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School of Business

Bachelor's Thesis

Department of Management and International Business

The challenges of commercializing technological innovations in the field of biotechnology – Case VTT

Teknologisten innovaatioiden kaupallistamisen haasteet bioteknologian kentällä

– Case VTT

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1. Introduction

1.1. The Background of the Study

Biotechnology has been used for thousands of years in various ways. The traditional applications are for example the using of yeasts and molds in different foods and drinks. For instance a classic example, beer, is a product of the fermentation of yeast. Nowadays biotechnology is applied in several different industries such as medicine, diagnostics, forestry and bioprocesses. Some of the major fields of study today are finding cures for fatal diseases, developing profitable biofuels and furthermore improving the sufficiency of energy. Biotechnological findings often aim to improve the quality of life – there have for instance been a lot of studies on Alzheimer, Parkinson's and curing vaccines. Therefore the subject is rather relevant in the modern world, as more emphasis is put on social responsibility and the well-being of the environment. Biotechnology is said to be a technology of several opportunities and as a growing field also a possibility for economic growth. (Tekes, 2006, 3; Helminen, 2006a)

In Finland biotechnology is a growing industry – there are approximately 150 companies in the field, out of which several have been founded in the late 1990's. A considerable amount of public investments have been done in the research, innovations and field of biotechnology in general. Finland has strong know-how, good facilities and world-class expertise and therefore it can be said that Finland is an internationally significant doer in the field. (Tekes, 2006, 3, 16) Most of the funding comes from the public sector, whereas the private sector is only rarely involved (TEM, 2009, 51).

The main problems in Finnish biotechnology are that although we have excellent preconditions and R&D even in international standards, the utilization and commercialization of them could be better. The developing of innovations to break through innovation successes is claimed to be a national weakness, though the problem is not in the people, but rather in the system (Kuisma, 2011, 86). The journey from innovation to end-product takes too much time and capacity, and furthermore not all innovations are ever utilized (Palmberg, 2002, 7). There are problems in making the research profitable, and therefore commercialization is a current topic in the industry. (TEM, 2009, 51)

1.2. Research Problems, Objectives and Limitations

The study is divided into the main research question and sub-questions. These questions and the theoretical framework create a frame and structure for the study. The main research question is:

"What are the main challenges of commercializing technological innovations in the field of biotechnology?"

There are also sub-questions, of which the purpose is to divide the main question into parts in order to clarify and deepen it. The sub-questions of the study are:

-What is biotechnology and what different applicative areas does it have?

-What are technological innovations and how are they managed?

-What factors are significant in the commercialization process?

The goal of the study is to define the main challenges in the commercialization of biotechnological innovations in order to clarify the problems concerning the commercial aspect of the bio industry. Through determining the main challenges it may be possible to further improve the industry's profitability. It is important to acknowledge these issues, for this is a matter companies selling high technology often struggle with. The aim of this study is to bring out new perspectives and ideas. One goal is also to find similarities and differences in the empirical section between this study and the publications conducted earlier.

The study is limited to Finnish biotechnology, more specifically two different areas of application: industrial biotechnology and pharma & diagnostics. The study is also limited to a company perspective, so different customer-decision processes are not for instance introduced. The study focuses mostly on the commercialization of innovations, such as products, services and knowledge, in the public sector and research centers.

1.3. Literature Review

The innovation process is a subject that has interested researchers for decades. New innovation process models have been developed through time. Rogers developed in the year 1962 one of the linear innovation process models that gave the base to the whole research.

Later Kline and Rosenberg (1986) came up with a more complex model characterizing the nature of innovations. Naturally there were many publications and models between these two also, but they are not further discussed in this study. The fifth-generation innovation model was introduced by Rothwell (1994). The innovation process concerning strictly technology and high-technology companies has also been researched to a great extent (For instance Bianchi, Chiesa & Frattini, 2011; Narvekar & Jain, 2006; Chen, Lee & Tong, 2006; Chiesa & Frattini, 2011) There is also a lot of other literature discussing the subject (Elite, 2006; Pulkkinen, 2003; Hautamäki, 2008; Palmberg, 2002).

Commercialization is a far less researched subject, at least if measured through the amount of publications and other literature. This can be due to the fact that in the innovation process literature, commercialization is seen as a part of the process and they are often discussed somewhat hand in hand. Prebble, de Waal and de Groot (2008) give new perspectives to the commercialization process whereas Siegel, Hansén and Pellas (1995) emphasize co-operation in the process. There has also been a lot of research concerning the commercialization of public research (For instance Markman, Siegel & Wright, 2008; Li & Morgan, 2010).

In some of these publications challenges are slightly discussed but mostly they emphasize other factors. The only article emphasizing challenges discussed in this study is the one of Komkov and Bondareva (2007), but even they have the perspective of Russia's economy in their research. No research concerning challenges of commercializing technological innovations in the biotechnology industry was found, so this study can be seen to give a more thorough perspective to the challenges in the industry. In that way, this study can fill a certain research gap.

1.4. Methodology

The research methods are often divided into two sections, qualitative and quantitative analysis. Quantitative analysis most often refers to research based on statistics whereas qualitative analysis is based on more interpretative research. Basic characteristics for qualitative analysis according to Eskola & Suoranta (2003) are for instance the using of the perspective of the researched, theoretical or discretionary sampling and the position of the researcher. The most commonly used research methods in qualitative analysis are interviews, observation, text analysis and transcribing (Metsämuuronen, 2003, 161-162)

The most common way of gathering information in qualitative analysis is through interviews. Research interviews aim on systematic gathering of information, and they can be divided into four categories: structured, half-structured, theme and open interviews. In a structured interview the order and format of the questions are the same for everyone. Also the answering options are the same. A half-structured interview differs from the previous one only by having no prepared answering options. In theme interviews only areas of discussion (theme areas) are prepared, which leaves room for open discussion and versatility in the answers amongst the interviewed. The interviewer does not have fully structured questions, but merely a support list of the areas wanted to be covered. An open interview is the closest to a normal discussion. Not all of the theme areas are covered with all the interviewed and the discussion is rather free. (Eskola & Suoranta, 2003, 85-86)

The reliability and validity of the study are important to define, for although researches strive to avoid mistakes, reliability and validity vary according to the empirical study. Reliability is the amount at which the study has produced results that can be repeated with a different researcher – how reliable the study is. In qualitative researches reliability may suffer from for instance the interviewee not being honest or not understanding the question. The researcher could also be subjective and write only wanted results. Misunderstandings are also possible for both parties. Validity is the term for the ability of the research method to measure the wanted factors. (Hirsjärvi, Remes & Sajavaara, 1997, 213)

The empirical part of this study has been executed in the autumn of 2012 as a qualitative research, which of the research method was theme interview. The interviews were recorded after which they were transcribed into a written form in order to be able to also visualize the whole context. Thereafter similarities between the interviewees and other important factors from each interview were highlighted and compared. The interviewed consisted of VTT employees: two Key Account Managers and one Technology Manager. They represent the pharmaceutical and industrial biotechnology sectors from the organization. The interviewees are further introduced in the beginning of the empirical study.

1.5. Theoretical Framework

In the framework of the study (see Figure 1) at first the different application areas of biotechnology are introduced, after which the areas covered in the study are further discussed. The main idea of the study is to research and discuss the challenges of commercializing

technological innovations through the interviews and the different theories published. As can be seen from the Figure 1, the empirical research is scrutinized based on the publications concerning the innovation and commercialization processes. Thereafter the challenges mentioned by the interviewees will be compared to the existing publications in order to find differences, similarities and new aspects to the matter.

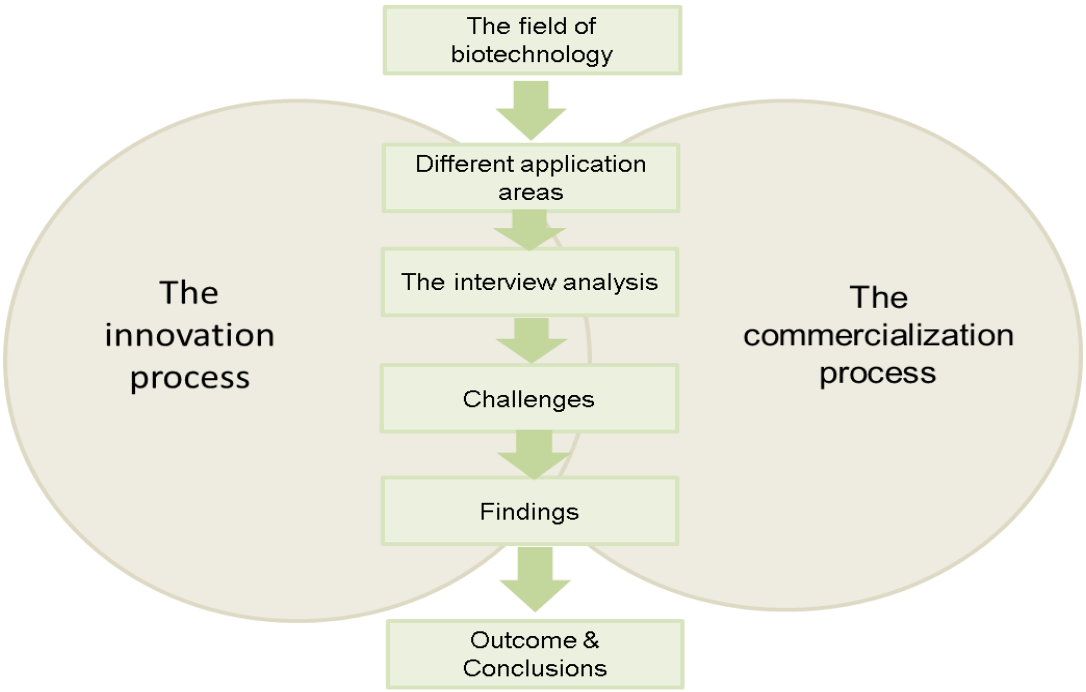

Figure 1. The Framework of the study

1.6. The Outline of the Study

The study is divided into the theoretical and empirical sections. The theoretical section begins with the introduction of biotechnology and its different areas of application in the second chapter. Thereafter the application areas researched in this study are further discussed. Later, the concepts of innovation and commercialization are defined and further discussed in the chapters three and four. Different theories for the innovation and commercialization processes are presented and discussed. The main emphasis in the theoretical section of the study is to show the benefits of the processes, introduce different options and give a thorough picture.

