) focused on the factors that enable certain regions to create and sustain successful clusters. The cluster diamond model he developed has four elements and his framework draws heavily on the earlier work of industrial geographers and political economists, who studied the elements necessary for the creation and continued survival of industrial districts like Piore and Sabel (1984) and Scott (1988).

Although Porter focused on the key factors, there is a relatively underdeveloped part of Porter's framework, the process of knowledge creation and diffusion. According to Finegold it is important to focus on the processes of knowledge creation and diffusion by analyzing a biotechnology cluster. The process of creation and diffusion is an indicator of the adaption of open innovation by the cluster.

The four distinct elements the framework of Finegold consists of are common to the development of biotechnology clusters and incorporate the aspect of knowledge creation and diffusion in the analysis.

These four distinct elements necessary are:

- A catalyst
- Fuel or nourishment
- A supportive host environment
- A high degree of interdependence

2.8.1 Catalysts

As with naturally occurring ecosystems, there is a strong element of historical contingency in how and where high-skill regions are formed (Arthur, 1989). To start the development of successful high-skill companies A region require a catalyst, or set of catalysts. A catalyst is an element influencing positively the rate of development of the cluster, such as inventions produced by basic research or the demand of sophisticated customers.

A high percentage of the biotech companies are started by scientists that spin out of their research projects on the university or private research institutions. Many of them are located close to a university or another research institute, thus basic research is a key driver of growth and location decision of firms within the biotech cluster (Prevezer, 1998).

2.8.2 Nourishment

Besides the above mentioned catalyst, the region also needs nourishment, which sustains the growth of the biotechnology cluster, on an ongoing basis. According to Finegold (1999), the most important nutrient for the biotechnology cluster is new talent or new human capital. New bachelors, masters and PhD graduates who move directly to companies within the cluster, or start off their own business. These new talents do not only come for the science and engineering fields, but the new talents also need to come out of the management field (Finegold, 1999). For the continuity of the cluster it is important that enough new human capital is available to ensure the growth of the cluster. On the other hand it is also very important the human capital has a good quality, otherwise the growth can stagnate within time.

A synergetic relationship will be established between the research institutes and the surrounding companies that hire their graduates and support their research. This relationship can be self-sustaining when the two act together to attract the brightest students of the world.

Alongside the steady intake of human capital, another vital nutrient that sustains the development of a biotechnology cluster is financial capital. Capital provided by the public but the key of becoming self-sustaining is the need of venture capital. Venture capital can be provided by the venture capitalists, but also from the first generation startups. The first generation can become an angel for subsequent generations. They can provide more then only money, by participating in an early stage they also supply vital capabilities, e.g. managerial, financial, legal and procurement skills, based on their experience in the biotechnology cluster.

2.8.3 Supportive host environment

Just as young humans or animals need a supportive environment free from toxic chemicals and big climatic changes if they are to grow, so too biotechnology clusters of small companies are more likely to thrive if they have the right set of external conditions.

A basic requirement for successful high skill companies in a global marketplace, where the biotechnology companies are, is good infrastructure. As the key drivers of wealth in the economy have shifted from manufacturing to high-tech industries, the underlying basis for economies of scale has shifted from physical concentration of natural resources in a single location to the ability to design and sell new products or services on a worldwide basis (Finegold, 2004). Like Galbraith already said in 1998, the only way to justify the multi-billion investment required to develop a new drug is to sell the product globally.

While possessing a physical and communications infrastructure of good quality, a cluster needs to create more specialized infrastructure tailored to the needs of new, biotechnology companies. Mechanisms such as incubators and science or technology parks provide an array of services that small firms are likely to need as they develop, but aren´t present in-house.

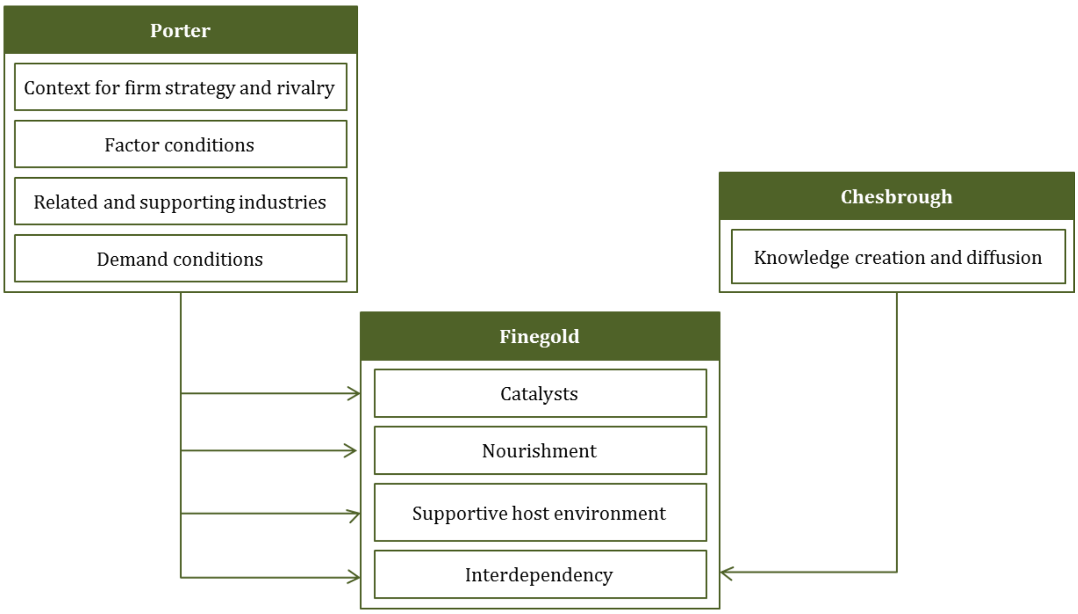
Another essential requirement for fostering the innovativeness of the biotechnology cluster is a regulatory and cultural regime that supports the risk taking needed to create new companies.

2.8.4 Independency

This element ensures the building of a system and not only a group separate units sharing the same space is that they are mutually interdependent. A high skilled ecosystem needs a shared focus on a common cluster and/or technology and a high degree of cooperation among the actors that facilitates the learning process and stimulates open innovation. The type of interdependency that is particular important in biotechnology is when companies replace vertical integration with partnerships across different segments of the value chain. This form of interdependence highlights the crucial role that demand drivers can play in transmitting signals down the value chain that stimulate the development of new companies (Porter, 1990).

2.9 Framework for analysis

For the analysis of the Dutch biotech cluster a model created by Finegold is used. Finegold formulated four distinct elements that are common to the development of biotechnology clusters. The elements are based on the Diamond model of Porter and a part of the Open Innovation Theory of Chesbrough.



Porter focused on the key drivers that enable certain regions to create and sustain successful clusters. Porter's diamond model draws heavily on the earlier work of industrial geographers and political economists, who studied the elements necessary for the creation and continued survival of industrial districts (Scott, 1988). In this earlier work, the continuous change of the environment these clusters exist in, was not recognized. To adapt to a continuously changing environment it is of vital importance to learn from each other (Finegold, 2002) and this learning part is relatively an underdeveloped part of Porter's framework. According to Finegold it is important to focus on the processes of knowledge creation and diffusion by analyzing a biotechnology cluster. The process of creation and diffusion is an indicator of the adaption of open innovation by the cluster. The theory of Chesbrough is founded on the principle of learning from each other. When a part of the theory of Chesbrough is combined with the basis theory of Porter, Finegolds framework arises to analyze the elements necessary to create and sustain a cluster. The elements the theory of Finegold consists of are: a catalyst; fuel or nourishment; a supportive host environment; and a high degree of interdependence.

2.10 Two different frameworks

The research exists of two components; the assessment of the Dutch biotech cluster and the analysis of the Dutch biotech cluster. Both components have their own framework. In paragraph 2.1 the framework for the assessment has been written down, For the assessment of a cluster a single indicator is not sufficient to capture performance. Several measures have to be combined to give an assessment of the performance of a cluster. To assess the Dutch red biotech cluster six indicators have been formulated: total employment; total turnover; total number of companies distributed by the number of employees; the total number of products; the number of public investments; and the number of private investments.

In the previous paragraph, paragraph 2.9, the framework for the analysis has been written down. The underlying theory of the framework used, is the theory of Finegold. Finegolds framework arises to analyze the elements necessary to create and sustain a cluster. The elements the theory of Finegold consists of are: a catalyst; fuel or nourishment; a supportive host environment; and a high degree of interdependence.

3. Methodology of the research

In this chapter the methodology of the research will be explained. First the type of research will be discussed and explained. After the research type this chapter will discuss the methodology of the assessment of the Dutch biotech cluster. The second part of this chapter will elaborate on the methodology of the analysis of the development of the cluster.

3.1 Type of research

In the research literature a distinction is made between a deductive and an inductive approach. A deductive approach in research: involves the testing of a theoretical proposition', an inductive approach: 'involves the development of a theory as a result of the observation of empirical data' (Saunders et al, 2007). In this research a deductive approach will be used. An existing model will be used to elaborate on the development of a cluster This will be done by different research methods, the research can be characterized as a multi-method qualitative study (Saunders et al, 2007).

3.2 Assessment of the cluster

As already mentioned in the previous chapter of this thesis the assessment of the Dutch biotech cluster will be based on six indicators. The data needed for these indicators was not readily available and therefore the indicators are constructed by combining readily available data.

3.2.1 Desk research

In order to answer the first sub question, data needed to be collected. For the assessment of the Dutch biotech cluster, secondary data was collected. According to Saunders et all. (2007) secondary data is data used in a research that was originally collected for some other purpose. In order to collect the right data per indicator, multiple data sources have been used and combined per indicator. The different data sources used per indicator can be found in table 5.

The secondary data needed for each indicator was obtained by a desk research. A research on data in existing resources was conducted. Organizational documents, business reports, and policy reports have been reviewed in order to find the data to quantify the indictors.

Indicator	Sub indicator	Data sources	NL – 2008	NL – 2007	Key clusters 2008	Key clusters 2007
Employ-ment		Beyond Borders – Ernst & Young			•	•
		Technopolis	•	•		
		The Decision Group Database	•			
		Websites; San Diego, RTP & Boston clusters			•	•
		Websites; Listed biotech companies in the Netherlands	•	•		
Revenue		Beyond Borders – Ernst & Young			•	•
		Biopartner 2005	•			
		Technopolis	•	•		
		The Decision Group Database	•			
Growth	Total number of companies	Beyond Borders – Ernst & Young			•	•
		Biopartner 2005	•	•		
		The Decision Group Database	•	•		
		Websites; San Diego, RTP & Boston clusters			•	•
	Total number of products	Beyond Borders – Ernst & Young		•	•	•
		The Biopharm Insight 2007			•	•
		The Decision Group Database	•	•		
		Websites; San Diego, RTP & Boston clusters			•	•
Financial assets	Public invest-ments	Beyond Borders – Ernst & Young			•	•
		Biopartner 2005		•		
		Biopolis		•		
		Biotechgate			•	•
		SenterNovem	•	•		
		Technopolis	•	•		
	Private invest-ments	Beyond Borders – Ernst & Young			•	•
		NVP 2008	•	•		
		PWC 2009			•	•
		Tornado insider research group 2008	•	•		

Table 5: Overview of used sources to quantify the indictors

3.2.2 Constructing the indicators

As mentioned before not all of the indicators to assess the Dutch biotech cluster could be founded directly in secondary data. Therefore formulas were constructed to calculate the outcomes per indicator. The formulas are based on data extracted from the sources mentioned in table 5 and The Decision Group database. Below the formulas for the indicators that needed to be constructed have been given.

Formula total employment;

$$\left(\textbf{\textit{Yearly growth of number of listed companies}} \times \textbf{\textit{Employment rate large companies (incl. listed) 2007}} \right) + \textbf{\textit{Employment rate multinationals}} + \textbf{\textit{Employment rate of Dutch SMEs}}$$

Formula total Revenue;

$$\left(\textbf{\textit{\% of FTE employed by Dutch healthcare department}} \times \textbf{\textit{Revenue healthcare department}} \right) + \left(\textbf{\textit{Growth of listed companies in 2007 (\%)}} \times \textbf{\textit{Revenue of large companies 2007}} \right) + \left(\textbf{\textit{Average turnover of SMEs 2007}} \times \textbf{\textit{Number of Dutch red biotech SMEs in 2007}} \right)$$

Formula total number of companies;

in 2008

$$\textbf{\textit{Number of companies in the red biotech cluster 2009}} - \left(\textbf{\textit{Sector growth 2005 and 2009}} \,/\, \textbf{\textit{\# Years}} \right)$$

in 2009

$$\textbf{\textit{Number known red biotech companies in database}} \,/\, \textbf{\textit{Sample size}} \times \textbf{\textit{Total companies in the database}}$$

Formula total number of products;

in 2008

$$\textbf{\textit{Average products per company}} \times \textbf{\textit{Number of drug producing companies}} + \textbf{\textit{Number of products of drug producing listed companies}}$$

in 2007

Growth in number of products from 2007 to 2008 **/** ***Number of products listed companies 2008*** **x** ***Number of products drug producing companies*** **+** ***Pipeline products listed companies***

Formula total public investments;

Public investments in PPPs **+** ***Private investments (government part)*** **+** ***Subsidies***

Formula total private investments;

(***Invested Venture Capital Life Science & Health*** **x** ***% red biotech***) **+** (***Invested Venture Capital biotechnology*** **x** ***% red biotech***)

A complete description of the formulas can be found in appendix 1. In the complete description also the main assumptions are noted, when there were any assumptions needed. The sources per indicator are listed in the complete description; also where the sources are used in the formula is described.

