
Commercialisation strategies for entrepreneurial firms

-A case study at Layerlab AB



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MASTER'S THESIS
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ABSTRACT

This master's thesis deals with commercialisation strategies for entrepreneurial firms. The basis of the work is a framework of investigation that incorporates a company's internal and external factors, crucial when determining an appropriate strategy. This framework of investigation is applied on the case company Layerlab. Layerlab is an entrepreneurial company in the biotech industry, aiming at commercialising a technology for analysing membrane-bound proteins in existing surface-based biosensors. This technology is much coveted in the industry as it will enable researchers to analyse this large group of important proteins in label-free biosensors instead of using labelled or cell-based methods, which are both time-consuming and expensive in an already costly and lengthy drug development process.

The first part of the work describes different forms of commercialisation and factors that influence the choice of an appropriate strategy. The second part presents the empirical results when applying the framework of investigation on Layerlab and its environment. Ten in-depth interviews with key personnel in instrument and biochip companies are performed to analyse the competition and the value system in the industry.

The focus of this work is on the protein biochip market and particularly the biochips that are used in SPR- (Surface Plasmon Resonance), PWG- (Planar Waveguide) and SELDI- (Surface-Enhanced Laser Desorption/Ionization) instruments where Layerlab's technology in the first product development step, is applicable. To enter this market, there are some entry barriers that will be difficult to surmount for Layerlab in a new venture with its limited amount of human and financial resources. These are the protected design of the biochips and the costs of development, production, marketing and sales departments. The complementary assets that are crucial in this market are marketing and sales resources because of the huge amount of different technologies that exist in the market. Moreover, the markets that are interesting for Layerlab are niche markets and therefore it is important to have a global presence in order to stay competitive. All this together makes a cooperation strategy, such as a strategic alliance or a joint venture the most viable alternative for Layerlab.

The empirical research results in a recommendation where Layerlab first should increase the value of its technology in order to appropriate the most of the potential return of its invention. Layerlab must therefore, obtain a proof of concept in a customer-based environment. Then Layerlab must demonstrate the value of its technology, which can be done by contacting renowned researchers in academia or industry. They will be asked to employ the technology and publish articles about their results in professional journal. Finally, it is time to choose potential partners and to contact them. The objective of the cooperation must be determined, and might be a result of the proof of concept-project. More value will be appropriated if the proof of concept is successful because then the cooperation can involve only a near market collaboration and less of Layerlab's competencies and technology will be lost to its partner.

PREFACE

This work was written as a Master's thesis for the Department of Industrial Management at Lund Institute of Technology (LTH), Lund, Sweden, the Department of Innovation Engineering and Management at Chalmers University of Technology (Chalmers), Göteborg, Sweden and an entrepreneurial company active in the biotech industry, Layerlab, Göteborg, Sweden. It has been interesting to be part of an entrepreneurial company during this time. Several changes have occurred and it is not the same company today as the one I first get acquaintance to in end of August 2003.

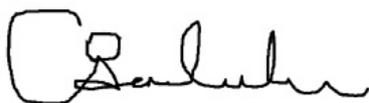
I would especially like to thank my academic supervisors Mats Magnusson (Chalmers) and Bertil Nilsson (LTH) for supporting me during the work, keeping me on the right track and giving invaluable feedback. I would also like to thank my former supervisor Jonas Båtelson and my present supervisor Johan Wideman at Layerlab for providing me with an interesting assignment, supporting me during my work and letting me be a part of their lives. They have, furthermore, given me the opportunity to participate in biotech trade fairs both in Hanover, Germany and Stockholm, Sweden in order to increase my knowledge in the biotech industry.

There are also other people that should be acknowledged for their contributions. All the interviewees all around the world for providing me with knowledge and insights about the industry and all other matters that concerns an entrepreneurial firm that wants to commercialise its products. In addition, I would like to thank Anders Carlsson for feedback on the investigation framework, long-lunches and several hours spent in front of a cup of tea discussing everything and nothing. I would also like to thank Joel Tärning for being my technical advisor and giving feed-back on the empirical results and analysis.

Finally, I would also like to acknowledge my family as well as new and old friends for making my return to Göteborg to a wonderful time in spite of its disastrous start.

I hope that I through this work can transfer some knowledge about commercialisation strategies for entrepreneurial firms and the biosensor market to the reader.

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Åsa Leckner

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1 INTRODUCTION

This chapter presents the background of the problem, the purpose of the work and its limitations. Finally, the outline of the work is described.

1.1 Background

Technology has been described as the engine of progress, creation of wealth, and, therefore, of economic growth. However, the technology does not create wealth itself. Instead the products and services generated from technologies through commercialisation create wealth.¹ Too often firms are so focused on the difficult challenge of developing radically new technologies that they miss to consider how to commercialise the technology². It is, however, crucial for a firm to choose a strategy of commercialisation, since this may determine whether the firm will succeed or fail.³ The strategic entry choices differ between established firms and start-up firms, because established firms often have access to substantial resources, which are unavailable to start-up firms. These resources, such as brand-name and access to capital, are essential in order to benefit from an innovation.⁴ Thus, a company's internal and external environments set limits on how an entrepreneurial company can commercialise its product.

Layerlab is a small start-up company, founded 2002 in cooperation with Chalmers School of Entrepreneurship and researchers at Chalmers University of Technology. Layerlab aims at commercialising a method for analysis of membrane-bound proteins invented by the researchers. The method will enhance the use of existing surface based biosensors in proteomic (the study of proteins) research and in drug development. Layerlab has patented the method in the first quarter of 2003. In the near future, Layerlab must decide on how the products are to be commercialised.

This work describes an investigation framework for entrepreneurial firms, identifying important factors that must be taken into consideration before choosing a commercialisation strategy. The investigation framework is then used to analyse Layerlab and its environment in order to choose an appropriate strategy.

1.2 Purpose

The purpose of the master's thesis is to build an investigation framework to evaluate commercialisation strategies for entrepreneurial firms and to investigate Layerlab's possibilities to commercialise its technology. Three different alternative actions are studied in depth, where

¹ Heslop et al., (2001)

² Day et al. (2000)

³ Börrefors & Welin, (1986)

⁴ Hariharan et al., (1999), Day et al., (2000)

descriptions of business potential and critical factors are discussed. The most appropriate alternative is then chosen.

The following sub-questions can be derived from this purpose:

- What kinds of commercialisation forms are appropriate for entrepreneurial companies?
- What kinds of factors influence the choice of commercialisation forms?
- What do Layerlab's internal and external environments look like?

Answering these sub-questions is believed to give a comprehensive understanding for Layerlab and its environment and to enable conclusions, which will help in providing a commercialisation strategy for Layerlab.

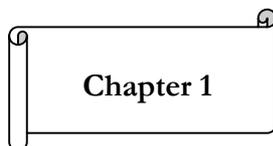
1.3 Delimitations

This work has been limited to include commercialisation strategies for entrepreneurial companies. The chosen forms of commercialisation must, thus, be appropriate regarding an entrepreneurial company's resources and capabilities. Due to the overall complexity in the choice of commercialisation strategy the evaluation approach is broad. This has limited the depth of analysis. The reason for choosing a broad stance depends on the importance of including certain internal and external factors in the evaluation framework. It would otherwise make a decision difficult and influence the significance of the result. It is however, not possible to consider all areas in depth that should be involved in a choice of commercialisation strategy such as the choice of a partner, the time perspective and the costs of each strategy.

Finally, an entrepreneurial firm also has the possibility of selling itself to another firm. This alternative is not included in this work as it is considered as a last resort for a company in its choice of commercialisation strategy.

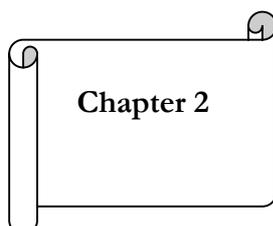
1.4 Report outline

The outline of this work is presented below with a short description of each chapter.



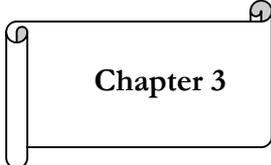
Introduction

This chapter presents the background of the problem, the purpose of the work and the limitations. Finally, the report outline of the work is described.



Method

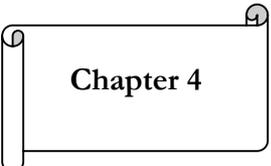
This chapter presents the choice of method for building the investigation framework and how the empirical study was conducted. After that follows a discussion about how and why certain data are used as well as the selection and identification of sample survey. Finally, an analysis of validity and reliability is presented. .

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Chapter 3

Investigation framework

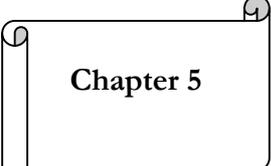
The objective of this chapter is to describe the investigation framework that will be used in this report. The first part gives an introduction to the possibilities of market entry that confronts a start-up company. Then the different forms of commercialisation strategies are assessed. Finally, evaluation criteria for the selection of a commercialisation strategy are presented.

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Chapter 4

Empirical Results

In this chapter the case company, Layerlab, and the empirical results of the three factors in the investigation framework – market-related factors, resource-related factors and commercialisation forms - are presented.

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Chapter 5

Conclusion

The last chapter presents recommendations for Layerlab in commercialisation issues as well as observations of general interest about the market for companies in the industry and entrepreneurs in biosensor industry.

2 METHOD

This chapter presents the choice of method for building the investigation framework and how the empirical study was conducted. After that follows a discussion about how and why certain data are used as well as the selection and identification of sample survey. Finally, an analysis of validity and reliability is presented.

2.1 Introduction

There are two different ways to collect information, either by consulting primary or secondary data. Primary sources are interviews, questionnaires and other direct methods and secondary sources are already published information, such as books and articles.⁵

2.2 Method for building the investigation framework

The investigation framework is the basis of the work. To establish a solid knowledge base, relevant secondary data were needed. The focus was first on the identification of forms of commercialisation in general, which was found in common textbooks on management. The next step was to identify appropriate commercialisation strategies for start-ups and the evaluation criteria used to make that choice. In order to identify a framework for possible commercialisation strategies, general management literature was reviewed. Most available literature deals with how established firms should commercialise new products and/or at new markets. The books dealing with start-up companies are generally assuming that these companies will manufacture and sell themselves. There was nothing about the choice of alternative strategies. Instead, the literature about choices of commercialisation strategies for start-ups was found in article databases, such as EBSCO (Göteborg University) and ELIN (Lund University). There are, however, only a few researchers that have dealt with commercialisation strategies for entrepreneurial firms and the articles that dealt with choosing a commercialisation strategy did all use different frameworks. Instead of choosing one of them, a combination of all was built into what is referred to as investigation framework. Due to difficulties to find appropriate evaluation criteria for deciding on a patent strength, two patent attorneys were contacted in order to get professional advice.

2.3 Work process and choice of methods for the empirical results

In the empirical part of the work, both secondary data and primary data are used. The secondary sources are internet, databases and journals. They are primarily used for technology and company descriptions. The primary sources are interviews, mail correspondence, attendance on Layerlab's board meetings and strategic evaluation of Layerlab by Chalmers Innovation. A market survey with in-depth interviews has been conducted to gather information about the market. For the

⁵ Lekvall & Wahlbin, (2001)

parts not concerning the market, short interviews and mail correspondence have given the answers to specific questions.

A rapport can either have a qualitative or a quantitative approach. A simplified explanation is that quantitative studies present the results in numbers while qualitative studies present the results of words. Quantitative studies are more suitable for processing large study populations. Qualitative studies go deeper into every observation and try to find the soft parameters that are harder to quantify.⁶ In this work a qualitative approach is chosen because the industry is small and consists of less than 25 companies. It was, thus, more important to get an understanding for how the persons working in the industry interpret the market. Therefore, the instrument to collect data has been ten in-depth interviews by telephone and three shorter on-site interviews.

Telephone interviews were chosen due to the distance to most of the interviewees. Telephone interviews are, moreover, regarded as less time-consuming and expensive than on-site interviews. The disadvantage is that the interviewer does not get the same personal contact with the respondent. Another way to gather primary data is through a questionnaire. There are, however, several disadvantages with a questionnaire compared to telephone interviews, for instance, there is no possibility to ask follow-up questions and the response rate is usually low. Due to the distance to Asia, a questionnaire was sent to two companies but without any answer.

The interviews were semi-structured with questions prepared in advance. In this way the interviewee was not forced into a specific way of thinking. The questions were only formulated in an open-ended way in order to receive more qualitative answers. It is, however, more difficult to compile and analyse than for close-ended questions.⁶ The models, Porter's five forces and the value system were used as sources of inspiration when formulating the questions.

All potential respondents were first approached by email to get a contact person. If no answer was received they were contacted by telephone in order to find a contact person and hear if they wanted to participate in the survey. The interviews lasted between 30 and 60 minutes.

2.4 Selection and identification for sample survey

The selection of the focus companies in the survey was based upon one requirement. The company must develop or sell biochips and/or instruments that use a technology applicable with Layerlab's method (SPR, PWG and SELDI). By consequent following this criterion the population can be seen as a general and all-embracing one.

To identify these companies both primary and secondary sources were used. The secondary sources were journals and internet. The professional journals were found through databases such as PUBMED (Göteborg University) and BIOSYS (Lund University). The articles in the professional journals are:

⁶ Lekvall & Wahlbin, (2001)

- Huber, A., Demartis, S., Neri, D., (1999), "The use of biosensors for the engineering of antibodies and enzymes", *Journal of Molecular recognition*, 12:198-216
- McDonnell, J., (2001), "Surface Plasmon Resonance: towards an understanding of the mechanism of biological molecular recognition", *Current Opinion in Chemical Biology*, nr 5
- Baird, C., Myszka, D., (2001), "Current and emerging commercial optical biosensors", *Journal of Molecular Interaction*, 14:261-268
- Homolo, J., (2003), "Present and future of surface plasmon resonance biosensors", *Anal Bioanal Chem*, 377:528-539

Some focus companies were also found in commercial journals, such as *Genetic Engineering News* that publishes articles about new technology and markets in the bioinstrumentation industry. A few of the companies were mentioned during interviews with other focus companies. The focus companies are based in a global market and reside primarily in USA, Germany, Japan and Netherlands. The table below shows the number of contacted and participating companies (Figure 2.1).

Industries	Contacted companies	Participating companies	Final rate
SPR	18	7	39 %
PWG	2	2	100 %
SELDI	1	1	100 %
Total	21	10	48 %

Figure 2.1: The number of contacted and participating companies.

The most difficult part of the survey was to convince the companies to participate in the interviews. The requested information about the market and the company was often regarded as sensitive, especially by the pure biochip developers and unfortunately none of these were interested to participate. In order to convince more persons to contribute to the survey the information given by the interviewees are kept anonymous. This is the reason why the information about the companies in Chapter 4.2.2 is only from the internet or published articles. If the information is from the interviews, permission has been given.

2.5 Validity and Reliability

To evaluate the quality of this work it is appropriate to discuss in terms of validity and reliability. Validity in a survey can be defined as absence of systematic errors. A survey has high validity if

the questions asked, answer what they were intended to examine.⁷ The validity might have been influenced by the fact that only 39 percent of the companies in the SPR-industry chose to participate in the survey due to the fact that the information asked was regarded as sensitive. It is, however, plausible that the rest would not have changed the result in the end. This has become apparent when reading articles about the market and interviewing other persons in the industry. More important is that 100 percent participation was reached in the two other areas which only consist of one or two companies. Due to a thorough base, in terms of a detailed study of secondary data, the extensive feed-back of the questionnaire from three persons and the distribution of participating companies in the survey, it is believed that the study has a high validity.

Reliability can be defined as the absence of random errors. A survey has high reliability if the one who makes the survey or any other circumstances that surround the survey do not affect the result.⁷ In this survey the majority of the respondents were approached in the same way. They received the same background information about the project and the same questions. This implies that the answering process has been done under similar circumstances and that increases the reliability. There is, however, a risk that the respondents have been withholding information because it has been regarded as sensitive for the company. To diminish this risk the respondents were informed that answers from the interviews were confidential.

⁷ Lekvall & Wahlbin, (2001)

3 INVESTIGATION FRAMEWORK

The objective of this chapter is to describe the investigation framework that will be used in this report. The first part gives an introduction to the possibilities of market entry that confronts a start-up company. Then the different forms of commercialisation strategies are assessed. Finally, evaluation criteria for the selection of a commercialisation strategy are presented.

