Bioentrepreneurship in Germany

Industry Development, M&As, Strategic Alliances, Crisis Management, and Venture Capital Financing

DISSERTATION

zur Erlangung eines Doctor rerum politicarum (Dr. rer. pol.)

an der Fakultät Sozial- und Wirtschaftswissenschaften der

Otto-Friedrich-Universität Bamberg

vorgelegt von Dr. rer. nat. Holger Patzelt

November 2005

Gutachter

(1) Prof. Dr. Dodo zu Knyphausen-Aufseß

(2) Prof. Dr. David B. Audretsch

Tag der mündlichen Prüfung: 3.4.2006

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Abbreviations

AG	Aktiengesellschaft
biotech	biotechnology
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CNS	Central Nervous System
CRO	Clinical Research Organisation
CSO	Chief Science Officer
DNA	Desoxyribonucleic Acid
DRAM	Dynamic Random Access Memory
DVC	Deutsche Venture Capital
e.g.	exempli gratia (for example)
ELISCO	Entrepreneurial Life Science Company
EMI	Electric and Musical Industries
GLSV	Global Life Science Ventures
GmbH	Gesellschaft mit beschränkter Haftung
GPC	Genome Pharmaceutical Corporation
HBM Bioventures	Henri B. Meier Bioventures
HI	Heidelberg Innovation
HLM	Hierarchical Linear Modeling
i.e.	id est (that is)
IKB	Industriekreditbank
Inc.	Incorporated
IP	Intellectual Property
IPO	Initial Public Offering
LSP	Life Science Partners
NA	North America
MBI	Management Buy-In
MBO	Management Buy-Out
n.a.	not available
n.d.	not determined

NASDAQ	National Association of Securities Dealers for Automated Quotation
NMT	New Medical Technologies
M&A	Merger and Acquisition
PhD	Doctor of Philosophy
PIMS	Profit Impact of Market Strategy
PHP	Pyridoxilated Hemoglobin Polyoxethylene
R&D	Research & development
RBV	Resource-based view
rDNA	recombinant DNA
RNA	Ribonucleic Acid
RNAi	RNA interference
SIC	Standard Industry Classification
SMT	Small Molecule Therapeutics
std. dev.	standard deviation
TMT	Top Management Team
TVM	Techno Venture Management
US	United States
USA	United States of America
UK	United Kingdom
VC	Venture Capital
VCs	Venture Capitalists
VP	Vice President

1 Introduction

We live in the "biotech century" (Rifkin, 1999). Modern biotechnological methods and products are part of our everyday life. In the supermarket, we buy biotechnologically engineered food such as pest resistant vegetables and fruits. We drink beer which was manufactured with the help of genetically engineered yeast, and wine from grapes of gene-manipulated vines, and we use cups of biodegradable plastics produced by modern biotechnological processes. The clothes we wear and the paper we write on are manufactured by utilisation of biomolecules such as enzymes gained from genetically engineered bacteria. At the pharmacy, we purchase drugs and diagnostic tests which are developed, tested, and produced by modern biotechnological methods. On the dark side, the media remind us of the danger of "bioterrorism", that is, the possibility that terrorists will employ the new technology to engineer deadly bacteria and viruses which may become the cruelest weapons ever known.

The importance of biotechnological products for our daily life is even more impressive if we consider that the modern biotech industry is only a quarter of a century old. The first biotech firms were incorporated in the late 1970s and early 1980s in the USA, and the industry did not emerge substantially before the mid-1980s. In Europe, the biotech sector is even younger and most firms were founded in the 1990s. Although some companies such as Amgen and Genentech in the USA have become extremely successful and today employ thousands of people, the industry is still highly entrepreneurial and mainly consists of small and medium-sized firms which are far from profitability.

Since modern bioentrepreneurial ventures are characterised by long product development cycles, high technological and market uncertainty, and a high capital intensity, starting a biotechnology firm is among the most complex entrepreneurial tasks. The failure rate of firms is high and it has become clear that success factors which are important in the context of other industries are only partially relevant for young biotech firms because of their specific characteristics. Instead, novel strategies such as extensive inter-firm co-operations and strategic alliances between firms have emerged. Due to the newness of the industry we have so far only limited understanding of the process of successfully founding and growing young biotechnology firms. Such

industry-specific knowledge is of utmost importance in order to facilitate the development of the sector as a whole as well as the development of individual firms in the most efficient way. Researchers must provide insights for biotech practitioners such as managers, investors, and politicians. For management scholars, systematic research is necessary to develop and empirically verify management and entrepreneurship theory specific for the biotechnology context. Therefore, the aim of this thesis is to analyse important and cutting-edge topics of bioentrepreneurship research.

In the remainder of this introductory part I will describe the emergence and economic importance of the biotechnology sector in the USA, Europe, and particularly in Germany, the context in which the studies of this thesis are conducted, in more detail (Section 1.1). I will then illustrate the topics and structure of this thesis (Section 1.2).

1.1 The emergence and economic impact of the biotechnology industry

Modern biotechnology has its roots in the USA. The webpage of Genentech, which is often referred to as the first biotech firm in the world, describes the birth of the sector as follows (Genentech, 2004b):

> *"Genentech, Inc. was founded in 1976 by venture capitalist Robert A. Swanson and biochemist Dr. Herbert W. Boyer. In the early 1970s, Boyer and geneticist Stanley Cohen pioneered a new scientific field called recombinant DNA technology. Excited by the breakthrough, Swanson placed a call to Boyer and requested a meeting. Boyer agreed to give the young entrepreneur 10 minutes of his time. Swanson's enthusiasm for the technology and his faith in its commercial viability was contagious, and the meeting extended from 10 minutes to three hours; by its conclusion, Genentech was born."*

Drawing on recombinant DNA technology Genentech succeeded in 1977 in the production of the first recombinant human protein, somatotropin,[1] in genetically engineered bacteria. In 1978, Genentech produced human insulin, which, after its

[1] Somatotropin is a growth-regulating hormone essential for normal human growth. Therapeutically, it is used against dwarfism. Before recombinant production was possible, somatotropin was gained from the pituitaries of dead persons.

introduction to the market in 1982, replaced pig insulin. At that time pig insulin was the state-of-the-art treatment for diabetes, but was often rejected by the body of patients. Recombinant human insulin was cheap to manufacture and, since it was identical to insulin produced by the human body, had no side effects. Genentech out-licensed commercialisation rights for recombinant human insulin to the pharmaceutical company Eli Lilly. After introduction to the market, human insulin became an overwhelming success. When Genentech went public in 1980, stock prices rose from 35 $US to 80 $US within one hour. Many investors had already recognised the enormous economic potential of the new biotechnology (Genentech, 2004b). Today Genentech employs more than 5200 people (Genentech, 2004a). In 2002, the company earned revenues of 2.6 billion $US and had a market capitalisation of 19.4 billion $US (Genentech, 2003).

After the inception of Genentech the US biotechnology sector grew continuously. Besides other factors (Cooke, 2001), one precondition for the development of the biotech industry was the existence of venture capital (VC) investors (Prevezer, 2001), which were willing to carry the high failure risk inherent in new, disruptive technologies. In 1986, ten years after Genentech's foundation, the US biotech sector already counted more than 800 firms and 40000 employees (Ernst & Young, 2001). Despite several periods of hostile financing environments such as in 1986 or during the economic downturn of the years 1993 – 1995, which constituted a major decrease in financing opportunities for young biotech firms, the number of bioentrepreneurial ventures as well as the number of industry employees grew steadily (Ernst & Young, 2003b).

Since the mid-1990s, the amount of firms in the US biotech industry has remained almost at a constant level (about 1400 firms). Today the sector is considered as a mature industry. A substantial number of firms is publicly traded at the stock markets (318 companies in 2002, Ernst & Young, 2003b). Many firms possess a product pipeline containing candidates in all development stages including marketed products some of which generate hundreds of millions $US annual revenues. In 2002, the US industry as a whole had a market capitalisation of 190 billion $US and employed 195000 people. Amgen, the largest biotech firm in the world, had more than 10000 employees and 5.5 billion $US revenues in 2003 (Amgen, 2004). Figure 1 summarises the development of the US biotechnology industry.