The empirical section of the study introduces the challenge perspective through the analysis of the theme interviews. At first the case company and the interviewees are introduced after which the themes discussed in the interviews are scrutinized. Finally the main findings are drawn together by analyzing both the theoretical and empirical sections as an entirety. In the conclusions chapter the whole study is discussed.

1.7. Key Concepts of the Study

The key concepts of the study are shortly introduced in this section in order to give the reader an idea of the study. The definitions of these concepts may vary depending on the researcher, but here the concepts are defined in a short manner that supports the context of the study.

Biotechnology: The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living material for the production of knowledge, goods and sciences (OECD).

Innovation: An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (OECD).

High Technology: A term used for cutting edge, advanced technology. Sectors such as biotechnology, nanotechnology, nuclear physics and information systems are often referred to with this term.

Radical Innovation: A groundbreaking innovation that brings something significant to the markets. Radical innovations bring competitive advantage to the company and disadvantage to competitors with older technologies.

Innovation Process: The complete set of actions a company goes through from developing an idea to transferring it into a product, process, service or other.

Commercialization Process: All the commercial activities involved in getting an invention or innovation to the markets. Also part of the innovation process.

Technology transfer: The commercialization of a technological invention/innovation.

Technology-push: The concept referring to a company trusting in the significance of the technology it has developed to the quantity, that no commercialization actions are thought to be needed. In other words, this is entering the markets technology first, trusting that the technology will sell itself.

Market-pull: The concept in which the markets are entered from the perspective of what is required by potential customers.

2. Biotechnology as a Science

In this chapter, the concept of biotechnology is defined after which the five main application areas are introduced. Thereafter the two application areas covered in this study are further presented and opened. Finally, the industry and research in Finland is scrutinized.

2.1. The Definition of Biotechnology

The official definition of biotechnology (OECD) is: "The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living material for the production of knowledge, goods and sciences". The Convention of Biotechnological Diversity defines biotechnology to be "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use." Therefore biotechnology is a very broad concept and it is utilized from many aspects. Its end-products and research results aim to ease everyday life and bring facilitation to the environment through ecological solutions.

2.2. The Areas of Application

Biotechnology is often divided into five main areas of application; Food, Environmental, Industrial, Pharmaceutical and Plant biotechnology (see Figure 2). These areas are essentially visualized through different colors, which are characteristic to each one.

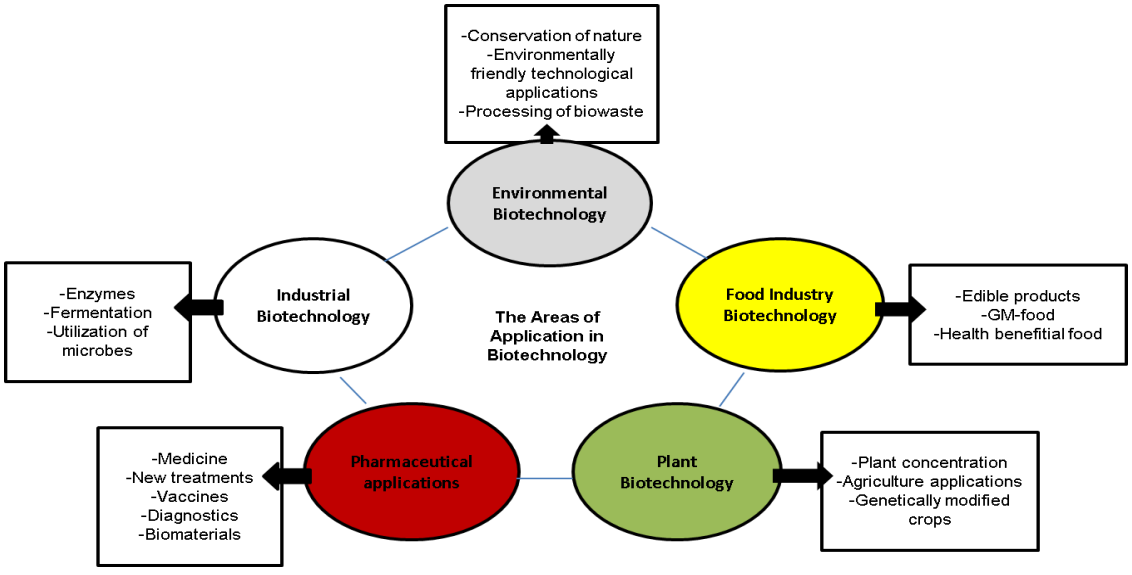

Figure 2. The areas of application in biotechnology (Based on Tekes, 2006, 9)

As can be seen from Figure 2, environmental biotechnology deals with matters such as the conservation of nature and the processing of biowaste, whereas plant biotechnology concentrates on for instance agriculture applications. Food industry biotechnology on the other hand aims on developing health beneficial food and the research of gene modified food. There are different opinions concerning how the application areas should be divided, for they cross each other's boundaries in many aspects. The two areas of application covered in this study will be further introduced in the following sections.

2.2.1. Industrial Biotechnology

Industrial Biotechnology utilizes living (such as yeasts, bacteria, algae) and components from cells (for instance enzymes) in order to create industrial products and processes. These products include biofuels and chemicals, whereas the processes are for example treatment of waste-water, pulp and paper industry processes and measuring energy efficiency. A recent innovation is an enzyme that enables washing laundry in lower temperatures. (AG, 2012; Tekes, 2012, 8-9) Cell metabolisms can be tailored in order to utilize their compounds as industrial raw materials and refine into valuable products. Other applications of industrial biotechnology are for example cell monitoring, culturing, fermentation processes and process development. (Tekes, 2012, 6)

Industrial biotechnology can be viewed as a key enabling technology to develop sustainable solutions for industries through biological resources and bio-based processes. In the recent years, biofuels have been a research trend in Finland but today, further emphasis has been put on bio-based chemicals. Through biotechnological processes, the dependence on oil can be reduced. Products traditionally manufactured from oil, such as fuels and plastics, can with biotechnology be made from renewable resources that could otherwise be considered useless for utilization. These are for instance non-edible parts of plants or pulp and paper factories' wastes (also often referred to as side streams). (Tekes, 2012, 4)

2.2.2. Pharmaceutical Biotechnology and Diagnostics

One aspect of pharmaceutical biotechnology is the research and development of new medicines and vaccines through the utilization of biotechnology. By harnessing microbes to the development of medicine proteins by using gene technology, more effective medicines may be developed faster and with fewer expenses. Insulin, used for the treatment of diabetes,

is an example of a biotechnologically manufactured medicine that has been used for years. (Tekes, 2006, 8) In general, diseases may be prevented and understood through modern biotechnology.

Gene therapy is commonly used as a treatment for curing sick cells by transferring curing genes to the cells. Through biological organisms complex medicine molecules, such as proteins and antibodies which the human body develops itself, can be produced. This is not possible with traditional synthetic chemistry. Stem cells are seen as a potential solution for difficult diseases. The utilization of plant based ingredients for medicines has also been a current area of research. (Tekes, 2006, 8)

2.3. Biotechnological Research in Finland

In Finland, there are many internationally recognized research groups in the field of biotechnology. Based on their work as well as spin-offs from large companies, several biotechnology companies have been founded in the recent years. Research in the field is conducted in several universities, universities of applied sciences and the government's research centers. The research centers and universities are most often located in the large cities, whereas the smaller companies are often located near them. This originates from the technical support and services the technology centers often offer to start-ups and small companies. (Tekes, 2006, 15-17)

There are currently six technology centers in Finland where biotechnology is emphasized. These are mainly publicly funded, which implies that the Finnish government has high expectations of the industry. There are also approximately 150 private companies in the sector. Since Finland is a small country, though emphasis has been put on the industry, the research activities are still low compared to many other industrial countries. (Kivinen & Varelius, 2003, 158-159) The domestic markets are small and therefore internationalization is important in the industry especially for smaller companies (Helminen, 2006b).

Through biotechnology, Finland has all the possibilities of gaining competitive advantage and in that way generally improving quality of life and bearing its part of global responsibility. It has high quality research, rich natural resources and strong know-how (Helminen, 2006b). The problem lies in commercializing and therefore also making the industry and its research profitable. It has been common to sell inventions abroad before truly benefitting of them. (VNK, 2010, 9-10, 51)

3. Managing Technological Innovations

In this chapter, the concept of innovation is first defined and introduced. Thereafter the nature of innovations generally and in the field of biotechnology are discussed through previous research. Finally, in order to explain the nature of the innovation process and its modifications in different time periods, two processes from different decades are introduced and discussed.

3.1. The Concept and Definition of Innovation

In all its simplicity, an innovation is an element of novelty that adds commercial value (Narvekar & Jain, 2006, 176). Innovations may be for instance products, services, organizational, process-focused or in the field of marketing (Tekes, 2004, 7). Innovations are seldom well-behaved and simple. They are commonly neither smooth nor linear, but rather hard to measure and complex. (Kline & Rosenberg, 1986, 285) Traditionally, the concept of innovation has been used to refer to new scientific discoveries, whereas more recently it has been seen to cover also inventions with viable marketing applications (Kivinen & Varelius, 2003, 3). OECD defines innovation as follows: "Innovation is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology based invention which leads to the development, production, and marketing aiming at the commercial success of the invention."

