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**Master Programme in Economic Growth,
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Innovation Activities in Biotechnology Industry in Denmark

-What are the key factors that influence Danish Biotechnology Companies' growth?

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ABSTRACT:

Denmark's biotech industry has a strong position in terms of R&D investment and net sales compared with other countries in the European Union. The biotechnology patent per million inhabitants has a leading position worldwide. This thesis aims to research the key factors that ensure and promote companies' growth in biotech industry compared with other industries in Denmark. The research results indicates that innovation is the driving force for biotech companies growth compared with all other potential key factors, which supports the relevant innovation and growth theories discussed in the literature review chapter. However, the effects differ in biotech industry compared with other industries in Denmark, as innovation play a less significant role for other industries in Denmark compared with biotech industry. On the other hand, the non innovation related factors are less important for companies' growth in biotech industry in Denmark compared to other industries in Denmark. The insights got from the case study provided qualitative illustrations regarding key factors enable and promote development, which could further prove the causal relationship between innovation together with other key factors and growth. Other key development success factors besides investing in R&D for biotech companies in Denmark are: a rich human capital that allow skilled and culturally diversified employees to corporate and contribute; work closely with the universities and research centers as well as actively involving building net works between other stakeholders strategically.

Key words: Denmark, biotechnology, innovation, growth

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Chapter 1: INTRODUCTION

1.1 Background and motivation for the research

This thesis attempts to examine whether Denmark has a strong biotech sector across countries in the European Union, how strong it is? And is innovation the driving force for biotech firm growth in Denmark, as well as what are other key factors that might have significant impact on the biotechnology company growth? By researching this, the thesis also aims to examine if the impact of innovation on growth differs by sector in Denmark.

Biotechnology has developed substantially in recent decades. Since the early 1980s, the majority of researchers have believed that "biotechnology would be the new technological base for our civilization."(Bud. R, 1991, Vol.21, p.415)

Biotechnology is a young technology and legislators as well as researchers have high expectations of biotechnology in terms of the speed of development. For example: researchers expected that "...biotechnology has the potential to create an increased number of more effective drugs and bring about radical changes in healthcare, involving a shift from reactive to preventative and more personalized medicine."(Nightingale, P.and Martin, P. 2004, p.564)

However, Nightingale and Martin (2004) further added in medicinal biotechnology development that "… Rather than producing revolutionary changes, medicinal biotechnology is following a well-established pattern of low and incremental technology diffusion." (Nightingale, P. and Martin, P. 2004, p.564)

Even though there has been no revolutionary change in this technology addressed by Nightingale, P. and Martin, P (2004), it does not necessarily mean that this pattern will remain unchanged in the future development of biotechnology. History has shown that technologies development were costly in terms of time and funds. Time spent on developing the technology and investments made on research and development would not be a waste but could prove to be a necessity to spin off new development areas. Moreover, the rapid change in the biotechnology industry cannot and should not be ignored when considering the significance of research and development in contributing to growth.

In general, biotechnology improves the living standard and increases productivity. It is widely used in several industries, especially the health care industry. With the development of biotechnology, new medicines are invented and used in the fields of public health and clinical diagnostics. Even though many biotech based drugs have not yet been launched onto the market and there is a "...very long and difficult processes involved in bringing new drugs to market" (Nightingale, P. and Martin, P. 2004, p. 567). Nowadays many diseases previously considered terminally and deadly are no longer a threat to human beings. Human life expectancy has increased and it might even have the potential to increase at an even higher rate worldwide. In agriculture, with the aid of biotechnology, we have the ability to produce more and healthier products even while using less land and less chemical fertilizer. Biotechnology also positively impacts the environment. Currently there are many challenges but the future may very well bring potential decreases in pollution as well as improved energy saving measures, for example to an increase in the development and use of renewable resources. Moreover, the advances in biotechnology is spilling over to and expanding other scientific fields, thus advancing these fields. One notable example is the Computer Science for researching and analyzing large amounts of biotechnological data which leads to the demand and development of smarter and faster computers.

In short, with the aid of biotechnology human beings might very well find themselves with vastly improved options for overcoming shortages brought about by limited resources. However, biotechnology is not without its own problems and some of the challenges facing the industry include the increased cost in time as well as funds necessary for efficient research and development. However, the primary focus of legislators and scientists alike should lie not with current expenses or any other challenges but with the long term possibilities and advantages of a well-funded biotechnology industry. It seems obvious that this young technology has great potential impact on the future economic as well as social growth. It is therefore important and essential for social scientists, policy makers, industrialists, professors as well as researchers in this field to study biotechnology in further depth. One of the key points is to investigate what are key factors that ensure and promote biotechnology growth.

In this thesis, in order to make the study more specific and reveal the main factors that influence growth within the field of biotechnology, Denmark has been chosen as the target research country.

Denmark is a Scandinavian country in Northern Europe, with a population of approximately 5.5 million, covering an area of 43,000 sq km. (http://www.denmark.dk) Although Denmark is a small country in terms of land mass and population, many argue that: Denmark has a long tradition of research and it has a strong biotech sector in the European Union. "Over time, research competences developed from beer to microbiology, from dairy products to enzymes, from pigs to insulin..."(http://www.investindk.com) In addition "...Denmark has turned into a major world player in areas such as industrial enzymes, food ingredients, diabetes care and cancer research…"(http://www.investindk.com) Therefore, it could be interesting to understand whether Denmark has a strong biotech industry across countries in the European Union, and how strong it actually is compared to these countries. Furthermore, if Denmark is successful in the biotech industry, the next important research question to be investigate is which factors most significantly impacts the biotechnology companies' growth in Denmark. Is innovation the driving factor for biotech companies' growth?

1.2 Research objectives

This thesis aims to determine the various key factors influencing the growth of the biotech industry in Denmark. As discussed previously, a significant reason for choosing Denmark as the focal point of this study has been the strength of the Danish biotech industry compared to the rest of countries in Europe. For the purpose of investigating the effects of various factors on growth, the comparative prosperity of the subject industry plays a substantial role.

This objective is achieved through investigation of the following three specific research questions:

a. Is Biotechnology a strong industry in Denmark at industry level? And how strong it is compared to other countries in the European Union?

b. Is innovation the driving factor for the growth of the biotechnology companies in contrast with other industries in Denmark?

c. Are there other factors, aside from innovation, significantly influencing the biotechnology companies' growth in Denmark?

The research study attempts to contribute practical, methodological as well as theoretical insights into the development of biotechnology in Denmark.

It is the intent of this thesis to provide a perspective to the focus of the biotechnology industry, such that it might become apparent on which areas to concentrate in order to enable and stimulate growth at a national level.

The main hypothesis is that innovation is the driving force behind the continued economic growth and development of the biotechnology industry in Denmark. As argued by Lundvall et al. (2009) that learning and innovation are the most crucial factors of growth and competitiveness of countries as well as firms. The question, however, is how significant the impact of innovation on growth really is. Moreover, if the significant level differs in biotech industry compared with other industries in Denmark. This part of the analysis contains mainly the analytical quantitative studies.

The second hypothesis is that besides innovation, there are also other factors that have significant impact on firm growth in the biotechnology industry in Denmark. However, in order to make the research possible, several key factors are initially identified based on the previous literature insights: the role of universities, human capital as well as the relationship/network between them etc. These will be analyzed in detail in later sections, and the selection of the mentioned key factors was based on previous research theories as well as empirical findings. The detailed reasons for choosing these key factors will be discussed in the literature review section.

1.3 Outline of the thesis

I shall begin the thesis with a brief introduction of the research and the research questions, and explain the motivations for choosing this topic, as well as provide a detailed thesis outline.

Chapter 2 discusses previous literature regarding innovation, biotech innovation, innovation systems and growth in a critical manner.

Chapter 3 presents the appropriate methodologies and discusses the selection of source material. The decision regarding choosing different research methods to investigate for the research questions as well as selecting the variables and case will be explained in detail.

Chapter 4 attempts to provide a detailed analysis of the quantitative data as well as present qualitative illustrations along with the appropriate theories in order to identify: first of all, whether Denmark has a strong biotech industry in comparison with other industries in Denmark, as well as comparing across countries in the European Union; Furthermore, if innovation is the driving factor for company growth in biotech industry in Denmark; Lastly, what are the other factors aside from innovation which may have a significant impact on the growth of Danish biotech companies.

Chapter 5 consolidates the results of the analyses carried out in the previous chapters.

Last of all, I shall provide a conclusion that sums up the analysis and findings of the previous sections while also discussing the limitations and suggestions regarding policies as well as future research studies.

Chapter 2 LITERATURE REVIEW

In this chapter previous literature related to technology and innovation as well as the growth theories will be detailed and critically discussed. I shall begin with an introduction of the definition of biotechnology, since the way which it is defined affects the methods and data selections; Secondly, I shall give an account of the role of technology and innovation from a historical point of view, followed by the concept of innovation. Thirdly, the characteristics of biotechnology innovation will be reviewed and discussed. The innovation system theories along with the characteristics of the factors: human capital, universities, and companies etc will be analyzed in depth. The purpose of this section is to apply a theoretical analysis to understanding the development of biotechnology in Denmark, in addition to providing theoretical insights into the process of choosing the appropriate methods and data in the following chapters.

2.1 Definition of biotechnology

"Biotechnology is considered to be one of the most important generic technologies to have emerged in the past decades of the 20th century. " (Sorisio, E.2009, p.2.) It is therefore, very important to have a clear understanding of the definition of biotechnology. The way it is defined affects the classifications of biotechnology. The biotechnology industry has to be distinguished from other industries; firms which belong to biotechnology industries are indentified and studied; and different variables are used to measure biotechnology etc. Also the factors that could actually impact biotechnology and influence society are discussed in the coming chapters.

From the name of biotechnology itself, it could mean a technology which uses biology as a base. Many also call it bio-engineering. Gaden (1962) explains that "technology based on synthesis of biology, especially microbiology, with engineering." (Bud. R, 1991, Vol.21, p.446).A more widely used definition across countries is from OECD, which defines it as : "the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non living materials for the production of knowledge, goods and services". (Van Beuzekom, B. and Arundel, A., 2009, p. 9) OECD also calls it "a single definition of biotechnology". (Van Beuzekom, B. and Arundel, A., 2009)

The OECD's definition is broader in contrast with Gaden's description of biotechnology. However, the following interpretation seems to present itself: at the beginning, biotechnology is a development on biology and with its development over time and across the nations it connects and expands together with other fields. As a result of this, not only the bio-products but also the bio-processes and models are considered as biotechnology. In another word, biotechnology could be anything that involves the use of bio-product and /or bio-process that applies science and technology for any society development purpose. This definition should provide an overall picture of what biotechnology really is.

However, it is hard to measure biotechnology and classify firms into biotechnology categories by using this single definition, it is somehow too general. Hence, OECD suggested using this mentioned single definition together with “a list based definition” (Van Beuzekom, B. and Arundel, A., 2009). This list is presented at below table, and it more specifically divides biotechnology into different subjects.

Table 01
OECD list-based definition of biotechnology techniques

- *DNA/RNA:* Genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology.

- *Proteins and other molecules:* Sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones); improved delivery methods for large molecule drugs; proteomics, protein isolation and purification, signaling, identification of cell receptors.

- *Cell and tissue culture and engineering:* Cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, embryo manipulation.

- *Process biotechnology techniques:* Fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation, biofiltration and phytoremediation.

- *Gene and RNA vectors:* Gene therapy, viral vectors.

- *Bioinformatics:* Construction of databases on genomes, protein sequences; modeling complex biological processes, including systems biology.

- *Nanobiotechnology:* Applies the tools and processes of nano/microfabrication to build devices for studying biosystems and applications in drug delivery, diagnostics etc.

Source: OECD 2009

With the aid of the above OECD single definition as well as the list- based definition of biotechnology, different perspectives of biotechnology can possibly be measured and compared, especially whether a company belong to biotechnology industry or not can be clarified. It is then now possible to do the comparative studies in the following chapters.

2.2 The role and concept of innovation

In human development history, the role of science and technology has become more important since the industrial revolutions. From an economy which was based on craftsmen and draft animals, to a machine and technology based economy, innovation has played a significant role of the economic and social growth. With different stages in the technological progress society could grow in many aspects such as; the productivity, the education level, the life expectancy and the living standard etc. Imagine, without the implementation of technologies and inventions, the world would not have the steam engine, trains, electricity, or the internet etc. It is obvious that the invention and innovation in science and technology has a fundamental impact on the modern economic growth as well as the current economic growth.

We need to distinguish between the terms invention and innovation although many find it difficult to separate them. Fagerberg et al explained that:"Invention is the first occurrence of an idea for a new product or process while innovation is the first attempt to carry it out into practice." (Fagerberg, J. et al 2005, p.4) In another word, inventions could be 'un-useful' within certain time periods and/or regions. Innovation occurs after invention, and it could be an invention in use in the commercialization process. Case such as: if there is no sufficient technology or infrastructure to complement the invention, it would not develop into any innovation. Conversely, without invention, innovation would not have occurred. Thus, the sustainable process of innovation contains the supports from complementary knowledge, financial resources, and appropriate institutions, as well as a successful knowledge diffusion process which helps the knowledge spill over to society.

According to Schumpeter (2005), innovation could be divided into the following types: "new products, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organize business."(Fagerberg, J.et al, 2005, p.6) One way to interpret this is that aside from new products (e.g. new machinery) which would belong to the category 'product innovation', everything else could be considered as belonging to the category 'process innovation' (incremental improvements on product innovation). Researchers often focus on the examination of product innovation. However, Lundvall et al (1992) argued that ignoring "…the cumulative impact of incremental innovation may lead to a biased view of long run economic and social change" (Fagerberg, J. et al 2005 p.8). In this thesis, even though process innovation is relatively more important for biotech industry than other industries, since the purpose is not to analyse any effects in long term, process innovation will not be examined in detail.

Both the evolutionary growth theory and the 'new growth' theory argues that among different factors (e.g. human capital, universities), the most important factor which generates growth is technology & innovation. Schumpeter has explained that innovation could break the market equilibrium, meaning that the price balance of supply and demand will be disturbed due to innovation. Entrepreneurs are the first to bear the risk of innovation, new technology is implemented into the market, and new opportunities are opened up; followed by imitators, interacting together with other actors such as institutions. Through this process productivity can increase, the economy may face structural change. After a certain period of time a new market equilibrium will be have been reached, and hence further innovation may appear in the market to disturb the new market equilibrium. It is therefore reasonable to make the assumption that innovation is the driving factor of the economy and society growth.

However, before breaking ground on the first hypothesis, that innovation is the driving factor of biotech sector growth, it is important to take a look at innovation in biotechnology. Since for different sectors and industries, the role of innovation, as well as the patterns of innovation significantly differs.

2.3 Innovation in biotechnology

As "…the sectors differ in terms of knowledge base, the actors involved in innovation, the links and relationships among actors, and the relevant institutions, and that these dimensions clearly matter for understanding and explaining innovation and its differences across sectors." (Fagerberg, J.et al,2005, p.381).

The knowledge base is usually divided into two categories: tacit and codified knowledge. Different knowledge bases affect learning, interaction and transmitting processes. Intensive tacit knowledge sectors such as the food & beverage, hotel and textile industries are basically learned by doing, or the application of knowhow. One cannot learn how to ride a bike by only making secondary researches, practicing is the main way to learn. In contrast biotechnology as well as other science based industries, belongs to the highly codified knowledge sectors, which are often "characterized by a high rate of product and process innovation, by internal R&D, and by scientific research done at universities, and public research laboratories…"(Fagerberg, J.et al 2005, p.384) Moodysson and Jonsson (2007, p.115) also explains that, "the performance of actors in this sector(biotechnology) in large part is defined by their ability to create new knowledge..."

In other words, for biotechnology firms, the ability to remain innovative is very crucial. Besides innovation, the interactions between firms and universities or public research laboratories are also more important in contrast with the intensive tacit knowledge sectors. Hence, a Biotechnology firm may have to invest in R&D in order to be innovative, but the firm may not necessarily become successful by investing in R&D only. At the same time it has to collaborate with other partners, and the outcome also relies on whether this firm has effectively implemented the knowledge into the commercialization process. For example, in case the company is not able to match the level the current market infrastructure, it will be difficult to succeed.

It is therefore important to understand the external context and external collaborators, as well as the relationship between them. The system of innovation and cluster concept will be discussed in the next section, as those concepts may help to indentify other potential factor in the external market contexts that may affect the firms' knowledge implementation process, and may influence growth in the biotech sector.

2.4 The concept of the system Innovation and clusters

“Systems may—just as firms—be locked into a specific path of development that supports certain types of activities and constrains others.” (Fagerberg, J., et al., 2005, p.13)

The general concept of the system of innovation could be understood as: “the determinants of innovation processes…. meaning all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovation.”(Fagerberg, J.,et al.2005, p.182). Even though the main point of the system of innovation is the knowledge creation and diffusion, the research should not be narrowed only to R&D investment, other factors and the relations between those factors which determine innovation processes should also be analyzed. (Nelson, R.R. 1993)

One of the main rulers of the system of innovation is institutions. “The behaviour of organizations is also shaped by institutions, such as laws, rules, norms, and routines that constitute incentives and obstacles for innovation.” (Fagerberg, J., et al. 2005, p.182) In other words, the appropriate institution is very important not only to the economic growth, but also to ensure that the society is improving under the “correct” path. For sector such as biotech, the moral part should be always taken into consideration. Therefore, the government/policy maker needs to always adjust the institutions to the current market needs for biotech sectors. Other players of the system of innovation includes firms, universities, research centres etc.

However, as institution is a “ruler of the game”, it should not be considered as an actor. Also, among countries in the European Union, it could assume that institutions in different countries function similarly especially compared to countries outside EU which have a very different society system. Since the focus of this thesis is within the Europe Union countries, I therefore will not discuss more regarding institution.

These mentioned players, as well as the interactions among them, can actually determine if the knowledge can be created and diffused successfully to society. However, the importance of these players varies in different sectors. For example, the role of the universities for the biotech sector is more important compared with other sectors. Fagerberg, J., Mowery, D.C. and Nelson, R.R. (2005, p.221) explained that “University research contributed to technological advances by enhancing knowledge of the fundamental physics and chemistry underlying manufacturing processes and product innovation, an area in which training of scientists and engineers figured prominently, and experimental techniques.”

Other than the national system of innovation, there are also sectoral as well as regional systems of innovation. Researches often focus on the national system of innovation, as “most public policies influencing innovation processes or the economy as a whole are still designed and implemented at the national level.” (Fagerberg, J., et al. 2005, p.199). Especially for a small country like Denmark, the national system of innovation is more relevant compared with larger countries.

The Danish innovation system is characterized “small and medium sized low tech firms mainly making local incremental innovations based on learning by doing, learning by using and a high degree of learning by interacting especially with customers and suppliers combined with efficient commercial ability." (Christensen, Lindgaard J., et al. 2005, p.3.) In other words, companies and industries in Denmark generally have low R&D intensity. Furthermore, for most of the industries in Denmark, generally speaking there might be less product innovations and more process innovations.

However, the biotech sector in Denmark is one of the exceptions. As biotech firms belong to science based industry, it is highly involved in the R&D investment, and high level of patents. The empirical studies in later chapters will try to analyze the comparative importance between the R&D investment biotech industry and other industries quantitatively, in order to test if the results support to such characteristics of the Danish innovation system. Since the research area in this paper is an exception of the national innovation system in Denmark, the detailed characteristics the Danish innovation system will not be discussed any further.