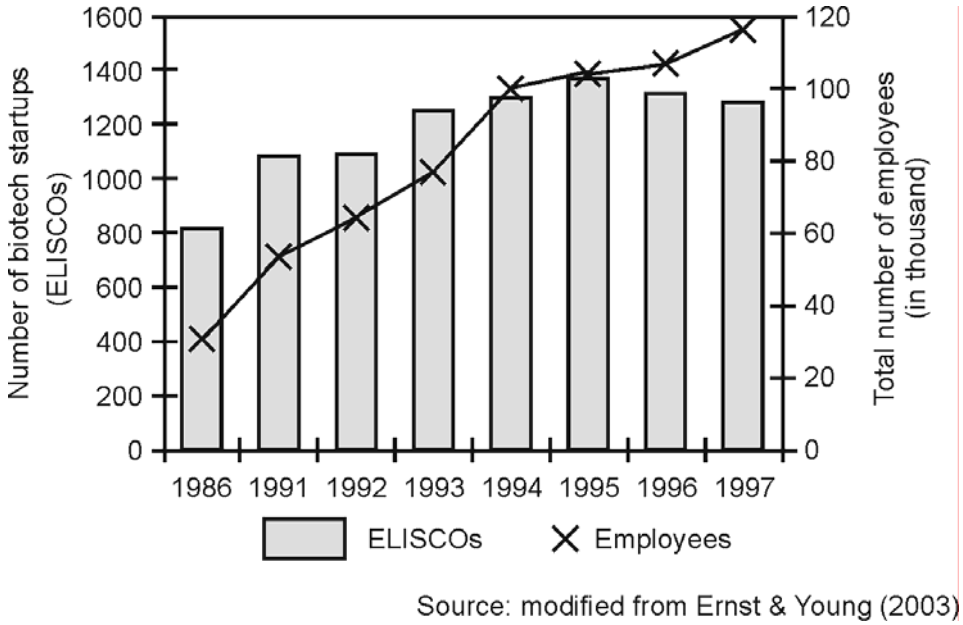
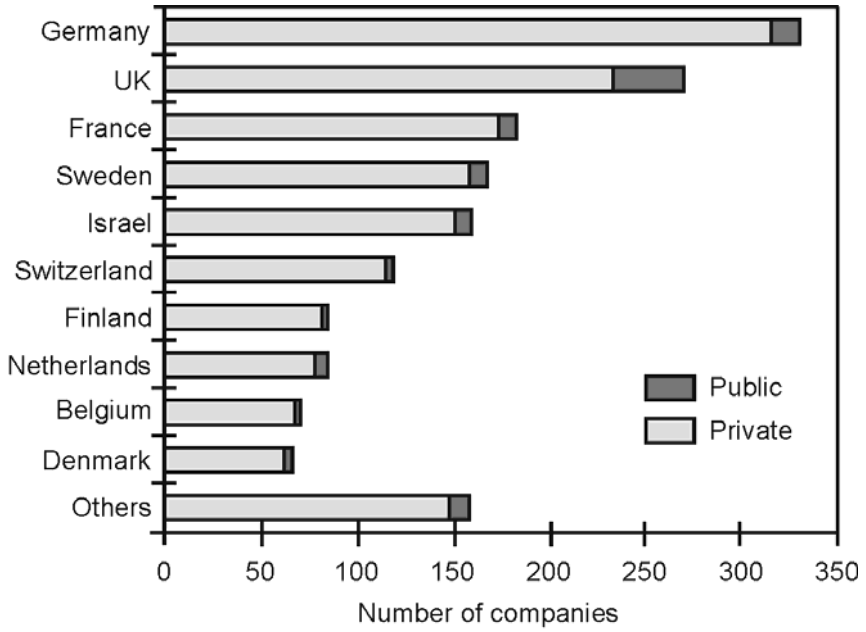


Figure 1: Development of the biotechnology industry in the USA

The origin of the European biotech industry dates back to the inception of Celltech in the UK in 1980. As in the case of Genentech, Celltech's foundation was only possible due to the established venture capital industry in the UK (Celltech, 2003; Sainsbury, 2003). Although Celltech was founded only four years after Genentech and is profitable today, too, the biotech industry in the UK developed more slowly than its counterpart in the USA. In 2002, it had a lower portion of publicly trades firms (46 firms in total), a lower rate of employment increase, and fewer marketable products. The common view is that the development of the UK industry, which is by far the most developed one in Europe, is 10 years behind the US sector (Cooke, 2001).

Since 1992 the number of biotech firms in Europe grew from about 450 to more than 1800 in 2002. This number exceeds the US industry (1400 firms). However, European companies employ fewer people (about 82000) than the firms in the USA, and the number of publicly traded companies is only one third (102) of the US industry. In 2001, the largest number of European biotech firms were located in Germany (360), followed by the UK (331), and France (239). Figure 2 shows the distribution of firms among the top ten biotech nations in Europe in 2000. As a whole the sector is not profitable yet, although its loss is decreasing continuously and was only 7 million € in 2002 as compared to 13 million € in 1999. During this timeframe, the number of

profitable firms within the top ten group (in terms of market capitalisation) doubled from four to eight (Ernst & Young, 2003a).



Source: modified from Ernst & Young (2001)

Figure 2: Distribution of biotechnology companies among European countries

In Germany, the biotechnology industry did not emerge substantially before the 1990s. Besides the generally hostile attitude of the German society against the new, living organisms-manipulating technology, major sector development hurdles were the restrictive law regulating use and commercialisation of genetic material as well as the lack of a venture capital industry (Becker and Hellmann, 2000). This situation changed during the 1990s when the Germans recognised that biotechnology does not only have a huge economic potential, but also contributes to wealth of humankind by, e.g., developing new drugs for unmet clinical needs such as cancer and Alzheimer's disease. In 1993, the German government reformed the regulatory and legal framework and, in order to facilitate foundation of new biotech ventures, in 1995 initiated the BioRegio Contest which led to a large number of bioventure inceptions in the following years (Dohse, 2000). In parallel, several venture capital funds were started in Germany, partly with governmental support (Giesecke, 2000). As a consequence, the number of German biotech firms rose from 95 in 1996 to 365 in 2001 (Ernst & Young, 2003c). During the downturn at the equity markets in 2002 – 2004, this number slightly dropped to 346. In 2004, 13 German biotech firms were listed at the stock markets. The sector employed

about 10000 people (Ernst & Young, 2005). Cooke (2001) claims that the German biotech industry is about 10 years behind in development as compared to its counterpart in the UK, and 20 years behind the US industry. Although this number appears overestimated in view of the development the German sector experienced during the years 1999 – 2004, the above numbers illustrate that the differences are still substantial. Figure 3 illustrates the development of the German biotech sector.

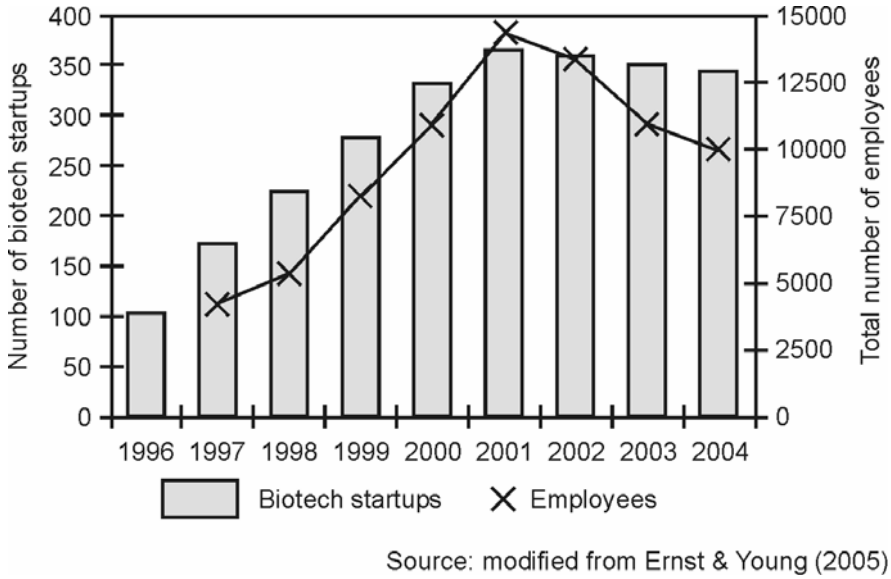


Figure 3: Development of the biotechnology industry in Germany

1.2 Structure and scope of this thesis

The above description of the biotech sector in the USA and Europe illustrates that, although still young, the industry has gained significant economic importance over the last two decades. However, it also shows that – particularly in Germany – the vast majority of firms are young start-ups far from profitability. Many of these ventures essentially depend on capital infusions from investors. How can these firms survive when the capital markets close as we experienced in Germany during the years 2002 – 2004? Are mergers and acquisitions (M&As) and strategic alliances between firms an appropriate means for young biotech companies to acquire financial resources? How can a biotech venture survive and grow in a hostile financing environment if it looses its basic technology? And how do VC investors deal with the high failure risk of biotech start-ups by diversification of their investment portfolio? These questions constitute the research guideline for this thesis.

This thesis consists of five empirical studies which cover such diverse topics as financing strategies, M&As, strategic alliances, crisis management, and venture capital portfolio strategies. I will address these issues from both, a theoretical as well as a practitioner-oriented perspective. Moreover, I will include the perspectives of biotech company managers as well as biotech venture capital investors. Methodologically, I will include qualitative case studies as well as a large scale statistical analysis using an experimental design. In order to deal with this diversity in a way that is most convenient for the reader, I dedicate to each empirical study a separate chapter. Each of these chapters contains a general introduction placing the topic in the context of existing research, followed by theory, methodology, and results sections. I will then discuss the findings of each study and illustrate limitations which suggest avenues for future research.

The following Chapter 2 introduces basic issues of biotechnology and bioentrepreneurship and is dedicated to readers who are new to the field. I will illustrate the business activities of new biotech firms as well as their business areas and business models. Moreover, I will describe how modern biotechnology reformed the classical drug development process leading to the foundation of many ventures developing biotherapeutics. I will also elaborate on the interdependencies of the pharmaceutical and the biotechnology sector.

Chapter 3 contains the first empirical study and provides a detailed and theoretically founded analysis of the development of the German biotechnology industry in the hostile financing environment of 2002 – 2004. I will draw on the perspectives of population ecology and evolutionary economics in order to understand the sector development. I will analyse external as well as internal mechanisms of adaptation. I will employ a case study methodology to explore how firms can adjust their financing strategy to the new environmental conditions. The results of this study will have implications for scholars studying organisational evolution processes as well as for biotech practitioners.