Assumptions had to made (appendix 1) to get a result on the separate indicators, these assumptions affect the reliability of the research results, thereby the use of all kind of different data sources also doesn't improve the reliability of the outcomes. Therefore to improve the reliability of the results, afterwards the results of the assessment were presented to a selected group of experts connected to the Life Science and Healthcare program, which was the sponsor of this research. The group of experts was a diverse group of persons. The group of experts has been selected on their professional specialism, to get a broad representation of the Dutch red biotech cluster. Further their opinion leadership within the cluster combined with the position held by the experts in their organization was a criterion. Also the availability of the experts within a certain period of time was a criterion for entering the interview list. This selected group of experts has been put together with consultation of Willem de Laat, managing director of the Life Science and Healthcare program.

The data collected by the desk research to assess the Dutch biotech cluster will be all quantitative data. To structure the data, it will be presented in charts. The use of charts ease the understanding of the large quantity of data and it shows the relationships of the variables. Charts will also improve the understanding and readability of the raw data collected from the desk research.

3.3 Analysis of the development

For the answering of the first sub research question a combination of primary and secondary data has been used. For the secondary data a desk research has been done, for the primary data interviews were held with experts in the biotech cluster.

3.3.1 The interviews

An interview method will be used for the analysis of the development of the Dutch red biotech cluster. The interview method for this research was semi-structured interviews. In semi-structured interviews a list of themes and questions will be present for the researcher, while the list can vary per interview. It is possible to leave out or add some questions in particular interviews, given the specific context (Saunders, 2007).

With semi-structured interviews there may be concerns about reliability, bias, validity and generalizability, because of the lack of standardization. In advance a list of topics was sent to the interviewees, this to increase the reliability and validity by allowing the interviewee to consider the information being requested.

All interviews will start with an introduction on the topics, in order to show the knowledge of the interviewer about the topics to gain more credibility. Validity refers to the extent to which is researched what one intended to research. Because of the flexibility of the interviews its validity is taken care of (Saunders et al, 2007). All interviews will be recorded on tape and contextual factors are written down, this ensures every detail of the interview can be accessed after the interview has taken place. Recording the interviews will increase reliability and validity, it also decreases biases. Results of semi-structured interviews are not easy to generalize to an entire population, because interviews are based on a small number of cases.

This research was part of a research to the biotechnology cluster done by The Decision Group for the Life Science and Health program. Therefore the interviews held were not completely focused on the subject of this thesis. The interviews had a wider content, so the questions related to this research were only a part of the conversations.

3.3.2 Interviewees

This research has been performed commissioned by the Life Science and Health program. In consultation with the LSH program four main stakeholders were appointed, the government, investors, academics and the industry as can be seen in the figure 6 below.

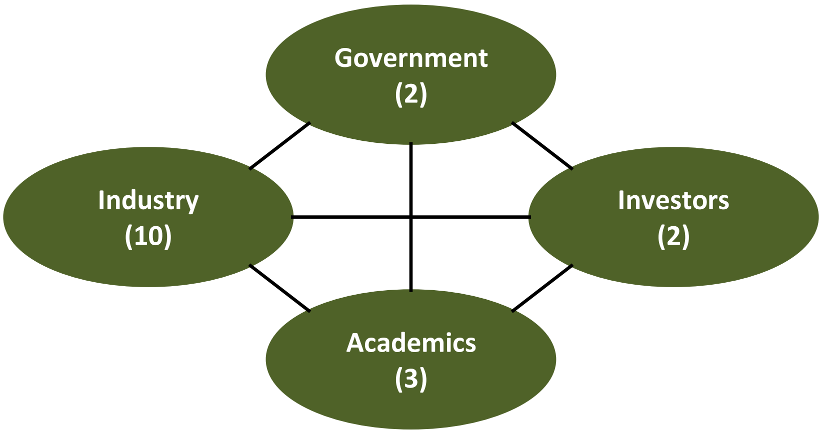


Figure 6: Stakeholders in the Dutch biotech cluster (number of interviews)

Each of these groups of stakeholders were interviewed for the research. In total 17 interviews were held, uneven distributed over the stakeholders.

The focus of the research to the biotechnology cluster, done by The Decision Group was on the industry. Therefore substantial more interviewees were selected from the industry. In total ten interviews were held with industry members, two with persons out of the governmental stakeholder, two investors and three academics were interviewed. The researcher composed a list of persons eligible for an interview. The list existed of persons out of the four different stakeholders (see figure 6).

However the pith of the matter for this research was on the industry, the experts interviewed should be distributed over all stakeholders. The group of experts has been selected on their professional specialism and their field of work within the cluster, to get a broad representation of the Dutch red biotech cluster in the interviews. By composing the interview list also the position held by the experts in their organizations has been looked at, to ensure a broad distribution in leadership. Al last the experts have been selected on their opinion leadership in the biotechnology cluster.

After selecting the interviewees by the researcher, the interviewees were also validated by the contractor of this research to have a second opinion on the researcher's choice. Next to all criteria mentioned above, availability of the experts also has been a limitation that had to be taken into account. A total list of interviewees can be found in appendix 2.

3.3.3 Topics discussed during the interviews

The input for the interviews was the conclusions of the assessment of the Dutch biotech cluster. As can been seen in figure 6, the interviewees come from different groups within in the cluster, and within these group they also have different interests. Because of these differences it is impossible to create a standard questionnaire that can be used for all interviews.

To ensure good interviews, every interview was prepared individually. The interviewees were profiled before entering the interview. A quick search on business articles, academic papers, public profiles and internet articles gave a brief profile of the interviewee. The position of the interviewee in the cluster, the interest of the interviewee, and his professional opinion were linked to the conclusions of the assessment and the drivers of the analysis of the Dutch red biotech cluster. The linkage of the interviewee characteristics with the parts of this research resulted in two or three main discussion points for the interview.

Missing the structure of the predefined questions, a good preparation en knowledge base was demanded from the interviewer. The quality of the interviewer was improved before the interview by a self-prepared paper dealing only with the special topics selected for the interview. This ensured the quality of the interviewer and thereby also the quality of the interview. On headlines the following topics have been discussed: the Dutch biotech cluster in international perspective, and also in a national perspective. Within these themes several subthemes were discussed per interviewee. Subthemes varied from the investment climate in the Netherlands to the use of business knowledge within the cluster and the valorization of knowledge in the Dutch biotech cluster to improvement of the innovation system.

The interviews gave an interesting view on the improvement of the innovation system of the Dutch biotech cluster. In chapter 5 these insights will be described, but first the assessment of the Dutch biotech cluster will be explicated.

4. Results of the assessment of the Dutch biotech cluster

The first research question discusses the status of the innovation system. Like earlier in this thesis mentioned the innovation process starts after the diffusion of knowledge (see figure). As described in paragraph 2.1 indicators have been formulated that will be used to assess the Dutch biotech cluster. In this chapter the indicators will be elaborated.

4.1 Employment in the Dutch biotech cluster

For this research the total employment is divided in three groups, based on the size of the companies. The companies are distributed in the following groups; multinationals, large companies and SMEs.

Total employment decreased with 2% in 2008 compared to 2007. The total number of employees working in the Dutch red Biotech cluster in 2008 was 29278, while in 2007 still 29992 people worked in the cluster. The decrease in employment is caused by the multinationals; they showed a decrease of 8.7%, while both large companies as SMEs showed an increase of 0.5 percent and 5 percent.

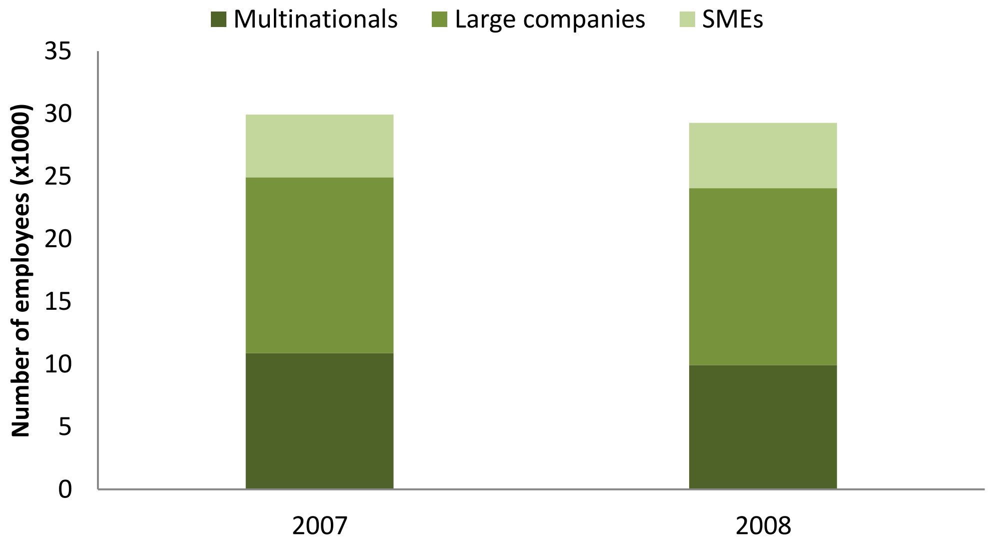


Figure 7: Total employment Dutch red biotech cluster

Compared to the international clusters the Dutch clusters scores lowest on employment. The Dutch cluster showed a little decrease on total employment, while other international clusters showed an increase. From the international clusters the Boston Area scores the best with an increase of 2 percent.

4.2 Revenue of the Dutch biotech cluster

The total revenue of the Dutch red biotech cluster has increased by 10 percent from 10b€ in 2007 to 11 b€ in 2008. The increase is mainly caused by multinationals and large companies with 8 percent and 11 percent. The SMEs also showed a growth, but it was only a marginal growth of 1 percent in 2008 compared to 2007. The main sources of revenue for the companies are product sales, license deals, and government grants.

The revenue of listed companies in the Dutch red biotech cluster is much lower than the U.S. and comparable to the European average. However the listed companies in the Dutch red biotech cluster showed an increase on revenue of 12 percent, it is lower than the European average.

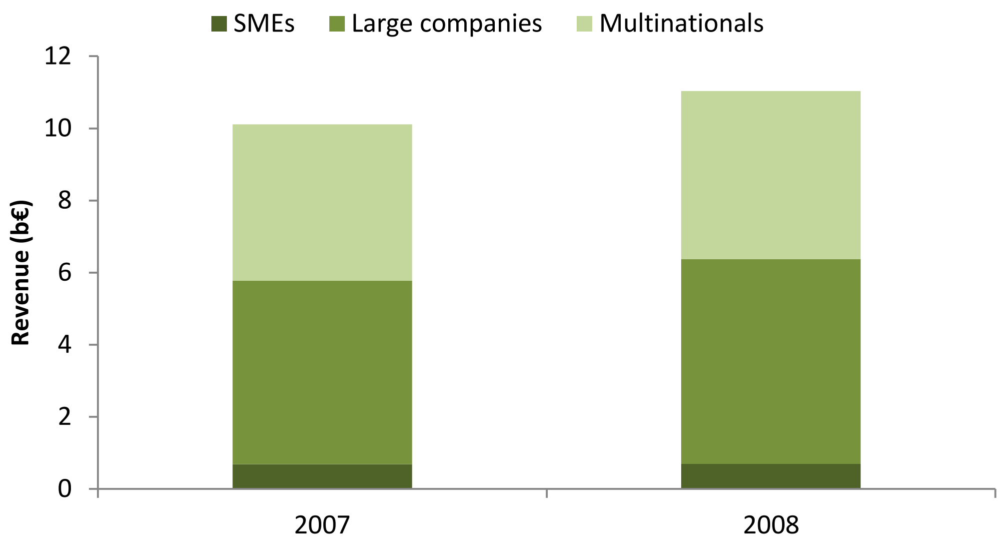


Figure 8: Total revenue Dutch red biotech cluster

4.3 Growth of the Dutch biotech cluster

To assess the growth of the cluster two sub indicators are combined, that together give a good view on the growth of the cluster. The first sub indicator that is used is the number of companies within the cluster, the second sub indicator is the number of products in their different phases.

4.3.1 Number of companies

The total number of companies in the Dutch red biotech cluster has grown from 262 companies in 2008 to 291 companies in 2009. When the companies are classified in order of employee numbers it can be seen that the growth in companies is largest for companies with 6 – 10 FTE (fulltime-equivalent) with 14 percent. The Dutch cluster is dominated by companies with 10 or less FTE, these small companies represent almost three-quarters (74 percent) of the cluster.

Compared to other clusters internationally, the Dutch cluster scores well. The total number of companies is the Dutch cluster represents 15% of all biotech companies in Europe. The Dutch cluster showed a growth in total number of companies of almost 14%, which internationally is very good, and twice the growth percentage of the European average.