Besides the national system of innovation, the cluster approach should also be taken into consideration. The widely used definition of clusters is: "…geographic concentrations of interconnected companies, specialized suppliers and service providers, firms in related industries, and associated institutions (e.g. universities, standard agencies, and trade associations) in particular fields that compete but also cooperate."(Porter, M. 2000, p. 253) "Innovation tends to cluster in certain industries/sectors, which consequently grow more rapidly, implying structural changes in production and demand and, eventually, organizational and institutional change" (Fagerberg, J., et al. 2005, p.20)

One of the differences between cluster and national system of innovation might be that they have different scale and scope. For example, cluster can be within the national system of innovation, but it can also be on the outside of the country border such as the Medicon valley between Copenhagen in Denmark and Sweden, whereas the national system of innovation is within the border. Hence, the external environment should not be limited by the national border if any factor is part of the cluster. Nevertheless, the concepts of cluster and the national system of innovation have a common feature that both of them are part of the external market contexts of the companies, they do have impacts on the companies' development, which means it could have both advantages and disadvantages, depends on the networks between actors as well as rulers. However, the focus of this thesis is neither studying the effects of cluster nor the national system of innovation, but uses them as theoretical inputs when selecting the additional key potential factors which may influence biotech firm growth in Denmark.

To sum up, based on above theoretical discussions regarding innovation and growth, innovation in biotech industry, the national system of innovation as well as the theory relates to cluster, the following key potential factors that are crucial for biotech industry growth are: other than innovation, first of all, whether the biotech companies have worked closely with the universities and research partners and secondly, whether the biotech industry is rich in terms of human capital. Thirdly, if the biotech companies can get competition and corporation among its stakeholders such as: suppliers, customers and competitors etc. In the meanwhile, the relationship between firms, universities, and other stakeholders will be analyzed, as it was suggested by previous findings that the network has impact on the companies' development.

Based on the above theory discussions, the assumptions are made as follows:

- Hypothesis one: There is a positive linear relationship between innovation and growth in biotechnology firms, and it is more significant in biotechnology industry than in other industries in Denmark.

- Hypothesis two: There is a positive linear relationship between non-innovation related investment and growth in biotechnology firms; however, it is less significant in biotechnology industry than other industries in Denmark.

Chapter 3 DATA AND METHODOLOGY

This chapter first of all presents the appropriate methodologies.

It also provides discussions regarding the selection of variables to perform both quantitative and qualitative analysis which is done using the previous relevant theories that have been discussed in the Literature Review chapter as a base.

Thirdly, the source data and compile the data for quantitative analysis for use in the coming sections will be introduced.

Lastly, the limitations of the data and methodology will be discussed in the end of this chapter.

3.1 Basic methodological choices

As discussed in the introduction section, the aim of the thesis is to investigate whether Denmark has a strong biotech sector across countries in the European Union, how strong it is? And is innovation the driving factor for biotech firm growth in Denmark, as well as what are other key factors that might have significant impact on the biotechnology company growth?

In order to achieve this research objective, secondary analysis is carried out, which will be based on collecting the report information and quantitive data from research papers, statistical insitutions/organizations, official websites, companies' annual reports, and journals etc.

The general disadvantage of using secondary analysis might be that the depth would be limited from using existing data. However, in the case of studying the biotechnology innovation and firm growth, it could be argued that the best option will be using already available sets of data. This is because first of all, in this field, many researchers as well as organizations have already collected rich datasets, such as R&D investment by firm and patent applications. Secondly, the focus of this thesis is to make re-analyses of the available data and information from previous research studies to provide different perspective. Moreover, choosing the secondary analysis carries with it lower costs compared with using other research methods. In addition, the sample size available is much larger compare with collection of data by the author alone and hence the results should be able to better represent an actual picture of the current market situation due to the larger sample size.

Both the quantitative and qualititive researches are considered in this thesis. Based on the knowledge gained from previous research analyses, combining the quantitative approach and qualitative approach would provide a more realistic result of the research objective. For example, one of the reasons is that quantitative research result might provide a statistically significant correlation of different variables; however, it could not prove the causality between them. But on the other hand, qualitative research result might give an insight on the causality between different variables, which in turn can complement the quantitative research.

Quantitative research is suitable for various studies, for instance: comparative analysis. As it gives quantitative measurement of the rankings, as well as how much certain key economic factors influence other factors within the company. By quantifying certain key indicators would provide a more precise picture of the overview of Danish biotech position in comparison with other countries in the European Union. Therefore, the descriptive method of quantitative research is mainly applied for the research question one: is Biotechnology a strong industry in Denmark at industry level? And how strong it is compared with other countries in the European Union?

The analytical method of quantitative research is mainly used to answer the research question two: Is innovation the driving factor for the growth of these biotechnology companies compared with the companies in other industries in Denmark? Since by using multiple linear regression analysis to understand the correlation between firm growth and its innovation, as well as non innovation related investment for both the biotech industry and other industries in Denmark would provide an insight into whether innovation is the driving factor of biotech firm growth compared with other industries in Denmark. In the multiple linear regression analysis, the firm growth is chosen as dependent variable and innovation indicators as well as non innovation related investment as the independents variables. Using other industries as reference industries compared with the biotech industry is because that in Denmark, besides the biotech industry, most of the other industries are doing less product innovation in Denmark. Therefore, the knowledge base should be less science based for other industries than for the biotech industry in Denmark. For the time being, industries other than biotech are not separated, but have been consolidated together into one “reference industry” to make the comparison. The list of the selected industries is presented in the source data section.

As discussed in the literature section, based on the previous research findings, several other factors are identified as the potential key factors that have significant impact on biotech firm growth: university, human capital, as well as the network between organizations and universities, etc. However, these mentioned factors which are hard to quantify according to the findings from the previous research papers and using the quantitative research could give a biased result due to neglect of the important unquantifiable factors. Therefore, the qualitative research is chosen as the main method, the quantitative research will be used as a supplementary method to perform a case study which will be the most suitable approach to understand the if there are other potential key factors aside from innovation which have significant impact on biotech firm growth.

Novo Nordisk is chosen to be given a detailed focus in this case study. Since this company is dominating the biotech sector in Denmark. It has large share of the Net sales, Number of employees, R&D investment, as well as Patent applications, in studying the innovation activities in biotech industry in Denmark, it is obvious that Novo Nordisk plays a crucial role in any changes in the Danish biotech industry.

In summary, the methodology approach in this thesis is as follows:

Quantitative research methods are used as the main method to answer the first and second research questions. The descriptive method in the quantitative research is used in answering the research question one: Is Biotechnology a strong industry in Denmark at the industry level? And how strong it is compared with other countries in the European Union? And the analytical method in quantitative analysis is used as the main method in answering the research question two: if innovation is the driving factor for the growth of these biotechnology companies compared with the companies in other industries in Denmark?

The qualitative research will be carried out as the main method and quantitative research as the supplementary method to conduct a case study on Novo Nordisk in order to answer the research question three: if there are other key factors that have significant impact on biotech company growth. The qualitative illustrations regarding the innovation activities among the factors which were discussed in the literature review chapter will be provided in this section as well.

3.2 Variable choices

3.2.1 Descriptive quantitative research variable choices:

R&D investment and patent data is widely used as key indicators to measure innovation activities for certain technologies. R&D investment is usually considered as input indicators whereas patent applications as one of the output indicators of innovation activities.
(Kleinknecht, A. and Jeroen O.N. Reijnen, 1993) It could be assumed that any company spending on R&D is due to their belief that there will be significant returns from the investment on R&D. Moreover, the returns should cover the cost of the investments. Furthermore, the more they spend on R&D, the higher the potential return for the company. On the other hand, if firms do not invest in R&D; they would possibly not develop quickly enough, especially for those firms which are in high tech sector (e.g. the biotech sector). For non- R&D related investment, as it is a type of investment, it could be assumed that a company is expecting returns as well in terms of growth from it. However, the difference is that for the biotech industry, the R&D investment should play a more important role than in other industries in Denmark, and on the other hand, the non-R&D related investment for the biotech industry should be less important compared with other industries in Denmark.

"Patent data are often used as indicators of innovation in several technological areas, and although it may be argued that the simple granting of a patent does not give sufficient proof of commercialization, patents may still be regarded as relatively robust indicators of innovation in the pharmaceutical and biotechnological sectors because of high dependence of the commercialization process on patenting"(Sorisio,E. 2009, p.9) In order to compare the number of patents in the Danish biotech industry with different countries, I shall apply a relative patent indicator: patent per million inhabitants is used.

As discussed in the previous literature part, innovation contains both product and process innovation. For process innovation, it is somehow harder to measure in contrast with product innovation. As, Alfred Kleinknecht and Jeroen O.N. Reijnen (1993) argued that: "Process innovation measured as far as they are incorporated in new machines or equipment that is sold on a market" (Kleinknecht, A. and Jeroen O.N. Reijnen, 1993, p.201) It is therefore possible that the output cannot be clearly identified (e.g. internal use within a firm), even though firms invested in R&D in process innovation. This is one of the situations where the innovation is underestimated.

Hence, it is important to include other output factors as indicators to measure the output of innovation. Such factors could be could be firm size in term of number of employees, and the firm's sales, patent application per million inhabitants etc.

Although there are also several other indicators that might provide insights on different aspects of biotechnology, for the time being only the several indicators mentioned have been selected in the descriptive quantitative research analysis, since those key indicators are often used in growth related and technological activities research.

The variables in the descriptive quantitative research part are summarized as follows:

- R&D investment;
- Net sales values;
- Number of employees;
- R&D net sales ratio
- R&D per employee
- Net sales per employee
- Patent application per million inhabitants;

3.2.2 Analytical quantitative research variable choices

For the analytical quantitative analysis part the net sales growth has been chosen as the dependent variable, the non-R&D investment as well as the R&D investment has been chosen as the independent variables. The purpose is to determine whether there is any correlation between the selected independent variables (R&D investment growth & Non-R&D investment growth) and the dependent variable (Net sales growth) and if so, how significant the impact is for the biotech industry compared with other industries in Denmark.

In order to make the quantitative research analysis more valid, the selections of the appropriate firm growth as well as innovation indicators are discussed in detail, on the basis of the past researches information.

Using Net sales growth as the dependent variable of the regression analysis is more appropriate than using the growth in the number of employees as the dependent variable of company innovation and growth. Since it is the focus of this thesis to check which factors significantly influence company growth economically, the company revenue is the best indicator, rather than the relative employee size of the company. Even though innovation can help to improve efficiency, it does not necessarily lead to changes in number of employees, but it might lead to an improved economic performance.

Choosing between R&D investment and patent applications per million inhabitants, the R&D investment will be more suitable in this case. From the theoretical point of view, patents might be one of the outcomes of R&D investment, but not all R&D investment will lead to the result of getting patents. However, as R&D investment is the innovation input, it will lead to increased growth.

Besides using the R&D investment growth as independent variable, the non-R&D related investment is also included in the multiple regression analysis as the other independent variable. As discussed previously, besides R&D investment, the non-R&D investment is the other input of a company's revenue. It could be assumed that all investments put into production are for the better development of the company growth. Therefore the non-R&D related investment can be an important input for a company's development. It is expected that the more R&D as well as non-R&D related activities a company invest, the higher growth rate the company should achieve.

Therefore, comparing whether non-R&D investment or R&D investment is more crucial for biotech industry compared with other industries in Denmark would allow this thesis to find out whether innovation in biotech industry plays a more important role than the rest of the industries in Denmark.

In short, the variables in the analytical quantitative research part are summarized as follows:

- X independent variable 1:
  R&D investment growth, which is used as the innovation indicator

- X independent variable 2:
  Non-R&D related investment growth, which is used the non innovation investment indicator

- Y dependent variable:
  Net sales growth, which is used as the company growth indicator

3.2.3 Qualitative research variable choices

In the qualitative research part, a case study on the firm Novo Nordisk is carried out. The quality evidence is examined in order to understand if there are other key factors that influence biotech firm growth beside innovation, since many of these factors are hard to quantify.

The choices of selecting the other potential factors are discussed in detail during the literature review chapter, and will therefore not be discussed further in the main body of the text, but it is summarized as follows:

- Universities
- Human capital
- Other stakeholders

3.2 Source material

Both the descriptive and the analytical quantitative researches are basically using two main source data sets: Firstly, the Eurostat Patent Statistics (2011), and secondly the European Commission, European Union Industrial R&D Investment SCOREBOARD from 2006 to 2010.

The case study in the qualitative research is basically built up around the relevant official web sites, books, journals, as well as the company's annual report. A detailed list of these can be found in the Literature section.

The patent applications per million inhabitants are based on the data from Eurostat; Patent Statistics. The latest data available is up to 2007. Ten years data backward from 2007 has been taken in order to look at the historical trends of the position of Denmark in the biotechnology industry compared with the rest of the world.

The source data of R&D investment, number of employee, R&D per employee, and net sales come from the 2010 the European Union Industrial R&D Investment SCOREBOARD, which is" part of the Industrial Research Monitoring Activity carried out jointly by the joint Research Centre and Directorates- General of the European Commission."(The 2010 the European Union Industrial R&D Investment SCOREBOARD, p.2) It was "compiled from companies' annual reports and accounts with the reference data of 1 August of each year." (Felix, B. 2007, p.7) The sample is the top 1000 R&D investment companies in the European Union, the sample size is large enough to represent the companies in the European Union. In order to make this study more up to date, in the descriptive quantitative research part, the latest data is chosen which is from 2009.

In the analytical quantitative research part, the source data; the European Union Industrial R&D Investment SCOREBOARD, is the same as in the descriptive research part. However, due to the fact that the research has been narrowed down to Denmark at the industry level the sample size becomes smaller. In order to include more observations so that the sample size can be large enough to represent the whole group of companies in Denmark in the multiple regression analysis, the period 2006-2010 has been selected from the source data.

3.3 Definitions of the selected variables

Since the wrong understanding of the selected indicators as variables would lead to invalid conclusions, the concepts of these indicators are presented as follows:

R&D investment: “Cash investment funded by the companies themselves. It excludes R&D undertaken under contract for customers such as governments or other companies. It also excludes the companies' share of any associated company or joint venture R&D investment. The amount shown in the annual report and accounts is given, based on the accounting definition of R&D. The definition is set out in the International Accounting Standard (IAS) 38 “Intangible assets” and is based on the OECD's Frascati Manual. Research is defined as original and planned investigation undertaken with the prospect of gaining new scientific or technical knowledge and understanding. Expenditure on research is recognized as an expense when it was incurred. Development is the application of research findings or other knowledge to a plan or design for the production of new or substantially improved materials, devices, products, processes, systems or services before the start of commercial production or use. Development costs are capitalized when they meet certain criteria and when it can be demonstrated that the asset will generate probable future economic benefits. Where part or all of R&D costs have been capitalized, the additions to the appropriate intangible assets are included to calculate the cash investment and any amortization eliminated.” (Felix,B. 2007, p.7)

Number of employees: “the average number of employees or the number of employees at the end of the reference period if the annual average is not available.” (Felix,B. 2007, p.7)

R&D per employee: Amount of R&D investment divided by the number of employee. “At the aggregate level, R&D per employee and the other non growth statistics are calculated only by aggregating those companies for which data exist for both of the numerator and the denominator.”(Felix,B. 2007, p.7)

Net sales: “follow the usual accounting definition of sales, excluding sales taxes and shares of sales of joint ventures & associates. For banks, sales are defined as the Total (operating) income plus any insurance income. For insurance companies, sales are defined as “Gross premiums written” plus any banking income.” (http://iri.jrc.ec.europa.eu)

Net sales per employee: Amount of net sales divided by the number of employee

3.5 Discussion of the data limitations

Above selected key indicators are the most often used ones in research studies, and these should be sufficient to achieve the thesis objective.

However, certain limitations should be kept in mind.

First of all, the sample data selected in the quantitative research part was from the European Union Industrial R&D Investment SCOREBOARD during 2006 to 2010 which contains limited sample data. The sample data was based on the R&D investment rankings, and top ranking 1000 firms were chosen in the European Union. Therefore, companies which are not belonging to top 1000 companies in the European Union are not considered in the analysis, which in reality; these companies may also play a part. In other words, the analysis as well as findings may not be fully representative of the actual market situation cross industries as well as countries, but only illustrating the results based on the top R&D ranking 1000 companies. Moreover, although the sample data size is large enough to carry out the research, it may not be fully representative of the total companies. Ideally, the more samples are chosen, the greater the overall validity of the final result. Readers should be aware of this issue, and use the result carefully when compare across industries as well as countries in the European Union.

Secondly, although the latest data available was selected in this chapter, it still has some time lag to the current situations. For R&D investment, net sales, number of employees, R&D per employee, the source data are till 2009. And for the patent applications per million inhabitant's data, it is only available up to 2007.

An additional limitation, besides the several key factors selected based on the inspirations of the literature review chapter, is that there might be other factors which have an impact on the biotech firm growth, but due to the limitations of a research thesis of this size, most of them are not analyzed in this thesis.

Unfortunately, these mentioned limitations are not possible to solve within the current research analysis. The gap between the results from these methods of analyses and the actual market situation has always been a problem throughout the history of any research, but is beyond the ability of this thesis to go into further depth on this subject – it only seems prudent to mention the relative uncertainty of conclusions based on limited research.

However, the author has tried to minimize this gap to some extent in this thesis. As discussed, the selected 1000 samples considered as the representative of the real world should be sufficient to achieve the research objective. Moreover, as the key relevant indicators indentified in both the quantitative and the qualitative analyses are based on previous research findings, it is reasonable to assume that this method is an adequate tool to carry out the analysis.

Chapter 4 ANALYSIS

4.1 Research question 1

Is Biotechnology a strong industry in Denmark at the industry level? And how strong it is compared with other countries in the European Union?

As discussed previously, in order to answer if Denmark has a strong biotechnology sector, as well as how strong this sector is, the best way would be to use descriptive quantitative analysis.

To get an overview of the position of the biotechnology industry in Denmark, a comparative analysis of several key indicators has been carried out in the following manner:

- Analysis one: to analyze the overall situation for all industries in Denmark at the national level in terms of R&D investment, net sales, and patent applications etc. in comparison with other countries within the European Union, in order to understand the position of Denmark at the national level within the European Union;

- Analysis two: to compare and contrast the biotech industry with different industries in Denmark by using the same selected indicators. This will provide an assessment of whether biotechnology is an outstanding industry in Denmark compared to other industries;

- Analysis three: comparing the biotech industry in Denmark with the biotech industry in other countries in the European Union in order to understand the position of the Danish biotech sector across countries in the European Union.

4.1.1 Analysis one: Comparison of all Denmark industries in terms of R&D investment, patent applications, net sales, number of employees with other EU countries.

Table 02 presents the R&D investment in Million Euro, Net Sales in Million Euros and R&D net sales ratio by EU countries for the top R&D ranking 1000 companies in 2009. Bulgaria is excluded in this analysis since the values for the two indicators are too small compared with the rest if the countries. Observations which contain any missing values in either R&D investment or Net Sales are also excluded in all of these three analyses. This is acceptable because there is about 11 out of 1000 observations are excluded, which is a very small percentage of the total sample size.