Chapter 4 copes with M&A activities of biotech start-up companies. Since there is no literature on M&As of entrepreneurial firms so far, which would provide any insights on important management issues related to this difficult task, the aim of this study is not

so much to develop theory, but it is rather addressed to bioentrepreneurs. I will draw on an exploratory case study approach to analyse six M&As from the German sector in detail. I will investigate motives, benefits, and problems which may arise when two entrepreneurial biotech firms decide to merge.

The subsequent Chapter 5 constitutes the theoretical and empirical heart of this thesis. Its aim is to develop and test theory and add to the strategic management and entrepreneurship literature. From a decision-making perspective, I will analyse how the internal and environmental situation of a biotech start-up firm motivate its managers to seek partners for strategic alliances. I will introduce a theoretical decision model for the managers and subsequently test hypotheses using a conjoint experiment which I conducted with 51 top managers of biotech ventures. I will analyse how three factors – the level of internal firm capabilities, the governance over the venture's intellectual assets, and the context in which the venture operates – impact the managers' decision to seek alliance partners. I will also investigate the moderating role of the venture's liquidity on the other factors. The findings extend the literature on strategic alliances and the capabilities view of the firm. Moreover, they help to understand previous empirical results from studies of other scholars analysing the alliance constellations of bioentrepreneurial ventures. Finally, I will discuss implications for biotech managers.

In Chapter 6 I will introduce an exploratory case study of Curacyte, a German biopharmaceutical start-up company which successfully survived a technology breakdown crisis. This topic has been untouched in the entrepreneurship and crisis management literature so far. The study is addressed to practitioners and aims at demonstrating how major crises in bioentrepreneurial firms can be overcome. I will analyse Curacyte's strategy to build up a new technological platform as well as Curacyte's management of financial, organisational, human, and social resources during the crisis management process. The results of this study are helpful for bioentrepreneurs facing similar crisis situations.

In Chapter 7 I will switch to the perspective of biotech investors and analyse portfolio strategies of life science venture capitalists. The scope of this study is to fill a gap in the VC literature and extend the concept of portfolio diversification to industry-specialised portfolios. I will illustrate how venture capitalists reduce their high investment risk

inherent in life science ventures by diversification within their specialised portfolios. I will introduce a framework for analysis of these portfolios and apply it to seven Central European venture capital firms with major investments in the German sector. This case study approach reveals two archetypical strategies venture capitalists in the chosen sample pursue. Additional interview data will unravel major determinants of portfolio diversification for life science VCs so far undescribed in the literature.

Finally, in Chapter 8 I will briefly sum up the results of this thesis and the contributions I made. I will draw final conclusions and suggest new avenues which scholars in the field of bioentrepreneurship might follow in the future.

2 What do biotechnology firms do?

This chapter is particularly addressed to readers who are new to the field of biotechnology and bioentrepreneurship. It will provide them with the background necessary to understand the empirical studies in the following chapters. I will first give a definition of modern biotechnology (Section 2.1) and introduce a categorisation for biotech firms (Section 2.2). I will then describe the different business sectors (Section 2.3) and business models of bioventures (Section 2.4). Finally, I will elaborate on the impact of the biotechnology industry on the modern drug development process (Section 2.5).

2.1 Modern biotechnology

There are various definitions for biotechnology in the literature. As a consequence, scholars have failed so far to agree on which companies are viewed as biotech firms and which ones are not. A commonly used source of information for biotech researchers are the industry reports published by the consulting company Ernst & Young (e.g., Giesecke, 2000; Dohse, 2000; Kaiser and Prange, 2004). Ernst & Young survey the sector annually or bi-annually and supplement these data with interview material and data from other biotech press such as BioCentury. Besides the German biotech report (since 1998), Ernst & Young also publish a report on the US-American (since 1986), European (since 1993), and global (since 2002) biotech industry. Therefore, in the context of this thesis, I will refer to Ernst & Young's definition of biotechnology (Ernst & Young, 2000b: 7):

> *"The term "modern biotechnology" refers to all innovative methods, processes, or products, which include the use of living organisms or their cellular compartments and draw on the results and knowledge generated from research in the fields of biochemistry, molecular biology, immunology, virology, microbiology, cell biology, or environmental and engineering sciences."*

The above definition demonstrates that biotech companies follow a broad range of different business activities. In the following sections, I will introduce these activities in more detail.

2.2 Categories of biotech firms

Nowadays biotechnological products and processes are employed in many industries. Breweries, for example, use genetically engineered yeast to manufacture beer. Despite of the utilisation of an organism modified by modern biotechnological methods, however, it would hardly make sense to view breweries as biotech firms. Therefore, it is important to define more accurate criteria which allow the identification of firms belonging to the biotechnology sector. A scheme commonly used in the literature is the one by Ernst & Young (2000b), who distinguish the following three categories.

Category I companies are called "Entrepreneurial Life Sciences Companies (ELISCOs)". These firms constitute the prototype of biotech firms in the Anglo-Saxonian sectors. They are "small and medium sized companies, the business objective of which is exclusively to commercialise modern biotechnology" (Ernst & Young, 2000b: 6). Typically, these firms are financed by venture capital and are led by a management consisting of scientists and entrepreneurs.

Category II firms are small and medium-sized companies (less than 500 employees) which do not exclusively commercialise biotechnology, but generate more than 50 % of their revenues using processes, products, or offering services belonging to the field of biotechnology. Ernst & Young (2000b) name these firms "Extended Core Companies".

Category III firms are large corporations with more than 500 employees which generate a "substantial part of their revenues from modern biotechnological products and products for biotechnological research and production, respectively" (Ernst & Young, 2000b: 6). Examples are pharmaceutical corporations and firms such as plant und food manufacturers, which earn more than 10 million € annual revenues by employing biotechnological processes or products (Ernst & Young, 2000b).

2.3 Business sectors of biotech firms

Depending on the area of application of biotechnological products and services, Ernst & Young (1998) distinguish three business sectors of biotech firms.

Firms that operate in the "red" biotechnology sector develop products for human healthcare. These products are therapeutics, molecular diagnostics, drug delivery

systems, or tissue engineering products. As Figure 4 demonstrates, by far most German red biotech firms are active in therapeutics development. Because red biotechnology has the highest economic potential of all sectors, in 1997 83 % of all German biotech companies were red biotech firms (Ernst & Young, 1998). This percentage dropped to about 50 % in 2004 because of the cost intensity of product development and the hostile financing markets during 2002 – 2004 (Ernst & Young, 2005).

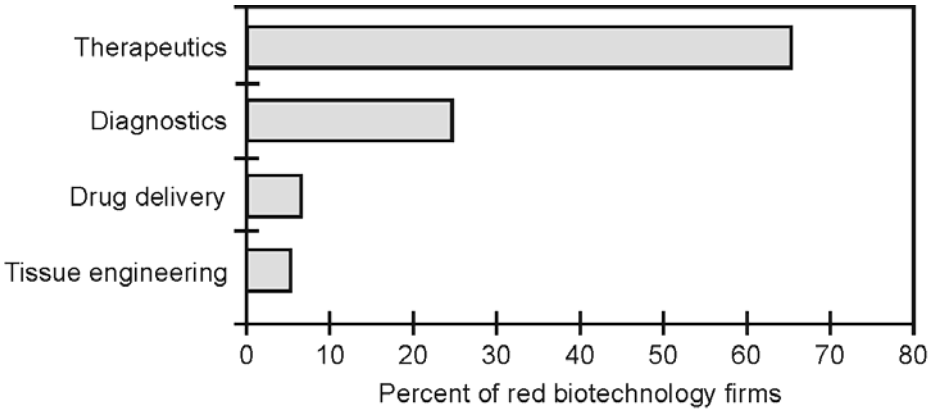


Figure 4: Products of red biotechnology firms in Germany

In 1997, about 11 % of German biotech companies belonged to the sector of "green" biotechnology (Ernst & Young, 1998). Green biotech firms develop or produce agricultural products such as transgenic plants or food. In Germany, market potential as well as acceptance in the society are much lower than for red biotechnology firms, which explains that much fewer firms are active in this sector as compared to other countries such as the USA (Ernst & Young, 1998; Ernst & Young, 2005). Globally, the green biotechnology sector has been booming over the last years as judged by the enormous growth of agricultural areas used for trials with gene-manipulated plants (Figure 5). In 2004, it was seven times larger than the total agricultural area in Germany. The total value of genetically engineered plants was about 3.8 billion € (Ernst & Young, 2005).