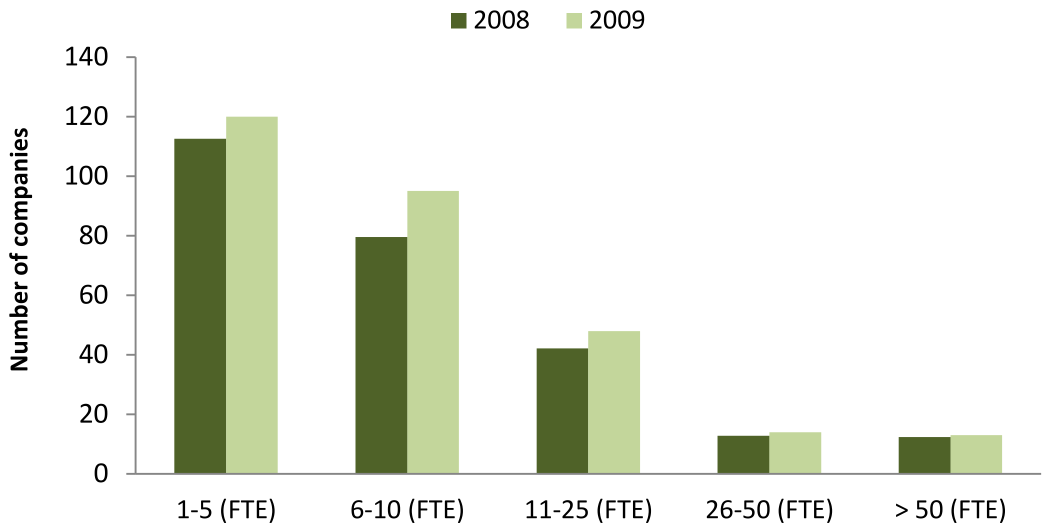


Figure 9: Total number of companies in Dutch red biotech cluster

4.3.2 Number of products

In line with the growth of the total number of companies within the Dutch biotech cluster, the number of products also showed an increase. The total number of products has increased 64% from 82 in 2007 to 143 in 2008 see figure 12.

Figure 10: Total number of products (phase 1 + 2 + 3)

The increase of products for the listed as for the non-listed companies is almost proportional. In 2007 the listed companies had a 34.1% share of all products all phases, while in 2008 the share was 34.3%.

Internationally the total number of products is lower than those of all selected clusters.

However the Dutch cluster showed an increase in product development, like all European clusters. The increase showed by the Dutch cluster (75%) is thereby the highest of all selected clusters.

4.4 Financial assets of the Dutch biotech cluster

To assess the financial assets of the cluster this research made a difference between private assets funded by the market and public assets funded by the government. Together these indicators will give a complete view of the financial assets of the Dutch biotech cluster.

4.4.1 Public investments

The total public investments increased by 1% from 371 m€ (2007) to 375 m€ (2008). As can be seen in figure 15 most of the public investments are concentrated in the public-private programs that were established to improve the funding of biotech companies in the cluster.

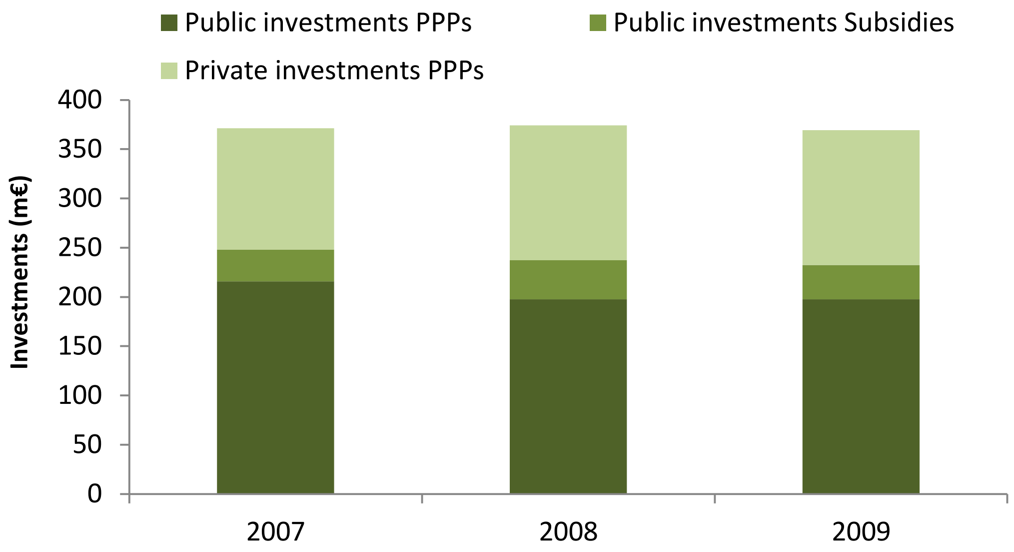


Figure 11: Total public investments Dutch red biotech cluster

International the public investments are 3rd lowest compared to selected clusters. Where the US leads the public investments, while the United Kingdom and Germany score minimal twice the investment of the Netherlands. The increase in investments is, besides Switzerland the lowest internationally.

4.4.2 Private investments

The year 2007 was a good year for the Dutch biotech cluster, in that year the private investments more than doubled and increased with 128%. But in 2008 the private investments in the biotech cluster dropped by 57% to come back at the 2006 level, due to the collapse of buy-outs.

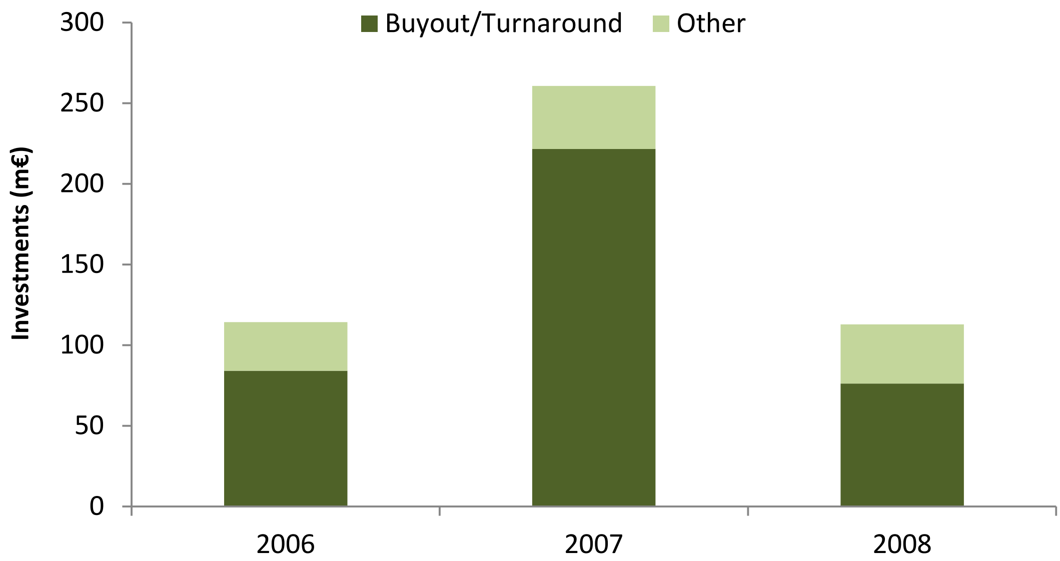


Figure 12: Total private investments Dutch red biotech cluster

Internationally the venture capital investments in the Netherlands are lowest compared to selected clusters. However the Dutch red biotech cluster is the only cluster that shows an increase of venture capital investments internationally.

4.5 Conclusion

The Dutch biotech cluster shows an increase in total products in the clinical pipeline. This can be due to the growth of companies within the Dutch biotech cluster, what certainly shows a growth of the cluster in size.

This growth in size is only not reflected in the growth of capacity of the Dutch biotech cluster. It was expected the total revenue of the cluster would show a big increase following the increase of companies and products, but on the contrary the increase of revenue was marginal. This means the cluster is growing in size, but this is due to a significant number of small companies that are not self-sustaining.

It was also expected that total employment within the cluster would increase following the increase of companies and products. Employment showed a marginal decrease, what strengthen the idea of the fact that the cluster has a lot of young small companies. However total employment showed a decrease, the employment outlook is still considered very good. As more entrepreneurs begin new businesses and more existing companies advance in the biotechnology field, the demand for biotechnologists will increase. In addition, as more biotechnology products that are now in development approaching the phase when they are ready for market, there will be increasing demand for chemical engineers to work on some of the production and scale-up problems of making biotechnology products in bulk, as well as bachelor's chemists for sales and marketing.

The increase in total public investments in the Dutch red biotech cluster has stimulated growth of venture capital investments. However compared internationally the absolute level of venture capital investments is lagging.

5. Analysis of the Dutch biotech cluster

In the previous chapter the assessment of the Dutch biotech cluster was completed. In this chapter the analysis of the cluster will be performed. As described in paragraph 2.9, this will be done using four drivers. In paragraph 5.1 elaborates on catalysts of the cluster, paragraph 5.2 treats the required nourishment for the cluster, paragraph 5.3 discusses a supportive host environment and paragraph 5.4 finally elaborates on the degree of interdependence. After discussing the defined drivers, the chapter will be ended by a conclusion.

5.1 Catalysts of the Dutch biotech cluster

The strong positive externalities and high level of risk associated with basic research or the development of new technologies in the biotech cluster suggests there is a major role for the Dutch government in funding the catalytic activities and acting as a lead user (Cohen & Fields, 1999).

The Netherlands is home to universities and research institutions that belong to the best of the world. The scientific knowledge a country possesses is a key driver for the innovativeness of any high-skill, knowledge intensive cluster, thus also a key foundation of the biotech cluster. To measure the scientific knowledge, the number of patent and publications in scientific journals can be reviewed. According to OECD statistics, the US Patent Office had registered a hundred patents by Dutch companies in the year 2000. This makes The Netherlands the seventh country in the world, and the fourth country in Europe (appendix 3) in terms of number of patents, ahead of countries like Australia, Sweden and Switzerland. The number of Dutch biotechnology patents that were granted by the US Patent Office showed an increase of 20% between 1990 and 2000, what globally was one of the highest increases that decade.

Next to the patents, the publications and citations in scientific journals do also give a view on the basic research capabilities of the Netherlands. Concerning the publications two percent of all scientific publications are Dutch and three percent of all global citations refer to the two percent publications. These percentages are made possible with only a quarter percent of the world population.

According to this figures, the basic research of Dutch biotech institutions is well taken care off.

5.2 Nourishment

The most important nutrient for the Dutch biotech cluster is new talents. Over the period 2002 till 2008 the availability and access to qualified human capital increasingly became a bottleneck for the Dutch biotech cluster. This due to the limited number of students graduating, but also to the rapid increase of biotech companies worldwide and thereby the higher demand for skilled labor. Especially the larger companies were able to offer good conditions and career opportunities to the graduates that smaller companies as research organizations couldn't offer. The area in which most significant shortage emerged was laboratory assistance (OECD, 2006). Luckily the field of biotechnology attracted more students over years. The number of higher education graduates in life sciences studies increased with 22 percent over the period 1998 to 2006.

The probability of working abroad is higher for life science graduates than for graduates from other disciplines (appendix 4). This applies also for the Netherlands, which scores high with a difference in percentage of 2 percent. In contrast, it does not apply for the United Kingdom, while the United Kingdom is par excellence a country with relatively good employment prospects for life sciences workers. It also tells us the biotech graduates are willing to leave their own country, to work wherever they get the best conditions.

Another significant influence on the development of a biotech company lies by the entrepreneur or management. Biotech companies need managerial expertise at the head of the company. These are often people which already have run a biotech company, and know how to stir the company into the right direction.

In addition, venture capitalists regard the presence of high-quality management capabilities in start-up firms a crucial condition for providing financial capital. With a slight of doubt by the venture capitalists about the management in the start-up life science firms, requests for venture capital are rejected.

The second important nutrient for a biotech cluster is financial capital. The financial vulnerability of biotechnology projects is related to the risky nature of the cluster. For the first start of the company public funds are available as the regional university funds that ensure sufficient funding for startup. For further growth of the company is substantially more capital needed. Start-ups need to attain growth, in order to become of significant meaning in the economy, for the growth of the start-ups seed en venture capital are crucial (appendix 3).

The LSP has 400 million Euros available to invest in the biotech industry, of which a part is invested in start-ups. The group that comes second, after the LSP, in terms of most funds available for investment in the life science sector, are funds like; Forbion (ABN Amro), Aescap, en Gilde (Rabobank). This group all together has an equal amount investment capital available as LSP, namely 400 million Euros.

Universities and city funds also have funds available for investment in the biotech cluster, the investment funds of these institutes have a range between twenty or thirty million euro's, which are set available to invest especially in start-ups. While the biotech industry is very capital intensive and risky business, it can be said that the Dutch market for venture capital is relatively well developed and that in The Netherlands sufficient venture capital is available, even of the world´s most successful life science venture capitalists, Atlas Venture, is based in The Netherlands. There is enough capital available in the Netherlands, the problem is that it is invested somewhere else.