Table 02

Number of Companies, R&D investment in Million Euros, Net Sales in million Euros and R&D net sales ratio by the European Union countries for top R&D 1000 companies in all industries in 2009

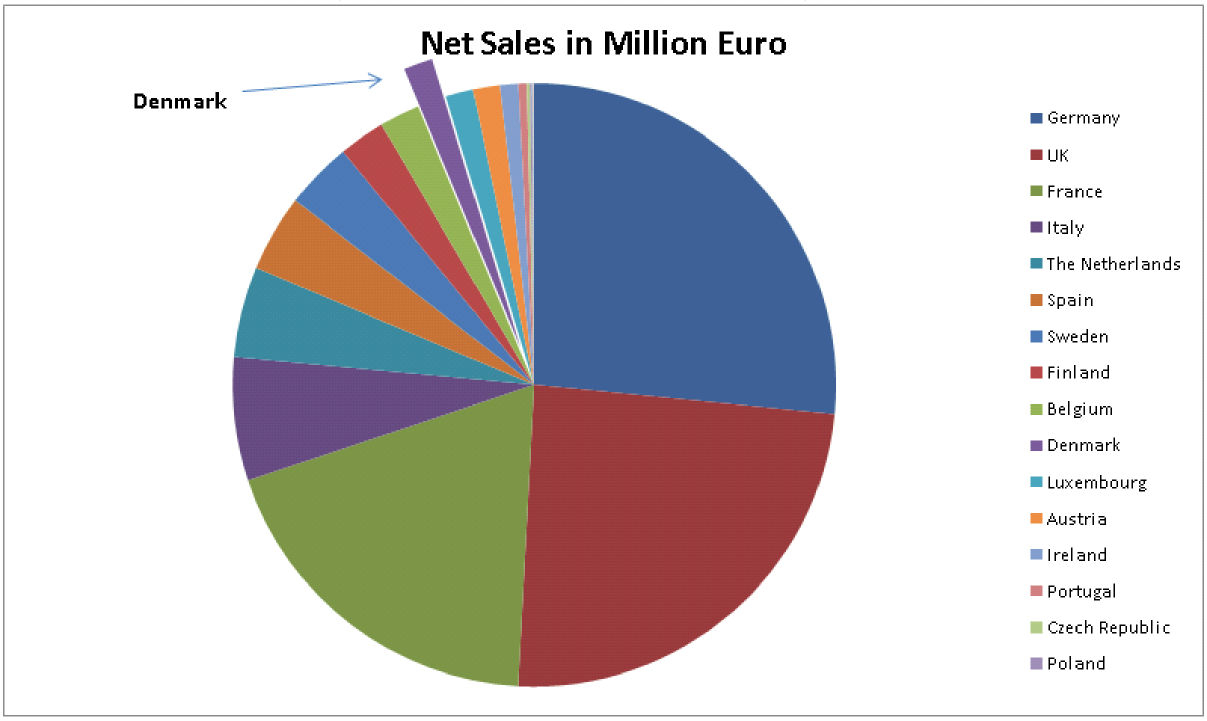
Country	Number of Companies	R&D investment(Million Euro)	Net Sales(Million Euro)	R&D Net sales Ratio(%)
Germany	206	43.981	1.435.339	3,06
UK	239	19.939	1.314.480	1,52
France	115	24.555	1.028.556	2,39
Italy	52	6.398	357.561	1,79
The Netherlands	51	9.497	262.702	3,62
Spain	27	2.912	223.316	1,30
Sweden	76	6.511	195.215	3,34
Finland	56	6.371	134.121	4,75
Belgium	40	2.378	116.042	2,05
Denmark	**46**	**3.707**	**84.371**	**4,39**
Luxembourg	8	600	80.240	0,75
Austria	31	764	77.462	0,99
Ireland	16	1.403	53.242	2,63
Portugal	8	397	24.203	1,64
Czech Republic	2	28	8.687	0,32
Poland	5	63	5.907	1,06
Greece	5	89	3.286	2,71
Hungary	2	126	1.415	8,93
Slovenia	2	93	1.126	8,30
Malta	2	58	614	9,38
The European Union	**989**	**129.870**	**5.407.886**	**2,40**

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Regardless of the types of industries of these countries, at the overall level of R&D investment and Net Sales by countries in the European Union of those 1000 companies, Denmark had 46 companies that are included in the calculations, which is close to the average of 49 companies in countries the European Union. The summary statistics of these selected variables is presented in table 02, Denmark spent about 3707 million Euro on R&D expenditure and the net sales was about 84371 million Euro in 2009. Denmark's R&D investment level ranked as number 8 among all countries in the European Union. Germany is on the top with an investment nearly twelve times as high as that in Denmark and France comes second with R&D investment more than six times higher than Denmark.

Figure 01 gives pictorial view of the net sales in Denmark compared with other countries in 2009. Based on the results of above tables, it is obvious that Denmark has relatively much lower R&D investment and net sales when disregarding the types of industries.

Figure 01
Net sales in Denmark compared with other countries the European Union in 2009



Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Based on the selected indicators, the above results show that Denmark overall level of R&D investment and the net sales absolute values ranked in the upper half among the EU countries. Denmark has a normal performance in terms of R&D investment and net sales at the overall level. It is insignificant compared with the average of EU, far behind UK, France, and Germany. The number of employee is in the lower half among these countries.

However, since countries such as: Germany and France had much larger number of companies in the top R&D ranking 1000 companies compared to Denmark, this might cause the results of relatively low performance in terms of R&D and Net sales of Denmark than these countries.

One possible method to avoid the problem caused by the different number of the sample companies in each country might be comparing the results of R&D net sales ratio between Denmark and other countries in the European Union.

The R&D net sales ratio is simply calculated as: R&D net sales ratio = (R&D expenditure/Net Sales) *100. The result shows that Denmark ranked number 4 in the European Union countries. Details are presented in table 02.

Furthermore, the comparisons between Denmark's R&D expenditure and Net sales to the average of the European Union are presented in table 03. The results indicate that: the total

R&D expenditure in Denmark is only 3% of the total R&D expenditure among EU countries, and 57% of the average of the EU R&D expenditure (6499 million Euro). The Net Sales ranking is even lower compared with the ranking for R&D investment in Denmark. With a ranking of number 10, the Net Sales only account for 31% and 2% of the average Net Sales and total Net Sales of the European Union respectively.

Table 03

Comparing Number of Companies, R&D investment, and Net sales between Denmark and the European Union average

Summary	Number of Companies	R&D investment(Million Euro)	Net Sales(Million Euro)
Denmark	46	3.707	84.371
EU Average	49	6.493	270.394
Denmark % of the EU total	5	3	2
Denmark % of the EU average	93	57	31

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

However, as mentioned earlier, due to the fact that Denmark is small in land size and population, it is not sufficient to know the overall picture by only looking at the absolute values of R&D investment and Net Sales. It is understandable that a smaller country will have fewer resources and have a smaller economy. Hence when comparing Denmark to other countries in the European Union, we have to normalize its performance of R&D investment and Net Sales with its size, e.g. the size of the population, or the size of the company in terms of number of employees. The comparisons between Denmark and other countries in the European Union regarding the number of employees, the percentage of R&D investment and net sales per employee are presented in the table below.

Table 04

Number of Companies, Number of Employees, R&D investment per employee, and Net Sales per Employee Euro by the European Union countries for top R&D ranking 1000 companies in all industries in 2009

Country	Number of Companies	Number of Employees	R&D per employee(Euro)	Net sales per employee(Euro)
Germany	206	5.836.721	7.535	245.915
UK	239	4.685.824	4.255	280.523
France	115	4.663.974	5.265	220.532
Italy	52	1.158.142	5.524	308.737
The Netherlands	51	1.031.187	9.210	254.757
Sweden	76	873.137	3.336	255.763
Spain	27	820.532	7.935	237.912
Belgium	40	539.473	11.809	248.615
Finland	56	508.746	4.674	228.095
Ireland	16	360.671	10.279	233.927
Austria	31	345.283	1.737	232.389
Luxembourg	8	341.691	2.237	226.701
Denmark	**46**	**326.673**	**4.294**	**162.984**
Portugal	8	83.925	4.725	288.386
Poland	5	44.708	618	194.311
Czech Republic	2	39.583	1.588	149.228
Hungary	2	13.383	6.662	245.507
Greece	5	10.533	11.998	134.332
Slovenia	2	10.476	8.919	107.477
Malta	2	1.391	41.364	441.185
The European Union	**989**	**21.696.053**	**5.986**	**249.257**

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Table 05

Summary of Denmark number of Employee, R&D per employee, and Net sales per employee compared to the European Union average

Summary	Number of Companies	Number of Employees	R&D per employee(Euro)	Net sales per employee(Euro)
Denmark	46	326.673	4.294	162.984
EU Average	49	1.084.803	5.986	249.257
Denmark % of the EU average	93	30	72	65

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Denmark had 326.673 people working in these 1000 companies, it is 32% of the average (1.033.171 employees), and 2% of EU in total employment (21,696,588). It is expected in Denmark that the number of employee working in those top R&D 1000 companies is far lower compared with other countries in EU since Denmark is a small country. Therefore, it is possible that the R&D per employee and Net Sales per employee of Denmark compared to other countries might be in better positions. However, the results did not support such logic.

Denmark invested R&D of 4.294 Euro per employee which ranked about the lower middle level among these 20 European Union countries, it accounts for about 72% of the European Union average (5.986 Euro R&D expenditure per employee). Denmark had about 163.984 Euro Net Sales per employee, approximately 65% of the European Union average (249.257 Euro Net Sales per employee). Therefore, based on the samples of R&D ranking top 1000 companies in the European Union, it could be concluded that Denmark does not have an outstanding position in terms of R&D expenditure and Net sales, and the situation of R&D expenditure per employee & Net Sales per employee is not better in contrast with other countries.

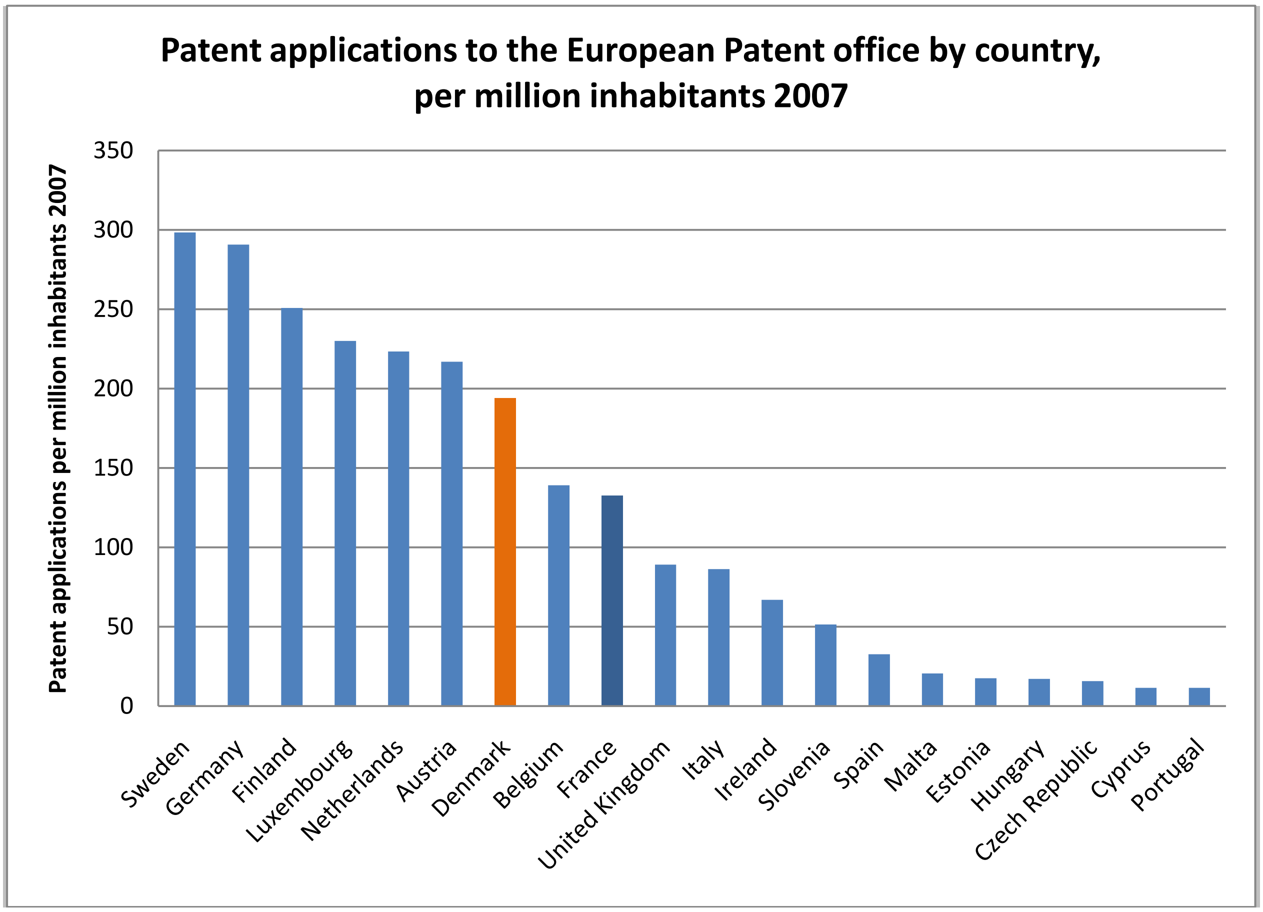
The next technology indicator to be analyzed in this section is the patent applications per million inhabitants of countries in the European Union. As discussed earlier, the source data for analyzing this indicator is from a different source (Eurostat, Patent Statistics) since the R&D ranking of the top 1000 EU companies lacks the information on patent applications.

The latest data of patent applications available is from 2007. Countries with less than 10 patent applications per million inhabitants, Details regarding patent applications for those excluded countries can be found in the appendix 1.

The result of patent per million inhabitants at national level in 2007 is presented at Figure 02, which is sorted from largest to smallest

Figure 02

Patent applications to the European patent office by countries, per million inhabitants, in 2007



Source data: own calculations based on the Eurostat, Patent Statistics, 2011

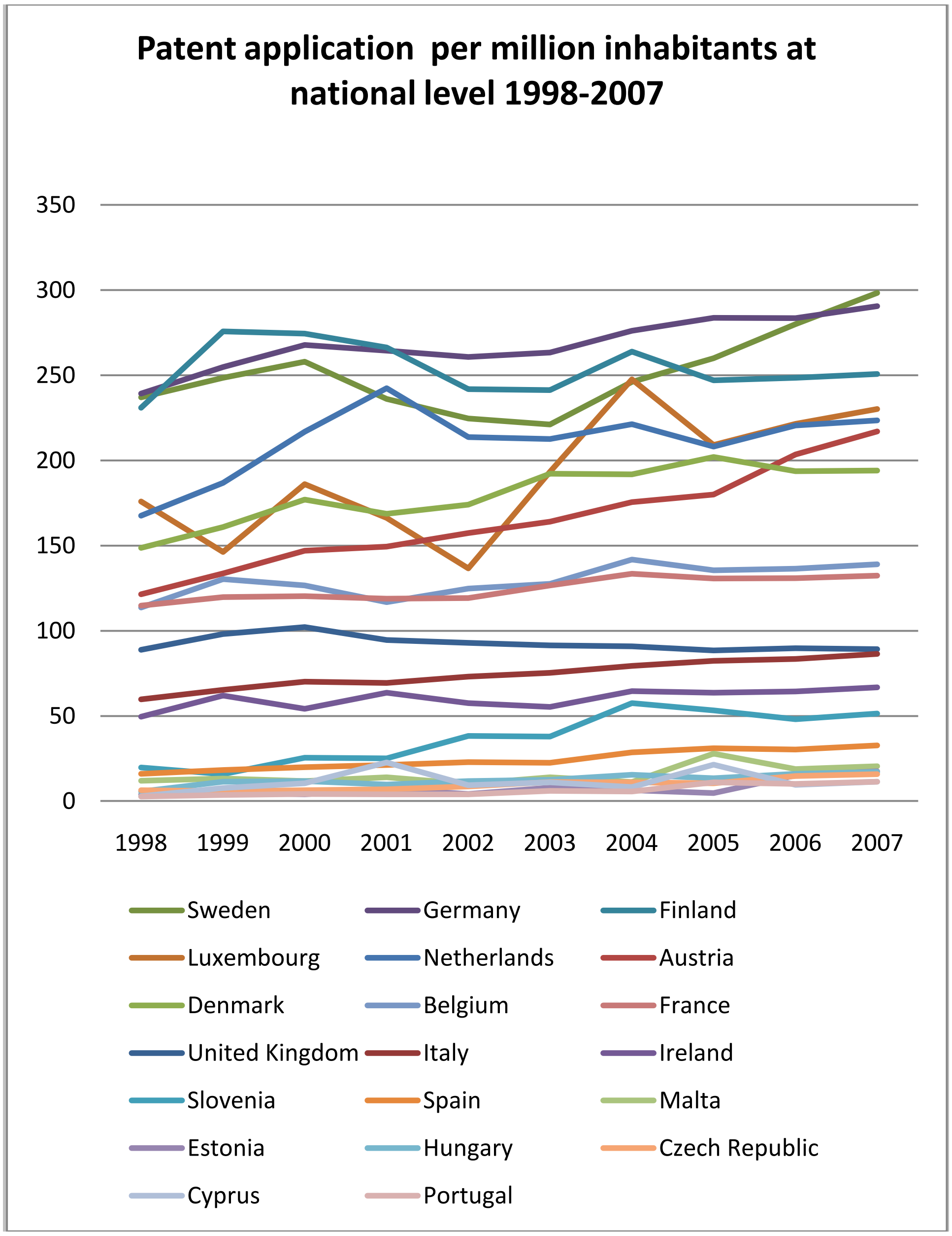
In 2007, Denmark had about 194 patent applications per million inhabitants. It is about 67% higher than the EU-27 average; the result is not in high position at national level, ranked number 6th, far behind Sweden and Germany.

Since the latest data of patent applications available is from 2007, which is not particularly up to date I have chosen to work backwards 10 years from 2007 in order to analyze the trend rather than just a snapshot of the patent applications per million inhabitants. The result is shown below in figure 03.

Most of the countries were having stable and a very slightly upward trend on patent applications over the observation period, except Luxembourg which had big variances especially during 2000 to 2004. It can be concluded that Denmark has always been in the middle upper position during this period which means the patent applications per million inhabitants is not outstanding. However, Denmark, like other countries in the European Union, has experienced an increase in patent applications over the last 10 year period which could possible indicate that Denmark is continuously investing in developing new patents to keep to technological evolutions.

Figure 03

Patent applications to the European patent office by countries, per million inhabitants, between 1998 and 2007



Source data: own calculations based on the Eurostat, Patent Statistics, 2011

In short, based on the data of top R&D ranking 1000 companies in countries in the European Union, the number of companies included in these top R&D ranking 1000, the R&D investment, the R&D net sales ratio, Net sales, the Number of employees, R&D per employee and Net sales per employee in Denmark compared with other countries in EU have been analyzed. The result shows that Denmark was neither in a high position at the overall R&D investment, nor in net sales. The number of employees, R&D per employee, and Net sales per employee are significantly less than the European Union average. Except for the R&D net sales ratio, Denmark had a relatively outstanding position in the European Union.

Based on the data of Euro stat, patent applications, the patent applications to European Patent Office (EOP) per million inhabitants at national level over the period of 1998-2007 have been analyzed. Denmark has a stable upward trend which is similar to the rest of the countries; the stable movements with the observation period could further indicate that the result of the ad hoc method analysis on the latest data of 2007 is reliable.

Nevertheless, although the year of the data collected for the above two source data sets differs, it shows a similar picture. Denmark's R&D investment, net sales value and patent applications per million inhabitants are just about the middle level in the European Union, it is not significantly strong. With this basic understanding of the overall R&D expenditure position in Denmark compared with other countries in the European Union, the next question is within Denmark, which sector is stronger in terms of above innovation activity indicators compared with other industries. What position does biotechnology industry hold at industry level?

4.1.2 Analysis 2: Comparison of biotechnology industry with other industries in Denmark, in order to understand better whether Denmark has a strong biotech sector

As discussed earlier in the previous section, both of the single definition and list based definition from OECD are used in this paper. Based on the understanding of this definition, Carter Bloch (2004) tired to classify biotechnology firms into three main groups: group 1, Core biotechnology firms, which are highly focused on investment on R&D; group 2, Firms active in biotechnology, which are not limited to investing on R&D only, but also evolves other activities; group 3, Biotech users, firms which are using biotechnology products. The author is aware that firms which belong to the biotech end users do have significant impact on biotechnology growth, since they are active in the use of the products or services. However, in order to make the study more specific, the biotech end users will not be discussed in this thesis. For the purposes of focusing purely on those companies which are active in biotech production this thesis will adhere to the definitions outlined in the previous chapter.

Hence, companies which belong to either pharmaceuticals or biotechnology industries are selected as biotechnology to be analyzed in contrast with other industries in Denmark as in the following sections.

Table 06

Number of Companies, R&D investment in Million Euros, Net Sales in million Euros and number of employee industries for top R&D 1000 companies in Denmark in 2009, sorted by R&D investment, from the largest to smallest.