Galanakis (2006) had a broader view of the concept: "Innovation is defined as an iterative process initiated by the perception of a new market and/or new service opportunity for a technology based invention which lead to the development, production, and marketing aiming at the commercial success of the invention." As these definitions show, technology is strongly combined to the whole concept of innovation, although there are also non-technological (such as marketing) innovations (OECD, 2010, 35). The term "technology" is still often used as a synonym for innovation though (Rogers, 2003, 139). Technology may refer to for instance know-how, techniques, patented or otherwise proprietary processes, materials, equipment or systems (Siegel et al., 1995, 19) According to Choi and Kim (2008), technological innovation can be described as an outcome of a dynamic, continuous process, which evolves from actions that take place in a certain period of time. They see technological innovation as a combination of product and process innovation (Choi & Kim, 2008, 126).

This study focuses on technology and R&D based innovations, though some others are also briefly introduced. In this study innovation is mostly seen as an invention that brings something new and significant to the markets. Its value can be measured commercially, but the value can also be for instance in easing peoples' everyday life. In this study an innovation is seen to be most often defined by its success, acceptance and acknowledgment on the markets – without positive response it is merely an invention.

The difference between creation, invention and innovation should also be acknowledged. The concepts can be viewed from the market relevance and market acceptance perspective. Innovation has high market acceptance and relevance, whereas in creations they are still low. (Kusiak, 2006, 1) According to Schön (1967), inventors create new technology whereas innovators bring the inventions to use.

3.2. Innovations Generally

Innovations are complex, non-linear and variegated. Their impact and importance are often difficult to measure, for they have no obvious or uniform dimensionality. The core of innovation is in combining both the commercial and the technological aspects. According to Kline and Rosenberg (1986), the dimension that organizes innovations is uncertainty. In the field of biotechnology, uncertainty is exceptionally high compared to for instance electronics; the latter is often barely about enhancing existing products. The amount of uncertainty involved is said to strongly correlate with the amount of advance proposed in the innovation given. The state of knowledge of the science or technology the innovation is based on also strongly affects the amount of time and resources required for the innovation. (Kline & Rosenberg, 1986, 285-295; Renko et al., 2006, 349)

Innovations may stem from the most unpredictable places, for instance company diversifications or new employees (Porter, 1990, 75). Drucker (1985) introduces seven sources of innovation opportunity: *The Unexpected* (such as success, failure, outside event), *Incongruities* (between assumed and true reality), *Process Need, Industry and Market Structures* (unexpected changes), *Demographics* (population changes), *Changes in Perception and New Knowledge* (scientific and nonscientific). Porter (1990) claims, that innovations are mostly the result of unusual effort. He argues, that innovations succeed best under pressure, for fear of loss often proves more powerful than the hope of gain. (Porter, 1990, 75)

Innovations are often divided according to their nature into incremental and radical innovations. Most often innovations are incremental, signifying that they rather make slight enhantments to former innovations or processes. Radical innovations are rare; they disrupt old standards of activity and revolutionize technology. They often do not develop through market or other research; visionaires are needed (Pulkkinen, 2003, 23). Truly significant innovations are often ahead of their time creating unexpected new markets (Kline & Rosenberg, 1986, 303). Radical innovations alter the status quota of companies, for corporations with older standards of activity will loose compatibility through the success of competitors' innovations. (Hautamäki, 2008, 107-108) The chart below (see Figure 3) introduces a theory for the direction of the different processes of innovation in the market potential axis. The chart shows the difference between radical and incremental innovations: product development may lead to radical innovations which open new areas of application and expand market potential. Thereafter, when the innovation is made into a product, its market potential grows as it becomes more incremental. If the innovation is displaced by other, competing solutions, its market potential naturally decreases. (Tekes, 2004, 32)

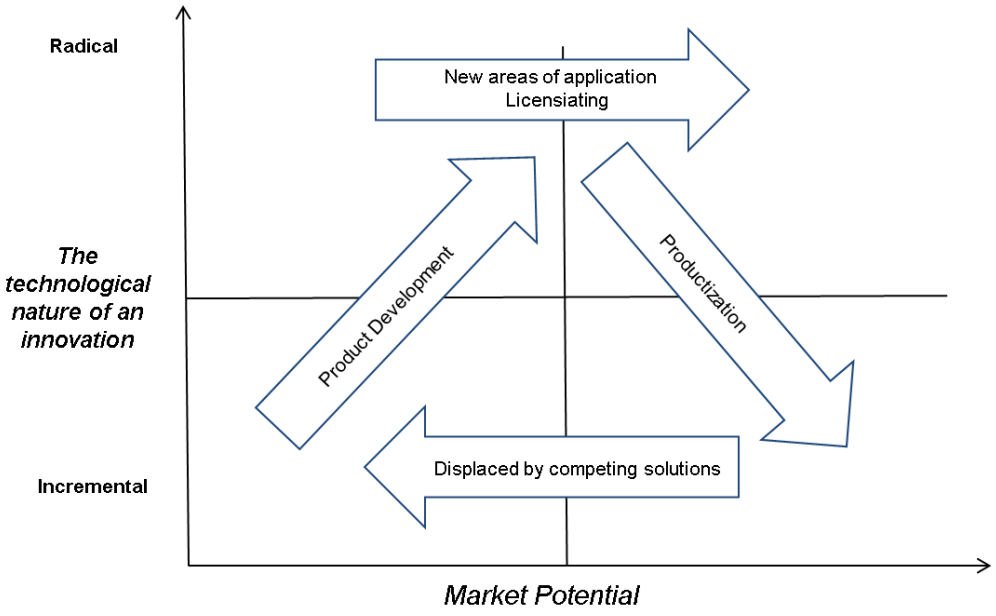

Figure 3. Marketing potential/innovation fourfield (Adapted from Tekes, 32, 2004)

A theory created by Christensen (1997) introduces the term disruptive innovations and further divides them into low-end and new market creative innovations. Disruptive innovations bring novel value and open new dimensions to previous innovations. Significant about Christensen's theory (the innovators dilemma) is the claim that large companies are not able to create disruptive innovations, for they are too fixed on their old technology and customers.

Innovations may also be non-technological; for instance affiliating in marketing, social and organizational structures. They have had a growing significance in countries with little possibilities to engage in technological R&D and innovate through that. (OECD, 2010, 35) Social innovations are also seen to have growing importance. These are innovations that progress by examining a problem through a different perspective. In that way new methods, devices, politics, networks or combinations of these may be developed. Altough technological innovations enhance social development, also social innovations are crucial in order to fully benefit from the technological innovations. (Valtion tiede- ja teknologianeuvosto, 2003, 25)

The success of Finland's economy is mainly due to the virtuous innovation environment and well-functioning institutions. Recently, Finland has been one of the greatest utilizers of natural resources, which are also one of its biggest exports (Kuisma, 2011, 38). Finland has risen to be one of the world leaders in high-technology, compatibility has grown and numerous financial investments have been placed on the research and development. (Hautamäki, 2008, 11)

Globalization raises challenges through increasing competition and rapid changes in objectives and circumstances. Finland should compete with quality and be strategically agile. (Hautamäki, 2008, 11) In the future, emphasis should be put on but energy sufficiency, also on the replacement of non-sustainable materials with great process-based emissions to more sustainable, emission-intensive solutions (Kuisma, 2011, 39). In global competition Finland's strengths are the basic factors of high-class knowledge and know-how – education- and research systems, competent work force and good infrastructure (Valtion tiede- ja teknologianeuvosto, 2003, 12). The concept of innovation is broader than formerly understood; it holds within but new products, also services and activity standards that enhance the organization's compatibility. (Hautamäki, 2008, 11, 43)

3.3. The Nature of Innovations in Biotechnology

Biotechnology is a very innovative field by nature. The innovation process is described to be very complex in the industry, due to the whole innovation process acquiring several sector players requiring long developing times (Renko, 2008, 349). The companies in the industry put great effort in developing new innovations, but it is claimed that they excessively rely on technology-push. This means that innovations may be created without the consideration of the customers' needs, by merely beginning the creation when advancements in science and

technology occur. Thereafter the innovation is pushed to markets through R&D and production and sales functions. (Friedman, 2009, 1; Kusiak, 2007, 2)

According to Renko et al. (2008), biotechnology firms frequently cross traditional industry boundaries by having different actors involved in the origins, development and use of innovations. These companies also operate simultaneously in several areas of the field. The research conducted by Renko et al. set forth the following figure (see Figure 4.), which introduces sources, development, and use of innovations in biotechnology. Sources of innovations in biotechnology are seen to be based on science, such as physics, biology and medicine. Several paths for the development of the innovation were found – it could be developed by for instance universities, suppliers, business consultants or technology partners. Renko et al. (2008) group the use of biotechnological innovations under three classes: Medicine, Agriculture and Environmental applications.