When trying to obtain external financial resources for the first time, start-up life science firms in The Netherlands experience a number of difficulties. Suppliers of financial capital have difficulties in assessing future risks of new products and services. In addition the suppliers of financial capital select start-ups that in reasonable time can attain notable growth through their product-portfolio of interesting products with future perspective. Suppliers of capital claim that many Dutch life science start-ups in The Netherlands are not able to attain notable growth in reasonable time through their product-portfolio of interesting products with future perspective. Investors prefer companies to have many high-potential patents instead of one of two, or one or two patents that have the potential to be applied in many different research fields to attain diversification.

5.3 Supportive host environment

Within a biotechnological cluster there is a need for a supportive rather than a hostile environment. A region's or nations regulatory and cultural regime may either attract and develop or discourage biotech entrepreneurs or existing firms from taking risk needed to turn scientific innovations into successful business.

One of those regulatory aspects is the patent application system. There are roughly two patent application systems, one grants the exclusive right to make and sell the invention to the first person that registers an invention to obtain a patent for it. This patent application system is used almost everywhere in the world except for the US and Canada, there the person who made the invention gets automatically the exclusive rights to make or sell the invention. Both application systems have their pros and cons, however for young small biotech firms the American system is more favorable, because they do not need to go into an expensive and long process of application, thereby the patent application system in which registration is obliged, encourages the filing of too many, poorly drafted, and premature patent applications, which will increase the costs of using the patent system for all, especially for the small, independent biotech firms (Coster, 2002).

A supportive regulation for biotech companies is a proven supportive addition to the environment. For the testing of biotech products, mostly animal testing is a must. The genetic modification of animals is only allowed when three requirements are met. The requirements include the following; animal testing is only allowed when the health of animals is not threatened, when there are no alternative ways to produce the biotech product and when it is 'ethical'. The last requirement is "when it's ethical" means that genetic modification only is allowed for the production of medicines, and not for the good of food production or cosmetic production. This strict Dutch policy resulted in a departure of companies who need this method for the development of their product. The companies left to foreign countries where regulations are less strict.

The process for an approval for animal testing in the Netherlands includes a request for testing, field experimentation with genetically altered crops and clinical testing. All these processes have a very difficult approval process. This affects the efficiency of the operational business processes of Dutch biotech companies, what have a negative influence on their competiveness. Therefore the Dutch government is experiencing a lot of pressure from the biotech cluster, to make this process more company friendly, like in other countries around Europe.

According to NIaba (2005), almost a quarter of the Dutch life science companies moved their activities, or expanded their business abroad in the past few years. Niaba also claims that about fifty-five percent of the Dutch life science companies considered or is already investing more abroad than in the Netherlands.

To translate knowledge from institutions to the private biotech cluster, the government started to support collaborations between researchers and business people, this to increase the number of spin-offs from institutions towards the private environment. Subsidies like the “research and development promotion act” encouraged the startups with a fiscal advantage.

Furthermore the life science action plan was implanted 10 years ago, specifically to support incentives for start-up companies. This followed by numerous other actions and initiatives as for example the Biopartner program, which had the objective to stimulate the life sciences and to encourage the commercialization of knowledge.

Universities in the Netherlands had two core activities in the past, these were education and research. Universities were focused on basic research and publishing, and pass that knowledge to their students. The universities got a third activity, the valorization of the knowledge extracted from basic research. This activity led to the establishment or the intensifying of activities of technology transfer offices (TTOs). The establishments of TTOs led to a better connect to the market.

To stimulate the translation from basic research to commercial useful knowledge public-private partnerships (PPP) were established to boost the Dutch biotech cluster. PPPs aimed to bundle top research groups in research institutes with global companies and small and medium sized companies to improve therapies and to bundle knowledge and resources. The Dutch biotech cluster knows three PPPs that cover up the area’s: drugs, devices and diagnosis.

5.4 A high degree of interdependence

To be successful, innovations need more than a spark, good resources and a supportive host environment. Especially companies working in a R&D intensive, high technology oriented environment need rich, multi layered and cross-bordered networks to be successful (Cooke, 2003).

In The Netherlands different life science organizations are cooperating with each other and thereby forming sub- clusters. The clusters establish themselves in University regions, namely around Leiden, Utrecht, Amsterdam en Groningen and within these clusters there are many small and young biotech companies established with strong links to the near universities. In contrast, the larger and older biotech companies are located on locations that have good infrastructural accessibility such as rail and road.

However the people within the Netherlands are overestimating sometimes the size of the Netherlands. There is less communication and cooperation between the sub clusters and that makes it difficult to present the Dutch cluster as one. Like Willem de Laat said, internationally it is much easier to present the Dutch biotech cluster, than to present the Leiden cluster and the Amsterdam cluster.

The Life Science and Health (LSH) program was started to connect the total Dutch biotech cluster. The program is a combined initiative for and by all parties active in the health-related life sciences in the Netherlands, that is driven by the cluster and empowered by the Ministry of Economic Affairs.

Stimulated by the LSH program the Dutch biotech cluster made a joint call in 2009 for subsidies on translational research. The call was largely granted, and was the first call ever presented for the whole Biotech cluster.. A ‘sector plan’ was developed by ten public-private partnerships together, facilitated by the centers of excellence, the NGI and the Life Sciences & Health program office.

The LSH program mends also the formation of the High Profile Group (HPG). The HPG The HPG brings together ten leaders in the life sciences sector, who deliberate and advise on the opportunities, hurdles and future of the Dutch biotech cluster. The HPG also sees the importance of interdependence within the Dutch cluster. In their joint vision for the cluster, what was presented in Cahier number two, they elaborated on the innovation structure in the Netherlands. The HPG was strongly encouraging to formulate a clear focus because the Dutch biotech cluster won’t be able to find solutions for all diseases. It was supporting to create thereby a healthy pipeline and strong support on the complete innovation process. The last pillar for the innovation system they see true partnerships, because no matter how brilliant and entrepreneurial the parties are, they will achieve more together than they will alone. A successful initiative stands or falls on how much cooperation is involved. Cooperation is the glue that holds the pipeline together, keeping the innovation infrastructure in place.

5.5 Conclusion

According to the figures, basic research is well taken care off in the Dutch biotech cluster. Basic research is the main catalyst for the biotech cluster and thereby it can be stated that the foundation for an innovative cluster is present.

Ten years ago the cluster was looking for employees; there were too little graduates to work in the biotech cluster. Gladly the numbers of graduates are rising, the availability of qualified people is necessary for the growth of the Dutch biotech cluster.

The knowledge of the graduates is however unilaterally, the cluster also needs people who combine the industry specific knowledge with business knowledge.

The Dutch biotech cluster has a well-developed investment organ, and there are enough financial assets within the Netherlands. The problem is that the capital is not invested within the Dutch biotech cluster. Suppliers of financial capital have difficulties in assessing future risks of new products and services and claim that many Dutch life science start-ups in The Netherlands are not able to attain notable growth in reasonable time through their product-portfolio of interesting products with future perspective.

The Dutch regime for animal testing is strict and counterworking entrepreneurs in the biotech cluster. Companies are moving their testing processes abroad. However the Netherlands invests a lot in their infrastructure and facilities for the biotech cluster. TTOs are being established at every university and public private partnerships are boosting the innovation infrastructure. However there is still a lot of work in connecting and cooperating in the cluster.

6. Main conclusions, implications, recommendations and limitations

In this chapter the main conclusions will be stated. The main conclusions are derived from the assessment as described in chapter 4 and the analysis of the Dutch red biotech cluster as described in chapter 5. The main conclusions are followed by implications and recommendations on the occasion of this research. This is the last chapter of this thesis and will thereby conclude this research.

6.1 Main conclusions

The central research question of this thesis is: which aspects of the Dutch red biotechs' innovation system can be improved to stimulate the utilization of the economic potential of the red biotech cluster?

The utilization of the economic potential of the red biotech cluster can be stimulated by improving the latter stages of the innovation process. Improving the latter stages of the innovation process can be found in three different directions:

1. Broadening the knowledge base in the Dutch biotech cluster;
2. A supportive regulation for biotech companies on animal testing;
3. Improving the degree of interdependence within the Dutch biotech cluster.

Before analyzing the innovation system on where it can be improved an assessment has been done to assess the current status of the Dutch biotech sector and thereby test the premises for this research. The assessment of the Dutch biotech cluster shows that the premise for this research was correct; the Dutch biotech cluster has problems to capitalize their strong knowledge base into products on market.

The assessment showed that the total number of companies in the Dutch cluster represents 15% of all biotech companies in Europe. The Dutch cluster showed a growth in total number of companies of almost 14%, which is twice the growth percentage of the European average. In line with the growth of the total number of companies within the Dutch biotech cluster, the number of products also showed an increase. The total number of products has increased 64%. However internationally the total number of products is lower than those of all selected clusters, the Dutch cluster showed an increase in product development.

However the Dutch biotech cluster shows an increase in the number of companies and products, the assessment shows it stays behind on total revenue and employment.

Total employment decreased with 2%, when compared to the international clusters the Dutch cluster scores lowest on employment. The total revenue of the Dutch red biotech cluster has increased by 10 %, but the revenue of listed companies in the Dutch red biotech cluster is much lower than the U.S. and comparable to the European average.

From the above it can be concluded that in the transfer of knowledge and in the exploration of young small biotech companies great progression have been made, while this progression is not yet visible in latter stages of the innovation process.

After concluding that the Dutch biotech cluster has problems to capitalize their strong knowledge base into products on market, and that progression is not yet visible in latter stages of the innovation process, the analysis of the innovation process started.

The analysis has been performed according the framework as constructed in paragraph 2.9. The first component of the framework that has been analyzed is the catalysts of the Dutch biotech cluster. The catalysts are the base of the Dutch biotech sector and looking at these it can be concluded that basic research of Dutch biotech institutions is well taken care off.

As stated in the answer on the central research question, improvement of the latter stages of the innovation process can be found in three different directions. The first subject comes from the analysis of the second component of the framework, nourishment, and is broadening the knowledge base in the Dutch biotech cluster. The numbers of graduates are rising and the availability of qualified people is improving. Dutch human capital is trained at the best institutions of the world in their biotechnological field. Besides the biotechnological knowledge the Dutch biotech cluster is looking for business knowledge.

When running a company entrepreneurs find out their business knowledge is lacking. Business knowledge could also improve better understanding of the investors. Entrepreneurs in the biotech cluster should be more aware of the drivers and needs of venture capitalists. The Dutch biotech cluster has a well-developed investment organ; the problem is that they do not invest in the Netherlands. Entrepreneurs looking for capital have to show to be able to attain notable growth in reasonable time through their product portfolio with future perspective.

Analyzing the third component of Finegolds framework revealed the second improvement to the innovation system. Next to improving the knowledge base of the human capital and the connection of investors with entrepreneurs the second point of interest is the strict regulation on animal testing. A supportive regulation for biotech companies is a proven supportive addition to the environment. For the testing of biotech products, mostly animal testing is a must. The genetic modification of animals is only allowed when certain strictly requirements are met. As a result companies left to foreign countries where regulations are less strict.

Applying for animal test in the Netherlands is a long and bureaucratic process. By making this process more company friendly, like in other countries around Europe, the efficiency of the operational business processes of Dutch biotech companies can improve. Improvement of the business processes will have a positive influence on the competiveness of the Dutch biotech companies. While the government is investing heavily in the biotech cluster, the animal testing procedures are counterworking the entrepreneurs and the efforts the government makes to support the industry.

The third and last point of interest for stimulating innovation within the Dutch biotech cluster is the degree of interdependence. Interdependency is the fourth and last component of the theoretical framework, and showed that in The Netherlands different life science organizations are cooperating with each other and thereby forming sub-clusters. The clusters establish themselves in University regions, namely around Leiden, Utrecht, Amsterdam en Groningen and within these clusters there are many small and young biotech companies established with strong links to the near universities. The sub clustering makes is difficult to communicate and cooperate with each other, and therefore it is difficult to present the Dutch Biotech cluster as one.

The cluster should aim on participations of everyone in the cluster with a shared focus. Public and private partners should more work together. By combining the Dutch sub clusters to one Dutch biotech cluster a strong brand name can be created. This will improve the visibility of the Dutch biotech cluster and improve international partnerships. Within the Dutch biotech cluster parties can trust each other and share their knowledge readily. Access to knowledge and setting up partnerships are easy thanks to databases of the players and researchers in the cluster. The partnerships are committed for the long term, exceeding the typical governmental terms of four years. True partnerships are essential for the innovation process, because no matter how brilliant and entrepreneurial the parties are, they will achieve more together than they will alone. A successful initiative stands or falls on how much cooperation is involved. In short, parties take a joint approach with a single vision and shared goals.

6.2 Implications

Implications of this research may relate to science and to business. Regarding science this research shows that the framework of Finegold can be used for other biotech clusters. In this research the framework has been successfully used for analyzing the Dutch biotech cluster and therefore it is can likely be applied to other biotech clusters in the world. The four defined drivers by Finegold, all have their influence on the innovation system of the Dutch biotech cluster. This became clear through the analysis and the interviews in particular in this research. The complementation of the Diamond model of Porter with an aspect of the Open Innovation Theory of Chesbrough has been proven as a useful addition in this research. The degree of interdependence within the Dutch biotech cluster was a hot topic during the interviews and shows the value of this addition.