Industry(Denmark)	Number of Companies	R&D investment(Million Euro)	Net Sales(Million Euro)	Number of Employees
Biotech	14	1.915	10.988	44.890
Banks	2	337	14.183	27.404
Industrial machinery	3	276	6.111	47.569
Alternative energy	2	265	7.413	26.761
Oil & gas producers	1	142	6.620	5.820
Health care equipment & servic	3	126	2.069	14.631
Leisure goods	2	116	1.942	9.361
Food producers	1	110	1.842	6.853
Construction & materials	3	85	6.699	33.031
Telecommunications equipmen	2	79	777	4.962
Electrical components & equipr	2	51	3.002	11.113
Software	2	48	210	1.256
Chemicals	1	33	731	2.027
Industrial transportation	2	26	5.242	24.339
Nonlife insurance	1	22	1.596	2.523
Fixed line telecommunications	1	19	5.104	13.042
Aerospace & defence	1	18	150	1.261
Computer services	1	13	514	3.225
General industrials	1	13	1.196	3.334
Beverages	1	12	7.980	43.271
Grand Total	46	3.707	84.371	326.673

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Table 07

Comparing Number of Companies, R&D investment, and Net sales between biotech industry and Denmark total and average

Industry(Denmark)	Number of Companies	R&D investment(Million Euro)	Net Sales(Million Euro)	Number of Employees
Denmark average	2	185	4.219	16.334
Biotech	14	1.915	10.988	44.890
Biotech % of Denmark total	30	52	13	14
Biotech % of Denmark average	609	1.033	260	275

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Above two tables compare the R&D investment, net sales as well as the number of employees of different industries in Denmark. In Denmark, there are 46 companies which are belong to the top R&D ranking 1000 companies in the European Union, which biotech industry had 14 out 46 companies. The R&D investment in biotech industry is approximately 1915 million Euro, which is the highest among all industries, and it accounted for over half of the total R&D investment in Denmark. Furthermore, biotech industry R&D investment is about more than 10 times higher than the average of all industries, and about six times higher than the Bank industry which ranked second highest in R&D investment. The net sales in biotech industry are about 10.988 million Euro in 2009, which ranked second, lower than the bank industry. The biotech industry accounted for 13% of Denmark's total net sales for all industries which is about 2.6 times higher than the average of all industries. In terms of the number of employees, Industrial machinery had the highest number of employees working in this field, biotech ranked second all over Denmark. Biotech industry has approximately 44.890 of employees, which is accounted for 14% of the total R&D investment in Denmark, about 175 percent higher than the average of all industries in Denmark.

In short, the biotech industry contribute significantly in R&D investment in Denmark accounting for nearly 52% of total Denmark R&D Investment whilst the net sales in biotech industry is over 13% of Denmark total Net Sales and the Number of employees is about 14% of Denmark total number of employees. This means that biotech industry plays a significant role in R&D investment as well as net sales all over Denmark.

Furthermore, since the number of companies belongs to the sample in biotech is much higher than the rest of the countries; the R&D net sales ratio, R&D per employee as well as the Net sales per employee are analyzed. Below table shows the details of the results.

Table 08

R&D Net Sales Ratio (%), R&D investment per employee in Euros, Net Sales per employee in Euros by industry in Denmark in 2009, sorted by R&D per employee, from the largest to smallest.

Industry (Denmark)	R&D Net Sales Ratio(%)	R&D per employee(Euro)	Net Sales per employee(Euro)
Biotech	**17,42**	**4.265**	**24.478**
Software	22,99	3.843	16.716
Oil & gas producers	2,15	2.448	113.750
Chemicals	4,47	1.613	36.049
Food producers	5,95	1.600	26.878
Telecommunications equipmen	10,18	1.594	15.654
Aerospace & defence	12,25	1.453	11.867
Leisure goods	5,96	1.235	20.745
Banks	2,38	1.230	51.755
Alternative energy	3,58	992	27.702
Health care equipment & servic	6,08	860	14.143
Nonlife insurance	1,36	858	63.274
Industrial machinery	4,52	581	12.847
Electrical components & equipr	1,71	463	27.014
Computer services	2,57	409	15.947
General industrials	1,10	396	35.881
Construction & materials	1,28	259	20.280
Fixed line telecommunications	0,37	143	39.136
Industrial transportation	0,49	106	21.538
Beverages	0,15	29	18.442
Grand Total	**4,39**	**1.135**	**25.827**

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Table 09

Summary of R&D Net Sales Ratio (%), R&D per employee (Euro), and Net Sales per Employee (Euro) between biotech industry and Denmark average

Summary	R&D Net Sales Ratio(%)	R&D per Employee(Euro)	Net Sales per Employee(Euro)
Biotech	17	4.265	24.478
Denmark industry average	4	1.135	25.827

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

The results indicate that, in terms of the R&D per employee, the biotech industry was by far the largest investor, spending more than 5 times that of all the other industries in total. The R&D net sales ratio is also much more significant for the biotech industry compared to the average of all industries in Denmark.

Nevertheless, the above results provide signficant indications that biotechnology is a strong sector all over Denmark, in terms of R&D investments, Net Sales, number of Employees, and R&D per employee compared with other industries. But is Denmark's biotechnology industry also strong at the national level compared with other EU countries? Analysis 3 provides insights to this question.

4.1.3 Analysis 3: Comparisons of Denmark's biotechnology industry with other countries in EU

This section compares Denmark's biotech industry with other countries in order to understand better the position of Denmark's biotech sector across other countries in the European Union.

The details for R&D investment, Net Sales, and Number of Employees in biotech industry of Denmark compared to countries in the European Union can be found in appendix 6. Below table presents the summary of these variables compared to the European Union total and average.

Table 10

Summary of the Number of Companies, R&D investment, Net Sales, and Number of Employees in biotech industry of Denmark compared to the European Union total and average

Biotech indsutry	Number of Companies	R&D Investment(Million Euro)	Net Sales(Million Euro)	Number of Employees
The EU average	6	1.131	7.775	27.575
Denmark	14	1.915	10.988	44.890
Denmark % of the EU	11	9	7	9
Denmark % of the EU	218	169	141	163

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

At the European Union level, Denmark had 14 companies in biotech industry which ranked inside the top R&D ranking 1000 companies, which is significant higher than the average companies of the countries in the European Union.

Denmark's R&D investment in the biotech industry is about 19.145 million Euro which ranked as number 4 and was about 69 percent higher than the European Union average (1.131 million Euro), and 9% of EU total (21.492 million Euro). This position is significantly stronger compared to the overall level of R&D investment for all industries in Denmark which was 40% less than the EU average.

The net sales in biotech industry of Denmark was about 10.988 million Euro in 2009 which is 7% of the total EU net sales, and 41% higher than EU average net sales in biotechnology(7.775 million Euro). Again, these tables indicate that Denmark is stronger in R&D investment as well as in Net sales in the biotech industry compared with other countries in the European Union. This is in stark contrast to the previous comparison of Denmark against the EU average across all industries where Denmark was about 70% below the average ranking. This would suggest that not only is the biotechnology industy a very strong industry in Denmark, it is even a strong competitor on the European market.

The number of Employees in the biotech industry of Denmark is behind UK, France and Germany, but stronger than the rest of the European countries in terms of firm size calculated by number of employees.

The details regarding R&D net sales ratio (%), R&D per employee (Euro) and Net Sales per Employee(Euro) are presnted in appendix 7, below table 11 shows the summary of these variables.

Table 11

Summary of the R&D Net Sales Ratio (%) , R&D per Employee, and Net Sales per Employee in biotech industry of Denmark compared to the European Union total and average

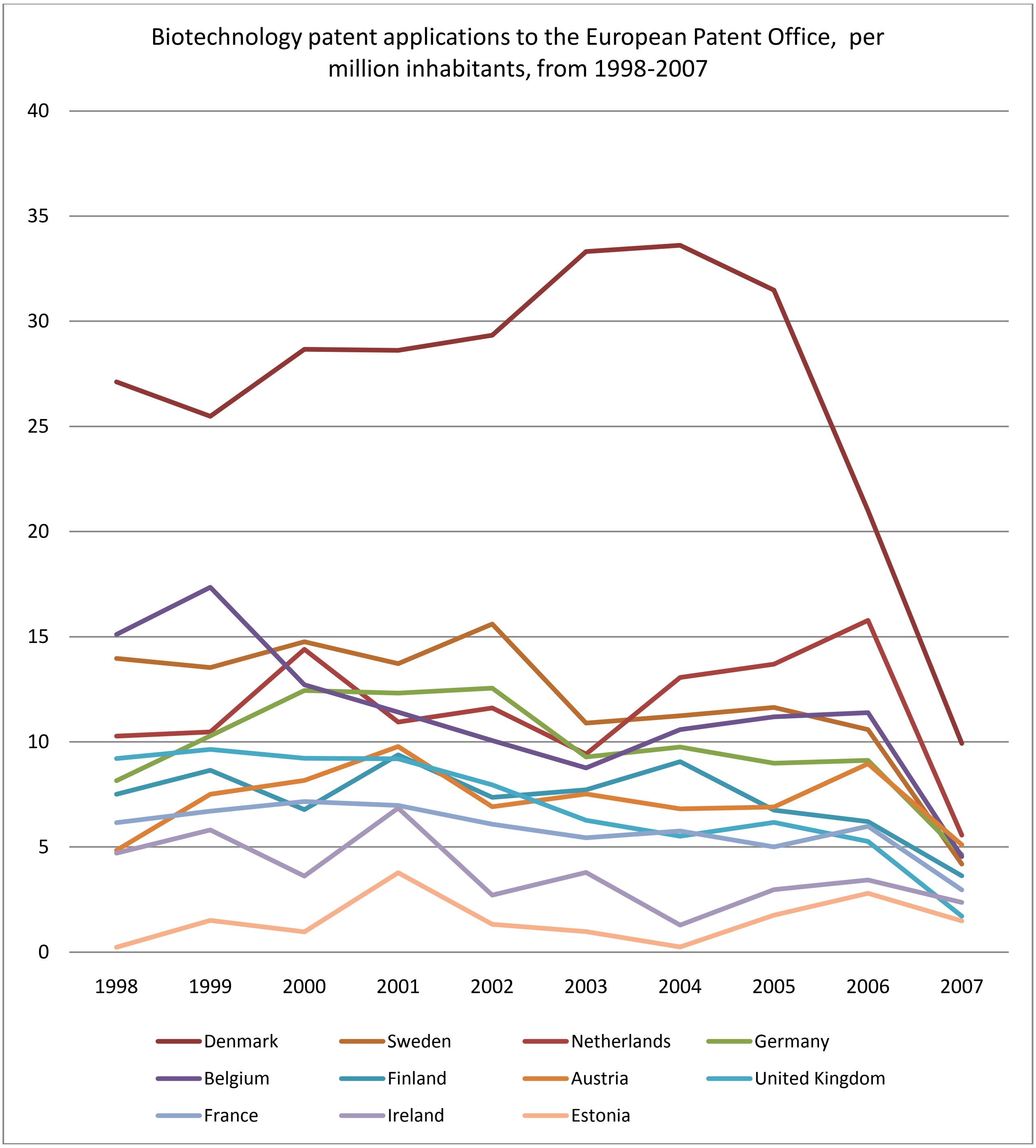
Biotech indsutry	R&D Net Sales Ratio(%)	R&D per Employee(Euro)	Net Sales per Employee(Euro)
Denmark	17	4.265	24.478
The EU average	15	4.102	28.196

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

The results indicate that biotech industry in Denmark peform better in terms of R&D per Employee, and the R&D Net Sales Ratio is also higher than the EU average, however, the Net Sales per Employee is lower than the EU average.

Next, the result of the patent applications per million inhabitants across countries over the period of 1998-2007 is presented at figure 04, Countries which have less than one biotechnology patent applications per million inhabitants are excluded in below analysis. Detailed information of these excluded countries can be found in Appendix 2. Countries missing biotechnology patent application data in selected period are not shown as well since including them might skew the overall picture of the tendency.

Figure 04
Biotechnology patent applications to the European Patent Office by country, per million inhabitants 1998-2007



Source data: own calculations based on the Eurostat, Patent Statistics, 2011

The above table would indicate that Denmark has been having the highest level of patent applications per million inhabitants at national level in biotechnology in the European Union.

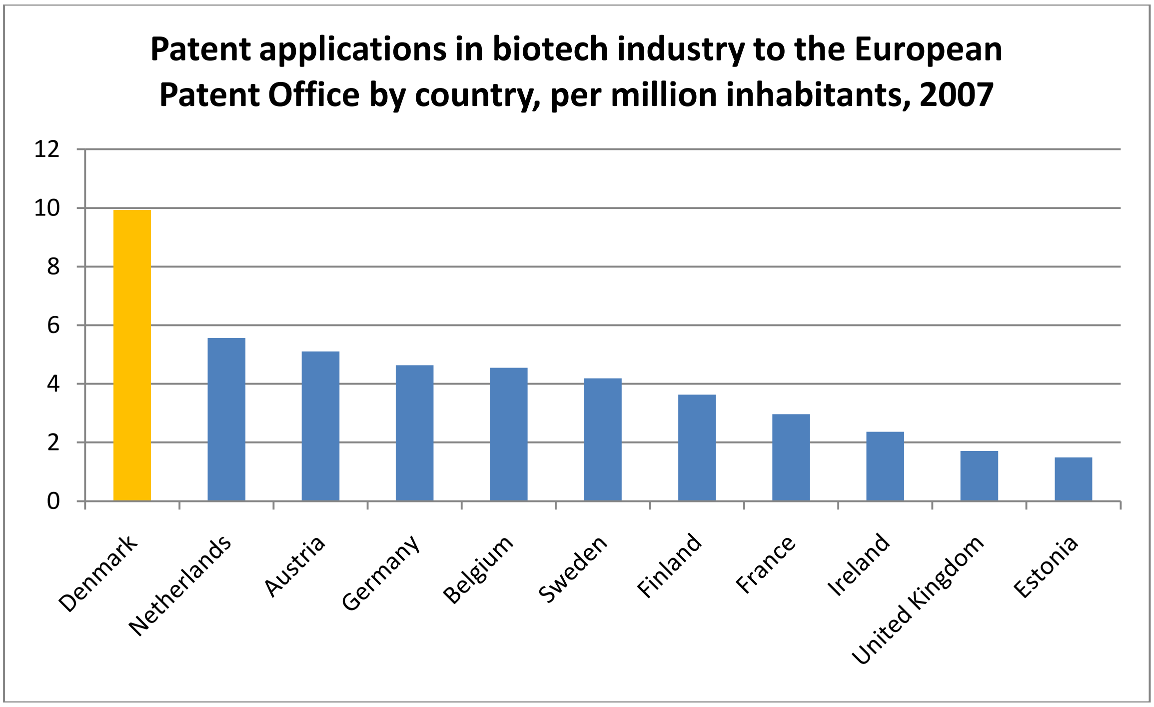
The trend for most of the countries is similar; the peak was during 2002 to 2005. However, after 2005, most of the countries experienced continuous decreases of patent applications per million inhabitants. The latest data was from 2007; hence, this year was selected to get a closer view on biotechnology patent applications per million inhabitants in Denmark compared with other countries. Although 2007 is the most up to date, that year was the lowest points for all selected countries during 1998-2007. In order to compile a more detailed analysis of Denmark's patent applications per million inhabitants compared to other countries I have also chosen to look at the average level over the period 1998-2007. Due to the fact that 2006-2007 show a remarkable drop in applications the average application level might give a clearer picture of the situation rather than choosing the newest available data.

In 2007, Denmark had about 10 biotechnology patent applications to the EPO per million inhabitants; this ranks first among below selected countries. Iceland is right below Denmark, and Switzerland is the third highest. With an average of 2,2 biotechnology patent applications of EU -27 countries, Denmark's level of applications was about 4 times higher than the European Union..

The average level of biotechnology patent application per million inhabitants during the observation period of 1998-2007 in Denmark is nearly 27, which is about 183% higher than the EU average, this results could further proven that Denmark has a rather strong biotech sector compared to other countries in the European Union.

Figure 05

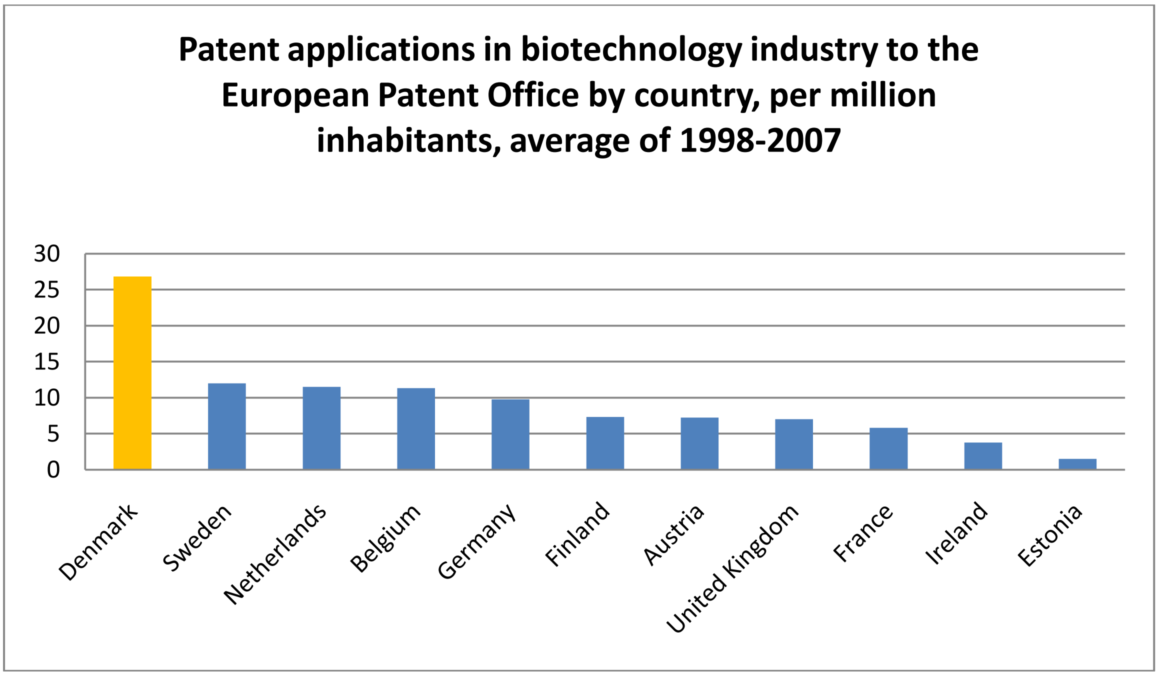
Biotechnology patent applications to the European Patent Office by country, per million inhabitants 2007



Source data: own calculations based on the Eurostat, Patent Statistics, 2011

Figure 06

Biotechnology patent applications to the European Patent Office by country, per million inhabitants 2007



Source data: own calculations based on the Eurostat, Patent Statistics, 2011

In short, based on the source of top 1000 companies ranked by R&D investment in EU from scoreboard 2010, and the patent data from Eurostat, three analyses which compare and contrast: R&D investment, net sales value, number of employee, R&D per employee, net sales per employee and patent application per million inhabitants have been made. These three descriptive quantitative research analyses were carried out in order to understand the overall situation of biotechnology at industry level in Denmark, as well as at national level compared with the rest of the EU countries. The choice of key indicators, methods and source data to understand different aspects of biotechnology in terms of innovation activities have been presented and discussed.

The research results provide evidence that at national level regardless of industry type, Denmark did not have an outstanding position among EU countries in terms of R&D investment, net sales, etc. However, Denmark's biotech industry is significantly stronger than other industries, and it also has a strong position in the European Union. Denmark is one of the countries which have the highest level of R&D investment; it has been the leader in biotechnology patent application per million inhabitants during the whole observation period. The net sales and the number of employees are both outstanding; Moreover, both of the R&D net sales ratio and the R&D per employee are higher than the European Union average.

All these facts demonstrate that Denmark has a strong biotech sector in the European Union in terms of both innovation input indicators as well as output indicators, despite that fact that Denmark is a small country measured in both land mass and population.

4.2 Research question 2

Is innovation the driving factor for the growth of these biotechnology companies?