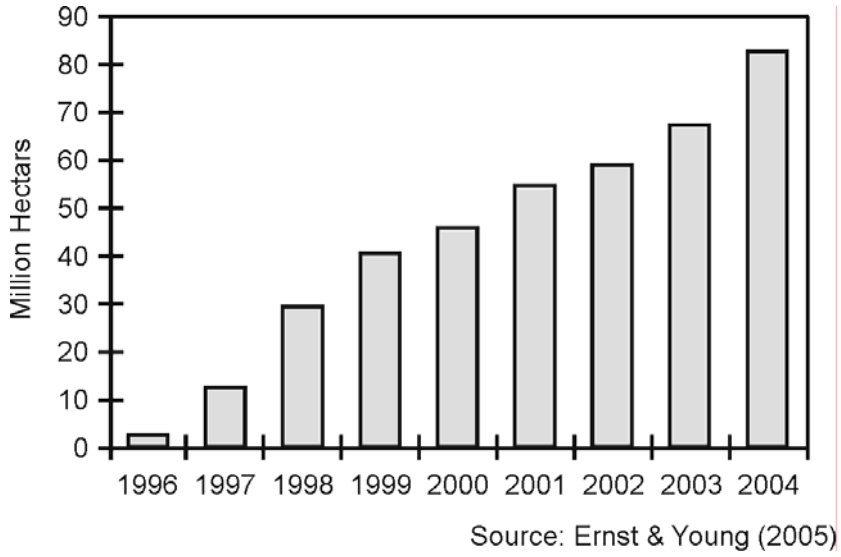


Figure 5: Global agricultural area for growth of gene-manipulated plants

The remaining 6 % of German biotech companies are distributed among the sectors of "white", "grey", and "blue" biotechnology. Firms active in the field of white biotechnology develop and commercialise biotechnological processes and products such as enzymes in the fields of speciality chemicals for the pharmaceutical, chemical, and food industries. Over the last years, the potential of the sector has grown substantially and more and more firms engage in this field (Ernst & Young, 2005). Table 1 shows examples of German firms active in white biotechnology.

Company	**Location**	**Products**
ASA Spezialenzyme	Wolfenbüttel	Enzymes and microbial cultures
e.gene	Feldafing	Genome analysis of extremophile organisms
Jülich Fine Chemicals	Jülich	Biotransformation and chirale synthesis
Nadicom	Wiesbaden	Microorganism genetics and enzyme optimisation
N-Zyme Biotech	Darmstadt	Transglutaminase technology for target-directed modification of proteins and peptides
X-Zyme	Düsseldorf	Chirale molecules from enzyme production for use in the pharmaceutical industry

Source: (Ernst & Young, 2005: 64)

Table 1: Examples of firms and products in the white biotechnology sector

Companies in the grey biotechnology field develop products related to environmental protection and environmental diagnostics, whereas firms which operate in the field of blue biotechnology exploit marine organisms. The high potential of blue biotechnology has been recognised already years ago in the USA and Japan, but only very few firms are active in this sector in Germany. One example is BlueBioTech GmbH in Elmshorn, which uses biotechnological processes to produce micro algae as nutrition supplements (BlueBioTech, 2004).

2.4 Business models of biotech firms

According to Ernst & Young (2000b) and in agreement with many articles in the biotech press, biotech firms follow one of three possible business models. The choice of the business model depends on the strategy pursued by the firm.

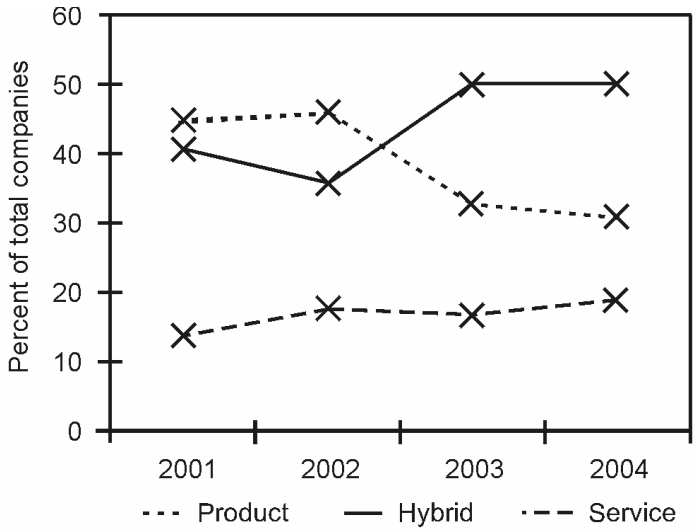
Product-oriented companies concentrate on development and commercialisation of biotechnological products such as therapeutics and diagnostics (red biotechnology), transgenic plants (green biotechnology), or enzymes (white biotechnology). As product development is capital and time intensive in particular in the field of red biotechnology, most product-oriented firms generate their first revenues not before several years after their inception. This business model is particularly risky since the success of product development is highly uncertain at the time of the venture foundation. However, if product companies succeed in bringing a product such as a blockbuster drug to market, they may earn several hundreds of millions of revenues each year.

Service or platform companies draw on an innovative but yet established technology which they either developed by themselves or purchased from another firm. These firms offer the utilisation of the technology to other companies as a research service. Often service firms are profitable few years after foundation. However, they generate substantially lower revenues than successful product-oriented companies. Examples for services include DNA sequencing or the supply of laboratory material.

Some biotech firms utilise their proprietary technology for their own product development besides commercialising it. These “hybrid companies” have the advantage to generate revenues soon after their inception. Those revenues are invested in in-house

product development. Thus, the firms are not profitable at an early development stage, but do not exclusively depend on external investors such as venture capitalists.

The business models adopted by biotechnology firms in Germany varied substantially over the last years. Whereas in 2001, when capital was easily available at the VC market and the stock markets, half of all firms pursued a product-oriented business model, during the hostile financing environment of the years 2002 – 2004 a hybrid model became more popular since it allowed the firms to become at least partially independent of external financing opportunities. Figure 6 shows the development of business models during the timeframe 2001 – 2004. I will provide a more detailed analysis of this phenomenon in Chapter 3.



Source: Author with data from Ernst & Young (2002b, 2003c, 2004, 2005)

Figure 6: Business models of biotech firms in Germany

Figure 7 summarises the above introduced categorisations of biotechnology companies (Herstatt and Müller, 2002). In this thesis, I will mostly focus on product-oriented, hybrid, and service companies, which are ELISCOs and operate in the sector of red biotechnology. They represent about 70 % of all German biotech companies and are indicated by the grey areas in Figure 7.

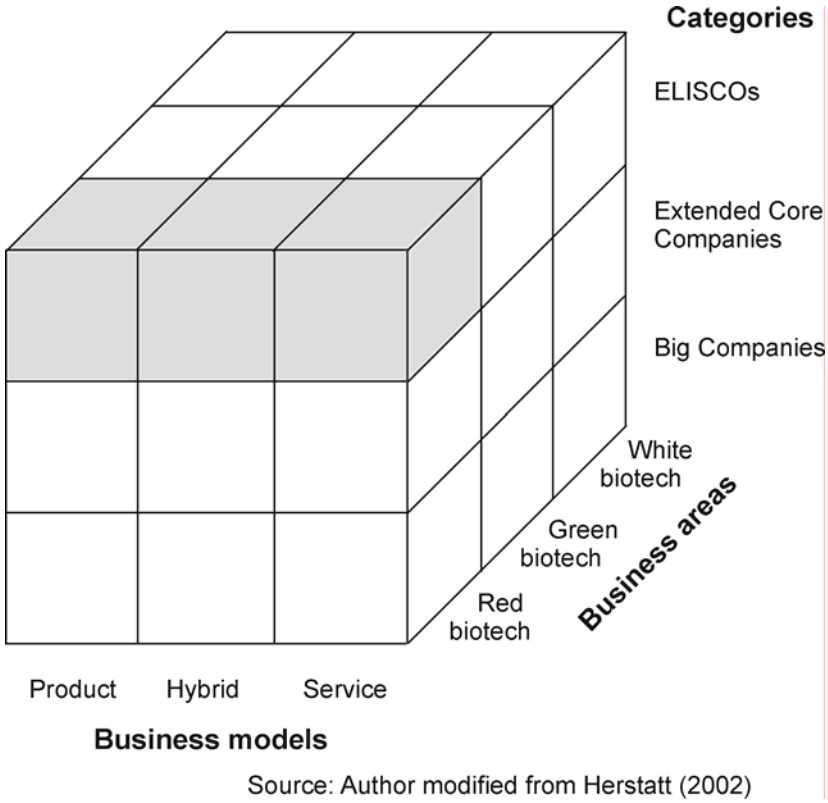


Figure 7: Categorisation of biotechnology firms

2.5 Biotechnology and drug development

Most biotech ventures in the German industry operate in the field of red biotechnology and thus contribute to the pharmaceutical value chain. Traditionally, pharmaceutical companies developed therapeutics by screening a large number of chemical entities with regard to their potential to inhibit the progression and/or cause recession of diseases in animal models. There was no understanding of the molecular mechanisms of these diseases (Giesecke, 1999). The development of modern biotechnological methods and the knowledge gained by their application about the molecular causes of diseases introduced a more systematic R&D process into the development of therapeutics.

The modern drug development process starts with the identification of a potential molecular target. A target is a gene or a protein the malfunction of which is responsible for the development of a disease. Target identification may be performed, e.g., by comparing gene patterns or protein profiles of ill and healthy individuals. Biotechnological techniques such as large-scale gene profiling and analysis of RNA and protein patterns in samples of diseased tissue by micro-arrays and two-dimensional gel

electrophoresis, respectively, are commonly applied within this first step of the pharmaceutical value chain.

In the second step, the identified potential target needs to be validated. That is, the connection between a modification of the target in the sick body and the cause of the disease must be well established and understood. Research must demonstrate that attacking the target, e.g. by lowering its abnormally elevated levels or inhibiting its function, does lead to death or recovery of the pathogenic cells. Cell cultures and techniques such as RNAi to modify pathogenic tissue cells in the laboratory are fundamental for the target validation process.