3.1 Commercialisation strategies for a start-up company

During the past two decades there has been a dramatic increase of investment in technology entrepreneurship, that is, small start-up firms developing technologies with commercial application. Because the youth and small size of these firms, they usually have little experience in the market, for which their products are most appropriate, and they only have a few technologies at the time for market introduction. A key management challenge is therefore to translate promising technologies into a stream of economic revenues. Their main problem is, in other words, not the invention but how to commercialise the product.⁸

There is a vast amount of different ways to commercialise innovations but the following are more frequently used than others:

- Sale – Selling the intellectual property rights to a third part
- Strategic alliance
- Licensing
- Joint venture
- Acquisition – Buying an existing company with appropriate technologies
- New venture – Initiating a new venture to develop, manufacture and sell products

Authors in the field of commercialisation strategies for start-up companies observe that entrepreneurs have two options for commercialising innovations. First, they can compete with incumbents in the product market, or they can cooperate with established enterprises by selling their technologies at the market for ideas. In the cooperation alternatives the start-up company can license its technology, form a strategic alliance or agree to be acquired.⁹ Thus, this text will only deal with;

- cooperation strategies, such as joint venture, licensing and strategic alliance
- competition strategies, such as new venture

⁸ Gans & Stern, (2003)

⁹ Börrefors & Welin, (1986), Gans & Stern, (2003), Megantz, (1997)

It is of course possible to exploit a company's technology using a combination of the above forms of commercialisation as licensing with minority stock ownership. Due to the sake of simplicity only the "pure" forms will be described in this text.

3.2 Forms of commercialisation

The limited financial and human resources of a start-up firm makes it more likely to restrict itself to a single commercialisation strategy. Therefore, the choice between different forms of commercialisation requires a careful consideration of the costs and benefits associated with each option.¹⁰ There are a variety of opinions whether cooperation or a competition strategy is the most profitable way to enter the market. According to Gans & Stern¹¹ and Teece¹², the best way to take an advantage of an innovation is to undertake a systematic analysis of the expropriation threat and to which degree complementary assets are controlled by established firms. Other authors¹³ argue that only after taken a firm's strategic considerations and market characteristic under consideration it is possible to make a decision if the technology should be exploited in-house or through cooperation.

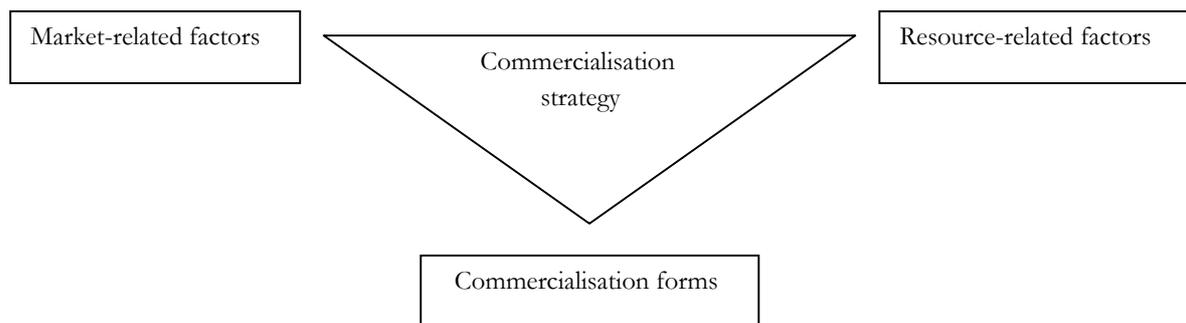


Figure 3.1: The investigation framework

Thus, in this framework of investigating commercialisation strategies three key factors will be discussed (Figure 3.1). These are market-related factors, resource-related factors and commercialisation forms. Market-related factors are the potential and structure in the market. Resource related factors are, for instance, the firm's present resources such as financial, human and intellectual property but also the general need for complementary resources that exists in the industry. Finally, the last factor – commercialisation form – describes the requirements for the different forms of commercialisation. This framework will give an indication about the complexity and interrelatedness of factors in the choice of commercialisation strategy. The risk and reward in Figure 3.2 might for example not be maximised in a new venture because it is also

¹⁰ Cassiman & Veugelers, (1998)

¹¹ Gans & Stern, (2003)

¹² Teece, (1986)

¹³ Arora et al., (2001), Börrefors & Welin, (1986), Bessant et al. (2001)

dependent of the competitiveness in the market. It might then be more rewarding to form a strategic alliance with another firm as it becomes easier to exploit the market with the help of an existing player.

Before the investigation framework will be presented in depth, this subchapter will discuss the different forms of commercialisation forms in order to get a brief understanding for requirements, risks, disadvantages and advantages. They will, however, be divided into two groups – competition and cooperation. The reason for the division in groups is because there are some characteristics which are shared between the different types of cooperation.

- Competition – New venture
- Cooperation – Joint venture, Strategic alliance and Licensing

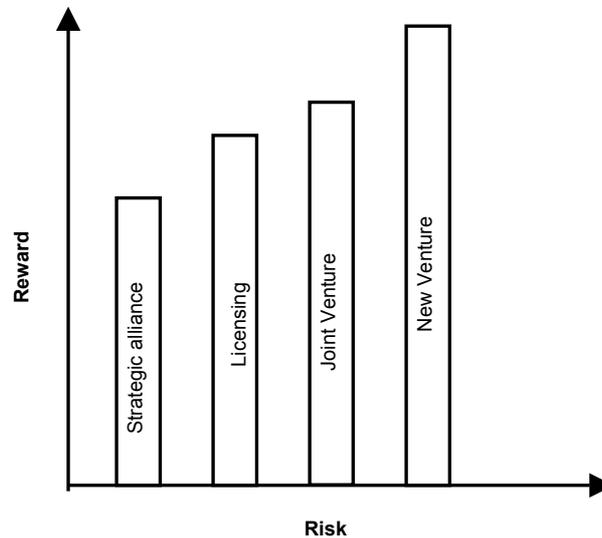


Figure 3.2: Risk versus reward for various commercialisation strategies. Source: Megantz, (1997)

3.2.1 Competition - New venture

For a start-up firm to enter the product market the entrepreneur must undertake heavy investments in complementary resources such as manufacturing and marketing, manage multiple dimensions of uncertainty and focus scarce resources on establishing market presence.¹⁴ In other words, when starting a new venture, the company has to manage all the steps necessary to generate profits from an innovation all by itself.

Megantz¹⁵ argues that both the risk and potential return are highest when a company manufactures and sells the products itself. It is riskier because products and infrastructure must be developed and that costs both time and money. If the new venture is successful, profits and

¹⁴ Gans & Stern, (2003)

¹⁵ Megantz, (1996)

other benefits will be maximised as they do not need to be shared.¹⁶ Profitability is, however, more nuanced than that and will in the long run depend on several factors. For instance, the new venture requires developed complementary assets such as manufacturing expertise, marketing skills, and distribution facilities to be successful.¹⁷ Then profitability will also be influenced by competitive strategies of incumbents such as aggressive price competition, but also the ability of established firms to imitate the functionality of the technology.¹⁸

Except from high initial costs, another main disadvantage is that the start-up may not be able to persuade enough people to buy the new product or service either at a high enough price or fast enough to make profit because of limited resources for marketing channels¹⁹. An advantage, on the other hand, is that the most part of the control over the company and its technology is kept within the boundaries of the firm.

3.2.2 Cooperation

The main alternative to competing directly in the product market is through a cooperation strategy. The start-up will identify and execute arrangements with other firms, usually incumbents, who serve as medium to reach the product market for commercialising its technology. A commonly held opinion is that cooperation is the most important growing trend for small research and development firms and this is particularly obvious in the field of biotechnology. The rate of technological change means that few organisations afford to maintain in-house development. Therefore, most managers recognize that no company, even large ones, can continue to survive as technological islands.²⁰

Bessant et al²¹ group the rationale for cooperation into technological, market and organizational motives. The technological reasons include cost, time and complexity of development. The market motives are mainly to reduce risk and cost of market entry but also to reduce the time to commercialise new products. Market motives is the main reason for a start-up company to form a cooperation arrangement as they can avoid sunk investments in complementary assets necessary for commercialisation¹⁸. The organisational reasons are the firm's possibilities to slim the organisation when choosing to outsource non-core or peripheral technologies²¹.

The greatest disadvantage, common to all of the cooperation strategies, is that of appropriation. The willingness to cooperate depends on the partner's knowledge of the idea but at the same time, knowledge of the idea means that potential partners do not need to pay in order to exploit it. The problem can be diminished if an intellectual property right is available but, for most

¹⁶ Megantz, (1996)

¹⁷ Andrew et al., (2003)

¹⁸ Gans & Stern, (2003)

¹⁹ Bygrave, (1997)

²⁰ Melett et al, (2003), Gans et al (2002), Olesen, (1990), and Pisano, (1990)

²¹ Bessant et al., (2001)

technologies and industries, intellectual property rights are highly imperfect.²² This will be fully discussed in Chapter 3.3. There are, however, other ways to diminish appropriability, if for instance skills and resources are tacit and people-embodied they are very difficult to imitate²³.

The main difference between the forms of cooperation is the object of the agreement. In a licensing agreement, the main object concerns the patent while in a joint venture and a strategic alliance it concerns the collaboration.

Joint venture

Roberts & Berry²⁴ argue that a new style of joint venture, that between a large and a small company formed to create a new entry in the market place, is growing in strategic importance. The small company provide the technology and the large company provides marketing capability and capital. Thus, it becomes synergistic for both.

A joint venture is the most formalised type of collaboration. According to Bessant et al²⁵ a joint venture can take two forms. The first is a new company that is formed by two or more separate organisations and which allocates ownership based on shares of stock controlled. The second type is a simpler contractual basis for cooperation. Bessant et al²⁵ mean that the critical distinction between the two types is that an equity arrangement, as in the first case, requires the formation of a separate legal entity. In such case, management is delegated to the joint venture, which is not the case for the other form of joint ventures.

In a joint venture the risk is still relatively high. Although it is lowered for each of the participants compared to a new venture. The potential for success is higher if the skills and resources of the participants are complementary.²⁶

The main advantage with a joint venture is that entering a cooperation is a serious undertaking and reflects the party's commitment to the project. This is especially true if a new company is created. Another advantage is that a separate business with its own identity and focus can be created free from the undertakings of its parent companies.²⁷

On the other hand, a joint venture can be difficult to manage due to different goals and degrees of control of the participants.²⁶ If there is a difference in opinion and the decision that needs to be agreed upon is fundamental to the continued situation the joint venture has a deadlock situation. There are several ways of avoiding deadlocks such as using third parties or alternating the casting vote but none of them are entirely satisfactory. Another disadvantage is that it is

²² Gans & Stern, (2003), Gans et al., (2002), Cassiman & Veugelers, (1998), Shane, (2001), Pisano (1991)

²³ Grant, (2002)

²⁴ Roberts & Berry, (1985)

²⁵ Bessant et al., (2001)

²⁶ Megantz, (1996)

²⁷ Mellett et al., (2003)

important to ensure that obligations are clearly set out in the agreements regulating the relationship otherwise joint ventures can be financial black holes.²⁷

Strategic alliance

A more informal way of cooperation than joint venture is a strategic alliance. Two or more companies cooperate in projects that usually involve near-market development. A strategic alliance typically has a specific end goal and timetable, and does not take a form of a separate company.²⁸ Megantz argues that an alliance can be either horizontal or vertical. In a horizontal alliance two companies might take advantage of the specialized manufacturing skills of each other in order to exploit the market more efficiently and competitively. In a vertical alliance one company can agree to market and sell products developed by another company in return for share of the profits. This is particularly common for small research intensive firms which lack resources and complementary assets²⁹. Then the risk and reward are limited to the areas of mutual cooperation³⁰.

One of the greatest opportunities for a small company joining a strategic alliance is that collaboration implies sharing of rewards and sends signal that a company has something that others value compared to pure licensing, which can be seen as giving away value.³¹ Another advantage is that bringing together complementary skills and expertise allows greater exchange of ideas and technology, which may result in new areas of application for the product.

A disadvantage is that cooperation in a strategic alliance can mean lost control for one of the parties. In Lerner & Mergers'²⁹ research of 200 alliances they found evidence that the financial condition of a small firm affects their ability to retain control rights. This was more important than mutual concern about maximizing joint value in cooperation. It is a great risk for a start-up company as they often have limited financial resources and which at the same time is one of the reasons for joining a strategic alliance. Furthermore, there is a risk that a collaboration partner may not perform according to the entrepreneur's perception of what contract requires and will thus control the pace of collaboration³².

Licensing

Licensing is one of the most common ways to exploit intellectual property rights (IPR). There is a range of IPR that can be used to exploit technology, the main types being patents, copyright, design right and registration²⁸. The licensor grants, for some payment, the right to exploit the licensed technology to a licensee. Licensing agreements differ from each other in terms of contents and scope, depending on the licensing objective and other circumstances. Some agreements only concern one licensed object, whereas others include several objects. The contracts may also include know-how, trade secrets, and patent applications, apart from a

²⁸ Bessant et al., (2001)

²⁹ Lerner & Mergers, (1998)

³⁰ Megantz, (1996), Mellett et al., (2003)

³¹ Teece, (1986), Mellett et al., (2003)

³² Teece, (1986)

protected right³³. Other considerations when drafting a contract include degree of exclusivity, territory and type of end use, period of license and type and level of payments.³⁴

There are many different types of license, where the most common are exclusive and non-exclusive. The licensor, who grants an exclusive license, agrees with its licensee not to sell other licenses or exploit the property itself in the territory admitted to the licensor.³⁵ According to Anand³⁶ approximately 37 percent of all contracts involve some form of exclusive rights being allocated to the licensee. In 11 percent of the deals licensees get worldwide exclusive rights, while exclusivity within a restricted geographic domain is granted 26 percent of transfers. In the area of biotechnology more than half of the transfers involve some exclusivity clause.

A nonexclusive license means that the licensor is free to exploit the licensed property in the licensed territory, either by himself, or an agent, or by granting other licenses.³³ Thus, a choice between exclusive and nonexclusive licensing must be made. Brown et al argues that exclusive licensing is often necessary to interest private industry. Nonexclusive licensing is more appropriate when the potential market is large enough to accommodate many firms, or where there are many potential direct or spin-off applications for the technology. Mellett et al³⁹ argue that exclusivity is usually the most attractive to both licensor and licensee because the licensor gets greater potential to demand upfront payments and a higher royalty and the licensee obtains protection from competition.

In a licensing agreement much of the risk is transferred to the licensee, which is responsible for developing, manufacturing, and marketing the licensed products. This articulates the need for finding an appropriate licensee as the innovator's earnings also depend on the effort and investment made by the licensee in commercialising the technology³⁷. Different licensing strategies create different levels of risk for the licensor and licensee. For instance, large initial payments coupled with low or no running royalties shift more of the risk to the licensee, while low initial payment together with higher running royalties is riskier for the licensor.³⁸

One advantage is that the licensor can quickly generate a revenue stream from a technology which it does not have expertise, financial or human resources to exploit. In this way both risk and costs involved in entering new markets are reduced.³⁴ The most common reason to licensing out technology is probably because the licensor does not have the in-house resources to get to the market.³⁹

Even if licensing means spreading the risks it also means losing some of the profit that the technology might generate. The further away from market the technology are at the time of

³³ Bergholtz & Svensson, (2002)

³⁴ Bessant et al., (2001)

³⁵ Levin & Nordell, (1996)

³⁶ Anand, (2000)

³⁷ Arora et al., (2001)

³⁸ Megantz, (1996)

³⁹ Mellett et al., (2003)

license, the more will be lost. Another disadvantage is that the licensor will want to keep as much control as possible but the very fact of licensing will involve loss of control. It is very difficult to measure the licensee's use of know-how in other processes. Moreover, the licensor needs to protect against the licensee taking a license but then doing nothing with the technology. The licensor needs to ensure that it can terminate an exclusive license or convert it to a nonexclusive one if the licensee fails to sufficiently exploit the licensed technology.⁴⁰

3.3 Evaluation criteria to the selection of a commercialisation strategy

The choice of commercialisation strategy is one of the most important decisions a company has to make and therefore it requires a careful investigation. In this framework, for investigating commercialisation strategies for a start-up company, three key factors will be evaluated (Figure 3.3). These are market-related factors, resource-related factors and commercialisation forms. They will be discussed in depth and finally the interrelatedness between them will be assessed.