As discussed in the data and methodology chapter, the source data is from: 2006 to 2010 scoreboard, as well as companies' annual reports during this period. In the analytical quantitative research part, the linear regression analysis is applied, the net sales growth has been chosen as the dependent variable, and non-R&D investment as well as the R&D investment has been chosen as the independent variables.

The purpose is to find if there is any correlation of the selected independent variables (R&D investment growth & Non-R&D investment growth) and the dependent variable (Net sales growth) and how significant the impact is for the biotech industry compared with other industries in Denmark. The purpose is to understand if innovation in biotech industry plays a more important role than it does for the rest of the industries in Denmark.

The assumptions are:

a) There is a positive linear relationship between innovation and growth in biotechnology firms, the significance is larger than in other industries in Denmark.

b) There is a positive linear relationship between non-R&D related investment and growth in biotechnology companies; however, the level of significance is lower than in for other industries in Denmark.

The "other industries" are selected using the 2006-2010 scoreboard source data, all missing observations in any of the variables are excluded. The list below is the remaining whole list of industries in Denmark and this list is used in the regression analysis as a reference industry in contrast with the biotech industry in Denmark.

Table 12
List of the rest of the industries selected in the analytical analysis

Industries
Aerospace & defence
Alternative energy
Banks
Beverages
Chemicals
Computer hardware
Computer services
Construction & materials
Electrical components & equipment
Fixed line telecommunications
Food producers
General industrials
Health care equipment & services
Industrial machinery
Industrial transportation
Leisure goods
Nonlife insurance
Oil & gas producers
Software
Telecommunications equipment
Total count: 20 industries

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Below methods which are used to calculate R&D investment growth, Non-R&D investment growth, and Net sales growth:

R&D investment growth (%) = (current year R&D investment – previous year R&D investment)/previous year R&D investment*100

Net Sales growth (%) = (current year Net sales – previous year Net Sales)/previous year Net Sales*100

Non-R&D investment= Total Cost- R&D investment

Non-R&D investment growth (%) = (current year Non-R&D investment – previous year Non-R&D investment)/previous year Non-R&D investment*100

It is important to check if there is any outlier data, wrongly coded or missing observations in the selected source data. It is important to get rid of the "bad data", as the selected data should be representative of the whole population.

Therefore, first of all, the unusual values compared with the majority should be more carefully checked. Since the outlier data is only a small part of the observations, but including them might affect the overall result.

In addition, for observations containing any missing data the selected variables will be excluded in the analysis.

Below are the detailed steps of adjusting the selected source data by using descriptive statistics.

After excluding those where values are missing, the data is summarized as follows:

Table 13

Summary Statistics for Biotech industry in Denmark

Variables, biotech industry	Obs	Mean	Median	Standard Deviation	Min	Max
Non R&D investment growth %	35	-28,7390913	8,94320702	229,3967722	-1.310	145,967742
R&D investment growth %	35	30,20200636	12,9062769	68,67708291	-74,8634937	315,29449
Net sales growth %	35	11,27813748	7,96766744	66,49331322	-98,5434345	294,444444

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Table 14

Summary Statistics for other industries in Denmark

Variable, other industry	Obs	Mean	Median	Standard Deviation	Min	Max
Non R&D investment growth %	91	8,06676	6,31982	20,74955686	-30,708	135,474
R&D investment growth %	91	17,4111	8,44261	46,8901403	-78,239	335,157
Net sales growth %	91	5,92361	4,2184	21,41121528	-61,395	92,8255

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

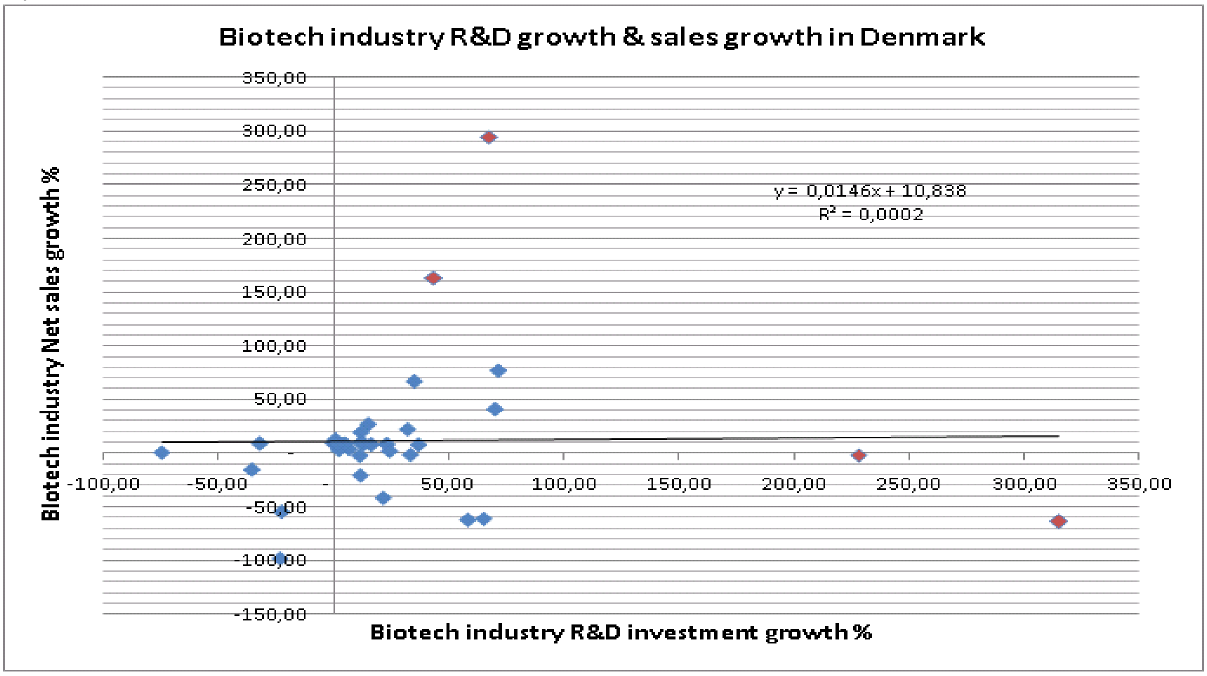
Due to the fact that the number of the companies for the rest of the industries in Denmark is much larger than the number of companies in biotech industry in Denmark, the sample for other industries is larger than for biotech industry in this analysis. However, the sample size 35 is still large enough to represent the whole biotech companies in Denmark.

First of all, I shall find out the outlier data and exclude them in the later analysis. Each of the variables for both of biotech industry and other industries are checked in detail as follows:

1) Variable R&D investment growth % in biotech industry in Denmark

Figure 07

Scatter variable R&D investment growth % and Net sales value growth % for biotech industry in Denmark



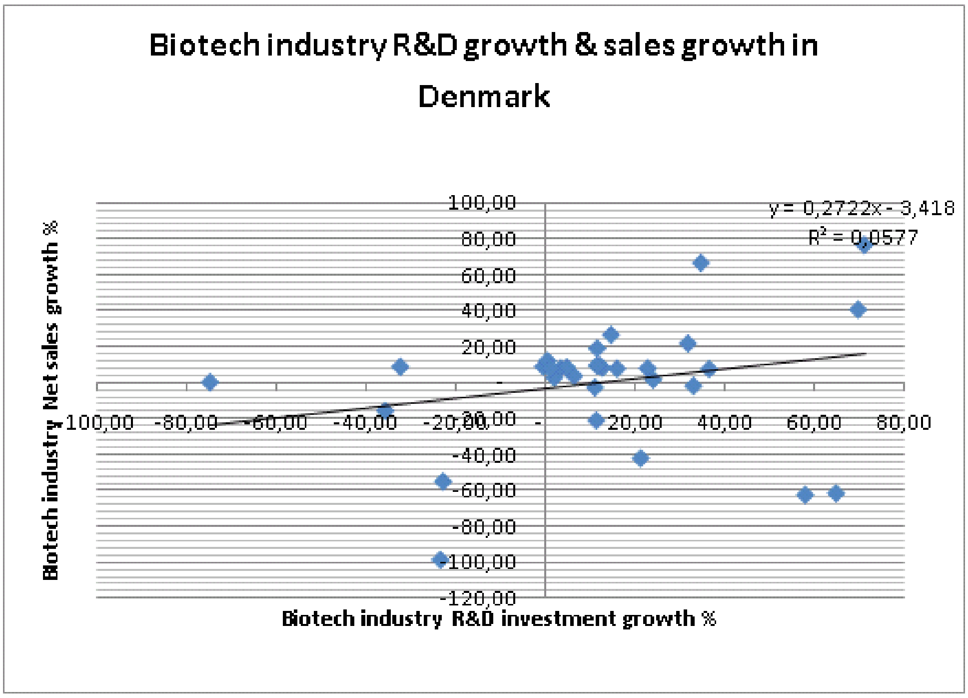
Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

The result of the scatter variable R&D investment growth % for biotech industry in Denmark indicates that there are several observations which differ significantly from all the others and these have been highlighted in red. They are: (x=61, 67; y=294, 44); (x=228, 33: y=-2, 16); (x= 43, 62; y=163, 06) and (x=315, 29; y=-64, 19). Taking one observation (x=61, 67; y=294, 44) as an example, it is the maximum net sales growth % in the data set; it affects the whole observations mean by nearly a factor two. Therefore, this type of observation which differs significantly from most of the others will influence the slope if it is not excluded. Thus, the above mentioned four observations are discarded in the analysis.

Below table shows the scatter plot of the remaining observations of R&D investment growth % in biotech industry in Denmark after excluding the four outlier observations.

Figure 08

Scatter plot R&D investment in % and Net growth Sales growth in %

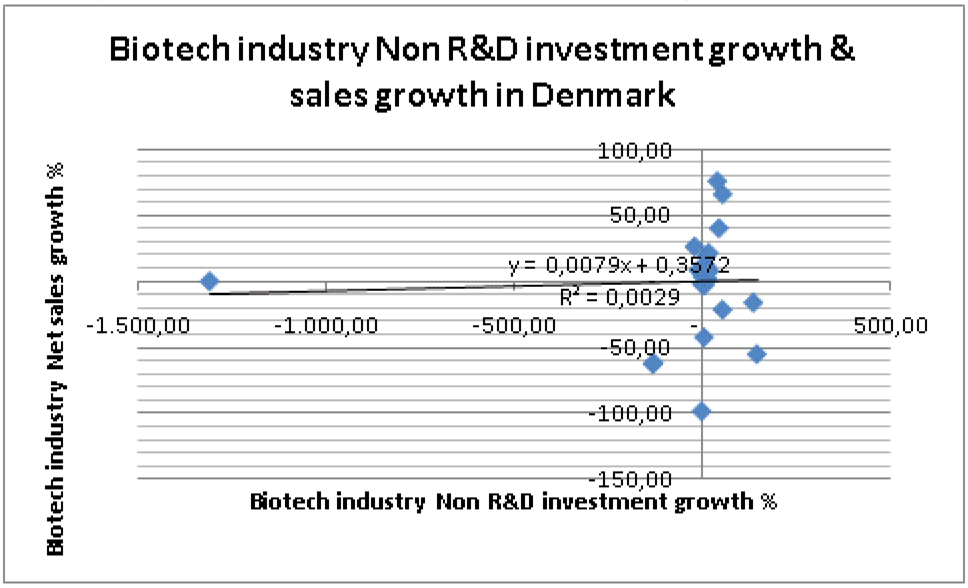


Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

2) Variable non-R&D investment growth % in biotech industry in Denmark

Figure 09

Scatter plot non-R&D investment in % and Net Sales growth in %



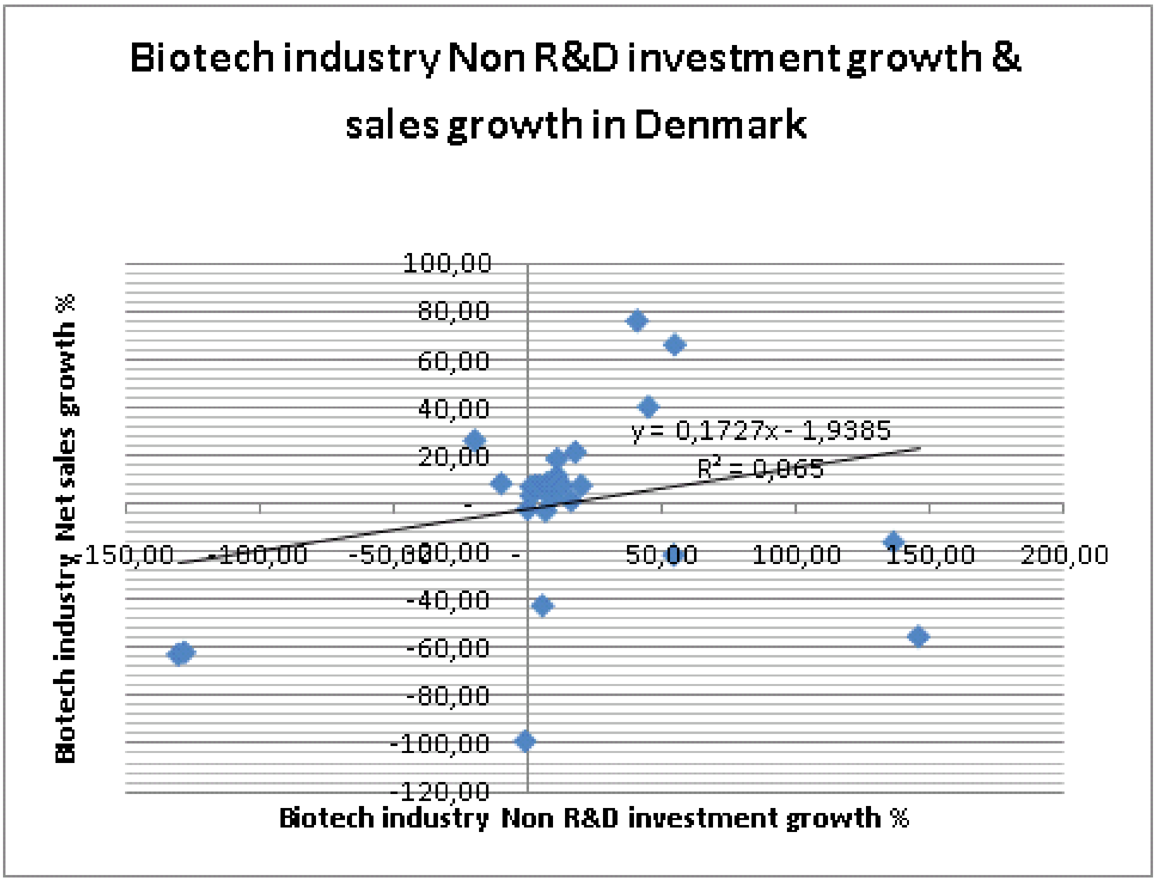
Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Variable Non-R&D investment growth for the biotech industry in Denmark also contains one extreme data, which is the maximum value the sample data set which is observation: (x=-1309, 80, y=0, 20). For the same reason, this observation is excluded in the analysis.

After excluding this outstanding observation, below table shows the scatter plot of the remained observations of Non-R&D investment growth % and net sales growth %.

Figure 10

Scatter plot non-R&D investment growth and Net sales growth % in the biotech industry



Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

In short, five out of thirty five observations have been deleted. This is acceptable because it is a relatively small percentage of the total sample.

The following is the summary of the adjusted variables for biotech industry in Denmark.

Table 15

Summary Statistics for Biotech industry in Denmark after excluding the five outliers

Variables, biotech industry	Obs	Mean	Median	Standard Deviation	Min	Max
Non R&D investment growth %	30	11,87344937	9,04327843	52,97190887	-130	145,967742
R&D investment growth %	30	15,90606863	11,9689647	26,98701654	-35,6631434	71,4533874
Net sales growth %	30	0,112232467	7,97090268	35,89588259	-98,5434345	76,5748031

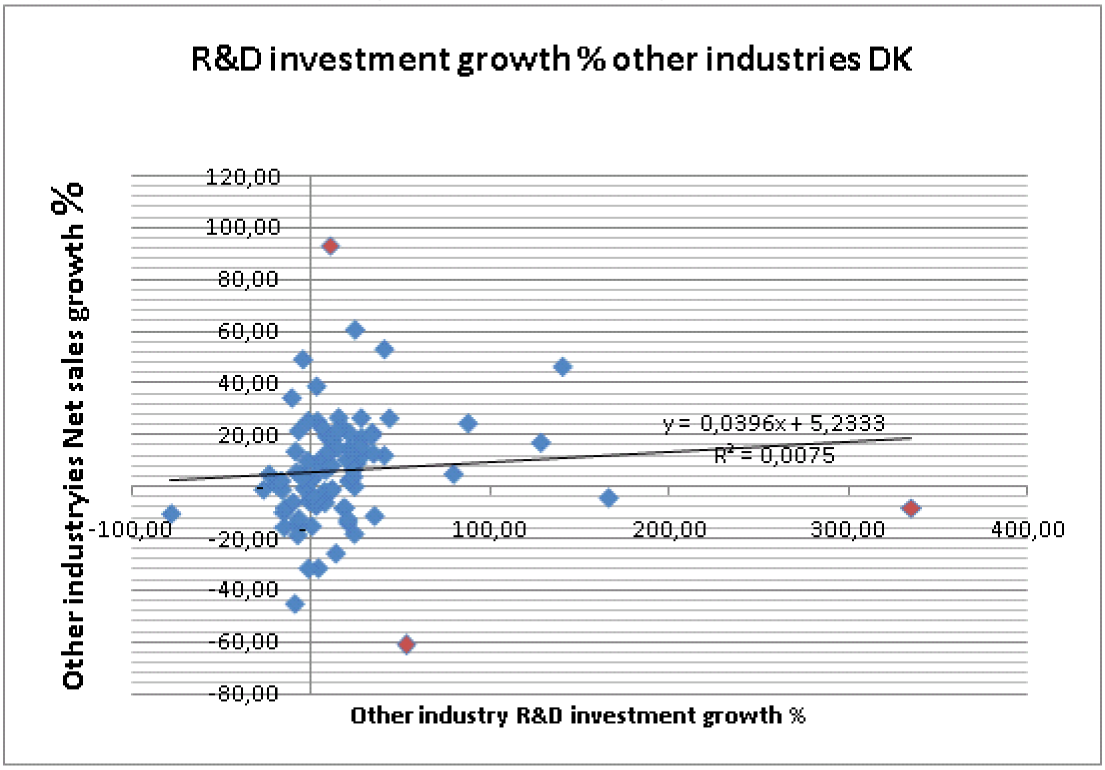
Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

The same method is applied to check outliers for other industries in Denmark.
The results are shown as follows:

3) Variable R&D investment growth % in other industries in Denmark

Figure 11

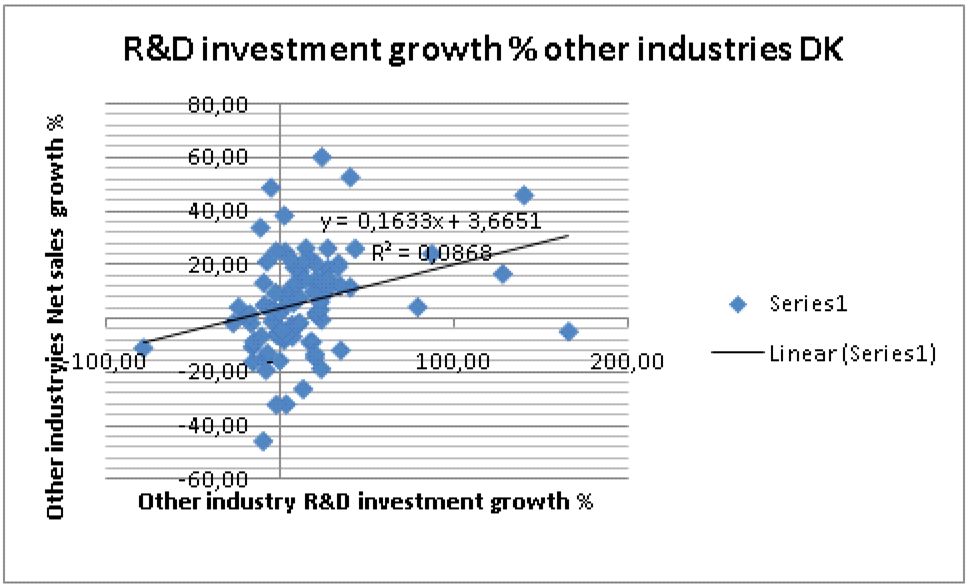
Scatter plot R&D investment growth and Net sales growth % in other industries



Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

The result of the scatter variable R&D investment growth % for other industries in Denmark indicates that there are several observations which differ significantly from all the others which are highlighted in red. They are: (x=335, 16; y=-8, 55); (x=52, 87; y=-61, 39); and (x=10, 73; y=92, 83). Therefore these three observations have to be excluded in the analysis. Below table shows the scatter plot of the remaining observations of non-R&D investment growth % and Net sales growth for other industries in Denmark.