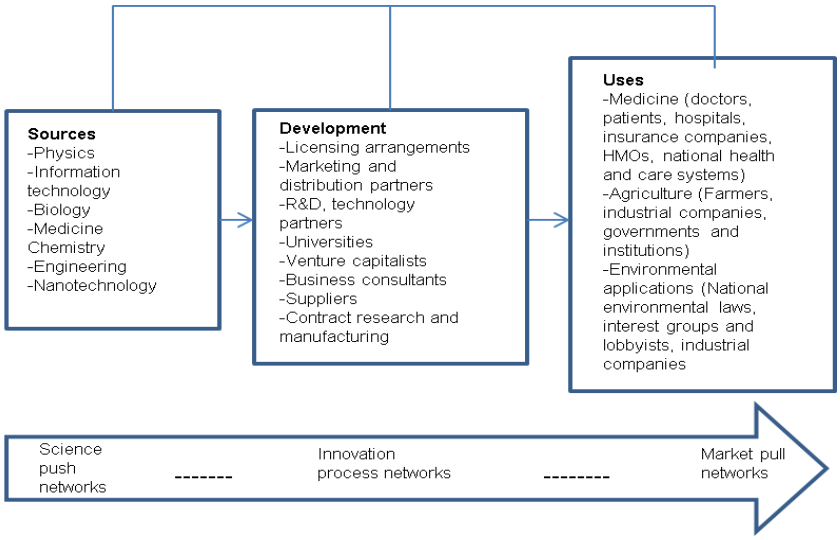

Figure 4. Sources, development and use of innovations in modern biotechnology (Adapted from Renko et al., 2008, 358)

In biotechnological innovations, renewability is a goal both in the beginning and in the end of the life cycle. Therefore products are often already in the development process viewed through the perspective of the whole life cycle. (Kuisma, 2011, 38) The field of biotechnology has been driven forward through public investments, which have enabled better scientific research. This research has produced knowledge with the potential to generate direct industrial applications. (Renko et al., 2008, 350)

3.4. The Innovation Process Models

The development of technology and economy has led to trends modifying the innovation process models through time. This has led to the need of versatile innovations in different time periods. (Elite, 2006, 24-25) The concept of innovation is a continuously researched, popular and important subject, mainly due to the developments in competition, globalization and technology (McAdam, 2005). Porter (1990) argues that a company which stops improving and innovating will inevitably be overtaken by competitors. The rate of technological change is rapid and may be seen as a challenge for technological companies (Narvekar & Jain, 2006, 174). Rothwell (1994) divides the innovation processes into five generations beginning from the 1950's putting emphasis on the societal and economical happenings on each decade. The early innovation models were linear whereas later, more emphasis was put on the market-pull technology-push concept (Narvekar & Jain, 2006, 176). Two models from different time fragments are introduced in the following chapters in order to demonstrate the way in which time changes the models.

3.4.1. The Innovation-Development Process

The model introduced in this section (see Figure 5) was first developed by Rogers in the year 1962 and it is one of the most traditional theories in the field. As previously mentioned, the early innovation process models were linear.

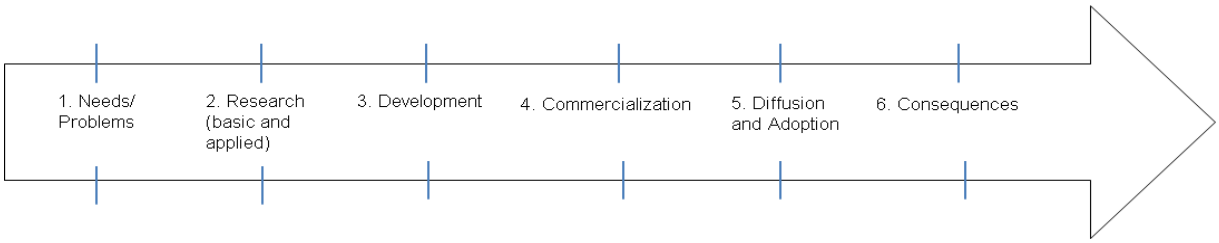

Figure 5. Six Main Stages in the Innovation-Decision Process (Based on Rogers, 2003, 138)

The innovation-development process describes the whole set of actions a company goes through when producing an innovation; from the recognition of a need or problem, to the consequences of the innovation. It is important to acknowledge that the stages do not always occur in this particular order and in some scenarios certain stages may be skipped. In addition, not all innovations arise through research and development. (Rogers, 2003, 138-139)

The first stage of the process is the recognition of a problem or need. The significance of defining the customers' needs and listening to them is often emphasized in literature and studies (For instance Pulkkinen, 2002; Simula et al., 2009; Hjelt et al., 2006). The recognition of problems and needs often stimulate the beginning of research activities in order to find a solution to the problem or need. In other words, recognition activates the innovation process. The second stage is basic and applied research. Basic research refers to original investigations that do not have part in any particular problem solving. Applied research on the other hand is conducted for some specified reason. (Rogers, 2003, 137-140) According to the current innovation research, the difference between basic research and applied research is often hard to identify from the innovation function perspective (Hjelt et al., 2006, 5). Rogers (2003) claims that an invention is often a result of a sequence of basic research, followed by applied research and leading to development.

In this model, research and development have been separated for it is argued that research always precedes development in the innovation-development process. Therefor they can be, at least conceptually, considered as different phases. The third stage, development, is the processing of the idea into a form in which it is thought to attract possible adopters. The ability to control product development speed is generally an important core competence, for being timely and fast compared to competitors is most often seen advantageous from the profitability point of view (Rothwell, 1994, 13). Commercialization follows this stage. It is the conversion of an idea into the form of a product or service in order to be sold at a marketplace (Rogers, 2003, 146-152). Chiesa and Frattini (2011) claim that commercialization is the most critical stage of the technological innovation process mainly due to the high risks and costs required. Commercialization is further discussed in the following chapter.

The fifth stage in the model is diffusion and adoption. Diffusion is a special type of communication process in which a specific innovation is transmitted through certain channels to the members of a social system in a certain time period. The point at which the innovation is diffused to possible adopters is according to Rogers (2003) one of the most crucial parts of the whole process. There is often pressure to diffuse as soon as possible, whereas in some cases it is more efficient to wait and not rush in the process. The final phase of the process is the consequences of an innovation. These are the changes that individuals or social systems discover or go through after the adoption or rejection of the new innovation. (Rogers, 2003, 152-157)

3.4.2. The Chain-Linked Model of Innovation

The Chain-Linked Model of Innovation (see Figure 6) was introduced by Kline and Rosenberg in 1986, and it is said to be an improved model to the ones previously published of concept of innovation. The authors claim it to give a more thorough picture of the complex process of innovation. The model has a lot of similar characteristics to the previously introduced model, but the one in question puts focus also on the importance of feedback and the different information transfers from one organizational structure to another. (Kline & Rosenberg, 1986, 289)

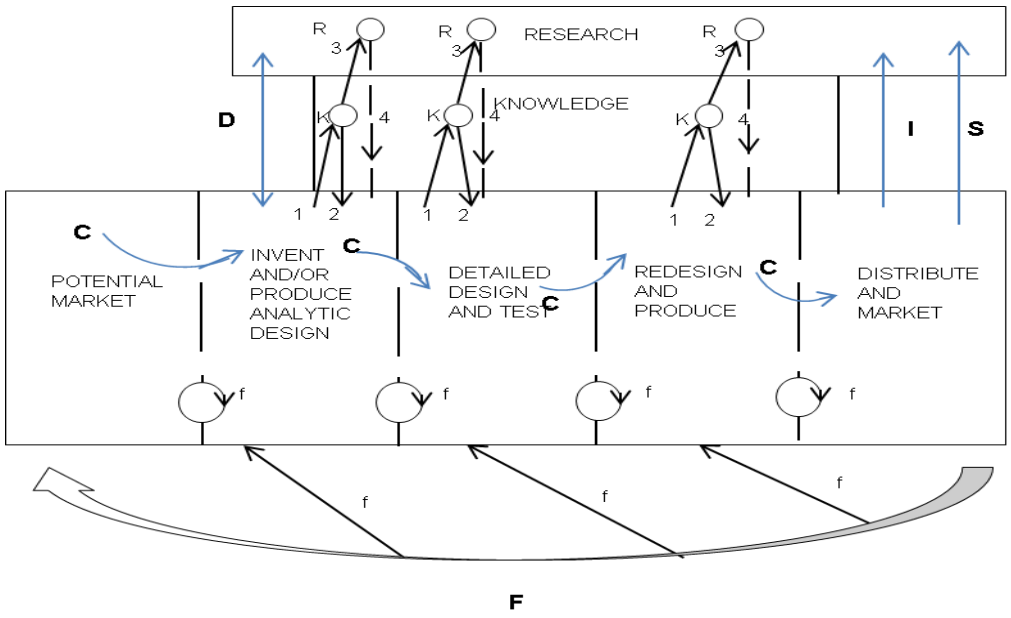

Figure 6. The chain-linked model of innovation showing the flow paths of information and cooperation. (Kline & Rosenberg, 1986, 290)

Symbols on arrows: C= central-chain-of-innovation; f= feedback loops; F= particularly important feedback.

K-R: Links through knowledge to research and return paths. If problem solved at node K, link 3 to R not activated. Return from research (link 4) is problematic – therefore dashed line.

D: Direct link to and from research from problems in invention and design

I: Support of scientific research by instruments, machines, tools and procedures of technology.

S: Support of research in sciences underlying product area to gain information directly and by monitoring outside work. The information obtained may apply anywhere along the chain

In the model (see Figure 6), there are not one but five paths in the innovation process. The first path is shown by the arrows marked “C”. These indicate the central path of innovation,

beginning from design, continuing to development and production and ending in marketing. The second path is the important one of feedback. These are marked with “F” and “f”, where the capital letters indicate the most important feedback. As the model in figure 6 shows, feedback is significant in every phase of the model making improvement possible in the next round of design. In this model, technology push and pull are claimed artificial, for each market need entering the innovation cycle leads through time to a new design, which, if successful, leads through time to new market conditions. (Kline & Rosenberg, 1986, 289-290)

The model is named the “chain-linked-model” because of the arrow “D” and links “K-R”, which visualize the linkage between science and innovation that can be used when necessary. It is essential to understand the linkage between science and the development process, whereas it should be noticed that science may be divided into two parts. When a problem is confronted in the innovation process, known science; knowledge, is utilized. Only if this fails, the innovator must turn to the second part of science, research. (Kline & Rosenberg, 1986, 290-291)

4. Commercialization of Technology

In this chapter, commercialization is studied as a process through publications and literature. At first, the concept is introduced and defined after which its necessity is discussed. Thereafter the commercialization process is viewed based on recent literature. Finally, the measurement of success and the main challenges are conversed based on earlier research.