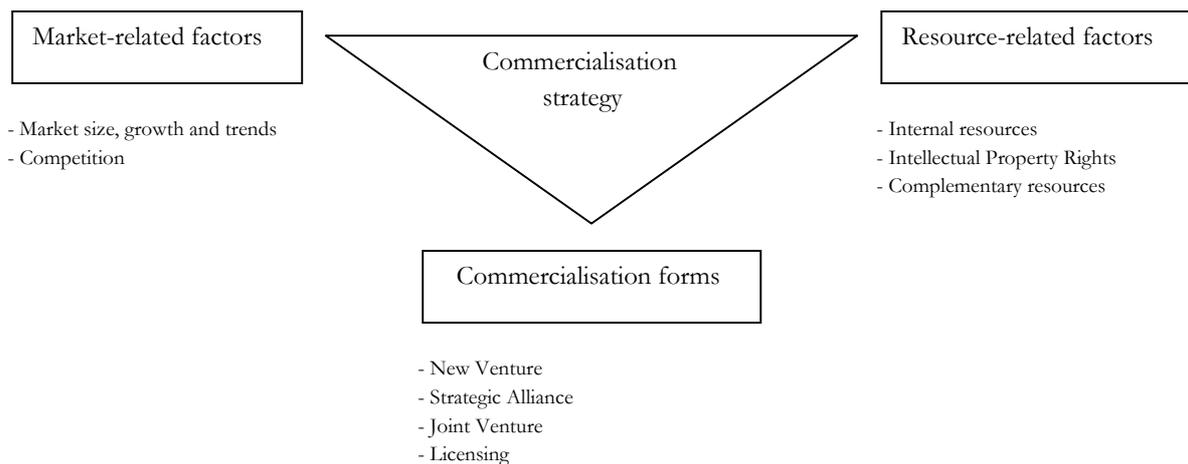


Figure 3.3: Investigation framework in detail.

The creation of commercialisation strategy will, thus, be dependent of the market situation, the companies' existing resources, the requirements for complementary resources in the market and the commercialisation form.

3.3.1 Market-related factors

Accurate and reliable market information is an important component for a successful strategy for two reasons. Firstly, a thorough understanding of size, growth, technologies, products and

⁴⁰ Mellett et al., (2003)

companies active in the market will allow an estimate of the product's potential⁴¹. Is there any need for the product in the market? It will also show if the size of the market is sufficiently large to cover manufacturing costs.⁴² Secondly, it will provide information about the nature of the industry. How competitive is the industry?⁴³

Market size, growth and trends

An analysis should be undertaken to estimate the size, growth and trends in the market. Because the applications for the technology is evolving, it is not clear who will be the most attractive customer, when and how they will use the product, or what they will be prepared to pay, assessment of markets for new technologies is an uncertain and complicated task. There are still some questions that need to be answered. Does the product satisfy a need or solve a problem for the customers better than alternatives? How large is the prospective market, and how quickly will this potential be realized?⁴⁴ What is the expected growth and trends in the market?

Day et al⁴⁴ means that in order to assess a market, where demand for products does not exist and customers do not know about them yet, the premises of adoption and diffusion are important to bear in mind. The *size of the market* is, namely, dependent of the rate of acceptance by the customers. This is determined by the fact that the product must be adopted (purchased) and diffused into the market. The faster this happens the better it is. Adoption is the decision of an individual to use the product and diffusion is the collective spread of individual adoption decisions throughout a market. The rate of acceptance often differentiates a successful product from a disaster.⁴⁵ It can be explained by at least three factors. Firstly, the characteristics of the product which consist of the following four factors⁴⁴

- The perceived advantages of the new product relative to the best alternative. They depend on the performance inherent in the technology but also on the intensity of stimulating efforts by competitors, such as competitive innovation, decline in price and collective investments in education and learning.
- The risk perceived by prospective buyers because of the uncertainty of performance, fears of economic losses or concerns about changing standards.
- Barriers to adoption because of commitment to existing products, investments in previous generation of technology.
- Opportunities to learn and try. The product must both be readily available (for trial, purchase and servicing) and the customer must also be informed of the benefits.

⁴¹ Megantz, (1996)

⁴² Börrefors & Welin, (1986)

⁴³ Day et al., (2000), Andrew & Sirkin, (2003)

⁴⁴ Day et al., (2000)

⁴⁵ Bygrave, (1997)

The first factor is the main driver of the rate of acceptance while the other three factors can dampen or impede this rate.

Secondly, the rate of acceptance will also depend on the number of buyers who progress through the adoption process. Customers usually go through a process of deciding to buy a product. The usual steps in the adoption process for new products are:

awareness → knowledge → interest → evaluation → trial → adoption

The purpose is to lead the prospective customers through the stages of the adoption process.⁴⁶ It is a combined effect of all advertising messages, sales calls and trade shows that moves the customer to the last stage. Thirdly, customers adopt to products with different speed and individual customers may be labelled according to how quickly they adopt a product, ranging from innovators to laggards (Figure 3.4).

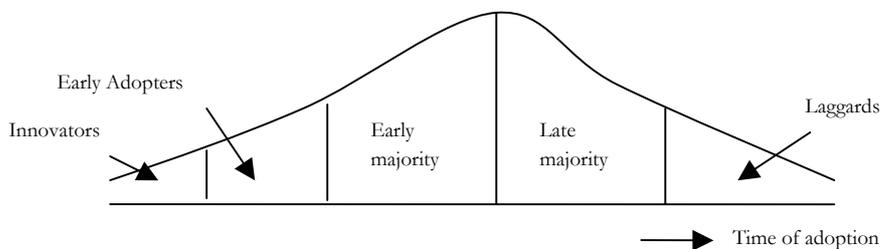


Figure 3.4: Adoption curve. Source: Day et al., (2000)

Innovators are also called lead users and they have needs in advance of the rest of the markets. They not only help to prove the new product but their acceptance are also key to acceptance in other segment. *Early adopters* often help to publicise the new technology but they are costly to support because they require special adaptation to their requirement. The next group to adopt the new technology is the *early majority*. This is a large group that decides to adopt only when the benefits of the technology are well proven and the risks are minimised. *Late majority* adopts an innovation only when a large majority of the people tried it. They tend to be price sensitive and very demanding in terms of service requirements. The last group is the *laggards*. These people are suspicious of changes and are likely to adopt an innovation only when they have no other choice.⁴⁷

The next step in the analysis is to determine the expected *growth rate and trends* in the market. This can be done by studying the industry life cycle, consumers (numbers and trends), product developments in the industry and competitive analysis⁴⁸. An understanding of future trends

⁴⁶ Bygrave, (1997)

⁴⁷ Day et al., (2000)

⁴⁸ Kuratko & Welsch, (1994)

makes it possible to better predict the development in the industry. If, for instance, there is possible shift in technology that makes the life of the product obsolete in a few years.

The competition in the market

To get an overview of the structure of the market, an industry analysis should also be undertaken. This will provide an answer to the following questions. Who are the customers and the suppliers? What kind of competition is there and what are the strategies of the competitors? What do the entry barriers look like for a new entrant? A useful method for answering these and other questions is Porter's five forces⁴⁹.

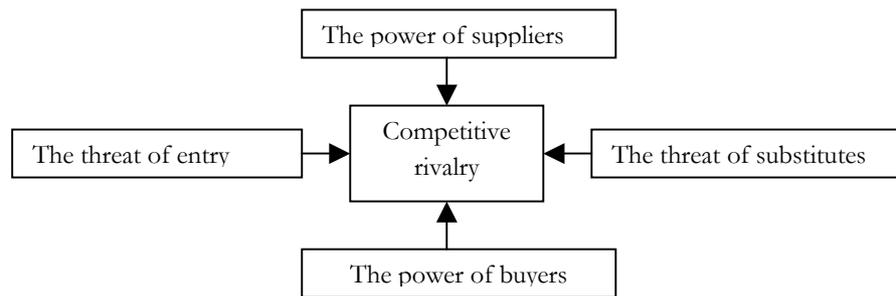


Figure 3.5: Porter's five forces. Source: Porter, (1985)

The threat of entry - The threat of entry will depend on the extent to which there are barriers to entry. The most common barriers are economies of scale, capital requirements of entry, access to distribution channels, cost advantages independent of size, expected retaliation, legislation or government action and differentiation. It is important to establish which barriers exist in the industry and to which extent the other companies are likely to prevent entry?

The power of buyers and suppliers – The power of buyers and supplier can be considered together as they are linked. The buyer's power is likely to be high when there is a concentration of buyers and especially if the volume purchase are high. It will be further increased if, for instance, the supplying industry is compromised of a large number of small firms. The supplier's power will be high if there is a concentration of suppliers rather than a fragmented source of supply and when the brand of the supplier is powerful.

The threat of substitutes – The threat of substitutes may take the form of product-for-product substitution (the fax for the postal service) or substitution of need. The questions that need to be addressed are weather or not the substitute poses a threat to the firm's product, with which ease the customer can switch to substitutes and to which extent the threat of substitution can be reduced by building in switching costs.

⁴⁹ Porter, (1985)

Competitive rivalry – The competitive rivalry will also be dependent on the above factors. For instance the most competitive conditions will be that in which entry is easy, substitutes is threatening, buyers and suppliers exercise control. There are, however, other forces that also affect the competitiveness such as the extent to which competitors are in balance. When competitors have almost the same size there is a danger of increased rivalry. Market growth may also affect rivalry. When market is mature, the growth of the company has to be achieved at the expense of another firm's market share.

3.3.2 Resource-related factors

There are three resource-related factors that are most commonly discussed in the literature and they will be evaluated in this framework in order to choose commercialisation strategy. These are internal resources, intellectual property rights and complementary resources. In this work intellectual property right are not part of internal resources because it is regarded as particularly important and deserves it own analysis.

Internal resources

Bessant et al argues that in practice technological and market characteristics will constrain options, and company culture and strategic considerations determine what is possible and what is desirable. Also Börrefors & Welin and Armesto & Krawetz articulate the need for a careful analysis of the company itself before making the decision about market entry strategy.

A useful method to make this analysis is SWOT. SWOT stands for Strengths, Weaknesses, Opportunities and Threats. Strengths are positive internal factors that a company can use to accomplish its goals. Weaknesses, on the other hand, are negative internal factors that inhibit the accomplishment of a company's goals. All areas of the business should be analysed such as – personnel, finance, production, marketing, product development and organisation. When the internal assessment of the company is done, the external environment also needs to be evaluated. The opportunities are positive external options that a firm could exploit to accomplish its goals. Threats are negative external factors that inhibit a company's ability to achieve its goals.⁵⁰ This method will, thus, give a deeper understanding of the company's competencies and resources and sheds light on what is needed and desired in order to commercialise its product. Particularly, a mapping of the firm's financial, human and complementary resources will be done, which give a pointer to what is essential for the firm in the choice of commercialisation form.

Intellectual Property Rights

Most authors on strategies of market entry hold the threat of expropriation as one of the most important factors for the choice of strategy.⁵¹ This phenomenon occurs both under competition and cooperation strategies. The start-up encounters incumbents under competition that will commercialise an imitation. On the other hand, the negotiations over the sale of an idea

⁵⁰ Zimmerer & Scarborough, (2002)

⁵¹ Gans & Stern, (2003), Gans et al., (2002), Shane, (2001), Teece, (1986), Anand, (2000), Day et al, (2000)

inevitably involves a risk of revealing secret information, which then erodes the bargaining power of the start-up and reduces the incumbents willingness to pay.⁵² Gans & Stern holds IPR or technical design as the two most valuable ways to prevent other firms to appropriate from an innovation. The ability to use litigation to temporarily halt the activities of an expropriation provides incentives for potential users to reach an agreement. Technical design has the benefit of displaying functionality while masking details that would allow imitation. Even if the entrepreneur holds intellectual property protection or have a strong design, imitation is often possible after some time⁵³.

For a small, start-up firm, patents may be a relatively effective means of appropriating the returns of its innovation. In part because some other means, such as investment in complementary assets may not be feasible. Hence, it makes the patent its most marketable asset.⁵⁴ The problem is that a patent does not work in practice as it does in theory. Rarely, if ever, does patent grant perfect appropriability. Many patents can be invented around at modest costs.⁵⁵ Invent around means that competitors can come up with their own invention without infringing the patent, but they succeed in appropriating some of the potential returns of the focal innovation⁵⁶.

There is a large body of evidence that provides sufficient basis for assumptions concerning the differences in strength of property rights across industries. In computer and electronics patents fail to ensure that the patentholder appropriates the gains from the innovation, whereas in pharmaceuticals and chemical patent protection is much stronger.⁵⁷ There are at least three reasons for this. They are patents scope, nature of technology and articulation of know-how. Thus, the strength of an innovation can be estimated in the following three ways:

- Patent scope: Broad patents enhance probability of protection because the broader the scope, the larger number of competing products and processes that will infringe the patent.⁵⁴ The patent scope is determined by its claims and depends on how the patent is formulated and, for instance, a general choice of words gives a broader patent. Due to the possibility of having an affect on the patent scope this is the most important aspect when drafting a patent.⁵⁸ Narrow patents can, however, also be very strong. If, for instance, a patent in a niche area has seized a critical point in the process/product it will be difficult to invent around.⁵⁹
- Nature of technology: Patents are especially ineffective in protecting process innovations with the exception of the petrochemical processes, which are designed around a specific

⁵² Gans et al., (2002)

⁵³ Gans & Stern, (2003)

⁵⁴ Shane, (2001)

⁵⁵ Teece, (1986)

⁵⁶ Day et al., (2000)

⁵⁷ Anand, (2000)

⁵⁸ Byström, Ström & Gullviksson, 031113

⁵⁹ Inger, Ström & Gullviksson, 040105

variety of catalysts that can be kept proprietary.⁵⁵ Process innovations are technical advances that reduce the cost of producing existing products, whereas product innovations involve development of newer and improved products.⁶⁰ One reason for the weakness in process patents is the difficulty of arguing for an infringement as it is hard to gain access to other firm's manufacturing facilities.⁶¹ Product innovations, on the other hand, are simpler to protect.

- **Articulation of know-how:** One reason for weak IPR is that it is difficult to clearly specify the content and boundaries of knowledge and other intangible assets. That is to say it is difficult to articulate the know-how embodied in the underlying technology. In pharmaceutical patent it is very difficult to invent around, since it is possible to patent molecules which then can be kept proprietary. A slight change in an underlying gene sequence for a protein can result in very different functions. Hence, a contract specifying the limits of its use can be more easily designed compared to computer industry, where information is context-dependent and difficult to define.⁶¹

The evaluation of IP strength is, however, a very difficult task because it depends on a vast amount of factors. It depends, for instance, also on the novelty of the technological area because then there is nothing that prevents the validity such as hidden publications. It is also argued that before the patent is verified in court it is impossible to make a judgement about its strength.⁶¹

Complementary resources

It is commonly held that small entrepreneurial companies which generate new commercially valuable technology fail, while large firms often with a less meritorious record with respect to innovation survive and prosper. One reason for this is clear, large firms are more likely to possess relevant complementary assets within their boundaries. They therefore do a better job milking technology to maximum advantage.⁶² In almost all cases a successful commercialisation of an innovation requires that know-how are utilised in conjunction with other capabilities. Services such as marketing, competitive manufacturing and after sales support are almost always needed. These services are often specialised as for instance in commercialisation of a new drug that requires marketing within specialised information channels.⁶³ A strategy choice should, thus, include, a complete accounting for complementary assets required for effective commercialisation and for the degree which they are controlled by existing players.

There are three different complementary assets.

- **Generic:** Generic assets are general purpose assets which do not need to be tailored. They are for instance manufacturing facilities for running shoes.

⁶⁰ Brown et al., (1991)

⁶¹ Inger, Ström & Gulliksson, (031127)

⁶² Teece, (1986)

⁶³ Gans & Stern, (2003), Teece, (1986), Gans et al, (2002), Day et al., (2000)

- Specialized: Specialised assets where there is a unilateral dependence between innovation and the complementary asset. That is for instance an ice-cream manufacturer that needs a distributor with cold-storage.
- Cospecialised: For cospecialised assets there is a mutual dependence between the innovation and the asset. Cospecialised asset is, for instance, specialised repair facilities for a specific brand.⁶⁴

Particularly, when specialised assets are required, the sunk costs of a product market entry become substantial. These reduce the returns gained from a competition strategy and weaken the relative bargaining power of the start-up when contracting with established firms. Because the start-up will either be dependant on the incumbent or it will cost too much to acquire the assets itself. In general, an increase in the importance or concentration of control of complementary assets, means a raise in the relative returns to cooperation over competition.⁶⁵ Thus, even though increase of importance of complementary assets reduces the absolute share of total value earned by an innovator this encourages cooperation.