Business wise the government can play an important role in stimulating the economic capitalization of the knowledge base in the Dutch biotech cluster. This role extent the part of giving money to the cluster, the government should actively be involved in the discussions and development of the Dutch biotech cluster. The ministry of economic affairs realizes that the government could stimulate the cluster with their organizing capacity. They are bringing different organizations together and help them to start up industry based projects. Next to this, the government should also take a look at the opposing legislation in the Netherlands. By stimulating a cluster it is necessary that legislation and regulation are not counterworking the efforts made. Here is also a role for the industry, the industry should make the government a part of their discussions. Together they should achieve constructive initiatives and solutions.

The industry, government and academics can also play a role in the expansion of entrepreneurial skills within the Dutch biotech cluster. The researcher believes that there are clear ways in which the government and academic institutions can affect the potential supply of entrepreneurial skills for students. For instance offerings more courses on how to start new businesses. These courses are often generic and can help also future biotechnological entrepreneurs save time and mistakes. The government can support this course by making their legislation more flexible. Students are working under high pressure to get their degree, so they have limited time for extracurricular activities like entrepreneurial courses. Furthermore the industry can play an active role in this by supporting the courses. Courses can be given by entrepreneurs out of the cluster. The industry can share their best practices with the academics and students.

Special scholarships can be created with help from the industry and government to allow high potentials achieve business skills during their study.

6.3 Limitations

Although this research yields interesting results, they should be considered against several limitations. The latest data available for this research to complement the data from the The Decision Group database, dated from 2005. To give a more specific and accurate assessment of the Dutch biotech cluster the data-set needs to be updated. The current set of data needs to be renewed and supplemented, to be up to date. Up to date data will increase the validity and the reliability of the assessment.

The insights gained by the analysis are to a large extent based on the interviews held. The conclusions of the analysis are based on a limited set of interviewees with experts, who may have a subjective view on the cluster. The interviews support a large part of this research. However efforts were made to formulate semi-standardized questionnaires, in practice it did not work. This was especially due to the diversity of the different interviewees. Increasing the interview pool and support this with primary data will increase the validity of the results of this research.

The research has been funded by the Life Science and Health program, with a commercial thought of monitoring the Dutch biotech cluster. During the process concessions have been made concerning the interview list. However the list have been composed carefully, due to time limitations and availability some interviewees had to be substituted or dismissed from the list.

6.4 Recommendations

In general the researcher wants to challenge scholars to come up with a definition of biotechnology with all its subdivisions. The definition of biotechnology, formulated by the OECD is widely used and reads: "*The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and service"*, but the subdivision to the different clusters is a problem. In this research the color distribution was used (blue, red, green and white), but there are many other distribution that all slightly differ from one other. While different scholars or research institutes use different definitions, their outcomes aren't comparable, what makes a quantitative analysis nearly impossible.

The invention process of the Dutch biotech cluster has improved in the previous years. The human resource base has improved and the growth in new products and new companies are also an example of the well-functioning first part of the valorization process.

This research showed that the latter part of the valorization process is however not functioning well. Employment as revenue is lagging behind the European average. Based on this conclusion future research should focus more on the latter stage of the valorization process. Although the first part should not be neglected, the greatest benefits for the entire process can be achieved by improving the latter part of the process. Based on this research more attention should be given to the back of the valorization process – the innovation part.

Cluster theory is a complex issue that can be studies from different angles. With the limited time and space, this paper only gives a broad and general discussion of the Dutch biotech cluster. However the researcher believes it is a good starting point for further research. The researcher suggests that further research can be carried out more in-depth to the Dutch biotech cluster. Focus on evaluation of policy implementation in the key cluster areas to study how The Netherlands can improve its use of policies to promote the Dutch cluster development can be one of the in-depth research issues. For example, in the area of using public fund as venture investment.

It is of high importance by assessing a system that relevant and up to date data is available about the system. Primary data for the assessment of the Dutch biotechnology cluster was outdated. To give a more specific and accurate assessment of the Dutch biotech cluster the researcher recommends to set up a data gathering system that supplies up to date data for a next assessment. For further research it is interesting to know if the same patterns and outcomes will hold after the dataset is enlarged and fully updated. When a data gathering system will be developed it will be very important to frame the research area, so the data that will be gathered is comparable. When available trends in the cluster will be more specific and reliable, what makes them better instruments to steer on.

A cluster is constantly moving and will develop during time. An interesting addition will be to check the results of this research, with the results of this research executed several years from now. Which elements have been changed in time and what are the effects of the change on the capitalization of the knowledge base.

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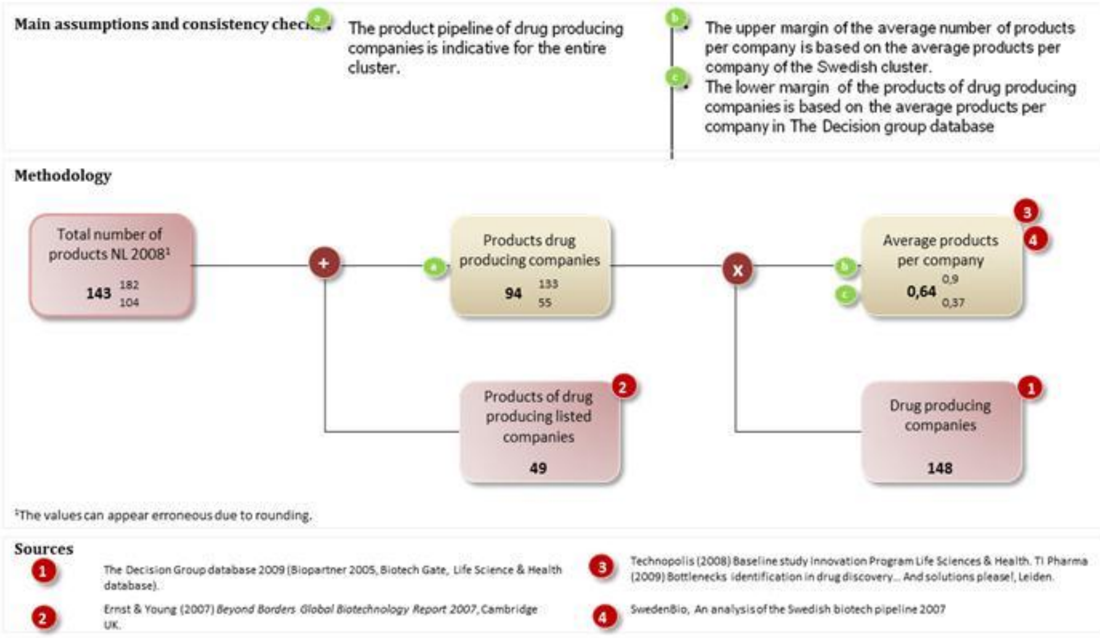
8. Appendix

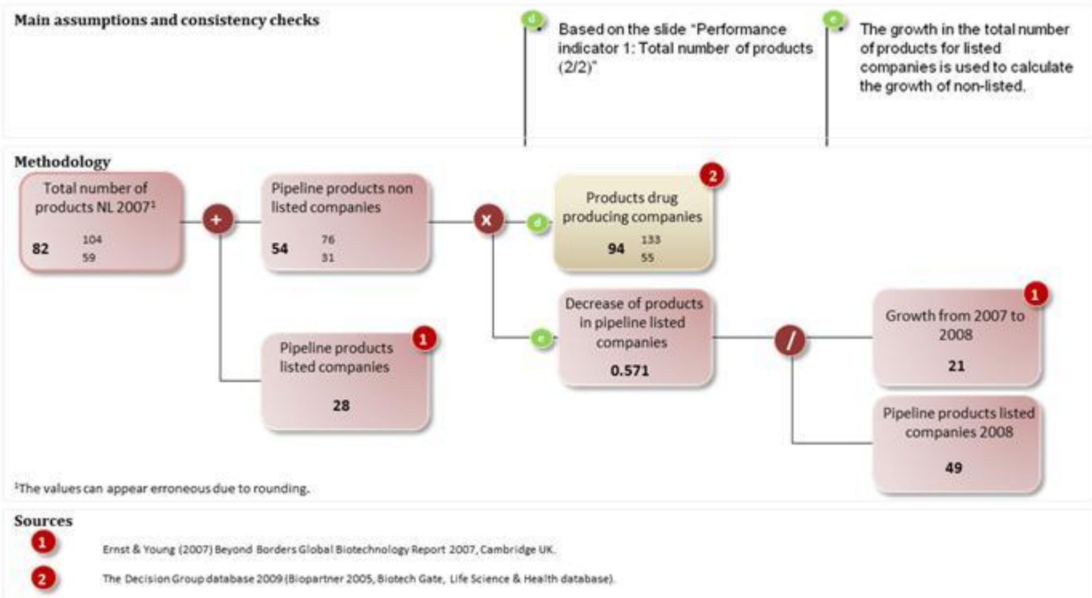
Appendix 1: Composition of the performance indicators

Total number of products

An upper limit to the total number of products in the Dutch red biotech sector in 2008 is based on the data for the Swedish red biotech cluster.

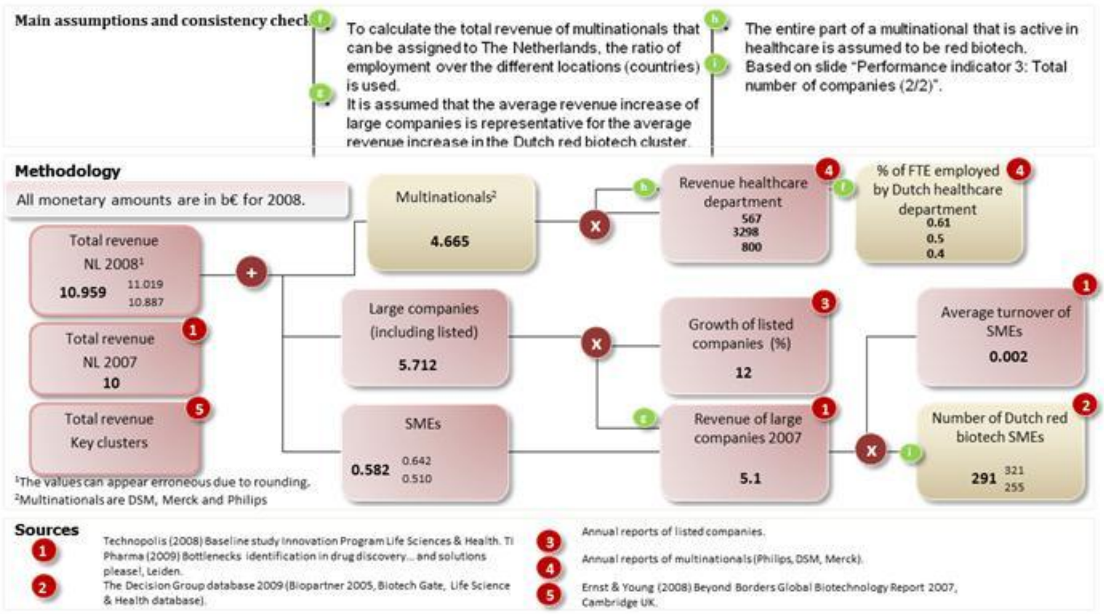


The total number of products in the Dutch red biotech cluster in 2007 is based on an extrapolation of the products in the pipeline of Dutch companies in 2008.