4.1. The Definition and Concept of Commercialization

Commercialization is a broad and commonly mistakenly understood concept, which occasionally is understood as non-scientific. Rogers (2003), defines commercialization as the "production, manufacturing, packaging, marketing and distribution of a product that embodies an innovation". It is at the intersection of innovation and entrepreneurship, where it comprises processes and activities combining the gap between economic value creation and economic value realization (Prebble, de Waal & de Groot, 2008, 312). Komkov and Bondareca (2007) see commercialization as "a process of allocating means for innovations and controlling step-by-step their spending, including the evaluation and commissioning of completed and industrially adjusted results of innovation activities".

In this study commercialization refers primarily to the process of further monitoring inventions based on R&D into products or services and getting these on the markets – turning them into innovations. In other words, commercialization is the whole process, in which an idea turns into new business (Tekes, 2006, 3); the realization of a vision based on either new or old ideas (Siegel, Hansén & Pellas, 1995, 18). The linkage between commercialization and innovation is visible and understandable through the literature related – commercialization is often necessary in order to make an invention an innovation and furthermore, successful. It comes in the picture in the beginning of the innovation process, when a new idea is identified potential and follows through the whole innovation process to the adaption to markets and all the way to life cycle evaluation (Simula et al., 2009, 41).

4.2. The Needs and Objectives of Organizing Commercialization

Commercialization is important in the many aspects of benefiting from research. Successful implementing of commercialization may at best reduce a firm's costs, increase revenues and

impact positively on key ratios (Rogers & Knemeyer, 2004, 54). Whether it is research results, products or services, all of them need to be turned profitable in order to maintain compatibility in the economy and markets. In general, profiting from the results of research holds within several aspects – the profiting may be economical, increasing general knowledge, supporting societal decision-making or other. Therefore, when the question is about commercial profiting, this is only one aspect in the whole profiting of research. (Kankaala, Kutinlahti & Törmälä, 2007, 29)

According to an empirical research conducted by Palmberg (2002), shorter commercialization times correlate significantly with shorter break-even times and therefore it can be said that commercialization and break-even times are related. This implies that in order to gain further value from a product or service, commercialization should be executed and furthermore, well planned. Although the correlation was found, the estimated values of commercialization durations had no apparent impact on the length of break-even durations. A successful innovation may be seen as a joint contribution of these two. (Palmberg, 2002, 59-60) Cooper and Kleinschmidt (1986) also emphasize the importance of paying further attention to the way innovations and new products in general are conceived, developed and commercialized. For an innovation to be successful on the markets, true customer value must also be understood. Both in gaining new customers and customer satisfaction, the understanding, communication and conducting of the value form one important section. (Simula et al., 2009, 11)

In the high-technology markets, even fully commercialized products often fail. The decisions in the commercializing of high-technology are claimed to have impact on this, but no clear understanding of the correlation has yet been developed. Decisions made in the commercialization process are for instance timing, positioning and the choice of the distribution channels. (Chiesa & Frattini, 2011, 438) In addition, a lot of emphasis should be placed particularly on sales, marketing, financing and the know-how and compatibility of international business (Tekes, 2004, 32).

4.3. Modes of Technology Transfer

The commercialization process for technological innovations may also be called technological transfer. Upstill and Symington (2002), introduce three different modes for the transfer of technology and applications of the modes from the public research agencies to the business sector (see Figure 7).

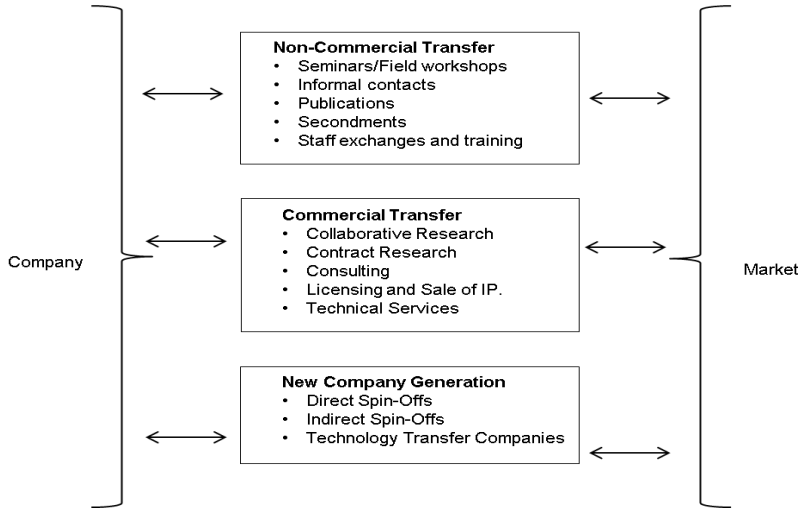

Figure 7. Modes of Technology Transfer. (Adapted from Upstill & Symington, 2002, 234)

The first mode is Non-Commercial Transfer, which occurs without any contractual agreements between the company and customer. The transferred technology is often meant for a larger audience and for common use, for the modes for transfer are for instance publications and seminars. The second mode mentioned is the Commercial Transfer. This differs from the previous in the way that the transfer also aims for profit. The methods are contractual and the transfer is of intellectual property. The third mode is New Company Generation which introduces the ways technology can be transferred to new commercial entities. (Upstill & Symington, 2002, 234)

The decision of choosing the mode of technology transfer or commercialization depends on the organization type, industry, character and complexity. The commercialization methods are different if a company is small with just a few products compared to being an international company functioning in many industries. (Simula et al., 2009, 45) The choosing of the correct commercialization mode such as licensing, consulting and the selling of ownership depends on the organizational type (Markman, Siegel & Wright, 2008, 1418-1419).

4.4. The Commercialization Process

Based on their empirical research, Prebble et al. (2008) divided the development of the commercialization process into an involvement/complexity matrix, where the functions and decisions required depend on the amount of decision involvement and complexity (see Figure 8). The authors claim that all of the individual decisions made in the development of the commercialization process can be connected to one of these central themes also presented in

the matrix: *Technical and Operational Themes* (e.g. communication, relationship management, internal buy in), *Strategic Themes* (e.g. desired growth rate, infrastructure, markets, products, competition, positioning) and *Commercial Themes* (e.g. governance, intellectual property, funding). These perspectives are required at all stages of the new product development and commercialization process. (Prebble et al., 2008, 315)

		Decision Involvement: Low	Decision Involvement: High
Decision Complexity	Low	Technical and Operational e.g. meeting schedule	Technical and Operational e.g. determine fit with company capability
	High	Commercial e.g. determining economic life of technology	Strategic e.g. describing the value chain

Figure 8. The decision involvement/complexity matrix (Prebble et al., 2006, 315)

Novel about the research conducted by Prebble et al. (2008) is the 'commercial' dimension. Although new to the matrix, it was seen by the interviewees of the research discussed as the most critical dimension to commercialization. (Prebble et al., 2008, 315)

Hjelt et al. (2006) present the commercialization process as a four-phase model (see Figure 9). They found the partition of the research process into smaller sections to enhance understanding. The model indicates the path of a singular idea's refinement into a commercialized innovation. (Hjelt et al., 2006, 5)

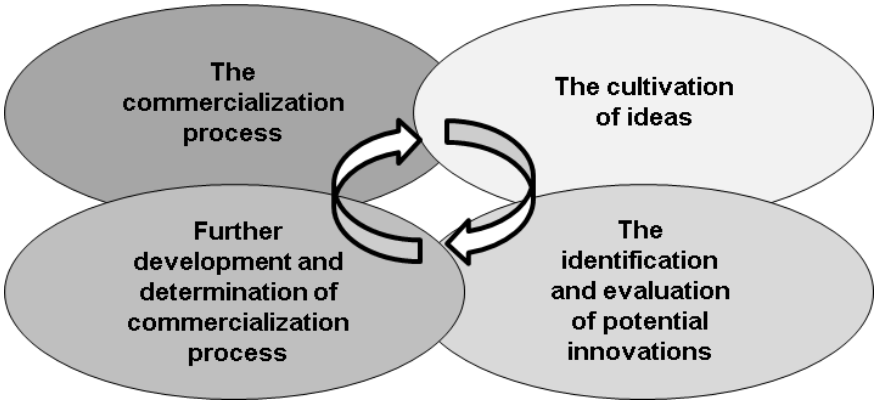

Figure 9. The four phases of the commercialization process (Adapted from Hjelt et al., 2006, 6)

The first phase in the model is the cultivation of ideas. This refers to the unprocessed ideas that are born through research. At this point these ideas are still raw and it is difficult to

identify their potentiality. These raw ideas may develop through any kind of research. The sources of innovation are further discussed in the chapter 3.2. of the study. Thereafter the potential innovations are identified and evaluated. At this point an idea is identified as a prospective innovation with market potential and is taken under further evaluation. After identification the innovation must be rapidly protected with patents or other methods. (Hjelt et al., 2006, 5)

Subsequently the idea is further developed and the commercialization process is determined. Further development may include market analysis, protection, further development of technology, testing and other functions necessary before commercialization. This further development produces knowledge based on which the choosing of the best commercialization process is justified. (Hjelt et al., 2006, 5)

The final phase is commercialization which may be conducted in several ways. Potential or further developed innovations may proceed to markets through for instance licensing, selling of ownership or by founding a company. (Hjelt et al., 2006, 5) These Commercial Transfer modes are also introduced in Figure 7 by Upstill and Symington (2002).