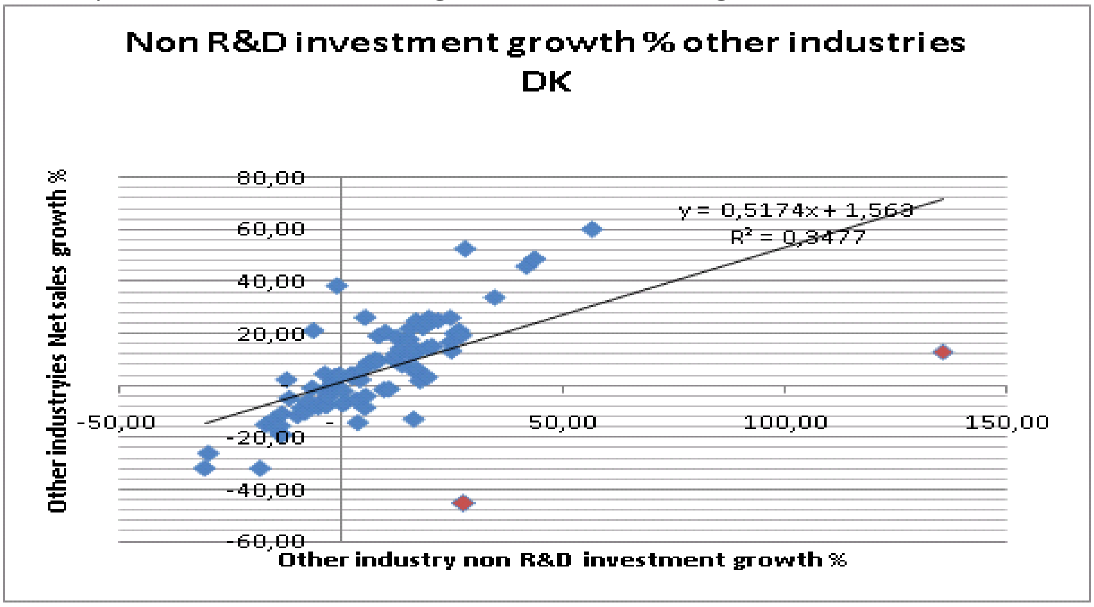
Figure 12
Scatter plot R&D investment growth and Net sales growth % in other industries after excluding outliers



Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

4) Variable non-R&D investment growth % in other industries in Denmark

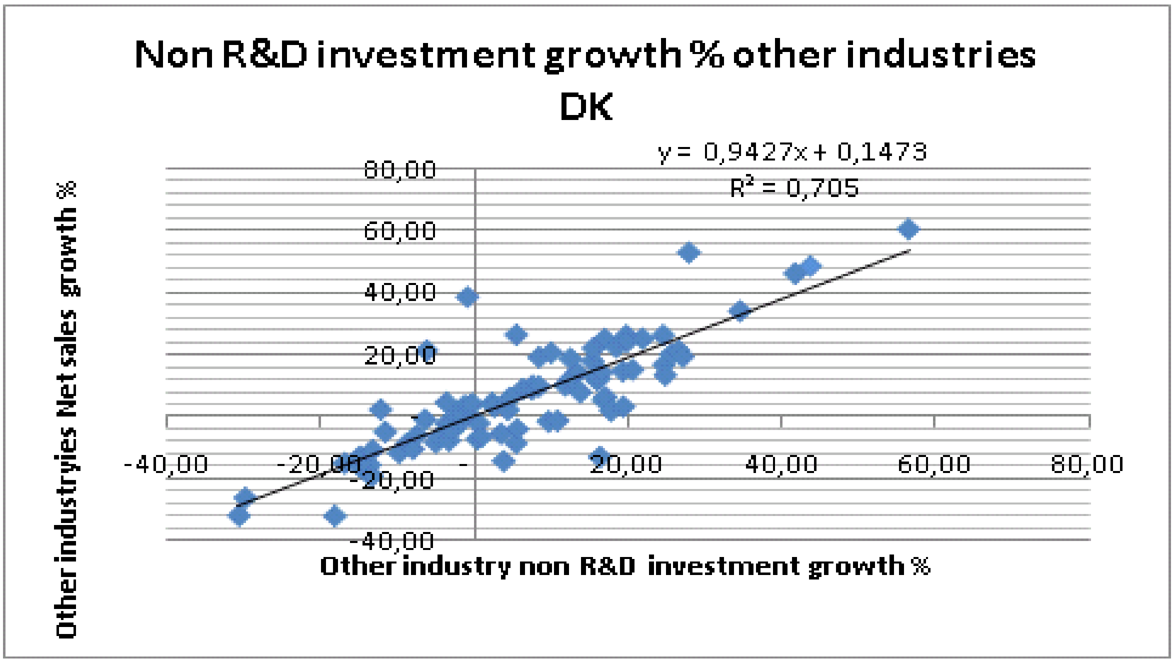
Figure 13
Scatter plot non-R&D investment growth and Net sales growth % in other industries



Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Variable Non-R&D investment % for other industries in Denmark also contains two extreme observations which are (x=27, 72: y=-45, 45), and (x=135, 47, y=12, 95). To avoid inaccurate influence of the slope, these two observations have to be excluded in the analysis.
Below table shows the scatter plot of the remained observations of non-R&D investment growth % and Net sales growth for other industries in Denmark.

Figure 14
Scatter plot non-R&D investment growth and Net sales growth % in other industries



Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

In the data set of other industries in Denmark, five observations out of the total sample size of ninety one observations are acceptable to be excluded in the analysis as it is small percentage of the total sample.

The following is the summary of the adjusted variables for other industries in Denmark.

Table 16
Summary of the variables after adjustment for other industries in Denmark

Variable, other industry	Obs	Mean	Median	Standard Deviation	Min	Max
Non R&D investment growth %	86	6,61173	5,53591	15,65572928	-30,708	56,6681
R&D investment growth %	86	13,7984	8,08416	33,20046088	-78,239	165,957
Net sales growth %	86	6,37996	4,33942	17,57652486	-31,83	60,2381

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Next step is to check the summary statistics for both biotech industry and other industries in Denmark.
Summary statistics

1) Mean:

Biotech industry in Denmark

Table 17
Mean, Biotech industry in Denmark

Variables, biotech industry	Obs	Mean	Standard Error	Confidence Level (95,0%)
Non R&D investment growth %	30	11,87344937	9,671303133	19,78003555
R&D investment growth %	30	15,90606863	4,927132572	10,07711743
Net sales growth %	30	0,112232467	6,553661539	13,40374264

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Other industries in Denmark

Table 18
Mean, Other industries in Denmark

Variables, biotech industry	Obs	Mean	Standard Error	Confidence Level (95,0%)
Non R&D investment growth %	86	6,61173355	1,688200705	3,356595217
R&D investment growth %	86	13,7983905	3,580097768	7,118193359
Net sales growth %	86	6,37995625	1,895325419	3,76841463

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

2) Correlation coefficient

The correlation coefficient shows the relationships between the variables. The higher the absolute value of the correlation coefficients, the stronger the relationship they have. The results below explain the relationship between R&D growth and sales growth.

Table 19
Correlation coefficient for biotech industry in Denmark

Variables, biotech industry	Non R&D investment growth %	R&D investment growth %	Net sales growth
Non R&D investment growth %	1		
R&D investment growth %	-0,458586582	1	
Net sales growth %	0,254876036	0,28222758	1

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Table 20

Correlation coefficient for other industries in Denmark

Variables, biotech industry	Non R&D investment	R&D investment	Net sales growth %
Non R&D investment growth %	1		
R&D investment growth %	0,297317194	1	
Net sales growth %	0,839655095	0,287047424	1

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

As discussed in the literature review section, innovation should have large influence on growth for all industries. In this research analysis, the growth in R&D investment is selected as the key innovation indicator, and it is chosen as the one of the independent variables and while the dependent variable is Net Sales Growth. The other independent variable is the non-R&D related investment growth. These two independent variables have been chosen since the assumption is that all investment put into production is intended for the further development of the company growth. It is expected that the more R&D investment as well as non-R&D related activities a company invest, the higher growth rate the company should achieve.

For such reason, the model could be written as below:

Net sales growth= β0+ β1 R&D investment growth + β2 Non-R&D investment growth +εi

The sub-indices i means each observation in the selected sample, i = (1, 2, 3… n)
The epsilon, ε means the random error, the expected value of the error term is 0.

However, as discussed in the literature review part, the impact of innovation differs in different industries. And Biotech industry is more knowledge intensive compared with the rest of the industries. Hence, it is expected that the non-R&D related investment for biotech industry should play a less important role for company growth in contrast with the rest of the industries in Denmark, but the R&D investment for biotech industry should play a relatively more important role for company revenue growth in contrast with the rest of the industries in Denmark.

In order to test if the empirical data supports the discussed theories, several regression analyses are carried out for both the biotech industry and other industries in Denmark.

1) multiple linear regression analysis on biotech industry in Denmark

Model: $Y = \beta_0 + \beta_1 X1 + \beta_2 X2 + ei(0\text{-}30)$
X1= Biotech industry R&D investment growth (%) in Denmark
X2= Biotech industry Non-R&D related investment growth (%) in Denmark
Y = Biotech industry Net sales growth (%) in Denmark
Null hypothesis one: there is no significant statistical relationship between
X variables and Y variable.

Table 21

SUMMARY OUTPUT I, the biotech industry in Denmark

Regression Statistics						
R Square	0,266670511					
Adjusted R Square	0,212349808					
Standard Error	31,85747329					
Observations	30					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	9964,654899	4982,327449	4,909187407	0,015189327	
Residual	27	27402,26232	1014,898605			
Total	29	37366,91722				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-14,49589152	7,537984403	-1,923046102	0,065080341	-29,96255778	0,97077473
X Variable 1	0,3297693	0,125671295	2,624062239	0,014121748	0,071913105	0,587625496
X Variable 2	0,672235556	0,246675967	2,725176534	0,011139684	0,166098286	1,178372827

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

The above multiple linear regression result shows that: in biotech industry in Denmark, if variable non-R&D investment growth goes up by one percent, the expected net sales would growth approximately 0,33 percents and if variable R&D investment growth goes up by one percent, the expected net sales would growth 0,67 percent.

R squared = “goodness of fit”; meaning the measure of how well future outcomes may be predicted by the regression model. In other words, R squared show how well the estimated line fit the selected sample data set. Where 0 is not at all and 1 is certain. The difference between R squared and is that adjusted R squared considers other factors which are not included in the analysis, which means that in most of the cases, adjusted R squared is more reliable, especially for simple linear regression analysis. As in reality, it is unlikely that one dependent variable could explain everything for the independent variable. Nevertheless, the better the model fits the greater its relevance to the hypothesis in question.
The values of R squared and adjusted R squared differs slightly in the biotech industry, and in this case, the adjusted R squared should be more reliable.

R squared for biotech industry= 0, 27
Adjusted R squared for biotech industry= 0,21

Next, I shall check the test statistic t as well as P value. For biotech industry, variable non-R&D investment, the test statistic t is 2, 62. For variable R&D investment in biotech industry, the test statistic t is 2, 73. The beta coefficients at 5% level, in two tails distribution; the table “Percentiles of the t-distribution” shows that the critical values are -1.96 and 1.96. T statistics for both of the two variables are more than 1.96. Therefore, the null hypothesis one is rejected.

The same result can be seen by checking the P value for both variables in this regression analysis. P value for both of the variable non-R&D investment growth and R&D investment growth is about 0.01 which is less than the level of significance 0.05. Meaning the probability of β_1 & $\beta_{2\,=}$ 0 is less than 5%. Hence, the null hypothesis one is rejected. Hence, it could be concluded that there is a statistically significant relationship between X variables: non-R&D investment growth & R&D investment growth and Y variable Net sales growth for biotech industry in Denmark.

For the model where P (β_1 = 0) ≈ 0, and adjusted R^2 = 0, 21, the model is statistically significant and the predictability of future outcomes based on this model will be 21 %.
Although a regression model with an R^2 of one would prove that Y is totally and exclusively dependent upon X_1, it is unlikely to happen in reality, since there are other factors that are not included in the analysis which might also have impact an on Y.

In short, for biotech industry: both of non-R&D investment growth and R&D investment growth affect net sales growth in Denmark. The effect of R&D investment growth on net sales growth is about 67% where non-R&D investment growth on net sales growth is about 33%.

2) multiple linear regression analysis on other industries in Denmark

Model: $Y = \beta_0 + \beta_1 X1 + \beta_2 X2 + ei$ (0-86)
X_1 = other industries R&D investment growth in Denmark
X_2 = other industries non-R&D related investment growth in Denmark
Y = other industries Net sales growth in Denmark
Null hypothesis two: there is no significant statistical relationship between X variables and Y variable.

Table 22

SUMMARY OUTPUT II, the other industries in Denmark

SUMMARY OUTPUT						
Regression Statistics						
R Square	0,706555365					
Adjusted R Square	0,69948441					
Standard Error	9,635328292					
Observations	86					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	18553,72646	9276,863229	99,92361121	7,98613E-23	
Residual	83	7705,682758	92,8395513			
Total	85	26259,40922				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0,061913392	1,172658987	-0,05279744	0,95802017	-2,39428491	2,270458125
X Variable 1	0,928976284	0,069916713	13,28689879	2,98228E-22	0,789914757	1,068037811
X Variable 2	0,021721807	0,032969335	0,658848813	0,511816524	-0,043852873	0,087296488

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

R squared for biotech industry= 0,71

Adjusted R squared for biotech industry= 0,70

Although both the R squared and adjusted R squared in other industries in Denmark is much higher than for biotech industry, the R squared is only significant if the significance of the model itself is proven, because prediction of future events by a variable upon which these events are not dependent is nonsensical.

The multiple linear regression model for other industries is not useful since the p-values for both of the variables are not within the level of significance 0,05.

Therefore, I further checked the each of the X variable with Y variable in order to understand if non-R&D investment growth has impact on net sales growth and / or R&D investment growth has impact on net sales growth for other industries in Denmark.

3) simple linear regression analysis on other industries in Denmark I

Model: $Y = \beta_0 + \beta X + ei(0\text{-}86)$

X= other industry non-R&D investment growth in Denmark

Y = other industry Net sales growth in Denmark

Null hypothesis three: there is no significant statistical relationship between

X variable and Y variable.

Table 23

SUMMARY OUTPUT III, simple linear regression on other industries in Denmark

SUMMARY OUTPUT						
Regression Statistics						
R Square	0,705020678					
Adjusted R Square	0,70150902					
Standard Error	9,60281625					
Observations	86					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	18513,4265	18513,4265	200,7657238	5,5407E-24	
Residual	84	7745,982713	92,21407992			
Total	85	26259,40922				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,147259735	1,125054873	0,130891158	0,896174381	-2,090035218	2,384554688
X Variable 1	0,942672065	0,066529744	14,16918219	5,54070E-24	0,810370375	1,074973755

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Above simple linear regression result indicates that if variable non-R&D investment growth goes up by one percent, the expected net sales would growth 0,94 percent.

R squared for biotech industry= 0, 71
Adjusted R squared for biotech industry= 0.70

The values of R squared and adjusted R squared are close to each other, which is over 70%.

The text statistic t for variable non-R&D investment growth is 14, 16. The beta coefficients at 5% level, in two tails distribution; the table “Percentiles of the t-distribution” shows that the critical values are -1.96 and 1.96. T statistic is significantly greater than 1.96. Therefore, the null hypothesis three is rejected.

The p-value is about 0, meaning that probability of β=0 is about 0 and adjusted R squared = 0, 70, therefore it could be concluded that there is a statistically significant relationship between non-R&D investment growth and net sales growth for other industries in Denmark. It explains the dependence of net sales growth upon non-R&D investment excellently.

4) simple linear regression analysis on other industries in Denmark II

Lastly, I shall also check if R&D investment growth has impact on net sales growth for other industries in Denmark.

Model: Y = β_0 + βX+ei(0-86)
X= other industry R&D investment growth in Denmark
Y = other industry Net sales growth in Denmark
Null hypothesis four: there is no significant statistical relationship between X variable and Y variable.

Table 24

SUMMARY OUTPUT III, simple linear regression on other industries in Denmark

SUMMARY OUTPUT						
Regression Statistics						
R Square	0,082396223					
Adjusted R Square	0,071472369					
Standard Error	16,93676371					
Observations	86					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	2163,67615	2163,67615	7,5427793	0,007369736	
Residual	84	24095,73307	286,8539651			
Total	85	26259,40922				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	4,283088772	1,979503318	2,163718916	0,033325987	0,346629415	8,21954813
X Variable 1	0,151964643	0,055332062	2,746412078	0,007369736	0,041930772	0,261998514

Source data: Own calculations based on the 2006-2010 EU Industrial R&D Investment SCOREBOARD

Above simple linear regression result indicates that if variable R&D investment growth goes up by one percent, the expected net sales would grow 0,15 percent.

R squared for biotech industry= 0, 08
Adjusted R squared for biotech industry= 0.07

Both of the values of R squared and adjusted R squared are very low on this model.

The text statistic t for variable R&D investment growth is 2, 75. The beta coefficients at 5% level, in two tails distribution; the table “Percentiles of the t-distribution” shows that the critical values are -1.96 and 1.96. T statistic is significantly greater than 1.96. Therefore, the null hypothesis four is rejected.

The p-value is about 0,007 meaning that probability of β=0 is small and adjusted R squared = 0, 07. Therefore it could be concluded that there is a statistically significant relationship between R&D investment growth and net sales growth for other industries in Denmark. However, the analysis does not show much of a dependence of net sales growth upon non-R&D investment for other industries in Denmark, as the R squared is very low.

In short, for the other industries in Denmark: the multiple linear regression is not statistically significant; however, both of the simple linear regressions are statistically significant. The result indicate that: firstly, non-R&D investment has huge impact on net sales growth for other industries in Denmark; Secondly, the impact on net sales growth from R&D investment change is low for other industries.

4.3 Research question 3

Are there other key factors which have significant influence on the biotech firm growth in Denmark? What are the factors?

The analysis of the previous two research questions explains that Denmark has a strong biotech industry in terms of innovation, patent applications and sales compared with the rest of the industries in Denmark as well as compared with other countries' biotech industries across the European Union and the rest of the world. It has been found out that the R&D investment is the driving factor of revenue growth in the biotech industry in Denmark, whereas the R&D investment does not have as significant an impact on the rest of the industries in Denmark. In other words, innovation is the driving factor for the growth of the biotech industry, since R&D investment is the key indicator of innovation, and revenue growth is the key indicator of company growth. Furthermore, in the analysis of other industries it has been shown that innovation plays a less important role compared with non innovation related investments.

Even though innovation could significantly influence growth in biotech industry in Denmark, there are other factors that also have an impact on the growth besides innovation, as the results from the multiple linear regression analysis indicates that besides the R&D investment, other investment aside from R&D also have impact on the biotech companies' growth. Hence, it is important to find out what the other key factors are that influence biotech company growth in Denmark.

As discussed in the data and methodology section I shall carry out a case study in order to understand the potential key factors that influence biotech company growth.