The need for and importance of complementary assets in the industry are crucial to analyse before entering a new market. Then the cost and access to these assets should be determined. One way to consider this is to evaluate the value system in the industry. In most industries it is rare that a single organisation undertakes all of the activities itself from product design to delivering a final product. There is usually specialisation of roles and one organisation is part of a wider value system which creates a product or service. Much of the value thus occurs in the supply and distribution chains, and this whole process needs to be analysed and understood.⁶⁶ The value system is also usable to assess how the competition looks like in the different “markets” in the value system. If the competition is great in the “distribution market” then the returns are likely to be small and it might not be viable for a small firm to make its entrance in such market. Hence the value system gives a thoroughly overview of complementary assets required in the industry and where to find them but also an idea of where the returns are likely to be biggest.

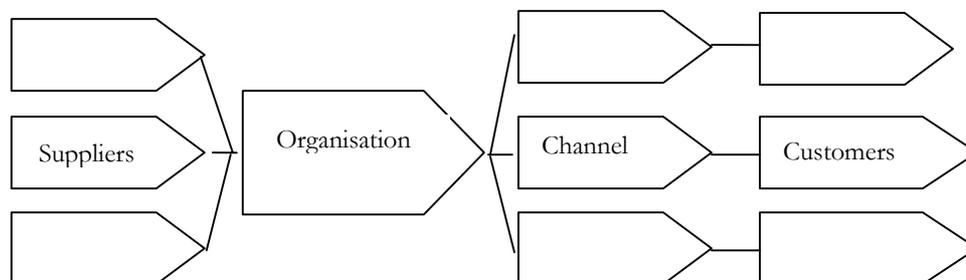


Figure 3.6: Value system in an industry. Source: Johnson & Scholes, (1999)

⁶⁴ Teece, (1986)

⁶⁵ Gans & Stern, (2003)

⁶⁶ Johnson & Scholes, (1999)

3.3.3 Commercialisation forms

The market-related factors provide an overview of the size and potential of the market but also of the attraction and competition in the market. This gives an answer to the questions if the market is big enough to warrant the product? Are there any foreseeable growth in the market that will make the product profitable? Are there any entry barriers for a start-up? The resource-related factors consist of three different areas; internal resources, intellectual property rights and complementary resources. Internal resources give information about existing competencies, the financial situation and what kind of complementary resources does the company already has. IPR provide information about the strength of the patent. Does it provide a security for the company and is it safe to license out the technology? Complementary resources gives information about resources needed to exploit products in the market? Are these complementary resources accessible? Market and resource related factors will delimit the choice of commercialisation forms. In this section the interrelatedness and dependency between the factors is assessed and the requirements for each of the commercialisation forms is presented.

Competition – New Venture

The choice of competition strategy is dependent on at least three factors.

- The firm has to decide if the market is sufficiently large to warrant the development project. The start-up has to balance the cost of acquiring capital and building in-house production, distribution and marketing capabilities against a possible market share⁶⁷. It is also important to consider the entry barriers, and if they are surmountable or not.
- If the intellectual property protection is poor, Gans & Stern⁶⁸, argues that the very fact of bringing the technology to the attention of established firms weakens the position of the initial innovator. They mean that a weak IP protection in a situation when incumbent firm does not control the complementary assets, the start-up has an opportunity to successfully exploit the technology itself. In this environment, Teece⁶⁹ means, that access to complementary assets are critical if not handling over profit to the imitators or owners of the complementary assets.
- The complementary assets must be tradable⁷⁰. In some industries the brand name reputation are very important for the customers⁷¹. This takes a long time to built and is, therefore, not tradable.

However, the heart of a successful competition strategy is to go for niche segments⁷². Shane writes that statistics support that new entrants can displace incumbents by entering market

⁶⁷ Börrefors & Welin, (1986)

⁶⁸ Gans & Stern, (2003)

⁶⁹ Teece, (1986)

⁷⁰ Arora et al., (2001)

⁷¹ Andrew & Sirkin, (2003)

segments with radical technologies and then expanding to the mainstream segment once they have established a foothold.⁷³

Cooperation - Joint venture / Strategic alliance

When should a firm perform cooperation strategy to commercialise its products? The size and structure in the market as well as internal resources must be assessed before choosing a cooperation strategy, such as strategic alliance or joint venture.

- A strategic alliance and a joint venture require a smaller market size and not as much internal resources as a new venture.
- If the competition is great and if there is a threat of reprisals from the incumbents then a joint venture or a strategic alliance are viable alternatives compared to a new venture.

The intellectual property protection and the complementary resources also need to be assessed. A survey with hundred start-up firms in five industries showed that cooperation was more likely to be chosen by a firm able to acquire IP protection or for whom control of complementary assets was not cost-effective.⁷⁴ The start-up can then enter the collaboration with its know-how and technology and the established firm with resources and complementary assets.

- If the firm has a strong IP protection and the complementary assets are under control of an incumbent the question is not whether to pursue a cooperation strategy but when and how.⁷² Strong intellectual property protection is, nevertheless, an exception rather than the rule.
- Entrepreneurs with weak IP can also benefit from cooperation if the start-up can find a partner who fosters a reputation of ensuring mutual advantage⁷². Gans & Stern means that a mutual advantage exists, when the start-up avoids investing in duplicative assets and the established firm reinforces their advantage by controlling the technology. Intel, is according to the authors, a company that have explicit incentives to encourage growth of semiconductor industry by signalling its commitment to avoid expropriation in the interest of longer-term relational contracts. Despite this incentive, Intel has been accused for expropriating by some firms that have had technologies too close to Intel's core technology. This means that even if a firm has strong incentives to invest in reputation, execution may in some cases be difficult.

⁷² Gans & Stern, (2003)

⁷³ Shane, (2001)

⁷⁴ Gans et al., (2002)

When the firm has a weak IP protection, a joint venture is to prefer to a licensing arrangement since it leaves the firms with more incentives and control.⁷⁵ Anand add that a weakly protected IP is always possible to invent around but in collaboration such as a joint venture the firm has more control and the possibility of monitoring⁷⁶.

It is important to find the right partner in order to be able to keep some of the control rights within the firm. The return of the innovation will also depend on the bargaining power of the start-up. It can be enhanced in at least two ways. First the value offered by the technology must be clearly demonstrated and secondly if the start-up is able to play the established firms against each other in bidding wars. The key to effective cooperation strategy is to initiate cooperation at a point when the technology uncertainty is sufficiently low but sunk investment costs have not yet become substantial.⁷²

To conclude, a firm should cooperate if the incumbents control the complementary assets. But if the IP protection is weak the choice of partner becomes even more important. Teece assesses that this situation is in reality very common, and require the most difficult strategic decisions.

Cooperation - Licensing

When licensing a technology the need for a large market is even smaller than for a strategic alliance or a joint venture, since the licensed technology can be a value adder to the licensee's product. The start-up's requirement for resources will also be diminished, because all the commercialisation activities for the technology will be handled by the licensee. There is though, a strong need for an appropriate partner as the return of the technology will be in its hands. The returns are, however, dependent of the bargaining power of the start-up firm as in the case for strategic alliance and joint venture. Moreover, a strong IP protection is preferable when licensing out because of the distance and lack of control between licensor and licensee. When a firm has weak IPR, Anand argues that exclusive contracts are unlikely to be effective, since former licensing parties might be able to invent around the patent. Thus, non exclusive contracts may reduce potential for cheating by co-opting the would-be patent infringers. Another instrument in this situation is the use of payment structure. A licensor might lower the prices through a combination of fixed price and royalty and thereby increasing possibility that a licensing contract would be acceptable to both parties.⁷⁶

⁷⁵ Cassiman & Veugelers, (1998)

⁷⁶ Anand, (2000)

4 EMPIRICAL RESULTS AND ANALYSIS

In this chapter the case company, Layerlab, and the empirical results of the three factors in the investigation framework – market-related factors, resource-related factors and commercialisation forms - are presented according to the outline in Figure 4.1.

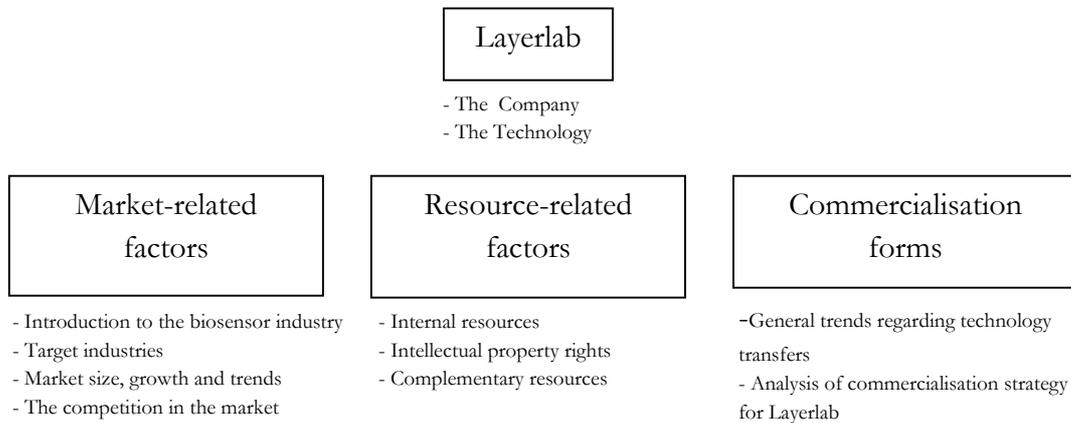


Figure 4.1: The outline for chapter 4.

4.1 Layerlab - the company and its technology

The case company, Layerlab and its technology, is presented in order to increase the understanding for the coming results and analysis.

4.1.1 The Company

Layerlab was founded in 2002 at Chalmers School of Entrepreneurship by three students. The aim was to commercialise a biochip technology developed by a group of researchers at the Department of Applied Physics at Chalmers University of Technology in Sweden. Today the company is located in the business incubator, Chalmers Innovation, and consists of a management and a research team. Only one of the founding students is active in the company on full time basis. This person represents the management team and is also the only person that is currently employed by Layerlab. The research team consists of seven persons, and is managed by an assistant professor. The researchers are employed by Chalmers University of Technology, but they have shares in Layerlab due to their contribution to the innovation.

Layerlab's business concept is to commercialise an immobilisation technology for membrane-bound proteins. The first application to be served is surface-based biosensors and other interaction and detection instruments for proteins. Then Layerlab will increase the number of applicable instrument technologies and application areas, for instance screening multiple targets. In the relation to the Department of Applied Physics at Chalmers University of Technology Layerlab will act as a platform to commercialise upcoming technologies.

4.1.2 The Technology

In order to understand Layerlab's technology, a description of the drug development process is a good start, because it is there Layerlab's future products will be used. Furthermore, the concept of biosensors will be presented as it is a prerequisite for the use of biochips. Finally, Layerlab's technology and the biosensor technologies, in which it is applicable, will be described.

Drug development process

The drug development process can be divided into five phases (Figure 4.2). The first is *discovery phase* with the aim of identifying potential drug targets. These targets are often proteins, associated in one way or another with a certain disease. Several proteins are involved in the origin and/or progress of a disease, although just a few or even one may have a function which allows them to be a potential drug target. Identified proteins are then evaluated to make sure that they are suitable as drug targets.⁷⁷



Figure 4.2: Drug development process. Source: Florin & Olbe, (2003)

The *development phase* consists of two parts, lead discovery and lead optimisation. The aim of the development phase is to identify chemical compounds, which have the characteristics of a potential drug. A drug is a compound that interacts with a target in such a way that the disease is cured or the symptom is eased. The first part of the phase involves finding compounds that bind to the target, a hit. High throughput screening (HTS) is often used to expose the target to a large number (more than 1 million) of chemical compounds. The hits are analysed in detail to select those hits that have a high potential of being a future drug, a lead.⁷⁸ During the second part of the development phase, lead compounds are optimised in a high-information-content screening in instruments such as Surface Plasmon Resonance (SPR)⁷⁹, in which Layerlab's biochip can be used. The optimisation process is often an iterative process where small chemical changes are made on the lead and then tested again, hopefully resulting in better drug properties⁷⁸.

Molecular studies, or even studies with isolated cells and tissues, cannot predict the response of a drug in a living organism, where the relevant combination of genetic, biochemical, pathological and environmental influences exists. Therefore, the *preclinical evaluation* is done in animals. This phase has several aims, which among others are to reveal unexpected secondary effects, assess safety and toxicology and also to predict the clinical dosage range.⁷⁸

⁷⁷ Florin & Olbe, (2003)

⁷⁸ Florin & Olbe, (2003)

⁷⁹ Cooper, (2002)

Clinical trials determine whether new drugs or treatments are safe and effective to humans but also at what doses the therapies work most efficiently and what side-effects they might have. These trials are done in humans, because controlled clinical trials are today the best way to determine how a new drug affects humans.⁷⁸

Drug development is a very costly and time-consuming process. The pharmaceutical industry is under increasing pressure to develop new drugs both faster and more efficiently.⁸⁰ To get an idea of the order of magnitude, it takes for example, 10.000 lead compounds, 10 years and costs 300 million USD to bring one drug to the market⁸¹. More than 75 percent of the cost to develop one drug is associated with failures. Companies try to learn as early as possible about a compound's mode of action, efficacy, safety and toxicology.⁸² One of the crucial rate limiting steps in the process is the conversion of HTS hits into lead compounds for preclinical evaluation. To find quality of leads under pressure is a drive to improve efficiency and to reduce failures in later stages.⁸⁰ The analysis of molecular interaction is thus a key part of the drug development process and many millions of dollars are spent on screening compounds. Biosensors are commonly used for such tasks. At present, most screens used in drug discovery require some type of fluorescent labelling or radioactive labelling to report the binding between the target (receptor) and the lead (ligand). This labelling imposes extra time and cost demands and can in some cases interfere with the molecular interaction. Ideally, a screening method should be label-free, sensitive and have sufficient throughput to be widely applicable in drug discovery. In 1980s SPR and related techniques that use evanescent waves were developed and allow the user to study interactions between molecules in real time and without labelling. Recent developments in instrument sensitivity have further increased the utility of optical biosensors in drug discovery.⁸³

Biosensors

The biosensor technology is used in applied and basic life science research. Drug discovery is perhaps the largest research application area.⁸⁴ Biosensor is an instrument to measure several biological properties, such as biomolecular kinetics, the strength of molecular interactions and the location of cellular binding sites. The central feature of a biosensor is a close coupling of biological materials to optically or electronically active surfaces in such a way that the biomolecular reaction is converted into an electrical signal that can be measured. These physical changes can be calorimetric (heat output), optical (light output) or piezo-electric (mass). The most common biosensor for commercial use has an optical response.⁸⁵ SPR and evanescent waveguide have been particularly successful biosensor technologies. The success of these two technologies has partly come from the integration with other technologies, such as new surface chemistries, surface modification methods, microfluidics and micromachining, which make it possible to attach a great variety of biomolecules to the surfaces and study very small amounts of

⁸⁰ www.biocore.com, 031015

⁸¹ Paulus, (2001)

⁸² Kerr, (2002)

⁸³ Cooper, (2002)

⁸⁴ Wrotnowski, (2002)

⁸⁵ Meyers, (1995)

material. Other technologies have become researched and can be competitive choices in certain niche applications⁸⁶.

Layerlab's technology

Most types of biosensors use biochips, which are usually composed of glass coated with a thin layer of gold, other metals or polymer. Biological compounds are attached to the thin surface in order to enable immobilisation (attachment) of a target. Then, a solution containing an analyte is passed over the surface and exposed to the target in order to allow a reaction. If there is a binding the captured partner is called a lead.

Proteins can be divided in two major groups, water soluble and membrane-bound proteins⁸⁷. Current protein chips are well suited to analyse the water soluble proteins. In the future there will, however, be a strong demand for chips that can immobilise membrane-bound proteins, as they represent more than 50 percent of all targets involved in drug research⁸⁸. The study of membrane-bound proteins is still difficult because the proteins require a lipid-bilayer environment to maintain their proper conformation and activity.⁸⁹

Today, when analysing membrane-bound proteins, the researchers must use either labels (fluorescent or radioactive) or cell-based methods which are both time-consuming and expensive. In other words it is considered inefficient in an already expensive and lengthy process for pharmaceutical companies, which are becoming increasingly aware of cost efficiency. Many researchers have tried to solve the problem with a label-free detection method for membrane-bound proteins, but until now there have not been any viable solutions. As one of the first companies, Layerlab has developed an immobilisation protocol to allow studies on membrane-bound proteins in biosensors. By using vesicles as basic carriers, the proteins can remain in their natural environment and their functionality are preserved. These vesicles are then immobilised onto a conventional surface, such as a standard SPR-biochip. To increase the sensitivity, Layerlab uses a unique multilayer technique, Figure 4.3.