4.5. Measuring Success

The measuring of commercialization success is difficult and complex. The indicators can be divided into three classes: financial, technological and market based indicators. The dilemma in measuring success is that if calculated through only financial key ratios such as the market percent of the product, revenue and sales volume, there is no feedback on the factors that lead to the results. Indicators that also should be noticed and utilized are those concerning customer satisfaction and the markets. These are factors such as response and satisfaction concerning the product, quality and performance. Simula et al. (2009) recommend the utilization of indicators from all the mentioned classes. This could be for instance the combination of customer satisfaction, profitability, profits and product performance. (Simula et al., 2009, 98-100)

In this study, the concept of a successful innovation has been discussed but it should be acknowledged that failure is also difficult to define. A product/service may at first seem successful but later turn out to be un-profitable. (Simula et al., 2009, 14) Cooper and Kleinschmidt (1986) found that innovation success is closely linked to the execution of the activities related and the completeness of the process. Based on their empirical study, they

suggest that companies should pay more attention to market studies, initial screening activities and preliminary market assessment in order to make innovation and commercialization success more probable. (Cooper & Kleinschmidt, 1986, 84)

4.6. The Challenges of Commercialization

Commercialization is often thought to happen by itself, after the product/service is developed. Most often, this certainly is not the case. Although it is simple to state that commercialization success factors are for instance rapidness in movement and functioning in several markets, wide use of versatile technology and advertising more, in practice these factors are difficult to accomplish. (Simula et al., 2009, 15-16).

Both Kline & Rosenberg (1986) and Chiesa & Frattini (2011) point out the high development costs of high technology products or processes. They explain these to raise the financial risk involved, which on the other hand is a threat for a company's ability to overtake innovation processes in the future. The development costs correlate with the development time, which in high technology is often very long. (Kline & Rosenberg, 1986, 301-302) Bianchi et al. (2011) found the keep-or-sell decision and its timing to be very risky and challenging especially for large companies; improper exploitation could be harmful. Based on their research they also pointed out challenges concerning for instance the choice of partners, potential revenue and control of the process. (Bianchi et al., 2011, 21-22)

Upstill and Symington (2002) emphasize the challenges of measuring performance and maximizing the opportunity for potential new companies such as spin-offs to emerge. Komkov and Bondareva (2007) list as a challenge the development of a mechanism to centralize the financing of the commercialization process in potential innovations.

5. Perspectives to Commercialization: The Results of the Empirical Study

In this chapter the results of the empirical study are discussed and analyzed. At first the case company and the interviewees are introduced after which the areas that rose up from the interviews are discussed. The main emphasis is on the challenge chapter, which has been divided to sections according to what the interviewees found important. Thereafter, the ways of approaching these challenges are discussed based on the interviews. Finally, the empirical section is discussed in the light of the theories related and the findings are presented and analyzed.

5.1. VTT Technical Research Centre of Finland

VTT Technical Research Centre of Finland is a state-owned research centre. It is the largest multitechnological applied research organization in Northern Europe and it provides high-end technology solutions and innovation services. VTT is a matrix organization, which means that the organizational flow moves both horizontally and vertically, across sector boundaries. This can also be seen from the Group Structure (see Figure 10), where Business Solutions is inside the larger box, communicating with the other sectors.

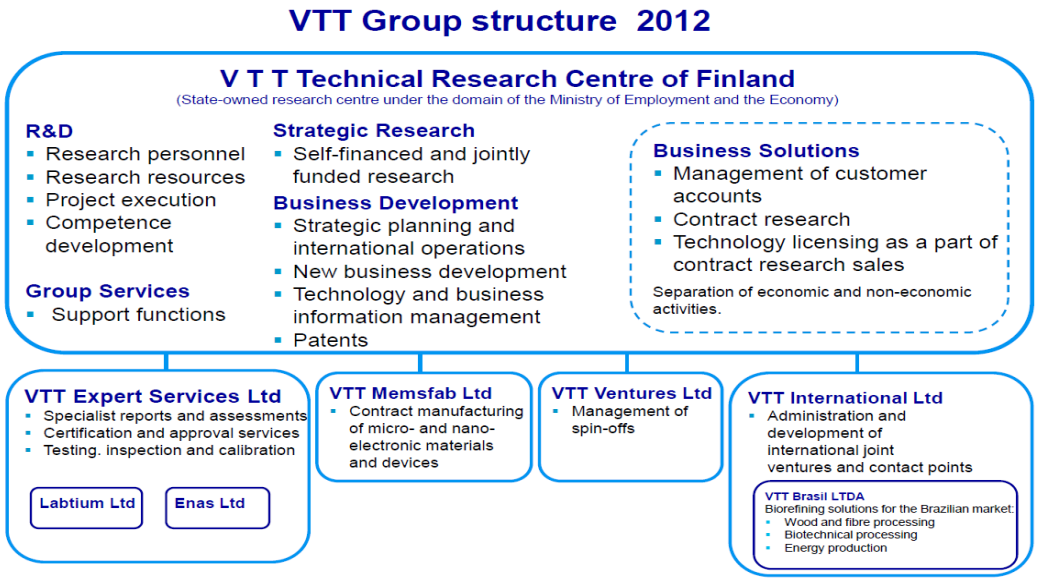

Figure 10. The Group Structure of VTT. (Adapted from VTT, 2012c)

VTT has research, technologies, products, services and versatile applications in many industries in addition to Biotechnology, such as for instance Energy, ICT, Real Estate,

Electronics and Machines and Vehicles. The organization was established in the year 1942 and it has close to 3000 personnel. (VTT, 2012a) VTT:s main tasks are R&D, technology transfer and the testing of technologies. Their projects are mainly commercial, joint or self-financed. (VTT, 2012b) The commercial projects have been emphasized more in the past years, and in the year 2011 28% of organizational profit came from the private sector (VTT, 2012d).

5.1.1. The Interviewees

Three employees of VTT were interviewed for this study, of which two work in the Pharmaceutical and Diagnostics –sector (here on referred to as Pharma) and one in Industrial Biotechnology. The two interviewees from Pharma were positioned as Key Account Manager and Technology Manager, whereas the interviewee from the Industrial Biotechnology -sector was also a Key Account Manager. The interviewees were chosen due to their emphasized interest in commercialization and expertise in their particular area of application. One goal was also to find versatile viewpoints in order to answer the research question thoroughly. Therefore employees from two different areas of application and position were chosen for interviews.

The Key Account Managers are part of the Business Solutions and their main aim is to sell the high technology R&D creates, develop new customer relationships and keep up the co-operation with older ones. This involves commercialization, marketing and other commercial activities in order to modify the complex technology into a form where it can be introduced to potential customers. The high technology that is commercialized and sold in Pharma is mainly concepts that assist the product development of the customer. This includes for instance different molecule methods that are utilized in versatile medicine research and diagnostics. VTT has also services in Pharma that include measurements with analysis, but mostly they deal with concepts. In Industrial Biotechnology the services are for instance protein production and metabolic engineering. These are also concepts that are designed to help the customer company in product development processes. The customer company may for instance not have the equipment, know-how or other resources to conduct these procedures.

The Technology Manager leads a knowledge center of approximately 120 people, which includes the areas of biotechnology for health and well-being. This is mainly medicine

development, diagnostics and biomarker search. The Key Account Manager of Pharma is in the organizational structure one of these subordinates.

In the Pharma –industry at VTT the main customers are either pharma companies that develop new medicines, do inventive product development or R&D. Some of the customers are molecule diagnostic companies that utilize antibody technologies in order to indicate the concentration or phase of some molecule. In Industrial Biotechnology the customers consist a great deal of large chemistry, biotechnology and biochemistry companies and small start-ups. Mostly the companies are international and foreign in both industries discussed, but there are also Finnish companies in co-operation.

5.2. The Background of Innovating and Commercialization in Biotechnology

The interviewees found that innovation could not be called a systematic and controlled process but rather an outcome of individuals that are innovative. One of the interviewees argued that inventing is not a process of the conscious mind but rather something that happens when the mind is given space to use the subconscious part. At least in the case of radical innovations, they cannot be forced out through some process – they devolve when least expected. Basic research gives a base for all of this to happen though.

Commercialization is a process that has in the past years come to be more noticed and emphasized at VTT. According to one of the interviewees, the organization has been moving from the strict research perspective for some years now.

”In these fourteen years this (the orientation) has changed significantly because when I came here this (VTT) was very research oriented. In the past six years VTT has continually turned very strongly more and more (towards emphasizing the commercial perspective also). It was very research oriented and of course still is; the question is should it be and how much.”

The interviewees found the research orientation to be remains from the organization’s history, when VTT was more strictly a research center with fewer commercial projects. Currently the organization has aligned that twenty percent of funding should come from private customers. The commercialization ideology has developed through the initiatives of individuals who are interested in the subject.

5.3. The Benefits of Commercialization

All the interviewees found commercialization to be very significant but from the company's and employee's also the customer's perspective. They thought that commercialization and sales go hand in hand. Especially in the field of biotechnology where very complex high-technology is researched and commercialized, it is important to find a way to put the invention into a clear form where it can be commonly understood as a product or service. Commercialization in this industry turns something abstract such as research results, into something concrete. In a way it can be thought of as the creation of something to sell. For the organization, this means more profit and product development funding. In addition, through commercialization and the measuring and evaluation of Return on Investment (ROI) a company can learn to invest more wisely in projects. Investing more wisely brings most often savings and added value for money for the company.

From the employee's point of view, commercialization was seen most of all as a motivation factor. For researchers, seeing their own name in a publication is important. It is often considered as a merit and an accomplishment. Therefore seeing the whole concreteness of a product in a store and knowing that their research and hard work is part of that product is said to also be very rewarding.

"There is no better validation for our work than seeing that our research results end up in a form in which they can help people or make the world a better place in some way."

"You can see your own research results in a company's product. It's a motivating thing."