After completion of target validation, a potential drug candidate (so-called lead compound) which interacts with the validated target needs to be discovered. A lead compound is either a new chemical entity ("small molecule") or a biomolecule such as an antibody, protein, or a piece of DNA or RNA. The latter four lead compound classes are often referred to as "biologics". In the case of small molecules, which constitute the lead class traditionally used for drug development in the pharmaceutical industry, High Throughput Screening methods select the best 10 – 20 candidates from a pool of 10000s of possibilities. Antibodies and proteins may be gained from living organisms whereas DNA and RNA are rationally designed in silico as to interfere with the DNA or RNA underlying the pathogenic target of interest.

As a final part of the four-step research process (the "R" in pharmaceutical "R&D", often referred to as "drug discovery"), the lead molecules of either class are optimised in a way that the interaction with their target is as strong and as specific as possible. Chemical modifications of the lead may facilitate easy oral uptake of the drug. A further aim is to avoid interactions with other, non-disease related molecules in the body which may lead to undesired side effects for the patient. Besides traditional chemical synthesis for small molecules and DNA and RNA lead candidates, biotechnological genetic engineering methods are employed to generate optimised antibodies and proteins constituting lead candidates.

After completion of the discovery process, the drug candidate enters the classical pharmaceutical development process (the "D" in "R&D") starting with preclinical development. At this step, the drug candidate is analysed in animal models and may be

optimised again in parallel to circumvent discovered and undesired side effects. Subsequently, it is tested in a clinical Phase I trial within a small group of healthy volunteers (typically about 15-50 persons) in order to elucidate general safety dosages and gain insights into the drug's metabolism, distribution within the body, excretion, and toxic effects. Phase II is the most critical step for the majority of drug candidates and constitutes the "proof-of-concept". It consists of a placebo-controlled, large scale study with up to several hundred individuals who suffer the targeted disease. The aim of this phase is to gain evidence on drug safety and efficacy. The subsequent Phase III clinical trials are the last tests before market approval and are conducted double-blind and placebo-controlled with sometimes more than thousand patients in multiple clinical centres in different countries. In this phase, the efficacy of the new drug must be established on a statistical level and rare side-effects are investigated (DiMasi et al., 2003). Figure 8 summarises the modern drug development process.

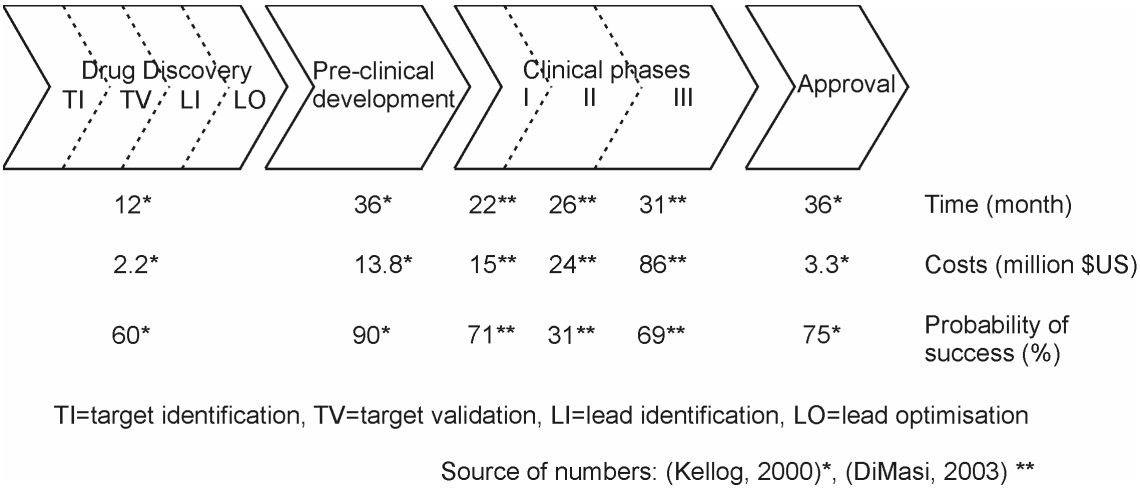


Figure 8: Modern drug development process

Besides the above described steps of the pharmaceutical value chain, Figure 8 displays the time each step takes as well as its estimated costs and success probability. The average total time an initial drug candidate requires for passing the R&D and approval process is more than 12 years. On average, the costs amount to 144 million $US. Taking into account the costs of capital in the pharmaceutical industry, this number even raises to 800 million $US (DiMasi et al., 2003). The probability that an initially selected lead candidate will enter the market is only about 6 %. In terms of initial candidates

screened, only one out of 5000 finally reaches market launch (Evans and Varaiya, 2003).

The numbers above demonstrate that biotechnology, particularly when it comes to development of biotherapeutics, is an extremely time and money consuming as well as risky business. Therefore, biopharmaceutical ventures essentially depend on capital infusions from VC investors. However, even when they succeed in acquisition of VC, it is impossible for most young firms to cover all steps of the pharmaceutical R&D process. Only established pharmaceutical companies ("big pharma") are capable of financing all activities along the value chain. Therefore, biotech companies usually focus on the early steps and have their core competencies in initial screening and discovering of new drug candidates by employing their innovative technology. Typically, they develop drug candidates jointly with pharmaceutical companies after Phase I or II clinical testing in form of a strategic alliance. Since alliance agreement is often associated with upfront and milestone payments or equity investments by the incumbent, it allows the biotech venture to generate revenues although its products are still under development (DeCarolis and Deeds, 1999). Moreover, alliances also save costs through pooling of resources (Eisenhardt and Schoonhoven, 1996). I will provide a more detailed analysis of the formation of alliances of bioventures in Chapter 5. On the long term, a biotechnology firm may become fully integrated and cover the whole pharmaceutical value chain. So far only the oldest and most successful biopharmaceutical companies in the world such as Amgen and Genentech have realised this strategic goal.

From the perspective of the pharmaceutical companies, there is a high need of filling up their R&D pipeline because many firms are about to loose patent protection for their best-selling products within the next years (Drews, 1998). Since modern biotechnological methods are most efficiently invented and developed in an academic and entrepreneurial atmosphere, it is difficult for pharma firms to build up these technologies internally. Therefore, they are dependent on the foundation and emergence of small bioventures from which they in-license promising drug candidates. In a number of cases, this leads to an equity participation of the pharmaceutical incumbent, or to total acquisition. However, in the latter case it is important that the biotech firm keeps

its independency in order to conserve the entrepreneurial spirit required for development of innovative technologies and products (Schweizer, 2005).

Unfortunately for many young biotech firms, the sequencing of the human genome and the quick development of drug discovery technologies over the last years led to an oversupply and thus to a severe price decline for validated targets and drug candidates in early development stages. In 1998, for example, US biotech company Millennium and pharmaceutical firm Bayer entered into an alliance according to which Millennium received 456 million $US for validation of 225 potential drug targets for which Bayer aimed to develop drugs („Bayer-Millennium-Deal“). Five years later, the average market value of a validated target was only about 100000 € – twenty times less than for the Bayer-Millennium-deal (Knittel, 2003). Thus, biotech firms face a dilemma: they do possess validated targets but are, due to limited financial resources, not able to develop drug candidates for these targets to the clinic. On the other hand, pharma firms prefer in-licensing of candidates in Phase I/II. For many biotech ventures revenue generation by out-licensing early stage product candidates is impossible. Their only way out is to acquire sufficient capital from VC investors. Thus, they are highly dependent on the capital markets and a downturn means a serious threat for most of the firms. The following Chapter 3 will provide a detailed analysis of the effect the hostile financing environment of the years 2002 – 2004 had on the German biotech industry.

3 Biotechnology in hostile financing environments – an organisational evolution perspective on the German industry

The preceding chapter has shown that biotechnology is an extremely money and time-consuming business, and that the probability that product candidates such as drugs will fail to complete the development process is high. Therefore, bioventures essentially depend on VC investors which are willing to take the risk and invest large amounts of money in these potentially very profitable firms (Prevezer, 2001). A downturn of the VC market thus severely threatens young bioventures' survival.

In this chapter I will provide a detailed analysis of how a sudden decline in the munificence of the financing environment influences the development of the biotechnology industry. Specifically, I will investigate from an organisational evolution perspective how the German sector responded to the hostile financing environment for biotech ventures in the years 2002 – 2004, which followed the burst of the high-tech bubble at the stock markets at the beginning of 2001. In Section 3.1, I will first give an introduction to the topic before I elaborate on the theoretical lenses of population ecology and evolutionary economics, both of which I employ in order to derive the analytical framework of the study (Section 3.2). Subsequently, I will describe the research design (Section 3.3). I will then illustrate how the German biotech sector developed in the years 2000 – 2004 (Section 3.4) before I analyse how external (Section 3.5) and internal adaptation mechanisms (Section 3.6) contributed to this development. I will discuss the findings in Section 3.7 before highlighting limitations of this study and suggesting opportunities for further research in Section 3.8.[2]

3.1 Introduction

A specific characteristic for many biotechnology ventures is that they burn huge amounts of money before they generate revenues. As demonstrated in Chapter 2, biopharmaceuticals, for example, demand more than 100 million $US R&D expenditure and a 12-year development process before they enter the market (Kellog and Charnes,

[2] I am indebted to Prof. Dr. Dodo zu Knyphausen-Aufseß, University of Bamberg, and Prof. Dr. David B. Audretsch, Max Planck Institute of Economics, Jena, for critical comments and discussions on this study.