⁸⁶ Wrotnowski, (2003)

⁸⁷ Bätelson & Wideman, (2003)

⁸⁸ Granéli, (2003)

⁸⁹ Lee & Mrksich, (2002)

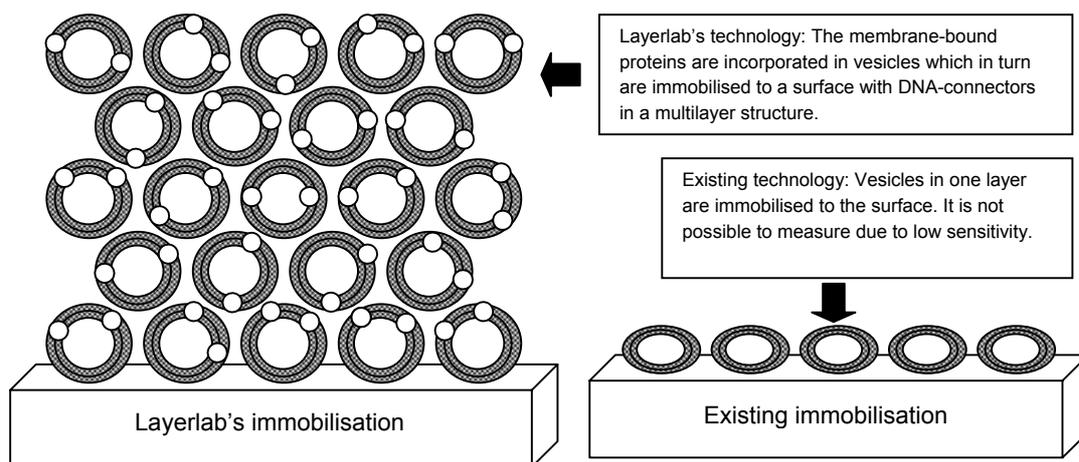


Figure 4.3: Basic principle of Layerlab's multilayer structure vs existing technology. Source: Business plan, Layerlab (2003).

Layerlab's technology is applicable in at least three types of biosensors. The requirement for applicability is that the technology is surface based. The technologies of application in a first product development step are SPR, PWG and SELDI (surface based mass spectrometry).

SPR biosensors visualise the progress of biomolecular binding by defining the change in mass concentration that occurs on a biochip during the binding and dissociation process of the proteins. The changes in mass lead to changes in the reflected light captured by the optical detection unit and converted to a resonance signal, Figure 4.4. The interaction is monitored in real time and the amount of bound ligands can be measured with high precision. This information provides valuable information in drug development and proteomics. The combination

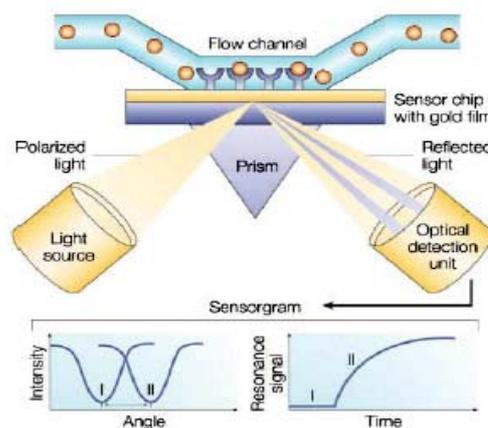


Figure 4.4: Typical set-up for a SPR biosensor. The SPR angle shifts (from I to II in the lower left-hand diagram) when biomolecules bind to the surface and change mass of the surface layer. Source: Cooper, (2002)

of binding and disassociation velocity gives a measurement of the potential as a drug candidate. A strong binding between the ligand and the receptor is a requirement for a potential drug target. In proteomics SPR will give insights into the mechanism of biological processes and the functions of proteins.⁹⁰

Planar waveguide (PWG) technology, Figure 4.5, uses an evanescent waveguide. Molecules are immobilised on a thin film (a planar waveguide) which consists of a high-refractive index material attached on a support material. Some of the fluorescently labelled proteins in the bulk medium bind to the immobilised molecules. Laser light is coupled into the planar waveguide and generates an evanescent field which extends only a few hundred nanometres into the solution. Therefore, only the surface-bound fluorophores are excited to emit light. The signals from the captured

⁹⁰ McDonnell, (2001)

analytes are monitored by CCD cameras.⁹¹ The advantage with this method is the restriction of the excitation light to only surface-bound fluorophores. The signal ratio is substantially increased which in turn facilitate the detection of binding molecules.⁹²

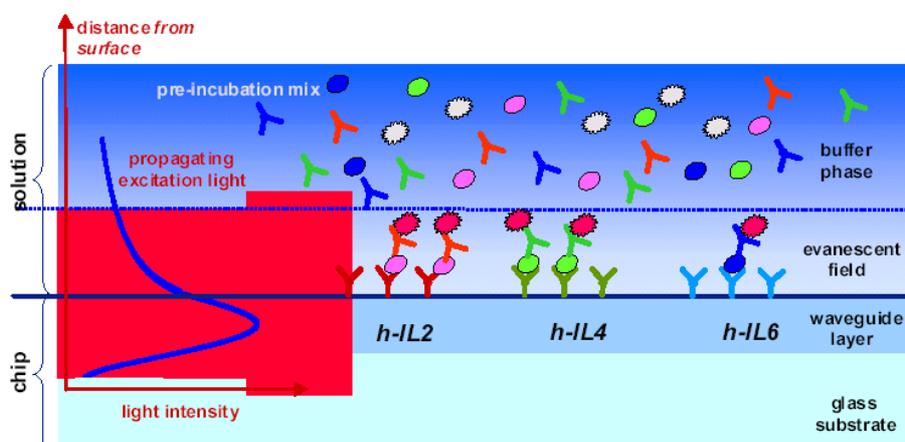


Figure 4.5: Example of planar waveguide technology. Source: Templin, 2001

SELDI, Figure 4.6, is a proprietary technology owned by Ciphergen and stands for Surface-Enhanced Laser Desorption/Ionization. It uses a ProteinChip Array with a pre-activated surface chosen to immobilise a specific target. Biological samples are applied in each of the spot on the array and left to react. After a short period unbound proteins are washed off the surface. Only proteins interacting with the immobilised targets are retained for analysis. The array is then analysed in a ProteinChip Reader which involves laser desorption and ionization of proteins from the array surface, and detection by mass spectrometry. The detection is possible since every protein has a unique mass and the mass spectrometry can determine the weight in an exact way. The SELDI technology enables protein discovery, profiling, characterisation and a better understanding of biological functions at protein level. This will give the researchers better insights in the molecular basis of the disease.⁹³

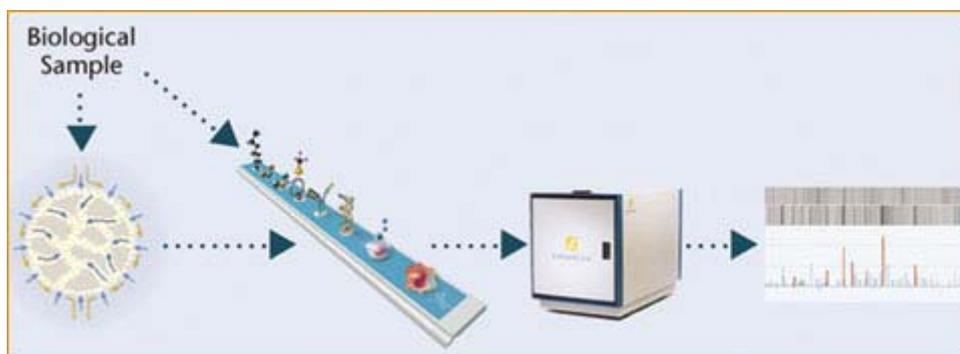


Figure 4.6: SELDI-technology. Source: www.ciphergen.com, 040122

⁹¹ Templin, (2001)

⁹² www.zeptosens.com, 040128

⁹³ www.ciphergen.com, 040122

4.2 Market-related factors

The market-related factors are market size, growth, trends and competition in the market. Before the market-related factors are assessed, there is an introduction to the biosensor industry and the target industries where Layerlab's technology is applicable. The section about the market size, growth and trends assess the potential of Layerlab's product. Finally, in the section about the competition in the market the potential for establishing a company in this area is analysed.

4.2.1 Introduction to the biosensor industry

The biosensor industry can be divided into different types of products and technologies. The industry consists of three types of products; initial systems, aftermarket and service, Figure 4.7. Initial systems, which are the instruments themselves, account for 73 percent of the total market. This segment is becoming increasingly competitive as several new vendors have entered the market the last two years. The aftermarket segment consists of sensor chips, reagents, computers and software and accounts for 20 percent of the total market. These products will become increasingly important as the user base expands from academia into the pharmaceutical and biotech sector. The latter sector has a higher analysis throughput than the academia. The last segment, service, accounts for 7 percent. The total market for biosensors is estimated to 124 million USD in 2001. By 2005, the market is expected to surpass 235 million USD.⁹⁴

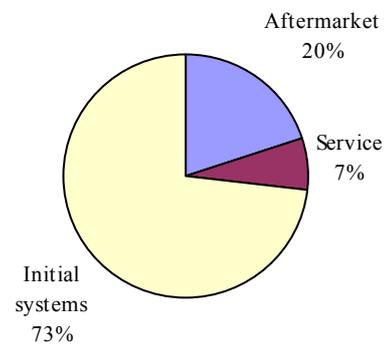


Figure 4.7: Biosensor worldwide demand by product type. Source: SDI, 2002.

SPR (Biacore, Xantec and Thermo in Figure 4.8) accounts for the majority of the demand but other technologies, such as SELDI (CIPHERGEN in Figure 4.8), are making impact in the marketplace. The industry is dominated by one big player, Biacore, with an estimated market

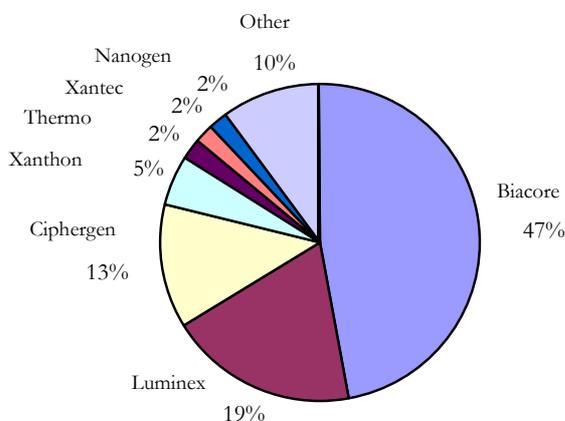


Figure 4.8: The biosensor market, 2001. Source: SDI, (2002)

share of 47 percent of total market. Biacore was the first company to develop and market biosensor instruments and has invested heavily in technology development since then. Thus, Biacore enjoys a strong customer loyalty today. Luminex and CIPHERGEN have a market share of 19 percent and 13 percent respectively. The other companies in the biosensor market are rather small and have only a couple of percents of the total market or are still

⁹⁴ Strategic Directions International (SDI), (2002)

developing their first product. Competition has increased in the last couple of years, especially for lower priced instruments. These small companies have difficulties in competing due to the lack of global marketing and distribution capabilities.⁹⁴ Much has however, occurred since 2001, and the industry landscape has changed, especially among smaller players. Several new companies have entered and some have left the market. Thermo Labsystem Affinity Sensors was, for instance, in a patent dispute and was issued a permanent injunction to Biacore by the court and is no longer providing a SPR-instrument⁹⁵.

Due to the relative newness of the biosensor technology, the current customer base primarily resides in research labs in North America, Europe and Japan. North America has the largest demand of biosensor products, but the Japanese sector, which consists primarily of academic and governmental users, is one of the fastest growing sectors. In Japan additional funds are provided to intensify international research cooperation in basic life science research, particularly in proteomics. This is expected to increase the demand for biosensor products in Japan.⁹⁴

4.2.2 Target industries

There are, as mentioned before, three technologies where Layerlab's technology is applicable in a first product development step; SPR, PWG and SELDI. These technologies can all measure or detect biomolecular interactions, even if the area of focus may differ. The industries for the three technologies have different appearances. The SPR-market is composed of about twenty companies, whereas the other two only are composed of one or two companies using the same technology. The companies reside primarily in USA, Germany, Netherlands, Japan, UK, Switzerland and Sweden.

SPR- A list of companies that belongs to the SPR-market will follow below. These companies produce either SPR-instruments and associated biochips or only biochips for SPR-instruments. They are, moreover, divided in regard to customer focus. Most of the companies states that they sell to academia as well as to biotech and pharmaceutical companies. However, some of the instruments are more appropriate to the requirements of pharmaceutical customers, for instance, high throughput instruments. The instruments that are primarily offered to the academia are usually portable, less automated and cheaper. Companies that only sell biochips are in their own group. All the companies in the SPR-industry except from Biacore share ten percent of the market.

Companies producing instruments and biochips for drug development process

Biacore has a market leadership position in SPR technology and holds approximately 90 percent of the market in terms of sales. The company was founded as a spin-off from Pharmacia in the middle of the eighties.⁹⁶ Biacore has developed a large and growing family of SPR-based devices. A proprietary gold-coated sensor chip with various immobilised chemistries is a key feature of

⁹⁵ Wrotnowski, (2002)

⁹⁶ www.biacore.com, 031207

the Biacore technology.⁹⁷ In November 2002 Biacore launched a system that uses fluorescence (labels) instead of SPR, designed to target membrane-bound proteins. The system was intended to complement its SPR-instrument. During 2003 Biacore decided to exit the cell-based market by discontinuing with this labelled system and refocus on SPR.⁹⁸

Applied Biosystems entered the SPR market as late as September 2003 by introducing a product called 8500 Affinity Chip Analyzer developed under a licensing and supply agreement with HTS Biosystems. Applied Biosystems is part of the public company, Applera Corporation, and develops and markets instrument-based systems, reagents, software and contract services to life science industry and research community. Applied Biosystems has 3400 employees worldwide. The SPR-instrument with associated chips for measuring binding events is in a high throughput format and the customers are primarily in drug discovery and development.⁹⁹

HTS Biosystems is a privately held, American company with 23 employees¹⁰⁰ who is specialising in high throughput bioanalytical systems for proteomics.¹⁰¹ The company has developed a high throughput SPR-instrument, which is now produced, marketed and sold by Applied Biosystems¹⁰², whereas HTS Biosystems produces the biochips. The company also has a licensing agreement with Gentel Biosurfaces who produces surface chemistries.¹⁰³ HTS Biosystems claims to have a method for reducing production costs for SPR-based protein biochips, but it has not released these biochips yet.¹⁰⁴

IBIS is a small Dutch company that develops, markets and sells SPR-instruments and sensor disks. The company launched beta versions of its second product line in the beginning of 2003 – the IBIS iSPR can be applied for high throughput screening.¹⁰⁵

Proterion Corporation (former known as AVIV), a public company that has served the research community for 35 years. The company has 38 employees worldwide. Only recently Proterion bought a patent for a two dimensional SPR-instrument called Plasmon Waveguide Resonance (PWR). The technique has its roots in both SPR and waveguide phenomena. This is one of three divisions in the company. The PWR-instruments still require product enhancements and products upgrades that came to hand from beta test customers during 2003. These instruments are designed to study the interaction of membrane-bound proteins. The technology was originally developed at the University of Arizona, USA.¹⁰⁶

⁹⁷ Wrotnoski, (2002)

⁹⁸ www.selectbiosciences.com, (2003)

⁹⁹ www.appliedbiosystems.com, 031206

¹⁰⁰ www.smalltimes.com, "SRU Biosystems tries to lighten the load for drug discovery", 040127

¹⁰¹ www.htsbiosystems.com, 040120

¹⁰² William Beltz, Product Manager, Applied Biosystems, 040121

¹⁰³ www.gentelbiosurfaces.com, 040120

¹⁰⁴ www.selectbioscience.com, Market report on Protein Biochip, 2003

¹⁰⁵ www.ibis-spr.nl, 040121

¹⁰⁶ www.proterion.com, 031206

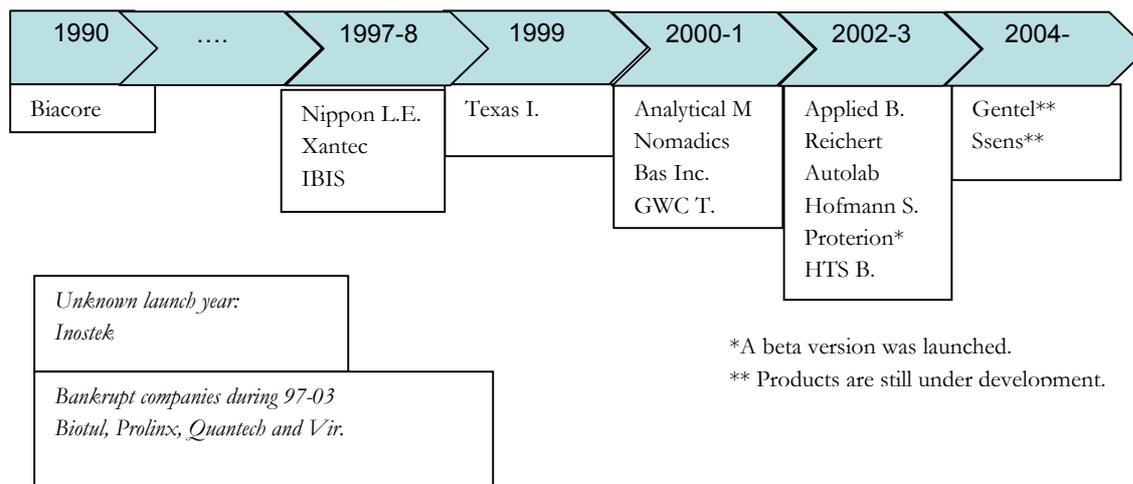


Figure 4.9: An overview of when the companies launched their first SPR-products.