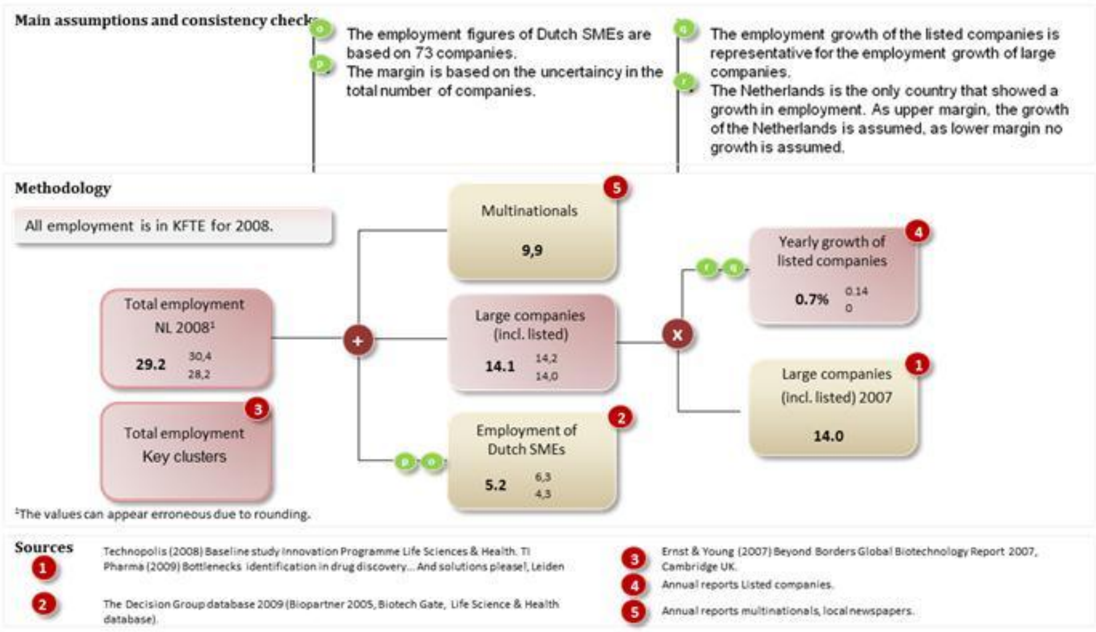
Total revenue

Multinationals and large companies give dominant contributions to the total revenue of the Dutch red biotech cluster



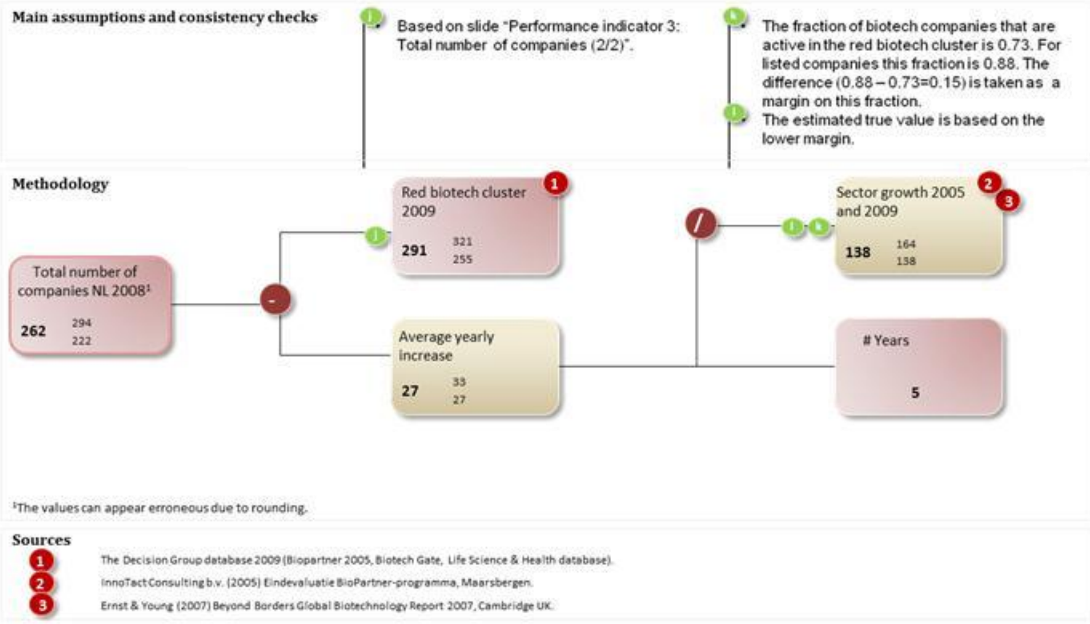
Total employment

The total employment of the key red biotech clusters in 2007 and 2008 is mainly based on data on listed companies.

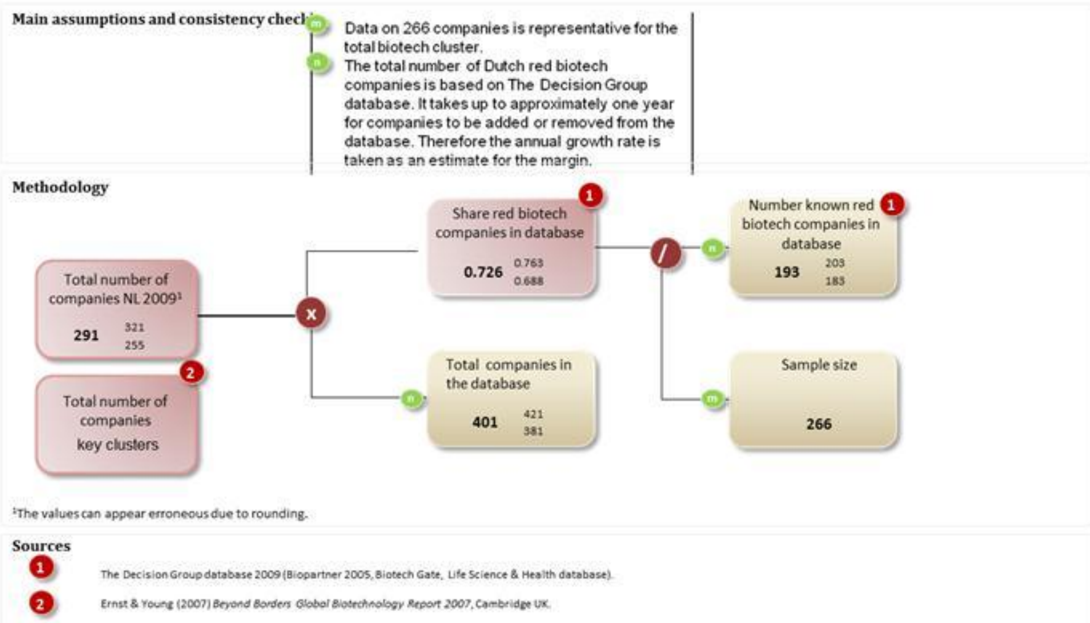


Total number of companies

The total number of companies in the Dutch red biotech cluster in 2008 is based on The Decison Group Database 2009.



Total number of companies in the Dutch red biotech cluster in 2009 is based on The Decision Group Database 2009.



Total public investments

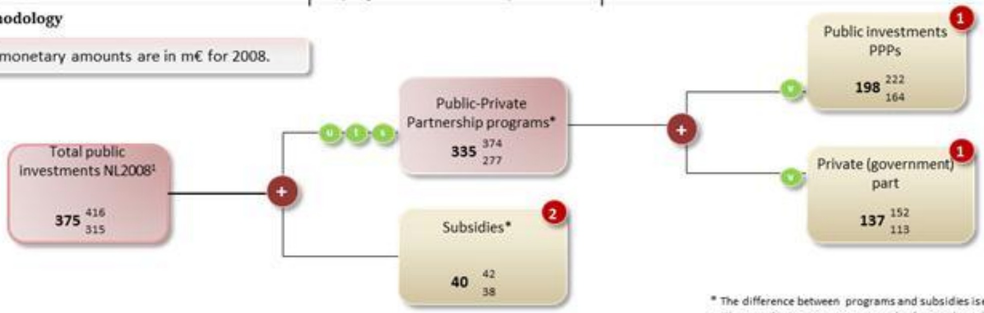
Total public investments in the Dutch red biotech cluster in 2007 and 2008 is mainly based on information from SenterNovem.

Main assumptions and consistency checks

- Double counting of subsidies can occur. Organizations can use the benefits of subsidies to join programs. It is assumed that this is insignificant and therefore left out of the equation.
- SenterNovem validated data on programs under their supervison.
- Most programs run for several years. Assumed is that the budget is divided evenly over the years.
- Margins are based on a calculation of the average program size (budget and time) with the assumption that 50% of the total program size is funded by the government.

Methodology

All monetary amounts are in m€ for 2008.



* The difference between programs and subsidies is explained in Chapter: *Business impact areas – background – public funding system.*

[1]The values can appear erroneous due to rounding.

Sources

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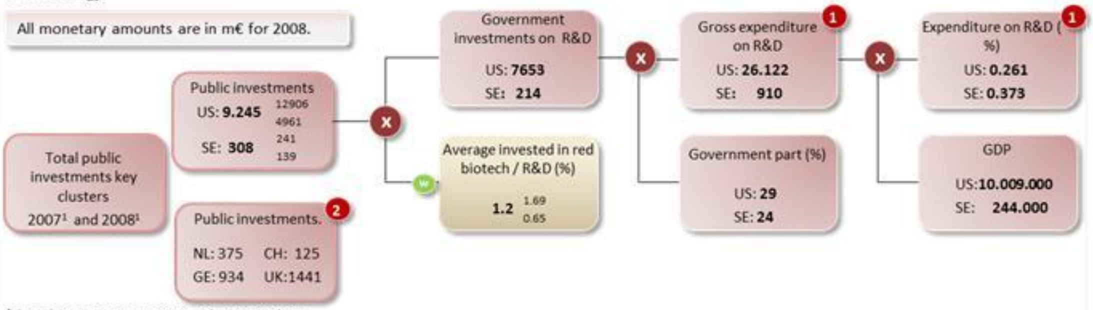
2. Technopolis (2008) *Baseline study Innovation Program Life Sciences & Health.* TI Pharma *(2009) Bottlenecks identification in drug discovery… And solutions please!*, Leiden.

Total amount of Euros invested by the selected key clusters government in 2007 and 2008 is based on R&D expenditure.

Main assumptions and consistency checks

- The average ratio of gross expenditure on R&D compared to public investments in red biotech of the Netherlands, Germany, Switzerland and the United Kingdom is representative for the United States and Sweden. The maximum difference from the average is taken as estimate for the margin

Methodology



[1]The values can appear erroneous due to rounding.

Sources

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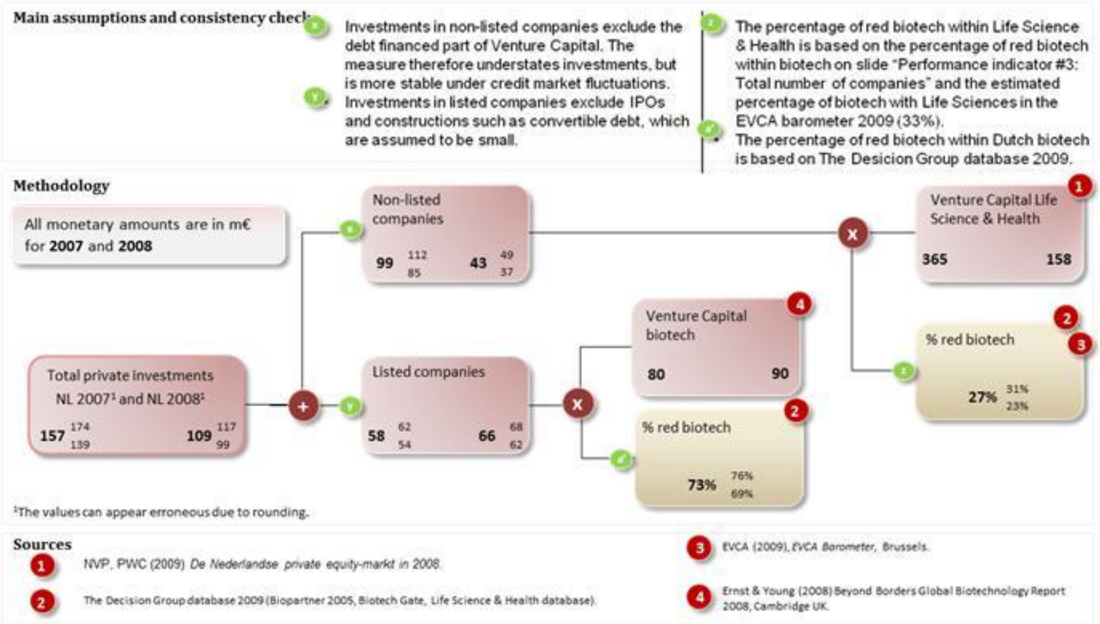
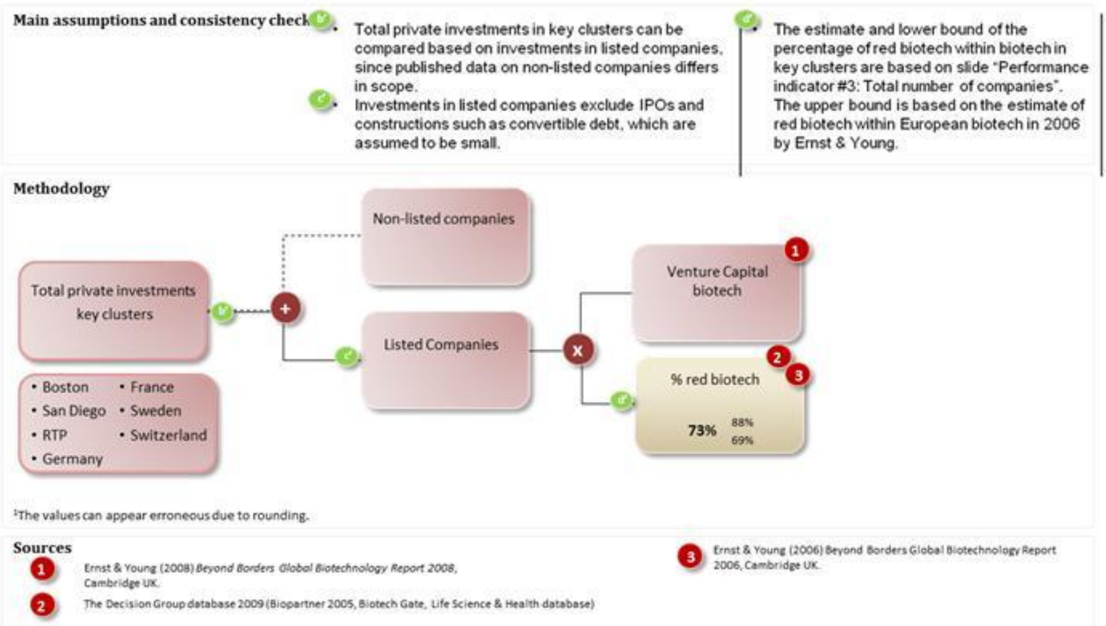
2. SenterNovem, innovation program websites; Germany Trade and Invest (2009) *The Medical Biotechnology Industry in Germany. Where science, innovation and quality meet.* Berllin; Swiss Biotech Report Update 2009; Department for Business Enterprise & Regulatory Reform (2009). *Government Response to Review and Refresh of Bioscience 2015 Report*; Department for Business Enterprise & Regulatory Reform (2005). *Departmental investment strategy 2005-2008.*

Total private investments

Private investments are based on an extensive yearly survey by PWC and Biopartner, LSH and the OECD databases



Private investments are indicated based on Biopartner, LSH and OECD databases.