Based on the data of top R&D ranking companies in Denmark 2009, Novo Nordisk ranked the highest in both R&D investment and Net sales. Novo Nordisk accounted for more than half of the total biotechnology R&D investments, and accounted for over 62% of the biotechnology industry's net sales in Denmark. This means that Novo Nordisk plays a significant role in the Danish biotech industry. Hence, Novo Nordisk has been selected as a case to be analyzed in detail regarding the potential key factors, besides innovation, which may influence growth in the biotech industry in Denmark.

Table 25
R&D investment, net sales and number of employees of biotechnology companies in Denmark in 2009

Company	R&D Investment (Million Euro)	Net Sales(Million Euro)	Number of Employees
Novo Nordisk	1.001	6.864	27.985
Lundbeck	396	1.847	5.526
Novozymes	142	1.135	5.217
Genmab	123	84	505
NeuroSearch	41	11	235
ALK-Abello	40	260	1.513
Dako	30	237	1.036
Lifecycle Pharma	27	0	93
Bavarian Nordic	26	10	340
CHR Hansen	25	514	2.157
Symphogen	23	5	79
Santaris Pharma	20	10	77
TopoTarget	12	6	58
Zealand Pharma	9	3	69
Grand Total	1.915	10.988	44.890

Source data: Own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

4.3.1 Case study on Novo Nordisk

Company background

The history of Novo Nordisk goes back to 1923, when Nordisk Insulin laboratory was founded. In the year of 1989, two Danish companies merged together – Novo Industri A/S and Nordisk Gentofte A/S, and Novo Nordisk was established thereafter. A more detailed company history can be found in appendix 3, which will provide a detailed overview of how the company has grown.

Novo Nordisk currently (as per March 2011) has over 30 thousand full time employees in about 74 countries, of which about 13,7 thousand of the employees (44%) are located in its head offices in Copenhagen, Denmark, while the remaining 17,6 thousand (56%) are spread out over the rest of the 74 countries.

Out of the 30 thousand full time employees, about "56 hundred (18%) are within research and development, 85 hundred (27%) are in production and production administration; 113 hundred (36%) are in international sales and marketing, and the rest of the 59 hundred (19%) are in administration".(http://www.novonordisk.com)

The distribution of employees clearly shows that the research & development section is an important part of the company, which is indicative of the nature of biotechnology companies where R&D is an important part of the operation. Aside from the large percentage of the number of employees in R&D, the other significant distribution is in international sales and marketing which might be due to the fact that this area is also important for the company's profile worldwide, and thereby indirectly influences the overall performance.

Novo Nordisk focuses on several areas; for instance diabetes treatment, insulin delivery systems, homeostasis management, growth hormone therapy, hormone replacement therapy as well as other biopharmaceuticals.(http://www.danskbiotek.dk) Within each of the focus areas Novo Nordisk "...is committed to improving the quality of life for people living with the particular disease, and it searches for innovative biologics projects at all stages of development-from early discovery to clinical phases." (http://www.novonordisk.com)
Their pharmaceutical products and services are manufactured and distributed in approximately 180 countries worldwide. Furthermore, Novo Nordisk is regarded as "The largest healthcare company in Denmark and a world leader in diabetes care with the broadest diabetes product portfolio in the industry."(http://www.investindk.com)

Moreover, "Novo Nordisk is committed to developing its business towards ecological, social and economic sustainability." (http://www.novonordisk.com)

Below table shows the sales and profit development based on the Novo Nordisk financial statement for 2010, which was made in Feb 2011.

Table 26

Novo Nordisk consolidated financial statement 2010 – Profit and Loss 2010

Profit and loss (Currency in Million DKK)	**2010**	**2009**	**2008**	**2007**	**2006**
Sales	**60.776**	**51.078**	**45.553**	**41.831**	**38.743**
Gross profit	**49.096**	**40.640**	**35.444**	**32.038**	**29.158**
Gross profit margin	80,80%	79,60%	77,80%	76,60%	75,30%
Sales and distribution cost	18.195	15.420	12.866	12.371	11.680
Percent of sales-Sales and distribution cost	29,90%	30,20%	28,20%	29,60%	30,00%
Research and development cost	9.602	7.864	7.856	8.538	6.316
Percent of sales-Research and development cost	15,80%	15,40%	17,20%	20,40%	16,30%
Administrative expenses	3.065	2.764	2.635	2.508	2.387
Percent of sales-Administrative expenses	5,04%	5,41%	5,78%	6,00%	6,16%
licence fees and other opreating income	657	341	286	321	272
Operating profit	**18.891**	**14.933**	**12.373**	**8.942**	**9.119**
Operating profit margin	31,10%	29,24%	27,16%	21,38%	23,50%
Net financials	-605	-945	322	2.029	45
Profit before income taxes	**18.286**	**13.988**	**12.695**	**10.971**	**9.164**
Income taxes	3.883	3.220	3.050	2.449	2.712
Effective tax rate	21,20%	23,00%	24,00%	22,30%	29,60%
Net profit	**14.403**	**10.786**	**9.645**	**8.522**	**6.452**
Net profit margin	23,70%	21,10%	21,20%	20,40%	16,70%

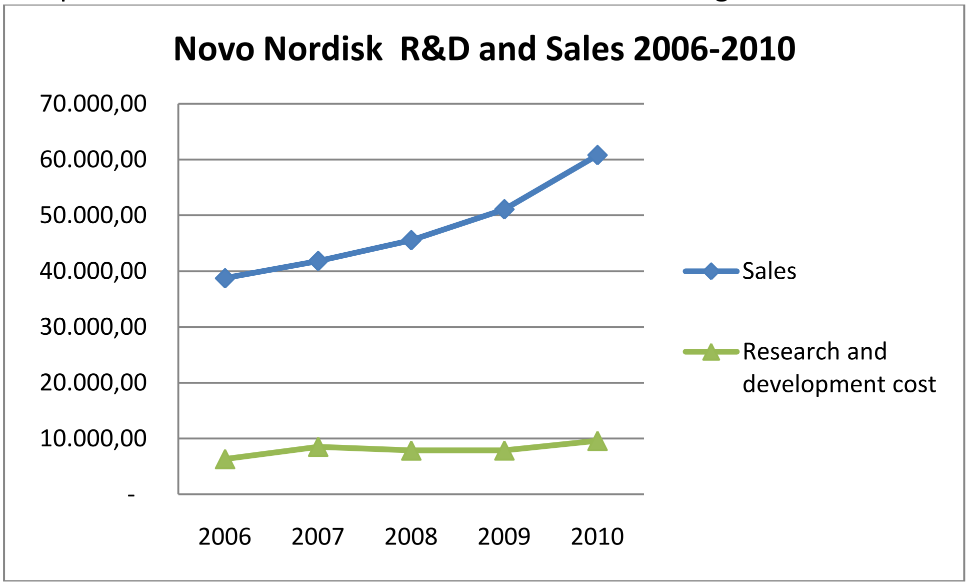
Source data: Novo Nordisk financial statement 2011

In order to avoid the exchange rate impact on the profit and loss statement, but only to analyze the results from the production point of view, the document currency DKK is used instead of Euro.

The above table figures indicate that the financial performance has increased steadily over the research period between 2006 and 2010 in terms of both company annual sales and profits. As it has been proven in the Results chapter (4) that R&D and sales is significantly and positively correlated in biotech industry, therefore it could be argued that the proportion of the contribution from R&D investment in Novo Nordisk has been increased dramatically due to the fact that the decreases in the percentage of annual sales from research and development (R&D) costs do not follow the trend of the other production costs, which remain stable in comparison to sales, while the annual sales has grown from 39 billion to 61 billion DKK during the observation period. Below table will provide more tangible evidence of that.

Figure 15

Comparisons between R&D investment and Sales during 2006-2010 of Novo Nordisk



Data source: Own calculations based on Novo Nordisk financial statement 2011

Next, several potential key factors which might have a large impact on Novo Nordisk are indentified with the basis from the insights on the relevant theoretical discussions in chapter 2. Apart from innovation, other key potential factors to be analyzed in detail to study Novo Nordisk development are as follows:

- **Human capital**: As research findings suggest that this plays a crucial role, based on the case study of Novo Nordisk I shall therefore illustrate whether this sector is rich in terms of human capital.

- **Universities and other education research centres**: Even though universities is one type of stakeholder I prefer to examine it separately, as previous literature suggests that a crucial factor for biotech industry growth is whether the firm is working together closely with universities, and/or other education research centres.

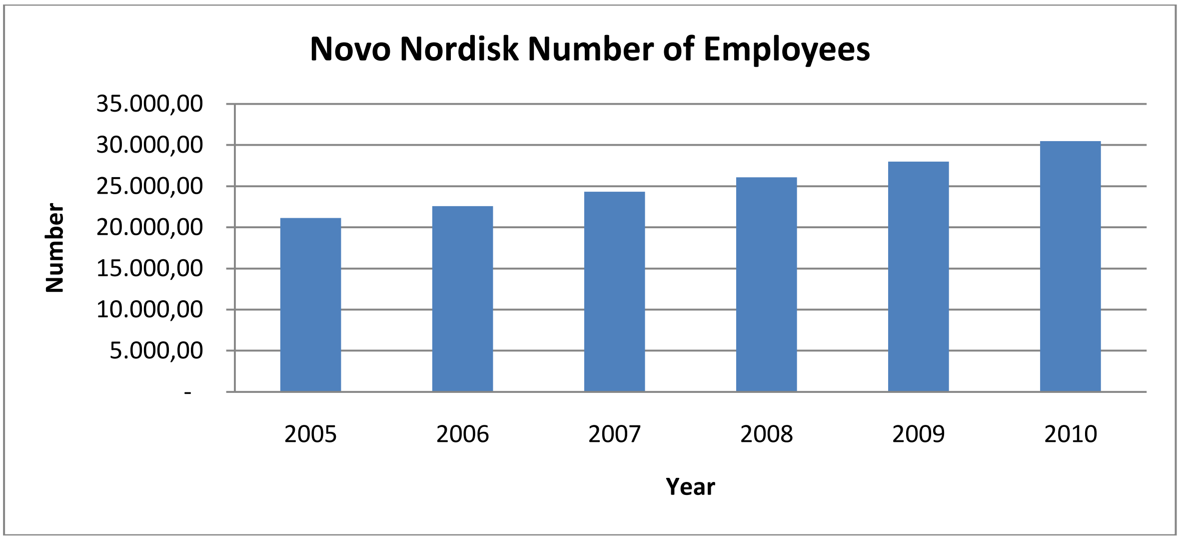
- **Other stakeholders, which includes**: suppliers, customers and competitors etc., whether the firm can benefit from the competition and corporation among those actors. The relationship between firms, universities, institutions will be analysed while discussing each of the mentioned actors.

Human capital

Based on the previous research findings, in any of the science based industries having talented employees could be crucial for a company in order to have sustainable development. In addition, keeping the talented employees employed, as well as training the existing employees to be more productive, could also be important for the overall company growth. On the other hand, understanding how to motivate the employees to work smartly is also important for a company to promote development.

Below table shows the number of employees in Novo Nordisk in the past six years. The number of employees has increased from 20 thousand in 2005 to over 30 thousand in 2010. Figure can provide a more specific overview of the changes on the number of employees.

Figure 16
Novo Nordisk number of employees between 2005 and 2010



Source data: Own calculations based on Novo Nordisk annual report, 2011 & Top R&D ranking 1000 Euro Scoreboard 2006-2010

Figure 17
Novo Nordisk number of employees between 2005 and 2010

Source data: Own calculations based on Novo Nordisk annual report, 2011 & Top R&D ranking 1000 Euro Scoreboard 2006-2010

The employee turnover rate of Novo Nordisk increased from 6,83 in 2005 to 8,93 in 2010, which is calculated by using the following method:

Employee turnover rate = (Current year number of employees – previous year number of employees)/ Previous year number of employees * 100

The average Novo Nordisk employee turnover rate is about 7,6 percent, which means the company size has been expanding during the observation period.

From the company point of view, it could be assumed that when a company employs one extra person it is because the company believes there is a need and that there will be an marginal gain from the outcome of hiring one more employee compared to the salary provided to the additional employee as well as other related costs incurred with this employee. However, a higher marginal gain for the company does not necessarily mean the employee is getting unfair treatment; it could be a win-win deal for both the employee and company, as for instance a good work environment can build a better skill set for the employee. In addition, the company should stop hiring extra personnel when the cost of an additional employee equals the value gained from the employee's contribution to the company.

Hence, it could be argued that the revenue growth of Novo Nordisk is influenced by the increasing number of employees hired.

Moreover, Novo Nordisk also has its own strategies regarding human capital. Such as: to keep the workforce diversified in terms of gender and nationality. As according to Novo Nordisk supplementary annual report 2010: "...Diversity is important...as it allows us to better understand customer needs, attract and retain talented people and operate more effectively in a global business environment." (Novo Nordisk supplementary annual report 2010, 2011, p. 22) Actions have been taken to enable the diversity of the working force, such as: "A second Global Diversity Summit was convened in Copenhagen in September 2010 with 42 participants from senior management...to examine the progress on diversity with presentations of best practice from the US, Europe, and Denmark."(Novo Nordisk supplementary annual report 2010, 2011, p. 23)

Besides getting talented and diversified employees to join the company, Novo Nordisk also provides different training programmes to support and develop the knowledge and skills of the employees in order to improve competence as well as the performance of the existing employees at all levels, especially for the leadership. Using one of the programmes from the various leadership programmes held by Novo Nordisk as an example: The New Department Manager's programme, which is "...mandatory for all newly appointed department managers in order to develop the competence, confidence and performance of new managers in the critical transition from contributing individually to contributing through others." (Novo Nordisk supplementary annual report, 2011, p. 23). Another example could be that Novo Nordisk also provides incentives in terms of salary and benefits when their employees perform better. Thereby, the talented employees can have high motivations for working harder to achieve the target. Such actions would lead to a more efficient workforce; hence the productivity can be increased.

In short, the above quantitative facts as well as the qualitative results indicate that the better financial performance that Novo Nordisk has achieved each year is closed affected by its rich human capital, which supports the previous theories regarding the importance of human capital on science based industries.

Universities and other education research centres

Universities, as well as other research centres, usually play a crucial role for science based industries.

Novo Nordisk established plenty of research centres in different organisations, universities as well as other institutions worldwide. The most important partners of Novo Nordisk are listed below, which could provide empirical evidence that Novo Nordisk is actively engaged with its stakeholders.

"In March 2010 a new Danish national stem cell research centre DanStem was established at the University of Copenhagen." (Novo Nordisk supplementary annual report, 2011, p. 49)

Due to the close collaboration between Novo Nordisk and various universities, research insinuations have leaded more possibilities to inventing better products and services, which could in turn generate higher growth for the company.

Table 27
List of the most important memberships of Novo Nordisk

Europe:

- *Emerging Biopharmaceuticals Enterprises (EBE)*
- *European Association for Bioindustries (EuropaBio)*
- *European Federation of Pharmaceuticals Industries and Associations (EFPIA)*
- *European Partnership for Alternative Approaches to Animal Testing (EPAA)*
- *Medicon Valley Academy*
- *Patent translation and Consulting (Interpat)*
- *The Danish Academy of Technical Sciences (ATV)*
- *The Danish Association of Biotechnology Industries (Dansk Biotek)*
- *The Danish Association of the Pharmaceutical Industry (Lif)*
- *Eucomed*
- *Medicoindustrien*

USA:

- *BIO (Biotechnology Industry Organization)*
- *California Healthcare Institute*
- *Center for Health Transformation*

- *Health Institute of New Jersey (HINJ)*
- *Healthcare Leadership Council*
- *National Association of Manufacturers*
- *National Governors Association*
- *Organization for International Investment (OFII)*
- *Pennsylvania Association for Biomedical Research*
- *Pharmaceutical Research and Manufacturers of America (PhRMA)*
- *Princeton (New Jersey) Chamber of Commerce*
- *United States Chamber of Commerce*

Major sustainability-related memberships

- *AccountAbility*
- *Amnesty International Business Club (ABC)*
- *Business for Social Responsibility (BSR)*
- *Boston College Center for Corporate Citizenship*
- *Conference Board Europe*
- *Copenhagen Climate Council*
- *Copenhagen Institute for Future Studies*
- *Global Business Initiative on Human Rights*
- *Global Reporting Initiative (GRI)*
- *SustainAbility (Engaging Stakeholders Forum)*
- *The World Business Council for Sustainable Development (WBCSD)*
- *United Nations Global Compact*
- *Boston College Center on Corporate Citizenship*

Source: Novo Nordisk supplementary annual report, 2011

Other stakeholders

A stakeholder is defined as: “A person, group, or organization that has direct or indirect stake in an organization because it can affect or be affected by the organization's actions, objectives, and policies. Key stakeholders in a business organization include creditors, customers, directors, employees, government (and its agencies), owners (shareholders), suppliers, unions, and the community from which the business draws its resources.”
(http://www.businessdictionary.com)

However, the definition of a stakeholder is very board concept since it almost includes everyone a stakeholder.

However, the strategy of focus as well as the priorities should differ as the timeline and resources are not unlimited. Considering such aspects the strategy of focus should be balanced with the company’s short term and long term business targets.

The key stakeholders for Novo Nordisk might be the suppliers, business partners as well as customers, which can be governments, hospitals and patients. Enabling and promoting development for a business might require considerations taken to each of the stakeholders.

A better understanding of the situations of the company's stakeholders as well as smart communication with these actors would provide better possibilities for solving the challenges faced in daily operations, thereby improving the outcome for the benefit of the stakeholders as well as the company itself.

For Novo Nordisk, "Stakeholder engagement is an integrated part of our business philosophy." (Novo Nordisk supplementary annual report 2010, 2011 p. 46) One of the methods that Novo Nordisk has applied to keep a closer relationship with its key stakeholders is to build partnerships with them. The purpose is to "seek influence, learning and networking through several forms of engagement with stakeholders."
(Novo Nordisk supplementary annual report 2010, 2011, p. 23)

Novo Nordisk has established several public affairs offices in different regions regarding institutional development. One of the aims would be to be "fully engaged in the public debate around health policy in order to improve access to quality diabetes care." (Novo Nordisk supplementary annual report 2010, 2011, p. 46). The public can get more knowledge as well as support regarding better treatment due to the development of these institutions. On the other hand, the high engagement between patient and the institutions might support the health care knowledge diffusion and better business solutions might be founded. Hence, Novo Nordisk might be more likely to succeed.

Reputation

Even though this aspect has hardly been discussed at all in the literature review chapter, I have found that Novo Nordisk pays a high degree of attention to matters regarding reputation. It might, therefore, be an additional key factor that affects company growth. Hence, the reputation aspect is discussed in depth as follows.

To have a better reputation might be costly, and the return might be hard to quantify. Moreover, the effects can be invisible in the short term. However, to manage the company in a way that is ethically viable can be critical for Novo Nordisk's sustainable development, as its products and services are sold to governments as well as hospitals worldwide. If other companies, institutions or governments lose confidence in the products which Novo Nordisk supplies it could mean that Novo Nordisk will lose its business. Trust is usually difficult to build but easy to lose.

Novo Nordisk is aware of this issue and different programmes, such as training for employees, have been carried out to improve business ethics and ensure that they can be applied to their daily operations as well as the environment.

In addition, Novo Nordisk is also actively evolved into different types of donations. From the financial terms point of view, one example can be that for ten years 0,25 % of the net insulin sales of the Group in each of the preceding financial years have been donated to the World Diabetes Foundation, starting in 2002. Another example can be: "In Morocco, 340 employees' networked while renovating a village school and establishing a new playground." (Novo Nordisk supplementary annual report 2010 p. 34)

Moreover, Novo Nordisk also designs their production processes to utilize resources more efficiently. The outcome can be seen from the 1% decrease in energy consumption and 5% decrease in water consumption during the period 2009 to 2010, despite the increase of 8, 93 % in the number of employees as well as the 19% increase in the net sales in Novo Nordisk for the same period.

In short, a good reputation in the eyes of the public should have a positive impact on the sustainable growth of Novo Nordisk.