Companies producing instruments and biochips for Academia

Autolab is a Dutch company, founded in 1986. The company develops, manufactures and sells electrochemical- and SPR-instruments. The SPR-instruments and adherent biosensor chips were added in the product portfolio in the end of 2002. Autolab has developed a special adaptor that allows the use of Biacore's sensorchip in its instruments.¹⁰⁷

Analytical Microsystems is a German start-up company, which markets a portable SPR-instrument for a number of research applications. The company offers a cheap, light-weighted and easy-to-use instrument. The company has been selling the instruments since 2000. Analytical Microsystems also offers a range of chemical and biological preparation for its sensor surfaces.¹⁰⁸

Hofmann Sensorsysteme is a small, newly restarted German company (former Jandratek) with four employees. The company manufactures and sells instruments mainly to the academia. Hofmann Sensorsysteme is considering starting to manufacture biochips in near future in cooperation with University of Marburg, Germany.¹⁰⁹

Reichert is an American, privately owned company. Reichert bought Leica Microsystems who developed a SPR-instrument and sensorsurfaces during 2002. Today Reichert consists of three divisions in which SPR is part of one.¹¹⁰

GWC Technologies is a small spin-off company from the University of Wisconsin-Madison, USA with six employees. The company, founded in 1997, manufactures and sells its own SPR-instruments and chip.¹¹¹ The company has a co-marketing agreement with Gentel Biosurfaces.¹¹²

¹⁰⁷ www.ecochemie.nl, 041217

¹⁰⁸ www.micro-systems.de, 031206

¹⁰⁹ Michael Wacke, Hofmann Sensorsysteme, 031211

¹¹⁰ www.reichert.com, 031210

Nippon Laser Electronics is a Japanese company that develops and sells SPR-instrument and biochips since 1997. The company is now the dominant player in the Japanese market within SPR. It is, however, only operating in Japan. Nippon Laser Electronics has entered the area of microarray and nanotechnology.¹¹³

Texas Instrument is a huge company with 35.000 employees worldwide and total revenue of 8.4 billion USD. The business segment “Sensors and controls” only stands for 1 billion USD and where the SPR-instrument itself, only is a tiny part. Texas Instrument has developed a low-cost and portable SPR-instrument called SPREETA. These sensors are designed for field work, environmental testing and other areas that can use a less sensitive instrument¹¹⁴. The company started the development of SPREETA in 1995 and it was introduced in 1999. The instruments are sold to biosensor developers and researchers.¹¹⁵ Texas Instrument’s biosensor is primarily marketed for applications in diagnostics, food/beverage quality and safety¹¹⁶. *Nomadics* are one of Texas instrument’s distributors. *Nomadics* is an American company that focuses on developing sensors and instrumentation that are small and portable for specialised research and as a training tool. The company offers an evaluation module that integrates the SPREETA sensor.¹¹⁷ *Bas Inc.* also distributes Texas Instrument’s SPREETA technology but is restricted to the Japanese market¹¹⁸.

DKK-TOA is a Japanese company that sells analytical and electronic instrumentation. The company sells a portable SPR-instrument. DKK-TOA employs 600 persons and the company has a European subsidiary in the UK.¹¹⁹

Biochip producers

GenTel Biosurfaces is an American start-up company with close relationship to the University of Wisconsin-Madison, USA founded in 2000. The company is offering substrates and surface chemistry to biochips and the biochip industry. GenTel’s biochips are compatible with different detection methods, among them SPR. GenTel will also produce custom surface chemistry, including patterned surfaces, creation of unique biochip shapes and sizes. The first product line, GenLink™ biochips will be launched in near future. GenTel has co-marketing agreement with GWC Technologies and a licensing agreement with HTS Biosystems.¹²⁰

¹¹¹ www.gwcinstruments.com, 030120

¹¹² www.gentelbiosurfaces.com, 030120

¹¹³ <http://www.nle-lab.co.jp/English/ZO-HOME.htm>, 040126

¹¹⁴ Wrotnowski, (2002)

¹¹⁵ www.ti.com, 031210

¹¹⁶ Wrotnowski, (2003)

¹¹⁷ www.nomadics.com, 040119

¹¹⁸ www.bas.co.jp, 040119

¹¹⁹ www.dkktoa.com, 040126

¹²⁰ www.gentelbiosurfaces.com, 040120

Ssens is a Dutch start-up company founded in the end of 2002. Ssens has the same owners as IBIS. The company states that it can provide any kind of surfaces and with any kind of surface chemistry. The surfaces are compatible with common commercial SPR-instruments.¹²¹

Xantec, founded in 1997, is small German company with only five employees. It offers SPR biosensor technology and biocoatings. The company claims to have the largest sensor surface suite in the marketplace and provides its customers with tailor-made surfaces for almost all experimental need. Xantec produces biochips for Autolab's and Ibis' SPR-instruments.¹²² The company was a former reseller for IBIS instrument.

Inostek is a Korean start-up company that produces SPR biochip.¹²³ It seems to only be a small part of business which mainly consists of electromechanical devices.

SELDI- The SELDI-technology is proprietary and owned by CIPHERGEN. SELDI technology consists of a biochip with mass spectrometry.

CIPHERGEN is a public American company that introduced its first version of SELDI ProteinChip in 1999. Today the company develops, manufactures and markets a whole family of ProteinChip systems and services. CIPHERGEN employs 360 persons worldwide. The products are sold both to academia and commercial institutions such as biotech and pharmaceutical companies.¹²⁴ CIPHERGEN and Biacore are largest suppliers of protein biochip¹²⁵.

PWG- There are two companies that use PWG-technology but in different applications.

ZEPTOSENS, founded in 1998, is a company from Switzerland that launched a protein microarray based on PWG technology during 2003. The company has both a protein microarray (Zeptomark) and DNA microarray (Sensichip) in the market. The protein microarray is used for analysis of protein modifications and early profiling of drug candidates for efficacy and toxicity studies.¹²⁶

FARFIELD SENSORS is a small English company founded in 1997. The company has launched a biosensor that uses PWG, called AnaLight Bio200. Farfield also sells biochips to its instruments that are prepared for different applications. The biosensors provide information in biomolecular analysis and in protein characterisation in academic research. In November 2003 was Jasco accredited to act as sales and service representative in UK for the Analight Bio200.¹²⁷

¹²¹ www.ssens.nl, 031205

¹²² www.xantec.com, 040119

¹²³ www.inostek.com, 040126

¹²⁴ www.ciphergen.com, 040122

¹²⁵ www.selectbiosciences.com, 040119

¹²⁶ www.zeptosens.com, 040119

¹²⁷ www.farfield-sensor.com, 040119

4.2.3 Market size, growth and trends

In this section market size, growth and trends in the protein biochip market for the above mentioned instrument technologies is assessed according to Chapter 3.3.1 in the investigation framework.

Market size

The prerequisite for Layerlab's products is the amount of instruments sold. The total market of biochips today is therefore dependent on the total amount of instrument in use. The more instruments there are in the market, the higher the demand for consumables such as biochips. Therefore, this analysis of the market will be focused on the size of the biosensor market and particularly the SPR-market.

Today the academia account for 65 percent of the purchases of biosensors, whereas biotech and pharmaceutical companies account for 35 percent. During the past few years biosensor vendors have increased their efforts to develop products designed for pharmaceutical and biotech users in order to increase their sales of consumables as these companies have a higher throughput than the academic sector. The academic sector is, however, still very important. Partly because there is a large installed base of biosensors and these installations generate revenues from consumables. There are, however, still issues regarding the instrument's throughput and sensitivity that need to be solved before the demand within the pharmaceutical sector will increase.¹²⁸ They need high throughput systems with high sensitivity to facilitate parallel screening.

The protein biochip market today for Layerlab's product consists of instrument users of SPR, PWG and SELDI. There are about 2125 instruments in use worldwide¹²⁹. The market drivers for the biochips are number of analysis a year for each instrument and number of chips to perform these analyses, by the different customer type. According to Select Biosciences market survey¹³⁰, Figure 4.10, the protein biochip market is underserved, even though it has been growing from 8,5 million USD in 2001 to 12,5 million USD in 2002. The market is projected to surpass 53 million USD in 2007. This would correspond to an annual growth of 36 percent. (The protein biochip market consists in this work only of biochips sold. Consumables accounts for approximately 25 percent¹³¹ of Biacore's total sale, why protein biochips should be approximately 10-15 percent of Biacore's total sale. This number is, therefore, used as an estimation of the total market).

¹²⁸ SDI, (2002)

¹²⁹ Biacore has sold approximately 1500 instruments and has a market share of 85 percent in terms of instrument sold. It makes 1725 SPR instruments worldwide. CIPHERGEN, Zeptosens and Farfields have together sold approximately 400 instruments.

¹³⁰ Steven Bodovitz, Market analyst on Protein Biochip Market, Select Bioscience, 040212

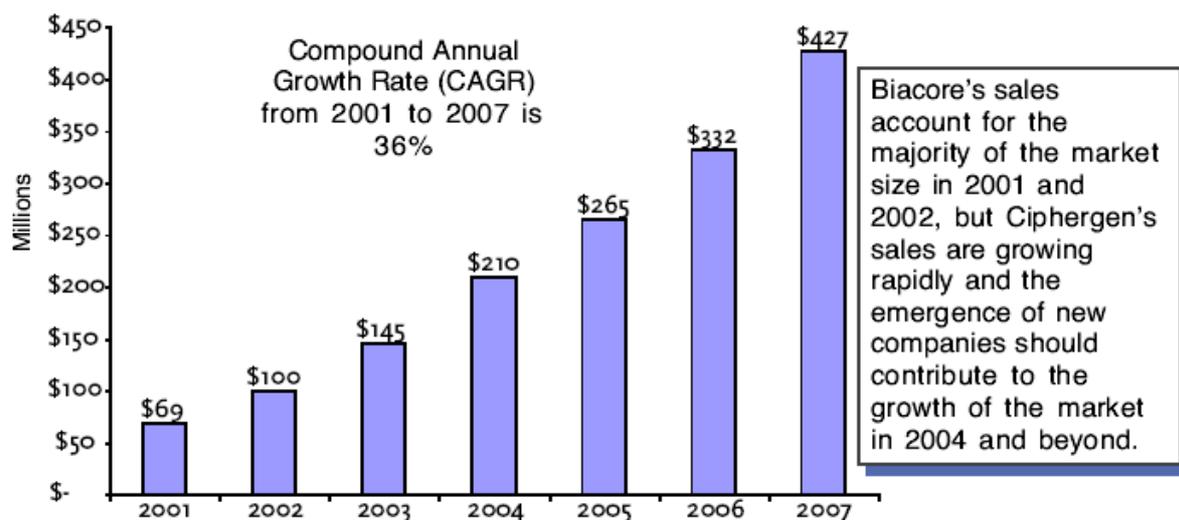


Figure 4.10: The total market for consumables and instruments. Source: www.selectbioeconomics.com, Market report on Protein biochip 2003.

The size of a potential future market depends of the rate of acceptance by the customers. The rate of acceptance depends upon three factors. The first factor is characteristics of the product and the perceived advantage relative to the best alternative. Many researchers have tried to give a satisfactory answer to the problem of analysing membrane-bound proteins with a label-free method, without any success. If Layerlab's technology fulfils the expectations the same customers as Biacore have today will be interested in such a method, especially the pharmaceutical industry. This is, namely, frequently demanded by Biacore's customers.¹³¹ Moreover, it is a problem for new instrument developers in the industry today to make surfaces with good quality, and the knowledge in surface chemistries are much coveted¹³². The nature of the surface chemistry and attachment strategy is one of the major factors for determining the quality of data obtained in the experiments. For optimal sensitivity and reproducibility, the activity of the immobilised target has to be retained and non-specific binding of proteins to the surface (the ligand binds to something else than the target but the mistake is not detected by the instrument) must be minimised.¹³³ If Layerlab can commercialise its biochip technology, it will also increase the market for the instrument producers, because the current biosensors are not satisfactory for analysis of membrane-bound proteins. Instead, these customers have to use other technologies for this purpose today.

Before a product will be accepted by the customer, to be order qualifying, it must however meet the basic requirements that exist in the industry¹³⁴. In the protein biochip market the products must be reproducible. It is impossible for the researcher to see what is happening in the instrument, and it must therefore be possible to repeat a test with a given input and produce

¹³¹ Stefan Löfås, VP and CSO, Biacore, 031204

¹³² Berka, Product Manager, Analytik Jena and two of the focus companies

¹³³ Syder & Nock, (2003)

¹³⁴ Waters, (2002)

identical results. The biochips must finally have an appropriate throughput for the purpose of use and be easy to use in order to be cost-effective discovery and screening tools.¹³⁵ In order for the product to perform better than the others, to be order winning,¹³⁴ it must have high sensitivity and produce high quality of data.¹³⁵

The second factor that influences the rate of acceptance is the speed with which customers adopt to new products. The lead users are also called “creators of public opinions” because their acceptance is a key to acceptance by other segments. In the biosensor market, the lead users are renowned researchers within the academy or the industry. These persons are generally working with applied research and they publish frequently in professional journals. Because of their success they receive considerable grants for their research and have therefore means to invest in new and unproven technology. These lead users are, for instance, researchers at University of Stanford/Harvard/Strasbourg or at Astra Zeneca/Pfizer. The next segment to adapt to new technology is early adopters. In the biosensor market, these are less well-known researchers who receive smaller grants than the former ones. They must be ensured that they will get value for their money and are therefore not able to invest in new technology in the same extension as the lead users. The third group to adopt new technology, the early majority, are even more price-sensitive than early adopters.¹³⁶ They want standard products that are well proven and are, for instance, researchers at medium sized laboratories and pharmaceutical companies.¹³⁷

For a biochip producer, such as Layerlab, the lead users are successful researchers that have existing biosensors and are working with membrane-bound proteins. When the technology has received acceptance by such a group of “creators of public opinions”, a biochip producer must sell to increase its volume. Prospective early adopters/majority for a biochip producer is a drug developing or a biotech company that are in the field of drug development.