Appendix 2: List of interviewees

Name	Function
Prof. Dr. C.A. van Blitterswijk	Professor tissue engineering University of Twente
J. de Boer, MD	Medical director Genzyme NL
Mw. R.N. Buitelaar, PhD, MBA	CEO Bio Science Park Leiden
Dr. R. Dekeyser	Managing director TTO Flemish Institute of Biotechnology
Dr. C. Laane	Director of Netherlands Genomics Initiative
Dr. R.G. Lageveen	CEO IQ Corporations
Dr. T. Logtenberg	CEO Merus Biopharmaceuticals
E. Moses, PhD	CEO Ablynx NV
Dr.ir. E.W.J. Mosmuller MBA	Director Public Affairs DSM
Drs. I. Piest	Senior Manager Corporate Finance Kempen & Co. N.V.
Dr. A.W.M. Rijnders	President & Site Head Discovery Schering Plough Netherlands
Karl L.M. Rothweiler, MBA	Aglaia Biomedical Ventures B.V.
M.P. Rubbens, PhD	Manager QTIS/e BV
H. Schikan, PharmD	CEO Prosensa
Dr. B Smailes	Director Luris (TTO Leiden)
Dr. R. Strijker	CCO Pharming Group N.V.
Drs. M. Stutterheim	Chairman Technopartner

Appendix 3: Additional graphs

Figure 13: Total employment key clusters

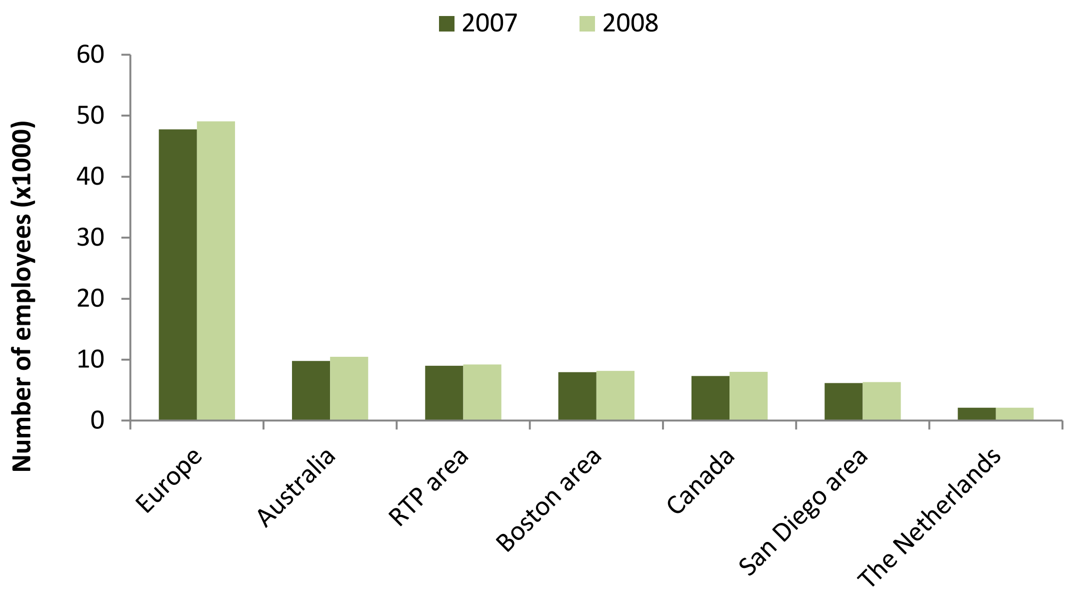


Figure 14: Total revenue key clusters (listed companies)

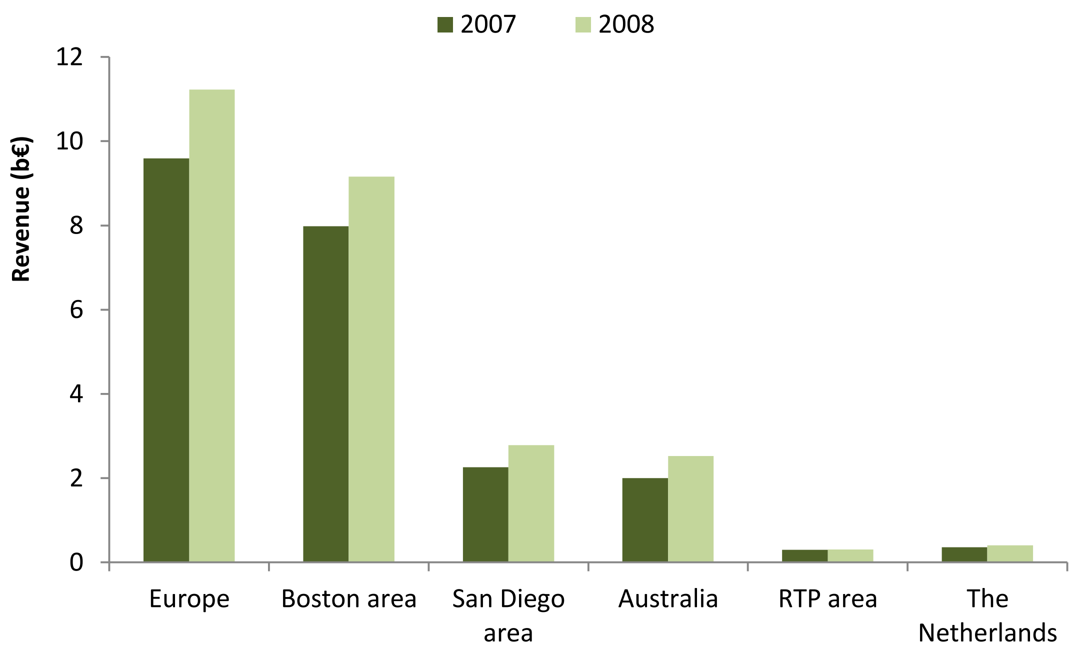


Figure 15: Total number of companies in key clusters (listed and non-listed companies)

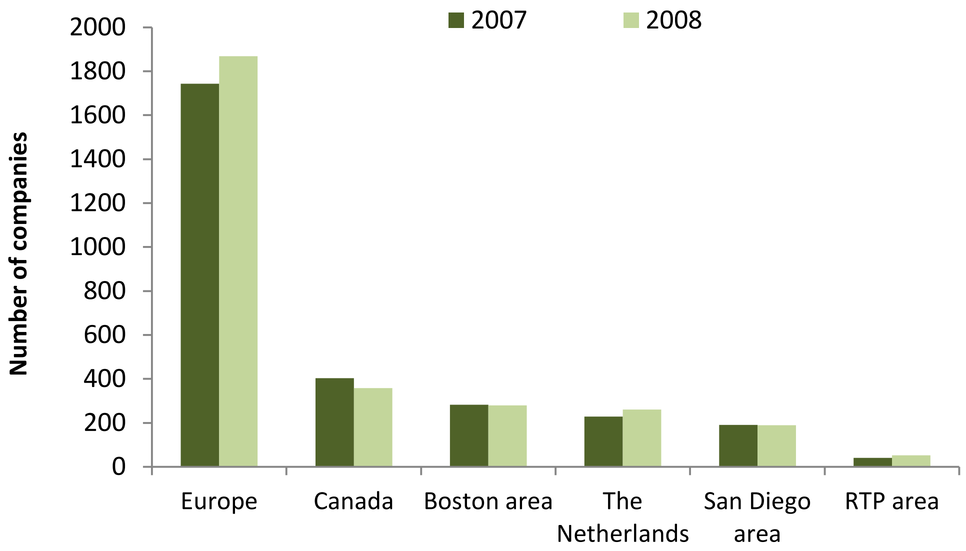


Figure 16: Total number of products key clusters in phase 1 + 2 + 3 (listed companies)

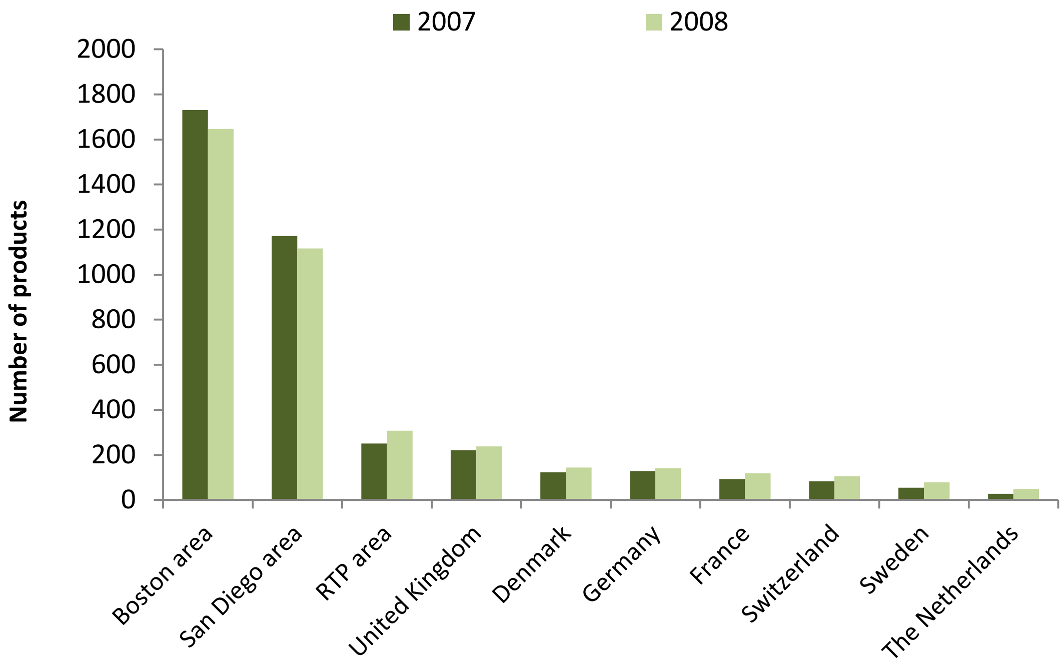


Figure 17: Public investments key clusters

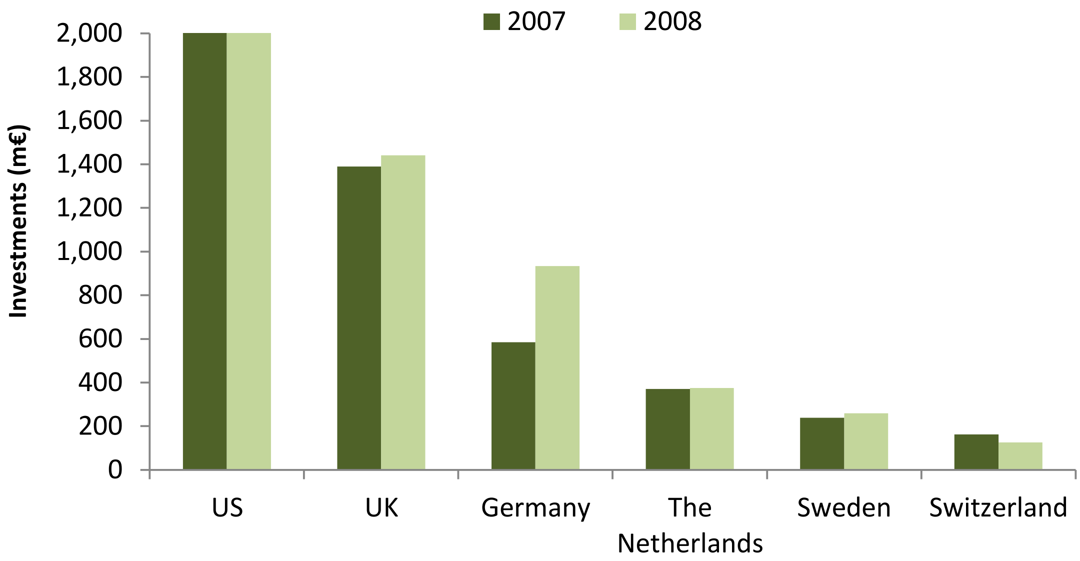
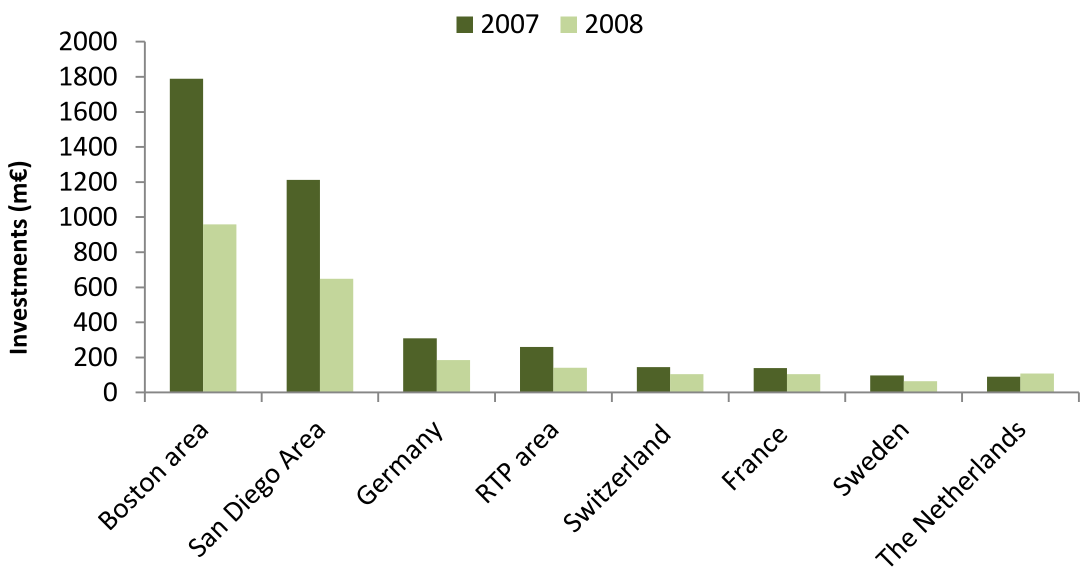