2000; DiMasi et al., 2003). Other biotechnological products such as genetically engineered plants or platform technologies also demand high R&D expenditures before they reach market launch. For most young bioventures, financing these expensive development processes essentially depends on the availability of capital from VC investors and the stock markets, which are the main financing sources of young bioventures (Ernst & Young, 2005). Therefore, the development of the biotechnology industry is substantially influenced by the munificence of the financing environment (Prevezer, 2001). In the context of this study, I understand as "development" the change in the total number of firms in the industry over time.

In a munificent environment where capital is easily available and investors are risk-taking, biotechnology ventures face optimal conditions. Bioentrepreneurs acquire capital for starting new firms and quickly expanding existing businesses. Their comfortable cash positions allow them to follow several R&D projects in parallel including time-consuming and risky ones. They can expand their R&D capabilities by enlarging laboratory facilities and hiring top scientific talents. Insolvencies are rare since money from investors is pouring in the firms. Thus, the industry will develop and grow substantially. In the context of this study, I understand as "development" the change in the total number of firms in the industry over time.

However, a sudden drop in the munificence of the financing environment creates a misfit of the bioventures' growth-oriented strategies with their environmental context. The firms are unable to attract further capital in order to finance their expensive and lengthy product development processes. Since many ventures were incepted in the munificent environment in the recent past, they are still too young to generate revenues. Due to their large R&D expenditures, they will quickly face severe financing constraints and run in danger of insolvency. Thus, a sudden hostility of the financing environment exerts a selective force on the young firms leading to survival of the most adapted ones and death of the unadapted. In this study I analyse this adaptation process from an organisational evolution perspective. I draw on the theoretical perspectives of population ecology and evolutionary economics, respectively, in order to investigate adaptation mechanisms at both, the industry and the firm level. The purpose of this work is not to provide a mathematical model or a large scale analysis, but rather to

qualitatively understand the effect a shortage of available capital has on the development of the biotech sector.

The German biotechnology industry in the years 2000 – 2004 constitutes an excellent setting for this research. The sector, which is much younger than its counterparts in the USA and the UK (Cooke, 2001) and mainly consists of entrepreneurial, VC-backed companies far from profitability, has experienced two fundamentally different financing situations in this timeframe. During the high-technology hype in 2000 and the beginning of 2001, bioventures faced a financing environment as munificent as never before in Germany. In each year venture capitalists invested more than half a billion € in the young industry, and companies did not only close large VC financing rounds like, e.g., Ingenium (50 million €), Micromet (46 million €), and Cardion (42 million €), but also raised more money at the stock markets than ever before. Prominent examples of successful Initial Public Offerings (IPOs) include Lion Biosciences (228 million €), GPC (188 million €), and MediGene (120 million €). In contrast, when the high-tech bubble at the stock markets burst in late 2000 and firm valuations kept declining in 2002 without recovering substantially in 2003 and 2004, young biotech firms were confronted with a completely different situation. The average annual VC investment in Germany during this timeframe was only 220 million €, and there was just one single IPO of a bioventure. By analysing the evolution of the sector in this time frame, I make the following contributions.

Firstly, I provide an explanation for the unexpected response of the German biotechnology industry to the hostile financing environment in 2002 – 2004. Industry experts were, based on data on the firms' cash reserves and R&D expenditures, expecting a large number of insolvencies and thus a severe consolidation of the sector. However, I show that the adaptive capacity of young biotechnology firms is substantial, leading to a much higher survival rate than assumed by the experts.

Secondly, I find empirical support for recent theoretical work calling for an integrative rather than a competitive application of the population ecology and evolutionary economics perspectives in order to explain organisational evolution processes. Whereas existing studies mostly apply only one perspective or offer and test competing hypotheses derived from both, I demonstrate here that the development of the German

biotech industry is best understood through both theoretical lenses in parallel. This suggests that the more integrated organisational evolution approach is a valuable perspective for analysing industry development.

Thirdly, I provide useful insights for bioentrepreneurs. By illustrating successful adaptation strategies of young biotechnology firms I show that cost reduction by downsizing, a change in the business model towards more service-orientation, and entering into strategic alliances and M&A activities are appropriate means to survive during times of low VC investments and closed stock markets.

3.2 Theoretical background

Organisational and management theories can be categorised according to two analytical dimensions. The first dimension is the level of analysis, which either focuses on populations of organisations or on individual organisational units. Moreover, organisational theories can be grouped into those which adopt a deterministic view, i.e., they consider the behaviour of organisations and the human beings which are part of these organisations as determined by environmental forces, and schools of thought which follow a voluntaristic perspective and assume that humans in organisations have a free will and choose and form their environment pro- or interactively (Astley and Van de Ven, 1983). The matrix in Figure 9 provides an overview.

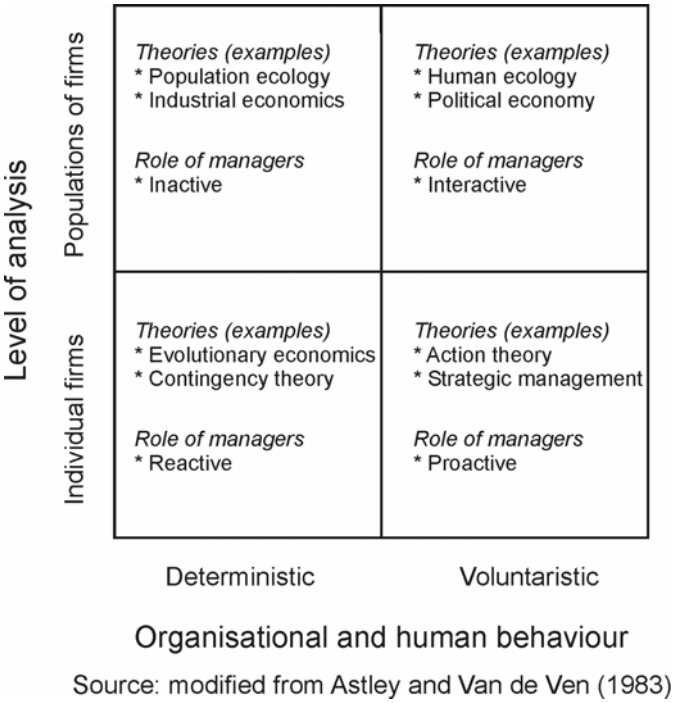


Figure 9: Categorisation of organisational theories

Hrebiniak and Joyce (1985) develop this concept further and treat determinism and voluntarism (strategic choice) as independent variables with the combinations high environmental determinism/low strategic choice and low determinism/high strategic choice representing the ends of the Astley/Van de Ven continuum (for a summary and continuative discussion see zu Knyphausen-Aufseß, 1995: 427-430). The question arises which of these concepts fits most for selecting theoretical perspectives in order to analyse the development of an entrepreneurial biotech industry in a hostile financing environment.

As I demonstrated above, bioventures demand huge amounts of money to finance their expensive and risky product development processes, and are usually not able to generate revenues for years after their inception. Therefore many bioentrepreneurs acquire financial resources via the VC market. The amounts raised usually provide them with enough liquidity for one to three years. However, when capital markets become hostile, they must quickly look for financing alternatives in order to maintain the cash flow necessary for further product development. In this case, bioentrepreneurs can not be choosers: the high cash burn and short financing horizon of their company demands that they acquire whatever financial resources available, otherwise their firm soon runs in danger of insolvency. Thus, with regard to the financing strategy, there is little choice

for a bioventure manager in a hostile environment. Therefore voluntaristic approaches like strategic management theory which stress the strategic choice and pro-activeness of managers (Child, 1972; for an overview of strategic management theories see zu Knyphausen-Aufseß, 2000) are less suited to describe the situation of bioentrepreneurs in times of tight equity markets than deterministic theories which at best assume a reactive role (Figure 9). Moreover, the argumentation suggests that these managers act under high environmental determinism/low strategic choice conditions as introduced in the Hrebiniak/Joyce (1985) model, which coincides with the deterministic end of the Astley/Van de Ven (1983) continuum. I will thus adopt a deterministic perspective below.

The purpose of this study is to analyse the adaptation of an entrepreneurial biotech industry in a hostile financing environment from a process perspective. Therefore, evolutionary theory is an appropriate approach for the analysis. The basis assumption of this approach is that, as for biological systems, the evolution of organisations can be explained by a selective force the environment exerts on each member of the population (Alchian, 1986). Like living organisms die if they do not adapt to changes in their environment such as food limitations or atmospheric variations, organisations such as firms can only survive when their behaviour is in line with the context in which they operate.

Figure 9 shows that population ecology serves as an evolutionary perspective for studies on the population level, whereas evolutionary economics is suited for analysis of evolutionary processes at the firm level.[3] The choice of an evolutionary approach for firm level analysis has the further advantage that, in contrast to most strategic management theories, it allows for variation of strategies pursued by organisations rather than drawing on a fixed "strategic space" of variants (Barnett and Burgelman, 1996). This is essential to identify so far undescribed financing strategies of bioventures in a hostile financing environment. I will below describe both evolutionary theories in more detail. I will then introduce a conceptual framework which is inspired by a recent

[3] Some scholars also analyse evolutionary processes from a population ecology-inspired perspective at the firm level. In this case, a firm constitutes a population of business units, which are selected for survival depending on environmental forces. One example is Burgelman (1991), who provides a detailed case study on Intel's strategic exit from its DRAM business. However, this approach is not suited for the analysis here because it is difficult to define the "population" of financing sources for small bioventures. Instead, identification of alternative financing strategies in a hostile environment is part of this study.

theoretical study by Valle (2002) and integrates both approaches. This framework serves as the basis for the subsequent analysis.