The third factor that influences the rate of acceptance is speed of diffusion. It depends on how fast the buyers progress through the adoption process. The ease of progress through the process depends primarily on the lead users experienced customer benefits and if they publish articles about their results. “Right word, in right time can replace five years of own marketing efforts” says Eva-Carin Tengberg, CEO at Q-sense that successfully launched a bioinstrument a couple of years ago. These lead users can also provide feedback that eventually results in enhancements that are essential in order for the early majority to be interested in the product. In other words, the lead users are essential for providing acceptance of new technology and they act as advertiser at public forums such as conferences or trade shows, where the early majority frequently attend. Finally, they provide feedback for further product development.¹³⁸ To move biochips beyond the early adopters and into a broader range of labs, manufacturers must solve some technological and biological problems. It can not take too long to get results or require extensive tinkering then it

¹³⁵ Interviews with focus companies, Bodovitz, (2003) and Robert Jones, Cambridge Consultant, 040218

¹³⁶ This section is written with input from Stefan Löfås, VP and CSO, Biacore and Eva-Carin Tengberg, CEO, Q-sense, 040128

¹³⁷ Peter Oroszlan, Business Developer, Zeptosens, Switzerland, 031210 and www.biacore.com, Press release 990928

¹³⁸ Eva-Carin Tengberg, CEO, Q-sense, 040128

will not gain widespread acceptance. Most labs will not invest until there is a packaged with a high likelihood of producing useful results.¹³⁹

Future trends and growth

What are the future trends and growth in the protein biochip market? There has been an increased emphasis on proteomics since the completion of the human genome project. This is driving an end user desire for affinity and kinetics information¹⁴⁰, which a biosensor with capability of protein studies can provide. DNA-chips are, however, still dominant in the biochip market. The trend in the DNA-chip market is towards increasing specificity to certain applications as well as efficiency and the DNA-chips are becoming optimised in order to increase the capacity.¹⁴¹ Protein chip is a fairly recent development, which has only been in the market since early nineties. It is commonly held that the protein chip market would have had a growth similar to that of DNA-chip, but the expectation has not been fulfilled and the protein chip market is still in its infancy¹⁴¹. There are, however, an increasing number of commercially available instruments that are driving forward the development of sensor surfaces, immobilisation techniques and attachment chemistries. The optical biosensors will gain in advantage where high-information content rather than ultra-high throughput is important. The impact of these biosensors will therefore grow over the next decade.¹⁴² Protein chips will, however, only see a wide-spread implementation in research laboratories when they are routinely available for commercial use¹⁴³. There are a few companies developing protein biochips but none is selling them in volume¹⁴⁴. A substantial effort will be required to develop procedures for quality control, for improving the shelf life of chips – particularly those that present membrane-bound proteins – and for training and implementing a technical marketing and services team. The leading researchers assess that the maturation of this technology will occur during the near future.¹⁴³ A protein chip market analyst argues that the reason for the slow development of the protein biochip and limited breadth of product offerings are due to a content problem. There is a lack of high-quality capture agents that can be immobilised on the surface of a biochip to bind proteins. Protein capture agents have more complex interactions with their targets than DNA capture sequences. DNAs are easier to generalise and have a much simpler construction. Each protein capture agents must be optimised empirically which presents a challenge for large-scale production. To solve the content problem there are four possible strategies according to the author. One of these strategies is to improve detection methods, such as SPR and SELDI. The challenges in adapting these platforms which currently use surface chemistry with the use of capture agents will reduce costs and increase throughput.¹⁴⁵ It will, furthermore widen the bottleneck that exists in the proteomic research because the researchers are generating a flood of potential drug targets but are facing a growing bottleneck in secondary screening¹⁴⁵.

¹³⁹ www.frost.com, Market report on Functional Proteomics, 040210

¹⁴⁰ Bethanie Benoit, Spreeta Marketing Product Manager, Texas Instrument, USA, 031202

¹⁴¹ Stefan Löfås, VP and CSO, Biacore, 031203

¹⁴² Cooper, (2002)

¹⁴³ Lee & Mrksich, (2002)

¹⁴⁴ William Beltz, Product Manager, Applied Biosystems, 040121

¹⁴⁵ Bodovitz, (2003)

4.2.4 The competition in the market

To get an overview of the competitiveness in the market Porter's five forces analysis will be undertaken. This analysis is based on interviews with focus companies in the biosensor industry. The competition depends upon the threat of entry, the power of buyer and supplier, the threat of substitutes and the competitive rivalry.

The threat of entry – The threat of entry depends on the extent to which there are barriers of entry for a newcomer. According to biochip and instrument suppliers in the interviews there are at least four barriers of entry that are most frequently mentioned. The first barrier of entry is Biacore, who is market leader in the protein biochip and instrumentation market and has a well-known brand name. Secondly, a new player must have marketing resources. One of the interviewees says that “To sell a product in an area where they have used other technologies for a long time is very hard. You have to take the customer by the hand and show them how it works”. Thus, to enter the market is a marketing challenge. The technology must get validated, accepted and announced to the world. Preferably is the feasibility of the biochip demonstrated with customer samples. Thirdly, there are several intellectual property rights for protein biochip technology. One of the interviewees argues that it is to begin with very expensive to develop new technology and then one also has to develop differently because of already existing patents. Another interviewee describes the area of optical detection method as a patent mine field, because it is very crowded with patents. For instance, Biacore has several patents around binding technology. This is experienced as hard to get around by several biochip producers and has also limited a few companies, for instance Thermo from successfully commercialise a product in this area. Fourthly, financing is an important issue for a start-up company in all industries and same accounts for the biochip market. It costs a lot of money to build up a company until profitability is reached, especially with own development, production, marketing and sales organisations. All of the interviewees, whose companies, were in need for more financing are of the opinion that it is difficult to find venture capital today, whereas the other not in need for financing think it is easy and depends primarily on how well connected the company is. There are several companies, among them Prolinx, that have went bankrupt during the last years because of problems to find additional financing. According to SwedenBio's report about biotech companies in Sweden entrepreneurs are reporting that it is more difficult today to find financiers. Due to the economic climate venture capitalists are less interested in financing the early stages. Finally, there is a barrier of entry not mentioned by the interviewees because all of them are producing instruments themselves. The last barrier of entry for a biochip producer is that all of the instrument developers except one have protected the design of the associated biochip. Milan Mrksich, a researcher in the area of protein chips at the University of Chicago, thinks that in the future there will be either joint venture agreements between biochip and instrument producers or the biochip producer sells the chip without any agreements. In the latter case he points out that there are a set of legal questions about the protected design that may emerge, but he thinks it will be practiced anyway.

The power of buyers - The power of the buyers is generally weak because the buyers are a fragmented group. Companies in the biosensor market sell to academia, pharmaceutical and biotech companies. These customers have different characteristics. Academia consists of independent researchers at the universities or institutes and the members in this group are smaller in size than the average biochip producer. These researchers only buy small quantities of biochips. Due to the special requirements of the pharmaceutical industry, only a minority of the biochip producers are focusing on these industries. Even if pharmaceutical and biochip companies' purchases are made in bigger quantities than the academia, it is still not volume purchases. The technologies are usually only a small part of their set of instruments. This might, however, change in the future due to further product development and automation. The switching cost of the buyer is high as the choice of biochips is dependent on the choice of an expensive instrument. This weakens the power of the buyers furthermore. The instruments are a great investment, where the most expensive costs 400.000 USD (Biacore) and the lower priced costs around 50.000 USD (Nomadics, DKK-TOA, Reichert, GWC Technologies). The instruments not only require high capital investment but also substantial investments in knowledge for the users. Thus, the choice of biochip producer is usually made already when purchasing the instrument because of the protected design of the biochip. The power of buyers will probably increase in the future, as several companies have entered the market and increased the choice of instruments and biochips.

The power of suppliers - The power of the supplier is high. The reason for this is that the biochip producer requires specialised components and makes great demands on quality, which increases the need for carefully selected suppliers. The switching costs are therefore high. The majority of the interviewed companies buy components and sub-assembled parts of the biochips and then they do the final assembly, tests and surface modifications in-house. One of the interviewees outsources all of the production. The instrument and biochip companies are moreover, often small and sell in small quantities, which increase the power of the suppliers. The supplier must thus deliver high quality products in time but without any volumes and it might only manufacture the biochips or parts of the biochips because of the image as supplying high quality products. The power is further increased, because of the threat of forward integration. The biochip producer is generally small and the supplier has already invested in specialised equipment. For instance, can a biotech supplier such as Amersham acquire a biochip producer if it does not obtain the prices it seeks.

The threat of substitutes - The threats of substitutes can be considered to be low. The protein interaction and detection technologies are new and there are no other upcoming technologies in a foreseeable future. The interviewed companies are, however, mentioning different substitutes depending on their technology, but they prefer to see the old-fashioned technologies as substitutes. They are, moreover, often seen as complementary technologies, as they are not providing exactly the same results. Two of the interviewees also mention that the other technology does not pose any threat because of the heavy investment of the instrument. When the purchase is made the researcher will have to use it.

Competitive rivalry – The competition has until now been low since the technology is new and at least the SPR-industry has been dominated by Biacore who has had monopoly-like position for a decade. The competition is likely to increase in intensity as a couple of new companies have entered the market during the last years. Within the mass spectrometry (MS) industry, with focus on protein has Ciphergen a dominant position. There are other companies entering that market as well. Biacore launched an instrument during 2003 that are combining SPR with MS. Even in the protein microarray industry the competition is increasing. The companies in this industry have an approximately similar size. Due to the forecasted growth in protein biochip market during the next five years, it seems to be space for more than one company to grow and prosper. Thus, the growth of the companies has not to be on the expense of somebody else's market share.

The newly entered companies have differentiated themselves and are focusing on different price segments, customers and technological features. The majority has entered in the low-cost division, whereas for instance Applied Biosystems is in a higher price range. The latter are competing directly with Biacore. Applied Biosystems has, however, the capabilities to pose a serious threat to Biacore with its existing marketing and distribution resources. Biacore assumes these newly entered companies to pose only a small threat due to outstanding quality of its products¹⁴⁶. During last year, companies that are only selling biochips have entered the market. The biochips are also differentiated with the type of surface chemistries and/or the number of tests that can be performed simultaneously (throughput). The companies with an installed base originating from their instruments have a clear advantage as the most biochips have a protected design. The increasing competition may, however, result in higher marketing costs for the involved companies. The new companies have so far only sold a few instruments each and have had to invest in capital-intensive machines for automated production. This might also result in price cutting activities in order for them to increase required turnover.

4.2.5 Conclusions of market-related factors

There are, as seen in the above analysis, a need for a method that can analyse the interaction between membrane-bound proteins and other biomolecules. It solves a problem that many of the customers in the current biosensor market have encountered. The market for protein biochips is emerging and, according to Select biosciences market survey, is underserved. The growth of the protein biochip market has, however, slowed down and is not following the same growth as for DNA which was predicted. This is due to proteins more complicated structure than DNA.

Five barriers of entry stands out as being of significance in the protein biochip market; Biacore, marketing, financing, IPRs and protected biochip design. The power of buyers is weak due to the high switching costs and it is a fragmented group. On the other hand, the power of suppliers is strong because of the biochip producers need for specialised components and high quality. There is only a low threat of substitutes as the technologies are recent inventions and there are no

¹⁴⁶ Biacore's Annual Report, (2002)

prospective new technology coming up in a foreseeable future. The old technologies are rather seen as complementary as they provide different results. Finally, the competition is increasing because new companies have entered the market.

4.3 Resource-related factors

The resource-related factors are internal resources, intellectual property rights and complementary resources. The section about internal resources describes Layerlab's present resources. The next section, intellectual property rights assess the strength of Layerlab's patent. Finally, in the section about complementary resources the specific requirements that exist in the market are analysed. These factors are assessed according to Chapter 3.3.2 in the investigation framework.

4.3.1 Internal resources

A SWOT-analysis is used to get an overview of Layerlab's internal resources. The analysis was partly produced as a result of a business development session, provided by the business incubator, Chalmers innovation, and partly based on an interview with the CEO at Layerlab. The focus of the analysis lies within the area of personnel, finance and technology. Due to reasons of confidentiality is this part found in Appendix 1.

4.3.2 Intellectual Property Rights

Layerlab filed a patent application in April 2003. An injunction to the patent was received in December 2003. This section will consider the strength of the patent with regard to the injunction. Due to reasons of confidentiality is this part found in Appendix 1.

4.3.3 Complementary resources

The need for and importance of complementary resources in the industry are crucial to analyse before entering a new market. This evaluation is undertaken with a value system and will answer the question of what is important in order to compete in the industry, and whether the crucial complementary resources are tradable? In this work, complementary resources are defined as those resources that support a development company to take its products to the market, such as human resource management, marketing, suppliers etc.

The value system (Figure 4.11) consists of suppliers, biochip companies, distributors and customers. The market of each part of the value system will be analysed to evaluate the requirements and their potential. The information in this section is based on the interviews with the focus companies.

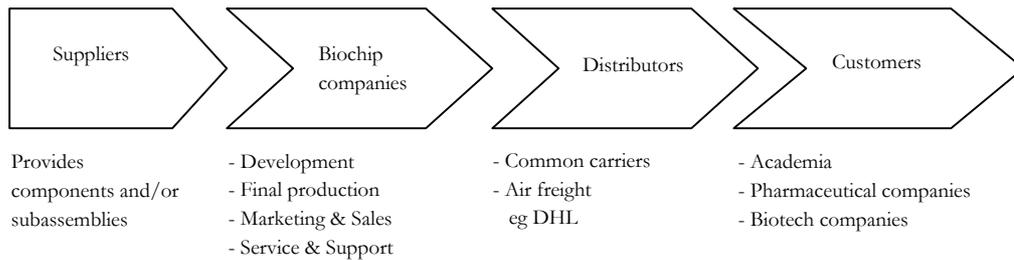


Figure 4.11: The value system in the biochip market.

Suppliers

The supplier in the biochip market provides the biochip developer with components, sub-assembled parts or the entire biochip. Biochips are consumables and the profitability will increase with the number of sold biochips. Economy of scale requires automated production systems, which means that the production of biochips requires investments in expensive equipment. If the company is interested in offering biological content on the surface, the company must also have special handling and storage area. This altogether, means that the company must invest for many hundred thousands USD. Thus, it will be difficult for a company to be profitable in the beginning as high capital intensity combined with low volume production is an unfavourable combination. As a result, a majority of the interviewees outsource parts of their production of biochips and they generally buy the sub-assembled components but do the final assembly in-house. However, all the companies that have a biological content on their biochips prepare this in-house. It is a way to differentiate itself from others but it also requires special knowledge. Most companies thus, use a supplier for the chip production, either to purchase parts, or the entire biochip. The production of biochips without biological contents is simple and can be easily outsourced. For a biochip producer without any existing production facilities it is difficult to be profitable in this area. Due to the proprietary knowledge of the surface chemistry it is, however, standard to make that operation in-house.

Biochip companies

The general biochip company carry out the development, final production, marketing & sale and service & support in-house. The organisation looks different depending on where in the product life cycle the company turns out to be. Organisations in the innovating phase have a majority of employees with a PhD in biochemistry, physics, chemists or in adjacent fields. One of the interviewees argues that when the company operates in a highly technical and complicated area, the employees must have credibility to interact with customers. The employee profile thus, depends on where the company is and what it must do. It will most probably change when the company develops from a developing company into a marketing and sales company. The established firms with less emphasis on product development and product commercialisation have also fewer numbers of PhDs. There are, however, a few companies that rely totally on the universities for competence in the area of biochips.

One of the interviewees mentions the importance of having a network with other companies and key users. In order to first learn about the special requirements of the customers and then produce biochips that satisfy those needs. Then, the company must have access to reagents to produce surfaces with an appropriate content. Reagents are kept proprietary and to get access the biochip producer must collaborate with a suitable partner¹⁴⁷. This is only essential if the company is selling biochips with biologically modified surfaces.

Marketing is seen as one of the most important complementary assets of the interviewed companies. A reason for this is that there are several technologies in the market. A company must make itself heard and get acceptance for its products. Almost all of the interviewees mentioned published articles as a particularly important marketing channel. One of the companies said to have increased its user base on peer review. The researchers use the technology in biological surveys and then publish the material in journals. An interviewee argues the importance for a newcomer to first generate data and publish the results. Then the products can be marketed. Part of the advertising by the companies is done on the internet, by direct mail or brochures. Advertising in journals are not common and only used infrequently.

These instruments and biochips are sold in a niche market which makes it important to have a worldwide presence in order to stay competitive and reach out to the customer. It is, furthermore, seen as important to be near the customer to give technical support because of the highly technical and complicated products that these companies are selling. One of the interviewed companies has a technical support with PhD in its sales force who acts as technical consultant to its customers in order to better understand the needs. The majority of the companies used a direct sales method. They either go directly to its customers or market its products at trade shows or conferences. Therefore, half of the focus companies, usually the larger ones, have a global sales organisation consisting of mostly own branches and in remote countries in cooperation with other companies. The other half of the interviewed companies have cooperation agreements with companies all over the world or are still looking for a future marketing cooperation because it is expensive to set up an own sales organisation. Only one company is selling their instruments from its home base but on the other hand has this company a small sales volume.

Distributors

Distributors are in this work the ones that transport the products to the customers. Distribution is also seen as an important complementary asset. There are, however, several distributors that qualify for the requirements held by most biochip companies interviewed. Biochips are robust and do not need special treatment. If the biochips are delivered with biological content they must, however, be kept on dry ice. This is not a problem as the most of the distributors have access to cold-storage room. The majority of the interviewees are thus, using common carriers and air freight to distribute their products. Only two of the interviewees do not consider the distributors to be in competitive supply. These companies think that the distributor has to have

¹⁴⁷ Biacore's Annual Report, 2002

an understanding of biochemistry as it makes the first contact with the customer. The distributor must also be able to give basic support to the customers. The instruments are generally thought as more complex and thus they need a specialised distributor. This might have influenced the answers of these interviewees in the matter of the distributor. In other words it was generally believed to be most cost efficient to outsource the distribution by most of the interviewees due to the amount of qualified distributors in the market.