Figure 18: Venture capital investments key clusters



Appendix 4: Characteristics graduates in higher education

Graduates in higher education in the Life Sciences (number and percentage)

	1998	2006	Groei %
Australië	9.162	8.000	-13
Oostenrijk	-	1.236	
België	-	1.798	
Canada	8.469	9.099	7
Tsjechië	256	991	287
Denemarken	-	782	
Finland	389	528	36
Frankrijk	-	16.637	
Duitsland	5.977	9.666	62
Griekenland	-	-	
Hongarije	244	366	50
IJsland	65	95	46
Ierland	1.529	-	
Italië	9.306	12.435	34
Korea	4.240	9.757	130
Mexico	-	4.837	
Nederland	839	1.020	22
Nieuw Zeeland	118	1.715	1.353
Noorwegen	305	577	89
Polen	-	10.299	
Portugal	-	1.506	
Slowakije	-	964	
Spanje	4.439	4.582	3
Zweden	1.614	1.445	-11
Zwitserland	934	1.440	54
Turkije	2.230	3.806	71
Verenigd Koningrijk	16.015	20.181	26
Verenigde Staten	75.253	83.634	11

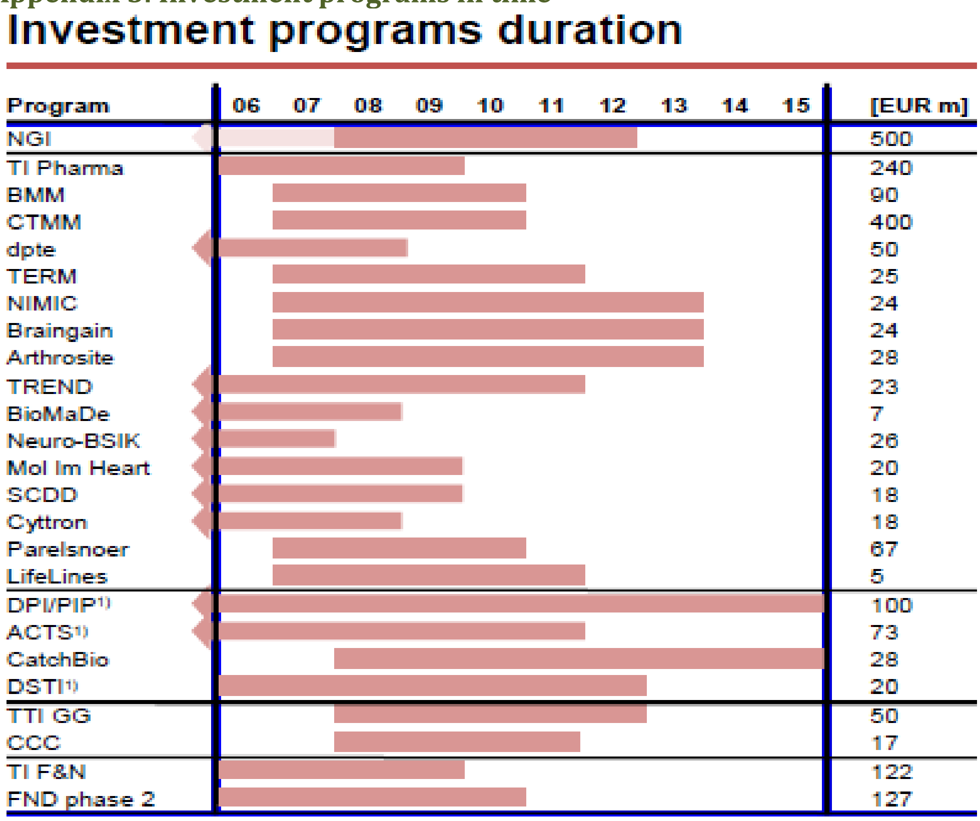
Source: Life sciences in Zuidoost Nederland, Researchcentrum voor Onderwijs en Arbeidsmarkt (2008)

Graduates that migrated to another country for the first or present job (to major choice)

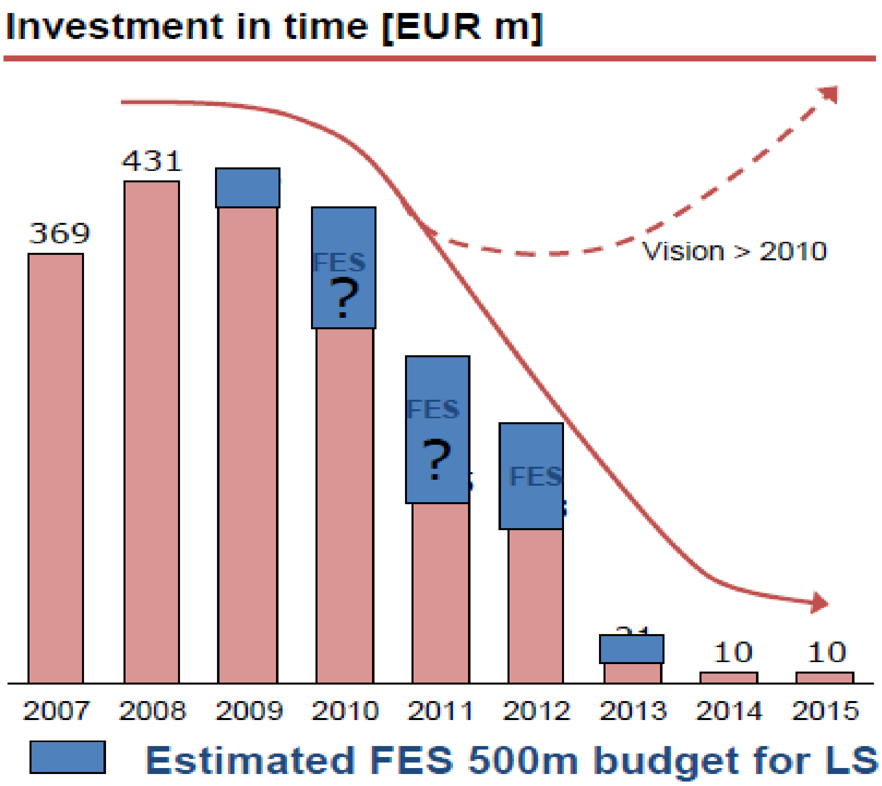
	Migratie voor eerste of huidige baan	
	Life Sciences	Andere studie
Oostenrijk	15	9
België	4	3
Tsjechië	2	2
Finland	2	3
Frankrijk	6	4
Duitsland	4	2
Italië	2	2
Nederland	4	2
Noorwegen	0	1
Portugal	1	1
Spanje	4	3
Zwitserland	4	2
Verenigd Koninkrijk	6	7

Source: Life sciences in Zuidoost Nederland, Researchcentrum voor Onderwijs en Arbeidsmarkt (2008)

Appendix 5: Investment programs in time

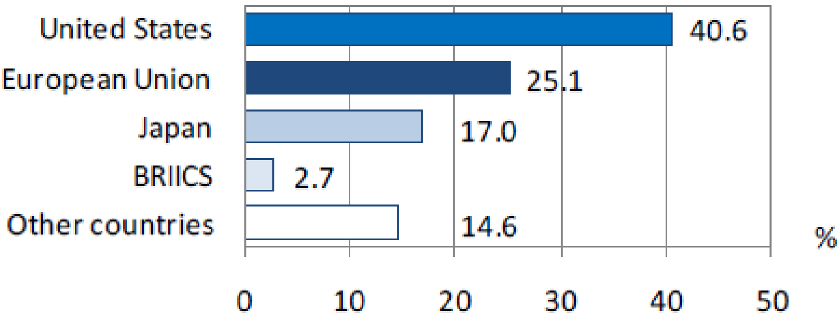


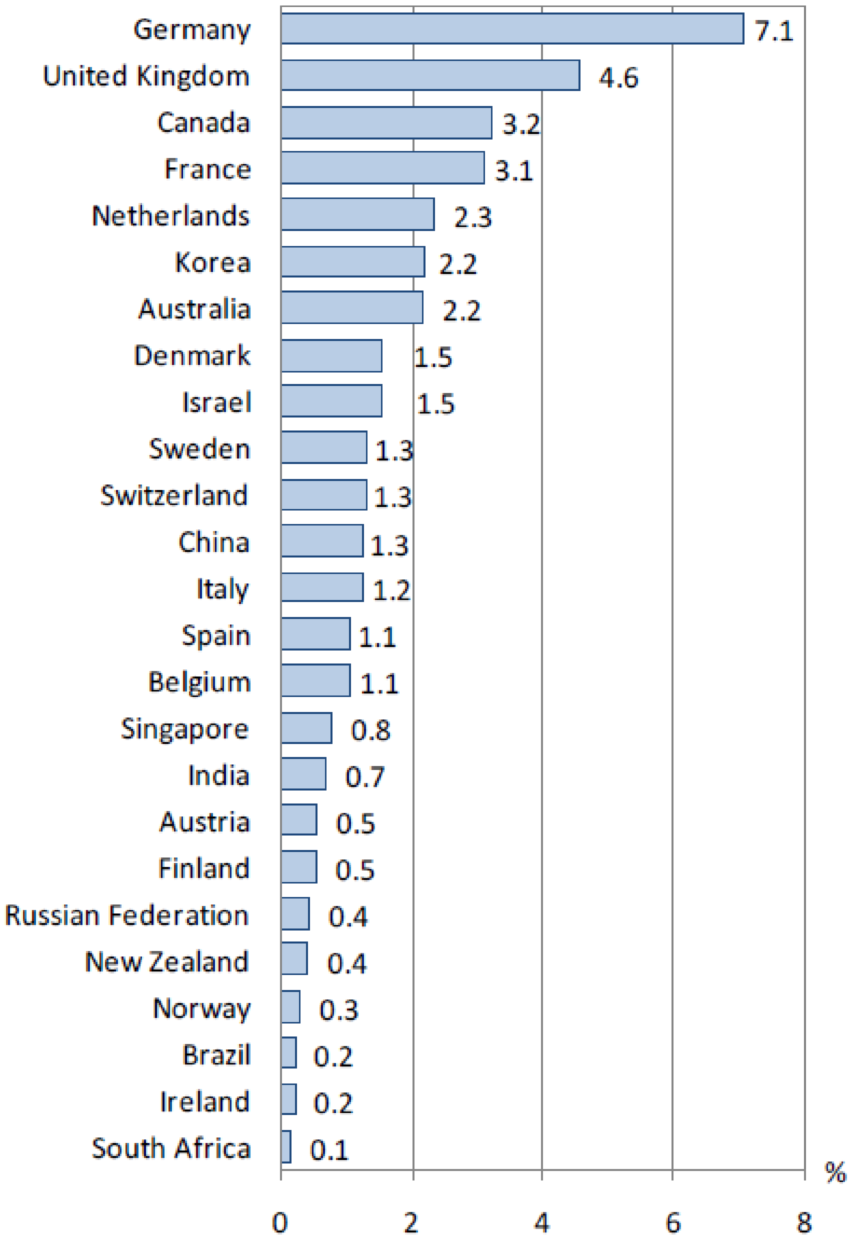
Source: Cahier No.1 *Off to a good start,* High Profile Group (2008).



Source: Cahier No.1 *Off to a good start,* High Profile Group (2008).

Appendix 6: Share of countries in biotechnology patents 2005





Source: Compendium of Patent Statistics 2008, OECD (2008).