3.2.1 Population ecology

The basic assumption of traditional population ecology is that organisations are inert to change because "there are very strong inertial pressures on structure arising from both internal arrangements (for example, internal politics) and from the environment (for example, public legitimation of organisational activity). To claim otherwise is to ignore the most obvious feature of organisational life" (Hannan and Freeman, 1977: 957). As the genetic code of a living organism is fixed over its lifetime and limits its adaptability to environmental variations, fixed structures in organisations cause inertia leading to the inability to adapt to changing environments (Nelson, 1995). Evolution occurs "principally at the population level, with forms of organisations replacing each other as conditions change" (Hannan and Freeman, 1984: 149).

Variety among organisations is essential for the population as a whole to survive (Campbell, 1969). Organisational diversity is based on differences between the competitive behaviour of organisations. Because organisations compete for resources, a selection process begins when resource limitations occur and the demand for resources exceeds the offer (Hannan and Freeman, 1977; Aldrich, 1979). Only the organisations which compete most efficiently survive while all others disappear.

An important implication of the population ecology approach is that managers and leaders of organisations have no impact on survival (Durand, 2001). Due to structural inertness, internal change does not take place and strategic adaptation is impossible. The evolutionary path of the organisation is exclusively determined by environmental forces and independent of its strategy.

Empirical studies have provided support for the population ecology approach. Prominent examples are longitudinal studies by Carroll and co-workers (Delacroix and Carroll, 1983; Carroll and Huo, 1986) on the news article industries in Argentina, Ireland, and the USA, which showed that newpaper firms' survival is mainly determined by the characteristics of the environment of their home country. Lomi (1995) used an ecological approach to explain the founding rates of rural cooperative

banks in different regions in Italy. By survival analysis, Nyhan, Ferrando, and Clare (2001) found support for the population ecology view on hospital closures in Florida. A unique longitudinal, interview and survey-based study among 100 young high tech firms in Silicon Valley, the so-called Stanford Project on Emerging Companies (SPEC), demonstrated that the conditions at company foundation such as founding team composition and the strategy chosen are major determinants of organisational inertia and change (Baron et al., 1996; Hannan et al., 1996; Baron et al., 1999). As an example for the entrepreneurial context, Shane and Kolvereid (1995) demonstrated that the performance of start-up firms in Great Britain, New Zealand, and Norway is best explained by environmental factors.

It is important to note that population ecology is a long-term perspective. Existing studies of populations often cover several decades and sometimes even exceed one century (e.g., Carroll and Hannan, 1989). In contrast, in this study I only analyse a three-year time span (2002 – 2004). However, I argue that the population ecology approach is nevertheless suited for this analysis for two reasons. Firstly, the financing horizon for most bioventures is considerably less than three years. VC firms usually provide staged financing to ventures leaving them with liquidity for one to three years. Thus, many VC-backed bioventures will be in danger of becoming insolvent in the timeframe of interest (see also the analysis below). In other words, biotechnology can certainly be classified as a "high velocity environment" as it is the case for microcomputers (Eisenhardt and Bourgeois, 1988). Secondly and more importantly, please note that I do not argue on the basis of an economic equilibrium and/or provide a generalisable mathematical model. I rather employ the perspective to give a dynamic description and identify and explain general tendencies of the sector in the respective time span. Therefore equilibrium considerations such as the time horizon analysed do not interfere with the results presented here.[4]

3.2.2 Evolutionary economics

In contrast to population ecology scholars, the lens provided by evolutionary economics assumes well-adaptable organisations (Nelson and Winter, 1982). In analogy to living

[4] T. Brenner, personal communication

organisms, evolutionary economics scholars argue that organisations are capable of learning (Foss, 1994). This learning occurs through a change of their internal routines, which become manifest in "activity patterns" of an organisation (Becker, 2004) and reflect its knowledge (Saviotti and Metcalfe, 1991). Routines are inherited from the past and constitute the basis for future behaviour (Nelson and Winter, 1982).

Variety among organisation is based on different sets of established routines (Nelson and Winter, 1982). Upon environmental change, some of these routines may lead to unfavourable results and suboptimal organisational performance. Thus, the organisation tries to replace them with new ones which either emerge accidentally or by systematic search for alternatives (Winter, 1971). Only those routines which contribute most to survival and performance in the new environment will be kept and adopted by the organisation (Aldrich, 2000). Feldman and Pentland (2003) distinguish two aspects of routines. Firstly, there is the "ostensive" aspect, i.e., its representation, such as "hiring routine" or "inventory control". Secondly, the "performative" aspect describes the concrete carrying out by specific people in specific organisations at specific points in time. In this study, I will emphasise the ostensive aspect and analyse the representation of "financing routines" in bioventures.

The assumption that new routines may be acquired by a systematic search process implies that, in contrast to the population ecology approach, managers and leaders of organisations do indeed matter. They decide which strategy the organisation takes and which new routines it implements in order to facilitate adaptation to the changing environment (Judge and Zeithaml, 1992; Westphal and Fredrickson, 2001). A change in organisational strategy thus always reflects a change of internal routines. Managerial choice is determined by various different variables including the managers' mental models (e.g., Hambrick and Mason, 1984; Carpenter et al., 2004) and group processes (e.g., Hambrick et al., 1996; Pegels et al., 2000; Carpenter, 2002).

Empirical evidence for the impact of a firm's strategy and internal routines on survival and performance in different environments has been provided by various scholars. Early work by Miller and Friesen (1983) showed that firms which engaged more in strategy-making activities such as analysis and innovation performed better in a rapidly changing environment than others. Others have used the PIMS database to establish that firms

with a good environment/strategy fit perform better than others (e.g., Zeithaml et al., 1981). With regard to small and new ventures, results from a survey among 344 US-American firms by Miles, Coven and Heeley (2000) suggested that an entrepreneurial strategic posture leads to higher performance in a dynamic environment than in a stable environment. Zahra and Bogner (2000) used a survey among 127 young US software ventures to demonstrate that the interaction of the firm's technology strategy with its competitive environment impacts performance.

3.2.3 Framework for analysis

Population ecology and evolutionary economics emphasise two fundamentally different mechanisms of organisational adaptation to environmental forces. Whereas the first approach focuses on "external" adaptation, i.e., adaptation at the industry level outside the organisational sphere, evolutionary economics scholars stress "internal" adaptation processes, i.e., the change of organisational routines and organisational strategy. Because in reality, however, both mechanisms impact organisational evolution processes in parallel (Valle, 2002), both theories can be considered complementary (Singh, 1990). Since there is a "lack of studies which include a simultaneous study, from a more global point of view, of the processes of change and disappearance" (Valle, 2002: 219), I will below try to overcome this limitation by analysing both mechanisms.

Availability of capital is known as an environmental factor which influences survival of new firms (Cooper, 1970; Hannan and Freeman, 1984) , and financing constraints are a major hurdle for small firm growth (Carpenter and Petersen, 2002). This is certainly true for biotechnology start-ups, which are capital-intensive and to a large extent dependent on the capital markets. Thus, a sudden drop in munificence of the financing environment constitutes the start of the adaptation process which simultaneously takes place outside and inside organisations (Valle, 2002). Internal adaptation at the firm level occurs when bioventures change their financing routines in order to become at least partially independent of capital markets. The extent and mode of internal adaptation depends on the reactions and strategic decisions of the bioentrepreneurs as a response to the environmental change. External adaptation occurs through replacement of firms which are unable to raise further capital and which are in addition too inert to change their financing routines. The relative amount of external versus internal adaptation

determines the observed consolidation of the sector in a hostile financing environment. In case of strong external and little internal adaptation, many firms will become insolvent and the industry will severely consolidate. In contrast, if many firms are able to adapt internally, only few of them will disappear and the overall observed consolidation will be rather weak. Figure 10 summarises the described framework.

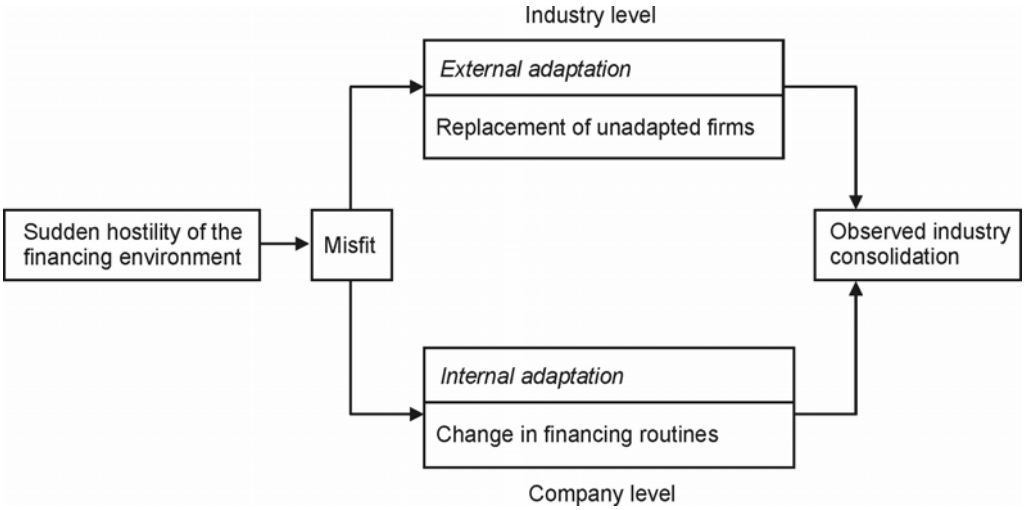


Figure 10: Framework for analysis of the evolution of the biotech industry in a hostile financing environment

3.3 Methodology and data collection

In this study I employ population ecology and evolutionary economics as theoretical perspectives to describe the development of the German biotech industry. Since both perspectives differ in their unit of analysis (industry versus individual firms), I use different methods and data sources for both analyses.