4.3.4 Conclusions of the resource-related factors

To successfully commercialise a product in the biochip market the company needs to have competent personnel, particularly with technical background that can enhance the product according to the customers' requirements as well as having credibility when interacting with the customers. It is commonly held that marketing is important in order to make itself heard and get acceptance for the product. The customers must be educated of the product's advantages compared to the competing ones. In order to stay competitive in these niche markets the companies must have a global presence. The bigger companies have their own branches whereas the smaller ones have marketing and sales agreement with other companies. Moreover, if the company will develop biological surfaces it must have a network with key users in order to get access to essential substances. Production and distribution are not essential to keep in-house because they are tradable in the market. It seems to be most cost-efficient for, particularly a small company, to outsource these activities.

4.4 Commercialisation forms

This chapter - commercialisation forms - first considers general trends regarding technology transfer in the industry in terms of different commercialisation forms. Then it ends up with an analysis of an appropriate commercialisation strategy for Layerlab. The analysis is based upon chapter 3.3 about the third factor - commercialisation forms - in the investigation framework and chapter 4.2 and 4.3 regarding the empirical results of the market- and resource-related factors. Finally, choice of partner and risks in a cooperation strategy is presented.

4.4.1 General trends regarding technology transfer

In the investigation framework it was recognised that no company can survive as an independent technological island. The statement applies to the focus companies, where all except one cooperate with other companies and/or with universities. Most cooperation concerns joint development, whereas only a minor part is related to market agreements. Joint development is common because it is both difficult and expensive to be competitive in developing everything oneself.¹⁴⁸ For instance, Biacore has started a cooperation with Millennium Pharmaceuticals to develop SPR microarray chips. The alliance enables Biacore to optimise its drug discovery

¹⁴⁸ Interviews with focus companies

applications with compressed timelines. Millennium Pharmaceutical gives exclusive access to the technology for six months and after that, Biacore retains the right to commercialise all SPR-related findings¹⁴⁹. Another example is a focus company that has a strategic alliance with an instrument producer to develop and sell an interface to the other company's instrument. They work together with support and service, but they sell their own parts.¹⁴⁸ Furthermore, it is common to have some kind of agreement with universities, either a licensing or a commercialisation agreement. Due to the present tough investment climate, it is difficult to finance the activities, something that the Danish instrument and biochip producer Vir experienced. Vir built up an entire organisation with developing, marketing and sales departments. The company engaged around 30 persons in the end of the summer 2003. Half a year later all but three had to be dismissed due to problems with liquidity. They had overestimated the market size and underestimated the resources needed to sell the instruments. At present, the remaining employees are trying to find a company for cooperation in order to continue the operation.¹⁵⁰

4.4.2 Analysis of commercialisation strategy for Layerlab

What is the most appropriate commercialisation strategy for Layerlab? What are the crucial factors that determine the choice of strategy? In this section a discussion about advantages and disadvantages of the different commercialisation strategies is given, and the reason why a strategic alliance or a joint venture is the most appropriate commercialisation form for Layerlab is identified.

Competition - New venture

There are some product-specific factors that will make a new venture directly inefficient because Layerlab will have difficulties to appropriate money from its invention. Firstly, there are problems with the sale of the product. At this moment there are two possibilities.

- One possibility is to sell the technology as ingredients with a recipe on how to build Layerlab's surface. The problem will be to monitor the number of times the recipe is used, because the ingredients are standard in every biomaterial supplier. The users will also need to have some knowledge in surface chemistry to be able to build Layerlab's surface on the biochip. A solution to this problem would be if an instrument is developed that builds the surface itself. The user would then have to buy an instrument from Layerlab, biochips from the instrument provider and ingredients from a biomaterial supplier. The results would be ready-to-use-biochips. It would, however, require substantial resources for development of the instrument.
- The other possibility requires some kind of cooperation. It involves selling a biochip with Layerlab's technology attached to the surface. In this case Layerlab will either have to

¹⁴⁹ Savage, (2002)

¹⁵⁰ Carsten Thirstrup, Researcher, Vir, 040217

license-in the biochip design or arrive at an agreement with a biochip developer, because of the protected design of the biochips.

Secondly, another product-specific problem that Layerlab will encounter in a new venture, is the issue of product development. Layerlab's method needs to be improved. Today it takes, for instance, too long time to attach the layers on a biochip, and there is also a problem with the purification step (Chapter 4.3.1). To undertake product development in-house would require a large amount of capital. If Layerlab had enough capital it could employ personnel who could work full-time with product development as well as renting a laboratory with the required instruments. Capital is, however, difficult to get for an uncertain technology due to today's economic climate as the requirements for the entrepreneurial company is much higher today.

All the markets in which Layerlab's technology is applicable are small niche markets. In order to stay competitive in these markets there is a need for global presence. This will be expensive for a company to establish. Besides sales departments around the world, another essential complementary assets in these markets are the marketing channels. Due to lack of resources for an entrepreneurial firm such as Layerlab as well as serious problem of appropriating value from the invention and the need for further product development this alternative is not discussed any further.

Cooperation - Licensing

The next commercialisation form is licensing. Layerlab's technology can function as a value adder to the instruments and will probably increase the market of the instrument producer because its instruments can also be sold to customers, who are analysing membrane-bound proteins. The customers have until today been forced to use labelled methods which is more time-consuming and expensive than label-free methods. This will increase the value of Layerlab's technology. Another advantage for Layerlab with a licensing agreement is that the requirement for resources will be limited, because all the commercialisation activities for the technology will be handled by the licensee. Layerlab will, thus, have access to the customer base, marketing, sales and distribution which otherwise had been controlled by the incumbent.

There are also some problems that need to be solved before Layerlab should consider a licensing strategy. One problem is that it is very difficult to evaluate the technology and to set a price, because Layerlab does not know how far or how close the technology is from the market. It is hard to say how long it takes to solve problems that have come up. The further away from the market the technology is, the more of the potential return will be lost. Thus, the problem with product development persists if Layerlab will be able to earn money from its technology. Another disadvantage with licensing out Layerlab's technology is the difficulty to find a hook on the licensee. If the licensee was dependent of Layerlab in a way or another it would have been much easier to monitor how many products that were produced and sold. Layerlab would, furthermore, have a possibility to exercise power, if the licensee, for instance, discontinue the payments. It is important because licensing leads to a lack of control due to the distance between the licensor and the licensee. As Layerlab's technology is a method, it weakens the protection that can be

obtained from the patent. Layerlab would, moreover, not be able to serve a process upon another company due to a lack of finances.

An important issue to consider is the owners' intention with their company. Do they want Layerlab to be a technology supplier or a sale company? If the technology is licensed out it will be a pure technology supplier.

Cooperation – Joint Venture / Strategic Alliance

The last types of commercialisation forms are joint venture and strategic alliance. These cooperation forms will come around the problems that were earlier distinguished.

An advantage with a strategic alliance or a joint venture is that it does not require as much internal resources as a new venture and more of the company is left in the hands of the owners compared to a licensing agreement. A mutual advantage exists, when the start-up avoids investing in duplicative assets and the established company reinforces its advantage by controlling the technology. The established company does not need to be overrun by a new development because a cooperation with the owner of the new technology will be an enhancer for its own products. A collaboration will, furthermore, increase the value of Layerlab compared to licensing which can be seen as giving away value.

The disadvantages with a strategic alliance or a joint venture are the loss of control. Layerlab cannot control the marketing channels to increase its returns, because more control requires higher investment in resources. A partnership with another company will furthermore decrease the contact with the end user, and it results in lesser extent of response and information from the customer and the market. A possible solution to the problem could be that both parties are interested in improving the products. The question is then which company appropriates from the information which depends who is in charge of the research and development for the technology in the cooperation.

Layerlab can cooperate in terms of product development and production as well as in marketing, sales and distribution. The objective of the cooperation might also determine the final type of cooperation. A strategic alliance is usually a cooperation in near market projects with a specific end goal and timetable whereas a joint venture is a more formalised type of collaboration where the companies usually forms a separate organisation. The latter kind will then include everything from product development to distribution.

Choice of partner

A decision common to all cooperation strategies is the choice of partner. The start-up is entirely dependent on the partner for the success of its commercialisation strategy and the return of the innovation will depend on the bargaining power of the start-up. There are of course several criteria that must be considered before choosing a partner. In this work only the two industry-specific criteria will be considered. When choosing a partner, Layerlab should select a company with an established user base, as its sales will depend upon the number of instruments sold.

Another important requirement is that the company should sell its instrument to pharmaceutical and biotech companies because these companies have the potential to do volume purchases of biochips.

Layerlab can increase its bargaining power in two ways. Firstly, it can clearly demonstrate the value offered by the technology, and secondly, Layerlab can play the established firms against each other in bidding wars. If the technology's value is to be demonstrated, Layerlab must know the technology's strengths and weaknesses and continue its product development. This can be done through collaboration with potential customers such as Astra Zeneca. A cooperation with customers are preferable in this phase because it will increase the value before the negotiation with the final partner. To demonstrate the value of the technology Layerlab can collaborate with "creators of public opinions". Layerlab should try to find ten to fifteen renowned researchers in the most important markets, who work with the specific instrument and who analyse membrane-bound proteins. In exchange for employing Layerlab's technology for a reduced price, these researches will be asked to publish articles about their results in professional journals. They are furthermore a valuable contact for feed-back in order to make further product development.

When the value of the technology is clearly demonstrated Layerlab will be able to play the established companies against each other in a bidding war. First will Layerlab have to carefully evaluate appropriate partners, for instance, the market leaders in each of the three markets can be contacted, which are Biacore, CIPHERGEN and Zeptosens. At the moment these companies have the broadest user base in their markets and are all selling to pharmaceutical and biotech companies.

Risks

Of course there are risks associated with cooperation strategies. In this work only the three most important risks are discussed. They concern the following areas: technology, choice of partner and financing.

- Risks associated with the technology are; firstly the problem with analysing membrane-bound proteins in a label-free instrument can be solved by another company and secondly, Layerlab cannot hold what is promised and that it proves to be too difficult and/or expensive to solve the remaining problems.
- Risks associated with the choice of partner. In order to successfully commercialise the technology Layerlab is dependent of the partner. There is a risk that the partner will not perform according to Layerlab's perception of the contract. The partner might not be sufficiently interested in marketing Layerlab's products if they, for instance, are only a tiny part of its own product offering.
- Risks associated with financing. Layerlab does need additional financing to continue its operations. There is, therefore, a risk that Layerlab will be forced to be offered for sale if no more financing is found.

5 CONCLUSIONS

The last chapter presents recommendations for Layerlab in commercialisation issues as well as observations of general interest about the market for companies in the industry and entrepreneurs in the biosensor industry.

5.1 Recommendations for Layerlab

Layerlab is recommended to form a strategic alliance or a joint venture with an instrument and biochip producer. The key to effective cooperation strategy is to initiate cooperation at a point when technology uncertainty is sufficiently low but sunk investment costs have not yet become substantial. In other words, Layerlab has to develop the product sufficiently far in order to attain most possible value from the technology, compared to the invested capital, when negotiating with a partner. Due to reasons of confidentiality is this part found in Appendix 2.

5.2 General observations...

5.2.1 ...of the market for companies in the industry

This work has dealt with the protein biochip market and particularly with biochips that is used in SPR-, PWG- and SELDI-instrument which are part of biosensor industry. There has been a general idea that the protein biochip market would have had developed in a similar way that characterised the fast growth of the DNA biochip market. This has not been realised, much due to the large difference between DNAs and proteins. DNAs have a simpler construction and are easier to generalise than proteins. Today, there are many indications that the protein biochip market will grow in the near future. Since the completion of the human genome there has been an increased emphasis on proteomics and especially affinity and kinetics information which a protein specific biosensor can provide. Customers active in drug development have an explicit desire for cost savings because of the lengthy and expensive process of taking a drug to the market. This altogether has increased the demand for more efficient ways of testing and validating the drug targets.

In the end of the nineties it was easy to find venture capital and several companies entered the market. However, they realised that the market did not grow as fast as they first thought. Some of these companies survived, but several went bankrupt or were acquired. During the last years a new group of newcomers have entered the market. The latest trend is the pure biochip providers. Market analysts have recognised that the protein biochip market is today underserved and will have an annual growth of about 35 percent during the next four years. The much quoted numbers of a biochip market 2003 being worth 145 million USD includes both instrument and biochips. An approximate estimate of the protein biochip market would therefore be 36 million USD the same year.

The SPR-market today is dominated by Biacore that has been a market leader since it launched its first SPR-instrument in the beginning of the nineties. Biacore has a market share of ninety percent and sells the most expensive instrument. The competition has, however, increased in the lower price segments, and these instruments are less automated and usually smaller. The new companies have usually difficulties to compete due to the lack of sale and marketing capabilities. In 2003, Applied Biosystems launched a highly automated instrument that was developed by HTS Biosystems which will compete directly with Biacore. Applied Biosystems has, however, all the complementary assets needed to stay competitive.

Within the mass spectrometry with focus on proteins holds Ciphergen a dominant position with its unique SELDI-technology. The competition is increasing when more companies discover the importance of protein detection and interaction in proteomics and drug development. Even in microarray industry is the competition increasing. In this industry there are a few companies with roughly the same size where Zeptosens is one of them.

Academia has initially been the dominant customer segment. The less expensive instrument providers still focus on academia, whereas the instrument providers with highly automated and thereby expensive instruments are focusing more on pharmaceutical and biotech companies. The reason for this is that the latter market segment has a higher throughput than academia and, thus, the demand for consumables will increase dramatically in the future. There are still developments that need to be done in terms of sensitivity and throughput before this scenario will be fully realised.

The protein biochip market is still in its infancy and the business model for the companies in the market is to sell the instruments for a considerable price, whereas the biochips are cheap in comparison. When the market for instrument reaches saturation point a most plausible scenario is a business model comparable with that of printers and mobile telephones. The price for the biochip will increase, whereas the instrument will become cheap. The return on sales will probably increase for biochips and other type of consumables in the future.

5.2.2 ...for entrepreneurs in the biosensor industry

A market entry for an entrepreneurial company involves a great deal of uncertainty. Who are the customers? How can they be reached? Are there other companies that try to satisfy the same needs? What internal resources do we need? Are some of the crucial resources tradable? Before entering the market it is important to evaluate the most appropriate commercialisation strategy. The decision depends on several factors, and the present work has considered some of them. Other factors that may be interesting to investigate are, for instance, customer needs, time perspective and cost of each strategy. The final choice is in the end highly company-specific and cannot be generalised.

This work has, however, investigated what is required for an entrepreneurial company that wants to commercialise a product in the protein biochip market for biosensors and particularly, SPR-, PWG- and SELDI-instrument. The bioinstrumentation market consists of a huge amount of different technologies, where SPR, PWG and SELDI are three. Due to the different types of technology it is crucial to have credibility and to be able to convince the customers about the technology concerned. The entrepreneurial company must first have a product that satisfies the needs of its customers and be sure of the advantages compared to existing products in the market. This is for instance a product that is easy to use and have an appropriate throughput and sensitivity for the purpose of use. In this field a company cannot sell promises, it can only sell proofs. For the entrepreneurial company to attain credibility creators of public opinion could be persuaded to demonstrate the excellence of the product in professional journals. It is, furthermore, important to interact with the researchers to hear about possible areas of amendments for the product. This in turn makes the interaction with the next group of customers, the early adopters, possible. Finally to increase credibility the company must have personnel with enough knowledge in the area, for the interaction with the customers to be beneficial. The customers in this field are highly educated and therefore the supplier must be able to speak with the same language.

Collaboration is common in this industry. It is regarded as both expensive and difficult to perform with excellent results in all areas of the value system. The companies cooperate, however, for different reasons. The entrepreneurial company will have to consider its core competence and try to cooperate in the other areas. For a biochip provider with surface chemistry attached on the chips it is particularly important to get access to biological contents. These are usually kept proprietary by the companies that develop drugs. Therefore, collaboration with the end users is essential. For a pure biochip provider the only legal access to the protected design of the biochip is through cooperation. It can either be achieved through joint marketing and sales cooperation or the biochip producer will be allowed to produce and sell an interface to the instrument. The former kind of cooperation will involve less freedom of action for the small company than the latter. The ultimate choice of cooperation will of course depend on the entrepreneurial company's internal resources and capabilities.

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APPENDIX 1

APPENDIX 2