From the customer perspective, the impact and benefits of commercialization depend on the customer type. Since the interviewees sell mostly concepts or components to customers in the middle of the value chain, they saw that commercialization in a way made ready markets for the customer. The product has already been put thought on and that makes it easier for the customer to take it further, towards the end customer. Especially in biotechnology, it is possible the customer does not even know what opportunities for instance enzymes have to offer to their business. Hence the customer might not even have the sufficient knowledge to ask for an application of biotechnology.

”If the invention has been turned into a clear product or solution it is easier for the customer to approach and understand it. Through this the customer can possibly evaluate the benefits it can bring to their business.”

For the end customer commercialization brings a kind of certainty, since a product that has been strictly considered and evaluated has often better qualities and will stay on the markets for a longer period of time. It is perhaps easier for the customer to trust the product.

The customer perspective was found very significant throughout the whole innovation and commercialization processes. When viewing the benefits of the company, it was emphasized that the customers benefit from the deal should also be thought of and concrete.

”I build win-wins. My goal is always that by doing business with us our customer makes a positive ROI. This has been proven in several of my cases. They have for instance grown their market share, developed a new product or been able to price a product higher.”

5.4. The Evaluation and Managing of Commercialization

At VTT there are three operative sectors that are involved in the commercialization processes: Research and Development, Business Solutions and Business Development (See Figure 10). Research and Development is where the product and service innovating takes place. Business Development is a rather new sector, which for instance manages the Intellectual Property Rights (IPR) such as patents, copyrights and trademarks. The Business Solutions sector is mostly in charge of sales and its sidelines. The interviewees saw that all these sectors were crucial for the commercialization process and that the co-operation among these should be seamless. Most of the interviewees thought that the co-operation could be closer and more structured and organized. It was seen that currently the co-operation and its depth is mostly in the hands of the individuals involved.

Measuring commercialization was found very important by all of the interviewees. There should be some concrete validation that the innovation has been profitable. The using of Return on Investment (ROI) was emphasized by all of the interviewees as a good way to measure profitability but they found that in practice it could be used more. The financial perspective was not thought to be the only important factor of profitability. Especially in the pharma –industry, the development of something that could advance general wellbeing and health was found most important.

”It (the invention/innovation) should be either economically profitable meaning a positive ROI, or than bring something new and useful.”

5.5. The Challenges of Commercialization

The interviewees were unanimous about many issues concerning commercialization. Depending on their application area, some differences rose up, but generally they found the same matters important and challenging. In order to clarify the analysis, the challenges the interviewees brought up have been opened in this study under different main themes.

5.5.1. The Biotechnological Issues

Biotechnology is a difficult field to approach, understand and master due to its complexity. The field is also difficult to predict, which increases uncertainty. Compared to many other fields, the process from idea to product or service is exceptionally slow. This is very difficult to explain to the financiers and the upper management.

”When they (the upper management) are used to the ship industry or something else where the process from idea to product takes one and a half years whereas here in biotechnology it can take fifteen years, the quartile economy doesn’t really fit. The understanding of this is very difficult for the upper management and the financial input is often very big although the profits may also later be very big.”

”Well it can be said as in everything, risk and profit go hand in hand. Biotechnology is always high risk activity.”

The longer the process from idea to markets takes, the more expensive it is. Uncertainty is also present – there is often no guarantee of success even though the input is easily very large. Another challenge that is correlated to the process time is the difficulty of measuring the profitability of a product or service. The innovation should be very successful in order to pay back all the fifteen years of work and the other expenses associated. If in addition it is calculated that the successful invention should also pay for the failed ones, in many cases it can be seen unprofitable. The profits may also come in a longer period of time through for instance royalties and licenses. This may also complicate the measuring. The challenge in these issues is managing the financial risk: at which point should the idea be sold forwards? When sold at an early point the risk is minimized, whereas if followed through at the

company to the end product, the potential profit grows. In the latter case the risk of failure is always greater.

"It is difficult; if as an idea its value is for example 10€, after IPR it is 100€ and if you have proven it works its value is 1000€. After that it costs maybe 1000 times more when it's on the markets. It's an exponential curve – at first its value is very small and it grows only in the end when it's been proven working."

"It probably can't be a goal as such that compared to the workload it (the invention/innovation) would be profitable"

One of the interviewees brought up that Finnish people in general often do not have the courage to take risks in business. He found this to be a cultural factor; in the Finnish culture failure is thought of as almost shameful. He argued that this kind of fear of failure cannot lead to great results for often without risk there is no remarkable outcome.

"In a generalizing way it can be said that Finnish people do low risk projects with an average outcome, which leads to the results being boring and not interesting anyone."

When asked about the competitors in the industry, the interviewees found the question rather difficult, for in this case the competition depends more on the individual product or service. In Finland there is no other closely similar research center, so no straight competitor could be named. The interviewees did not see competition and competitors as one of the biggest challenges in the industry, as long as the product or service was developed based on the customers' needs.

"When we go and offer a customer a solution, sometimes there is no one else in the world who can offer the same deal. In most cases there is, but sometimes the situation is that we have no competition."

5.5.2. Mutual Goals and Funding

One of the greatest challenges that rose up in the interviews was the absence of a 'language' that all of the sectors involved could understand. Researchers often view the innovation from strictly the technological perspective whereas the Business Solutions –personnel have also the profitability and commercialization in mind. It was also unclear whether all the sectors were

consciously moving towards the same target. This was seen as a challenge because for commercialization to succeed, all the parties involved need to co-operate closely.

”Perhaps the biggest problem or challenge is the understanding of the same language. The researchers should understand the need. The innovators don’t support commercialization or if they do, they don’t understand it.”

All of the interviewees found commercialization and customer orientation very important, although simultaneously they saw that these factors were not in the main emphasis for researchers. This was seen to be due to the fact that researchers do not essentially need the commercial customers. They apply research money from for instance EU, Tekes *(the Finnish Funding Agency for Technology and Innovation)* and other public sectors. The researchers receive the money often based on their amount of publications in a certain period of time. Therefore it may be difficult for the researchers to see how they benefit from the commercial aspect, for it does not for instance enhance their research funding. On the other hand, Tekes encourages and in some cases demands also the commercial aspect in order to give funding.

Researchers do objective research of which the results should not and cannot be altered towards the wanted direction. They have their ‘researcher’s freedom’, which signifies that they do not have any bounds for instance towards the commercial, political or societal aspects. Therefore some researchers may even find commercialization of especially publicly funded research unethical and wrong:

”Some researchers don’t want to sell products or do commercial work because they find it to limit their researcher’s freedom. Some find it even unethical to do something commercial.”

It may be a somewhat old fashioned paradigm that no profit should be made from public funding. Although VTT is a not-for-profit organization, some profit must be made in order to keep the organization on its feet. The interviewees argued strictly against this claim concerning public funding as long as the question was not about supporting a private company with public money.

”It is different if it can be interpreted that public funding is used to support the business of some private company. That would be illegal, forbidden and a bad thing. But otherwise publicly funded research should in fact aim on commercialization. If we are honest, no research or product development is of any use to anyone before it has been turned into a commercialized product.”

According to the interviewees, compared to R&D, in Finland a lot less money is invested in commercialization and marketing in the field. R&D in Finland has been very well funded from the public sector, whereas commercialization is given approximately one tenth of that. It was also seen that more people could be working on the commercial side at VTT although it is difficult to find employees with a commercial background who also master the complex field of biotechnology.

"It is a researcher's nature that they want to go to the customer and tell in their own scientific way what significant they have invented. It is possible the customer won't understand at all. On the other hand the Key Account Manager may not have enough know-how to tell about all the technical details if the customers have for instance a specialist with them. That is a challenge."

Naturally, not all research aims to be commercialized. This research may be identified as the silent knowledge or core competence of the company. It may also be other basic research of which the aim is to support further research. One interviewee emphasized that although all research is not commercialized, it should not be conducted just for the sake of research, but there should be some driving motive behind.

"All kinds of new things are of course researched, but it would still be good to keep in mind that the research should have something, that could be utilized in practice."

In the Pharma –industry, special pressure was brought by tightening regulations from the government concerning medicines. This exceeds costs when simultaneously the markets pressure the end products to be constantly priced lower.

5.5.3. The Technology Push –effect and the Customer Perspective

Researchers are often, at least stereotypically and in biotechnology, highly academic scientists who are very oriented in their own research. If they came to discover some groundbreaking technology, they might rely on the exquisite qualities of their discovery and not see any necessity to commercialize. In most cases, this will not work, for before the technology is commercialized it may be very abstract for a third party.

"A general challenge is that the people who develop the technology can't see it through others' eyes. A kind of specialist's curse. People grow fond of their own projects and on the

other hand when you can't see it through someone else's eyes you can't describe and explain it simply enough – kind of unlearn."

The interviewees emphasized the importance of not moving technology first to the markets. They found the idea should evolve from a recognized need or problem in order to have competitive advantage. The interviewees found that part of their job is also to discover the customers' needs when they themselves may not even be able to identify them. One challenge that came up was the dilemma of the customers not sometimes wanting to tell their problems for they know that the technology developer also discusses with competitors. These factors lengthen the beginning of the innovation process because several contracts must be made and several discussions conducted before the true need or problem is even close to being uncovered.

"These are long and slow processes and conversations. The deeper we went in the conversations the closer we got to the real problem. The issue they (the customer company) at first stated to be their problem wasn't necessarily the one at all in the end."

The customer perspective was emphasized by all of the interviewees several times. One interviewee told on behalf of his own experience in previous positions in companies that the commercialization process often fails if the markets are approached from the perspective of 'what we want to sell'.

"Often there is very exquisite technology but it should be made to match the customers' needs. Okay, of course there are also examples of technologies the customers don't even know they need."