Chapter 5 DISCUSSIONS AND CONCLUSIONS

This final chapter provides a consolidation of the results of the analyses carried out in the previous chapters, as well as drawing a conclusion that sums up what have been done regarding the thesis objectives set at the beginning, while also discussing the limitations and suggestions regarding policies as well as future research studies.

This thesis was intended to determine what the key factors that influence biotech industry growth are by investigating specifically a sample of the top 1000 ranking R&D companies in the European Union, with a focus on the biotech companies' growth compared with the rest of the industries in Denmark.

This objective of the thesis is achieved through investigation of the following three main research questions by using the top 1000 ranking R&D companies as the source:

a. Is Biotechnology a strong industry in Denmark at industry level? And how strong it is compared with other countries in the European Union?

b. Is innovation the driving factor for the growth of the biotechnology companies in contrast with other industries in Denmark?

c. Are there other factors, aside from the two mentioned above, which significantly influence the biotechnology companies' growth in Denmark?

These research questions were answered through several steps. First of all, a review regarding previous relevant literature regarding innovation, biotech innovation, innovation systems and growth were critically discussed. Secondly, the decision regarding the choice of appropriate methodologies and variables were explained in detail. The results of each of the research questions were presented next, which was followed by a consolidation of the results of the analysis that was carried out in the previous chapter regarding the research questions. In addition to this, I shall also discuss the link between the relevant literature and the findings of the research analyses.

The first research question was carried out by using mainly the descriptive quantitative analysis. The results indicated that Denmark at an overall level, regardless of industries, did not have a strong position in terms of R&D investment, net sales or number of employees. It might be due to the fact that Denmark is a small country in terms of land size as well as population.

I then checked Denmark at the industry level, in order to find out the position of the biotech industry among all other industries within Denmark, as well comparing the Danish biotech industry to that of other countries in the European Union, by using the top 1000 ranking R&D companies in the European Union. The results clearly indicated that within the researched companies, Denmark has an outstanding biotech industry compared with the rest of the industries in Denmark, as well as with other EU countries in terms of R&D investment, number of employees, as well as net sales.

Again to avoid a biased picture due to the limitation of using the top 1000 ranking R&D companies, the patent application per million inhabitants across countries worldwide was also compared. The results indicate that Denmark is a leader in the biotech industry in terms of patent application per million inhabitants.

Although this result might get affected by the fact that Denmark has a smaller population, therefore the position of patent application per million inhabitants is higher than those countries with larger population but have same number of biotech related patent applications.

Nevertheless, adding all the results from the analysis together could clearly prove that Denmark has a strong biotech industry compared to other industries in Denmark as well as across countries worldwide. Although there is a clear limitation to the source data regarding several selected variables such as: the number of employees and net sales when comparing with other countries, since the sample contains only the top 1000 ranking R&D companies, the patents per million inhabitants which come from another data source could provide a more reliable view of this research question, and it aligned with the results regarding the position of Danish biotechnology compared with other countries which I got from using the top 1000 ranking R&D companies.

The second research question was carried out by using mainly the analytical quantitative analysis – the multiple linear regression analysis on R&D investment growth, non-R&D investment growth, and net sales growth for both the biotech industry and other industries in Denmark. From the findings in previous relevant literature, the R&D investment is the key input innovation indicator, and sales as well as patent applications should be two of the important outputs of innovation. However, for the purpose of analyzing growth, sales should catch the interest from most of the stakeholders compared to patents. Hence, I decided to use net sales growth as the dependent variable to understand if there is any correlation between R&D investment change and net sales growth. By doing this, the effects of R&D investment might be underestimated in the case that R&D investment had little impact on sales, but it might lead to more patents, which is not analysed in this paper. In addition, patents also have the possibility to affect sales on a longer term, which is also not analysed in this paper. Therefore, these two aspects might be the limitation of the thesis.

One of the original points of this thesis might be the choice of using non-R&D investment growth as the other independent variable in the regression analysis. Based on the findings of previous literature it is hard to quantify the potential aspects which affect growth. However, it would be very interesting to find out how much they really affect growth for the biotech industry, as well as other industries in Denmark. Since it is difficult and time consuming to establish methods, indentify indicators on each of them and calculate the impact on growth I then decided to calculate the total of these potential factors by using total investment less the R&D investment, and use this as the other independent variable in the analysis. Although this might contain many weaknesses it could somehow avoid any missing considerations regarding the impact of other factors aside from innovation on company growth, and my hope is that it could be used as reference to the innovation indicator R&D investment.

Nevertheless, the multiple linear regression analysis result regarding the biotech industry in Denmark explains that there is a statistically significant correlation between the independent variables and the dependent variable. Although the correlation does not explain causality, the causality has been established based on previous models already and the case study which provided qualitative illustrations complements the aspect of causality to a certain extent.

The results further indicate that the R&D investment growth has a much more significant impact (about double) on net sales growth compared to non-R&D related investment for the biotech industry in Denmark. Whereas for the other industries, since the multiple linear regression model has failed; the single linear regression models were applied to analyse the correlations separately on R&D investment & net sales growth and non-R&D investment & net sales growth. Both of the single linear regression models are successful and they have very high goodness of fit. However, the non-R&D investment growth plays a more significant role in the company net sales growth compared to the effects of R&D investment for other industries in Denmark. In other words, it could be interpreted as: the more non-R&D investment a company has the higher revenue growth the company might achieve.

In theory, both R&D investment and non-R&D investment are direct costs of the companies, however, a company would make investment is due to the output which could cover the cost is consumed is expected. Therefore, it is assumed that both innovation and non-innovation investment have an impact on growth, but the effects might differ in different industries.

For a science based industry like the biotechnology industry in Denmark, the results indicate that the revenue growth rate is not closely related with the non-innovation related activities, but the growth rate is much more closely correlated with innovation input compared with the rest of the industries in Denmark. In contrast, for other industries in Denmark, as most of them are not science based, the results regarding non-innovation related activities are comparatively more important for the company growth in contrast with innovation investment. These results of the research questions are very much what was expected as it supports the literature fully in that innovation is the main factor that influences growth for biotech industry compared with other industries in Denmark. Therefore the assumptions made at the beginning of this thesis are supported, and it could be concluded that:

There is a positive linear relationship between innovation and growth in biotechnology firms, and it is more significant in the biotechnology industry than in other industries in Denmark. Furthermore, there is a positive linear relationship between non-innovation related investment and growth in biotechnology firms; however, it is less significant in biotechnology industry than other industries in Denmark.

In other words, innovation has a much higher relevance as a contributor towards growth compared with non-innovation related investments for the biotech industry. This may provide valuable input for biotech firms in Denmark, that in order to reach a higher growth in terms of revenue companies have to focus on investing more in R&D in the biotech sector in order to improve its performance.
The findings from the case study on Novo Nordisk should further prove that for the biotech industry in Denmark, besides innovation, there are various factors affecting the company growth. Since it matches the results in the quantitative analysis part, non-innovation related investment contribute about 33% of revenue growth at company level in the biotech indus-

try, and the qualitative illustrations complements the quantitative analysis as to the point of causality.
Based on the findings of the relevant literature, several potential factors have been studied in depth. The case study on Novo Nordisk supports such theories, as it explains that a rich human capital, well established relationships among its business partners, which include universities, and research centers, as well as actively involved communicating strategies towards other stakeholders are important for the company growth. In addition, Novo Nordisk is also ensuring that they keep up a good reputation in the public eye, which could also positively affect the company's sustainable development. Whether the good reputation is a key factor affecting company growth might differ from case to case, but if the company is large and well known to the public, a bad reputation would definitely affect its growth. However, the effects of the reputation are uncertain for a small company.

As discussed, the main method used to analyze the key potential factors aside from innovation investment on growth would be the qualitative illustrations, due to the fact that these factors are hard to quantify. However, during the quantitative research, I have tried to add the effects all together and named them as non-innovation related investments. Thereby it was possible to quantify the effects from all factors aside from innovation as a total, which would not miss any factors from the quantitative point of view. Therefore, the weight between innovation and non-innovation investment for the biotech industry is clear compared with other industries in Denmark, and this could provide insights especially to policy makers regarding which area to focus on in order to reach a better growth rate for both the biotech industry and other industries in Denmark.

Although the specific research objective has been reached and research questions were answered, there are still limitations at a broader level and this thesis has opened a set of new questions for future research.

Key Limitations and possible future research

One of the critical limitations is the data source used in the analysis. Due to the fact that each data source has its own limitations, for instance samples of the companies were selected from top 1000 ranking R&D companies in the European Union, which did not cover all companies in Denmark or in the European Union. Although I have tried to use different sources to supplement the results, such as the use of the patent data set which provided support of the conclusion that Denmark is in a leading position in the biotech industry compared to other countries in the European Union, still a different set of companies might provide different results. Hence, readers have to be aware of this data limitation. Obviously, more samples of companies are needed in order to improve the validity of the findings in future research.

Moreover, since this thesis did not study the long term effects of innovation on growth in the biotech industry in Denmark, the results of innovation is likely to be underestimated due to the fact there are might be time lags between innovation investments and the effects on growth. Thus, in future research within this area it could be crucial to study this using time series method to study a longer term in order to better understand the precise picture of how much innovation affects growth in the biotech industry compared to other industries in

Denmark.

Regarding the case study of Novo Nordisk, factors regrading non-innovation could be studied in more depth.

In addition, the factor of institutions as an impact on biotech company growth might be studied in further detail. Initially it was considered for inclusion in the analysis; however, it proved to be very complicated to analyze it across several countries. Thus it was assumed that the effects of institutions on company growth are appeared evenly across countries in the European Union.

Another instersting topic which this thesis has opened might be how much effect other key factors, aside from innovation, could have on the rest of the industries in Denmark, and comparing the effects of innovation and non-innovation factors in the longer term to check if innovation is really not important compared with other factors.

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Appendix

Appendix 1 Countries with under 10 patent applications per million inhabitants in 2007

pat_ep_ntot-Patent applications to the EPO by priority year at the national level				
Last update	20-01-2011			
Extracted on	05-05-2011 11:17:52			
Source of data	Eurostat			
INDICATORS	OBS_FLAG	UNIT	Per million of inhabitants	
GEO/TIME	2007	2006	2005	2004
Greece	9,79	9,32	9,9	6,06
Latvia	8,4	7,2	8,02	4,23
Slovakia	7,83	7,34	5,7	3,83
Croatia	7,21	7,77	7,4	7
Poland	3,82	3,61	3,2	3,15
Bulgaria	3,78	3,51	3,07	2,41
South Africa	3,22	3,18	2,76	3,07
Turkey	3,16	2,57	2,28	1,77
Lithuania	2,41	2,84	2,61	4
Russia	1,98	1,86	2,1	1,65
China (except Hong Kong)	1,59	1,36	1,23	0,76
Romania	0,98	0,89	1,32	1,05
Mexico	0,75	0,72	0,82	0,53
India	0,48	0,48	0,53	0,5

Source data: own calculations based on the Eurostat, Patent Statistics, 2011

Appendix 2 Countries which under one biotechnology patent applications per million inhabitants in 2007

GEO/TIME	2007	2006	2005	2004
Mexico	0,005	0,023	0,035	0,013
Romania	0,009	0,013	0,046	:
India	0,011	0,05	0,052	0,051
China(except Hong Kong)	0,022	0,042	0,053	0,037
South Africa	0,027	0,138	0,245	0,147
Russia	0,053	0,267	0,185	0,17
Greece	0,112	0,584	0,46	0,482
Poland	0,128	0,236	0,176	0,211
Croatia	0,225	0,741	0,299	0,421
Hungary	0,311	0,533	0,52	0,843
Czech Republic	0,365	0,54	0,567	0,392
Lithuania	0,414	0,882	0,146	:
Portugal	0,493	0,588	0,812	0,482
Latvia	0,583	:	0,238	0,216
Spain	0,81	1,825	2,315	1,722
Taiwan	0,821	0,946	0,679	1,074
Italy	0,919	2,277	2,626	2,623
South Korea	0,948	2,872	2,58	2,806

Appendix 3 Novo Nordisk Milestones

Novo Nordisk was created in 1989 through a merger between two Danish companies – Novo Industri A/S and Nordisk Gentofte A/S.

1923 Nordisk Insulinlaboratorium founded.

1925 Novo Terapeutisk Laboratorium founded.

1926 Nordisk establishes Nordisk Insulin Foundation with the object of supporting physiological and endocrinological research and people with diabetes in Scandinavia.

1932 Nordisk founds the Steno Memorial Hospital.

1938 Novo founds Hvidøre Diabetes Sanatorium.

1946 Nordisk develops isophane insulin (NPH), a neutral insulin with prolonged action.

1947 Penicillin Novo – Novo's first product to be manufactured through fermentation – is launched.

1951 Novo establishes the Novo Foundation with the object of supporting scientific, social and humanitarian causes and to provide the best possible protection for the company.

1953 Novo launches Lente® – a long-acting insulin–zinc suspension.

1973 Nordisk markets Nanormon® growth hormone for the treatment of growth hormone insufficiency. The growth hormone is extracted from human pituitary glands.

1973 Novo introduces Monocomponent (MC) insulin – the purest insulin available.

1974 Novo's B shares are quoted on the Copenhagen Stock Exchange.

1981 Novo becomes the first company in Scandinavia to be quoted on the New York Stock Exchange.

1982 Novo launches Human Monocomponent insulin – the world's first insulin preparation identical to human insulin. It is extracted from the pancreases of pigs and converted to human insulin.

1985 NovoPen® – an injection system similar in appearance to a fountain pen, with replaceable insulin cartridges – is launched.

1987 Novo starts production of human insulin with the help of genetic engineering.

1988 Novo markets Vagifem® – the first unique vaginal tablet for atrophic vaginitis.

1988 Nordisk markets Norditropin® genetically engineered human growth hormone.

1989 Nordisk Insulinlaboratorium, the Nordisk Insulin Foundation and the Novo Foundation merge to become the Novo Nordisk Foundation. The objects are to provide a stable basis for the Novo Group companies' operations and to support scientific causes.

1989 Novo Industri A/S and Nordisk Gentofte A/S merge to become Novo Nordisk A/S – the world's leading producer of insulin.

1989 NovoLet® – the world's first prefilled insulin syringe – is marketed.

1991 Novo Nordisk joins the environmental charter of the International Chamber of Commerce (ICC).

1992 The Steno Memorial Hospital and Hvidøre Hospital merge to form the Steno Diabetes Center.

1994 Novo Nordisk is the first company in Denmark – and one of the first in the world – to publish an environmental report.

1996 NovoSeven® – for the treatment of haemophilia patients with inhibitor reaction – is launched.

1998 NovoNorm® (Prandin® in the US) – a new oral treatment for type 2 diabetes – is launched in the US and a number of European countries.

1998 Activelle® (Activella® in the US) – the first low-dose continuous combined oral HRT for postmenopausal women – is introduced.

1999 Novo Nordisk publishes its first social report.

1999 NovoRapid® (NovoLog® in the US) – the company's first modern insulin, a rapid-acting insulin analogue – is marketed. Modern insulins are designed to better mimic the normal insulin response to changes in blood sugar levels.

1999 Norditropin® SimpleXx® – the world's first liquid growth hormone in a dedicated pen system – is launched.

2000 Novo Nordisk is split into three separate companies operating under the umbrella of the Novo Group: Novo Nordisk A/S, Novozymes A/S and Novo A/S.

2001 InnoLet® – the first insulin delivery system specially designed to suit the needs of insulin users with poor eyesight and reduced dexterity – is launched.

2001 Novo Nordisk establishes the World Diabetes Foundation with the purpose of improving diabetes care in developing countries.

2001 NovoRapid® FlexPen® is marketed. FlexPen® is a new prefilled pen, designed for easy and discreet use.

2002 Novo Nordisk signs the United Nations Global Compact, a platform for promoting good corporate principles and learning experiences in the areas of human rights, labour, environment and anti-corruption.

2002 NovoMix® 30 – a dual-release modern insulin – is introduced.

2003 Norditropin NordiFlex® – the world's first prefilled growth hormone pen – is launched.

2004 Levemir® – a long-acting modern insulin – is launched.

2004 Novo Nordisk's articles of association are amended to specify that the company will "strive to conduct its activities in a financially, environmentally and socially responsible way".

2005 The Novo Nordisk Haemophilia Foundation is set up in response to the significant need to improve haemophilia treatment in the developing world, underlining the company's social responsibility within haemophilia care.

2006 Novo Nordisk signs an agreement with the World Wide Fund for Nature (WWF) that commits the company to reduce its carbon emissions by 10% by 2014 compared with 2004. Novo Nordisk is the 10th company in the world to join the WWF Climate Savers initiative.

2007 Activella® 0.5 mg/0.1 mg – the first ultra-low-dose oral HRT for women with menopausal symptoms – is launched in the US.

2007 In Montes Claros, Brazil, Novo Nordisk inaugurates its largest insulin production facility outside of Denmark.

2009 Victoza® - human Glucagon-Like Peptide (GLP-1) analogue for once-daily treatment of adults with type 2 diabetes - is launched in Europe.

Source data: http://www.novonordisk.com

Appendix 4 Summary statistics: R&D investment in Million Euros, Net Sales in million Euros and R&D net sales ratio

Variable	Obs	Mean	Median	Min	Max
Number of Countries	20	49	29	2	239
R&D Investment(Million Euro)	20	6.493	1.890	28	43.981
Net Sales(Million Euro)	20	270.394	82.305	614	1.435.339
R&D Net sales Ratio	20	3,25	2,51	0,32	9,38

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Appendix 5 Number of Companies, Number of Employees, and R&D per employee and Net Sales per Employee by the European Union countries for top R&D 1000 companies in all industries in 2009

Variable	Obs	Mean	Median	Min	Max
Number of Countries	20	49	29	2	239
Number of Employees	20	1.084.803	352.977	1.391	5.836.721
R&D per Employee (Euro)	20	7.698	5.395	618	41.364
Net Sales per Employee (Euro)	20	234.864	235.920	107.477	441.185

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Appendix 6 Number of Companies, R&D Investment Net Sales, and Number of Employees, by the European Union countries for top R&D 1000 companies in the biotech industry in 2009

Country	Number of Companies	R&D investment (Million	Net Sales(Million Euro)	Number of Employees
UK	30	8.071	61.042	186.603
France	14	4.971	31.925	114.904
Germany	16	3.919	23.371	88.304
Denmark	14	1.915	10.988	44.890
Belgium	6	742	3.963	11.710
Luxembourg	1	246	3.109	11.975
Italy	6	245	1.954	7.635
Ireland	4	244	1.579	4.226
Sweden	10	213	2.336	8.927
Spain	5	212	2.299	11.201
The Netherlands	5	179	1.163	5.431
Hungary	2	126	1.415	13.383
Finland	2	99	777	3.273
Slovenia	1	88	953	7.975
Austria	2	73	91	593
Portugal	1	60	146	570
Malta	1	48	458	973
Greece	1	32	89	320
Poland	1	10	70	1.040
Grand Total	**122**	**21.492**	**147.729**	**523.933**

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD

Appendix 7 R&D net sales ratio, R&D per employee, Net sales per employee for the biotech industry in 2009 in the European Union

Country	R&D Net sales Ratio(%)	R&D per Employee(Euro)	Net Sales per Employee(Euro)
UK	13	4.325	32.712
France	16	4.326	27.784
Germany	17	4.438	26.466
Denmark	17	4.265	24.478
Belgium	19	6.336	33.844
Luxembourg	8	2.050	25.964
Italy	13	3.209	25.592
Ireland	15	5.778	37.373
Sweden	9	2.382	26.168
Spain	9	1.895	20.527
The Netherlands	15	3.289	21.413
Hungary	9	944	10.572
Finland	13	3.032	23.744
Slovenia	9	1.107	11.950
Austria	80	12.255	15.381
Portugal	41	10.482	25.667
Malta	11	4.968	47.072
Greece	36	10.051	27.914
Poland	14	950	6.703
Grand Total	**15**	**4.102**	**28.196**

Source data: own calculations based on the 2010 EU Industrial R&D Investment SCOREBOARD