It was stated that this technology the customers do not even know they need is very rare – it is somewhat groundbreaking technology. For this kind of technology the commercialization need may be different. Generally it could be said that the commercialization process should be combined to the innovation process at an early stage.

"Perhaps people should turn their way of thinking the other way around so that commercialization comes first, hand in hand with innovating. Often the process has been going on for some time before commercialization is applied. The whole (commercialization) thought isn't present early enough in the process. That's the biggest problem."

5.6. Approaching the Challenges

All of the interviewees found that the challenges concerning commercialization should be approached. They also explained that some steps towards fixing these issues have already been taken. VTT has established a program, where employees from different sectors of the organization get together to discuss, share ideas and find solutions to the commercial challenges. This was found very beneficial but since the program is based on voluntarily taking part, the personnel that do not agree with some factors may not want to attend. This was seen as a shame, for these people also have so much to give to the program.

”Only they come who agree and with whom the thing works. It’s so difficult to get those involved who most should come – the ones that have the most to give and learn. The interested and enthusiastic ones come.”

At VTT the whole processes of innovation and commercialization have been attempted to bind together also by having the researchers move along in the process along with their idea. This way the know-how of all of the different sectors involved could be utilized throughout the whole process. The idea was found otherwise beneficial, except for the fact that if researchers are for years closely tied to one project, they have no time to do publications. This leads to the cutting of their research funding. The researchers have also been motivated to commercialization through perks although in some cases even money is not seen as a motivator.

”From IPR:s side we have guidance to innovating and commercialization rather well compared to many others. If an invention is patented and the patent is licensed to a customer the license income of 20% is divided between the inventors. In some cases this can be a very significant amount of money”

The interviewees found that in order to do real changes in the organizational culture, the initiative to emphasize commercialization should come from the upper management. They have identified the importance and according to the interviewees, work is been done towards this direction. This indicates that commercialization is at a better state at VTT than for instance at many universities. Through the upper managements initiative the attitudes could slowly modify towards a more common policy.

”If you want people to do something differently, it’s important to motivate them to it and inform why it’s smart to do something in another way than before.”

The question still remains, whether the common policy should altogether even be more commercial. One of the interviewees expressed the general concern of losing scientists with significant expertise and know-how due to the organization turning excessively commercial. The interviewees found that there could be a path somewhere in the middle, when both the commercial and the research perspectives would be emphasized in a suitable proportion.

To conclude, the interviewees found commercialization to be in a rather good state at VTT, although improvements could always be done. As in all large organizations, change is slow and attitudes difficult to alter. As one interviewee stated, with a personnel with expertise, good team spirit and a common language, commercialization and innovations can more often be turned into success. Change happens slowly through small steps, by doing a lot of little things right for a long time period.

“Then, even big ships sail in the right direction.”

5.7. Findings

The main factors the interviewees found challenging in the commercialization process were related to the complexity of the industry, commercial co-operation between different sectors inside the organization and developing from the customer perspective.

Although the interviewees found that the innovation process could not be systematic, structured and based on a model, they stated several similar phases to the ones Rogers (2003) (see Figure 5) and Kline and Rosenberg (1986) (see Figure 6) introduced in their innovation process models. This implies that both of the process models are logical and proceed without great effort, on their own weight. As in both of the models, the interviewees also emphasized the importance of beginning the innovating from the markets’ or customers’ needs or problems. The interviewees found important the co-operation between R&D, Business Solutions and Business Development, which can also be seen in Kline & Rosenberg’s model where the arrows point out the co-operation between research and the process. One interviewee also pointed out the importance of feedback, which was a significant part in Kline & Rosenberg’s model. If the feedback is not positive at every phase, the process should be reversed to the earlier phase and fixed.

One difference between the interviewees view and the innovation process models discussed was the linking of the commercialization process to the innovation process. The interviewees saw that commercialization should start from the very beginning of the innovation process and follow through the whole process hand in hand with innovating, not as a single phase as in both of the models discussed. Based on the interviews, the innovation and commercialization process would be a mixture of the two models (Figures 5 & 6) introduced in this study, with even more emphasis on customer perspective and co-operation.

Although Kline and Rosenberg (1986) talked about innovations in general, they pointed out in their research many similar factors to the ones the interviewees found challenging in the biotechnology industry. These were for instance long process times and expenses. The customer perspective and importance of co-operation, which the interviewees emphasized, were also brought up in many publications (for instance Siegel et al., 1995) One interesting factor was how many researchers (for instance Friedman, 2009; Kusiak, 2007; Narvekar & Jain, 2006) saw the technology push effect as common for companies with high-technology and the interviewees described the same phenomenon without using the term.

Several of the modes of technology transfer such as publications, licensing and other IPR introduced by Uphill & Symington (2002) (see Figure 7) were also mentioned by the interviewees. The commercialization process model developed by Hjelt et al. (2006) (see Figure 9) also fit the discussions in the interviews, although it could be seen as a rather simplified version of the process compared to what the interviewees discussed.

Common about all of these findings is that the interviewees had not familiarized themselves with the literature this study's theory is based on, but still often crossed or referred to the subjects without using the same terms. This implies that the theories are at least to some extent close to reality and perhaps do not require a lot of conscious application. On the other hand, perhaps the processes could be enhanced in the organization through the knowledge of these studies.

When comparing the previous research on the challenges of commercializing technological innovations and the empirical part of this study, an important factor not discussed in the publications but emphasized by the interviewees was the challenge of finding a common language between the different sectors involved in commercialization. Although co-operation was found important, a challenge was seen by the interviewees in commercial personnel and researchers heading towards a mutual goal and understanding each other.

6. Summary and Conclusions

Biotechnology is a complex field to approach, understand and sell, which makes the process of commercialization ever more important. Biotechnology is utilized in many industries through its five areas of application: Industrial, Pharmaceutical, Food, Plant and Environmental biotechnology. The industry is very innovative by nature, and innovations may stem from very versatile sources. They can be incremental or even radical, but that is often defined by the markets. The difference between an invention and innovation is also defined by the markets, for in its simplicity, an innovation is an invention with commercial success – commercial referring to also others than the financial aspect. It can be seen that before a complex high technology can be sold, it should at first be commercialized. Therefore commercialization is very important to be well planned and thought of. It is not an easy process especially in biotechnology, but rather risky, uncertain, expensive and extremely slow.

There have been many models to describe the innovation process through time – at first they were linear and later their complexity was tried to capture in the models. One certainty is that the innovation process is complex, non-linear, variegated and especially in the biotechnological industry, difficult to measure. This study suggests that the commercialization process should proceed hand in hand with the innovation process from the beginning rather than being just a part of the model and the customer perspective and co-operation between different organizational sectors should be emphasized.

The main goal of this study was to define the main challenges of commercializing technological innovations in the field of biotechnology. The results indicate that the main challenges of commercializing biotechnological innovations lie in the complexity of the field and the differing interests of the different sectors involved in the commercialization and innovation process. Commercialization is always expensive, but especially in biotechnology, where the process times are long, the risks and expenses grow. Even great resource inputs do not guarantee successful innovations. It was found that commercialization could be better acknowledged and emphasized, and also invested in to a greater extent. In addition, all the sectors involved in the process should find a common goal and mutual language in order to move in the same direction and enhance their co-operation. Researchers do not necessarily have the commercial aspect in mind whereas the personnel from the commercial side may not in all occasions understand all the technological aspects. Therefore in order to create a

successfully commercialized innovation, the input and seamless co-operation of all three sectors should be emphasized.

At VTT, such as in all large organizations, change is slow. It comes from the upper management, and especially in this case, could almost be seen as a change in the culture of the organization. Commercialization has been acknowledged and emphasized increasingly by the upper management in the recent years, and work has been done on the matter. The application of commercialization is left to the personnel, who according to the interviews are interested in the matter and emphasize it in their work. At least the organization's biotechnological industry is most likely further in commercial thinking than for instance many universities or other public research centers. The question still exists to what extent the commercialization culture even should be adapted to the company, and how much the researchers should be interested in the matter.

Since the subject of this study was challenges, these issues cannot even be expected to be simple, easily solved or clear. Acknowledgement is the path to finding solutions, and with the personnel with strong know-how, communication, co-operation and the willingness to improve and modify their way of thinking, even more successful innovations may be developed through commercialization.

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Interviewees:

Richard Fagerström, Technology Manager

Sampo Sammalisto, Key Account Manager, Pharmaceutical Biotechnology & Diagnostics

Jouni Ahtinen, Key Account Manager, Industrial Biotechnology

ATTACHMENTS

Attachment 1. Theme interview

The commercialization process of technological innovations in the field of biotechnology

1. Background

- Tell about yourself and your job description
- What kind of customers do you work with generally?
- How do you see commercialization in your organization and in the field generally?
- How do you see innovation as a process?
- What kind of services/products and their commercialization do you work with?

2. Commercialization and innovation processes

- Is commercialization an organized and systematic process?
- What parties do you see to be acquainted in the process in your organization?
- How would you describe a successful commercialization process?
- How would you describe the innovation process in your organization?
- How would you describe a successful commercial innovation?
- Do you have any examples of a successful commercialization process of an innovation?

3. The benefits of commercialization

- Do you see commercialization as a significant part of sales?
- What benefits do you see in commercialization from the organization and employee perspective?
- What benefits are there in commercialization from the customer's perspective?

4. The challenges and difficulties in commercialization

- Are there any characteristics in the field of biotechnology that complicate commercialization in general?
- What kind of problems do you see to be involved in commercialization generally?
- What are the greatest challenges in commercialization?
- What are the greatest challenges in your specific area of application?
- What factors could be behind these issues?

- Do you have any example of a failed commercialization process?

5. Development and the solving of problems

- What factors do you find significant in the success of commercialization?
- How do you think the challenges of commercialization could be approached?
- At what level are these factors and their development discussed and considered in your organization?