Population ecology studies often derive and test a mathematical model describing the adaptation process of a population over a long period of time (for examples see Hannan and Freeman, 1989). These analyses draw on data on the founding and disappearance events of each member of the population. There is no database available containing these data for every biotechnology firm in Germany, and it is therefore impossible to describe its development on a mathematical basis. However, the aim of this study is not to provide an exact model for the German biotech industry, but rather to qualitatively understand its development in the hostile financing environment of the years 2002 –

2004. For this purpose, I rely on aggregated industry data which are available for the German industry.

A clear definition of the population under study is critical for analysing its development (Hannan and Freeman, 1989). Therefore, for choosing a source for industry level data, it is necessary to define which firms I classify as biotechnology firms and which not. Because scholars have not yet succeeded to agree on this topic, I rely on the definition of biotechnology by the consulting company Ernst & Young, the leading industry observer in Germany (see Section 2.1). All quantitative data I use are from Ernst & Young biotechnology reports on the German industry, specifically those of the years 2002 (which covers 2000 and 2001), 2003, 2004, and 2005 (each reporting the development of the preceding year). These reports have often been used as data sources in the literature (e.g., Giesecke, 2000; Dohse, 2000; Kaiser and Prange, 2004). In order to access also qualitative data on industry development such as expert opinions, which I use for interpretation of the quantitative material, in addition to the industry reports I draw on biotech press, conference contributions, and published interviews.

With regard to firm level analysis, no literature is yet available on adaptation strategies of bioventures in a hostile financing environment. Thus, a substantially detailed approach is necessary to analyse the phenomenon. Miles and Huberman (1994) suggest a qualitative research design when an in-depth understanding of the research object is desired. I therefore chose to apply a case study methodology. Yin (1994: 9) considers case studies as appropriate when a "a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control". As I will analyse "why" young biotech firms survived and "how" they adapted their strategy and financing routines to the changing environmental context, a case study methodology is most suited for analysing the research questions. Cases studies have often been used in process research on organisational evolution (e.g., Burgelman, 1983; Burgelman, 1991).

Sampling of the cases is a critical issue because the results of the study depend on the choice of the cases (Miles and Huberman, 1994). As a starting point, I used a list of German biotechnology firms which Ernst & Young issued in combination with their 2003 industry report. This list contains 212 German biotechnology firms which

participated in Ernst & Young's 2002 industry survey. I then investigated which firms were financed by VC and survived in the years 2002 – 2004. Subsequently, I reviewed published case studies (e.g., in dissertations, books and journal articles), industry reports, biotech press, published biotech executive interviews, and press releases of firms and their respective VC investors in order to identify companies which adapted their strategies to the changing financing environment. Further case selection was mainly determined by availability of data on the firms. I chose to analyse the cases of Micromet, Ingenium, Curacyte and Epidauros, which are all typical entrepreneurial bioventures of the German industry. This sample size is consistent with recommendations for case studies in the literature (Eisenhardt, 1989). Data from different sources on one case were triangulated in order to ensure construct validity and substantiate the findings and interpretations (Denzin, 1978).

3.4 The development of the German biotechnology industry

The German biotechnology industry did not emerge substantially until the 1990s. Before, potential bioentrepreneurs were facing unfavourable social, political, and financial conditions. This changed at the beginning of the 1990s, when the German population and politicians recognised that biotechnology does not only have an enormous economic potential, but also contributes to wealth of humankind by, e.g., facilitating the development of drugs for unmet clinical needs such as cancer, Alzheimer's disease and diabetes. Hence, biotechnological practices, in particular when intended to treat human diseases, gained support in the German society. In 1993, the German government reformed the law for use and commercialisation of genetic material and techniques. Furthermore, government programs such as the BioRegio Contest in 1995 financially supported biotech start-up companies and facilitated formation of local biotech clusters (Dohse, 2000; Cooke, 2002). Simultaneously, several VC funds were started in Germany. Their formation was aided by the introduction of the "Neuer Markt" in 1997. This stock market for technology-based firms offered investors an attractive opportunity to exit their biotech investments by an IPO (Cooke, 2001; Müller et al., 2004).

Figure 11 demonstrates the late but rapid development of the German biotechnology industry and the amounts of VC invested. The number of firms increased from 104 in 1996 to 365 in 2001, the highest among all European countries. The VC investment rose from 21 million € in 1996 to 565 million € in 2000. However, due to their late incorporations, only 13 German biotech companies were listed at the stock markets in 2004. Many of them were still financed by VC (Ernst & Young, 2003c; Ernst & Young, 2004; Ernst & Young, 2005).

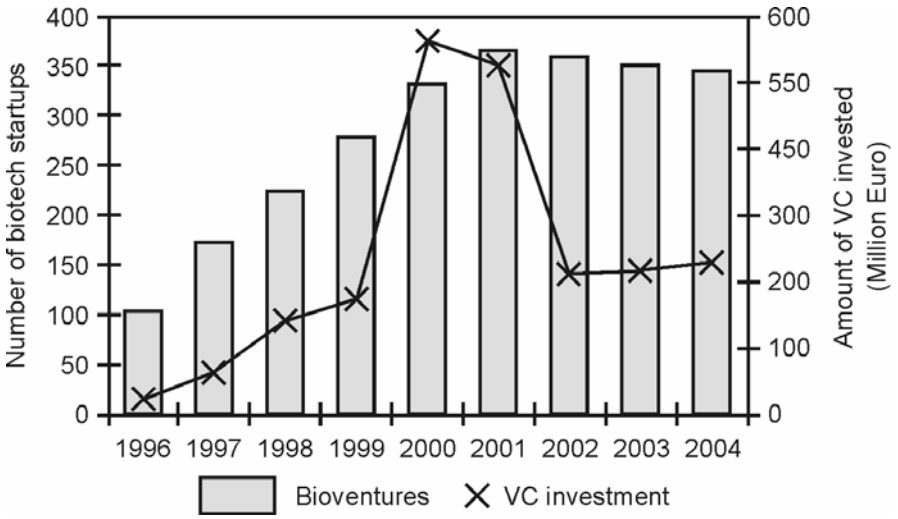


Figure 11: Development and VC financing of the German biotechnology industry

After the burst of the high-tech bubble in late 2000, the IPO window closed and did not open again for biotech firms until 2004. Because venture capitalists lacked their favoured exit option, investment in the sector dropped from 525 million € in 2001 to 207 million € in 2002 without rising substantially again during the two years following. However, the number of biotechnology companies in this timespan decreased only slightly to 346 companies in 2004 (Ernst & Young, 2005). I will now analyse how this development is explained by external and/or internal adaptation mechanisms.

3.5 External adaptation

External adaptation and organisational death occurs either when firms become insolvent or when they are acquired by/merged with another company. Whereas insolvencies constitute the classical form of organisational death, in the case of an M&A parts of one organisation continue their existence as part of another organisation. Because, in

contrast to organisations, biological systems are not decomposable, there is no classical analogy in biological evolution which would make it easy to categorise M&As as survival or death of the partner firms (Aldrich, 1979). However, since in every M&A one firm looses its formal independency and the overall population decreases by one, I consider it as most appropriate to view M&As as organisational death of the target company (Hannan and Freeman, 1989). Creation of new organisations is represented by new company foundations. Table 2 provides an overview of insolvencies, M&As, and foundations of biotech firms between 2000 – 2004 in the German biotech industry.

Year	**2000**	**2001**	**2002**	**2003**	**2004**
Insolvencies	n.a.	6	26	24	31
M&As[5]	4	5	4	9	3
Foundations total	59	44	25	23	26
Foundations VC-backed	30	12	6	3	0

Sources: (Ernst & Young, 2002b; Ernst & Young, 2003c; Ernst & Young, 2004; Ernst & Young, 2005)

Table 2: Insolvencies, M&As, and foundations in the German biotech industry

3.5.1 Insolvencies and M&As

As Table 2 demonstrates, the number of insolvencies increased rapidly upon the drop in the munificence of the financing environment in 2002. Whereas only 6 companies ran out of money in 2001, 26 became insolvent in 2002. This number finally amounted to 31 in 2004. These insolvencies include companies which, two years before, had been considered flagships of the young industry and had acquired significant amounts of VC, such as Axxima (64 million €), Munich Biotech (40 million €), Apovia (29 million €), and Xerion (26 million €). Obviously, these ventures were not able to adapt their strategy to the new situation and thus were subject to external adaptation.

[5] Please note that this number does not include international M&As where the bidder firm is German. Moreover, I do not include firms which were acquired by strategic investors but continue to operate independently. These two kinds of M&As have no impact on the number of firms in the German industry and therefore do not contribute to industry development as I understand it in the context of this study.

With regard to M&A activities, the level stayed surprisingly low during 2002 – 2004. Although experts were awaiting a wave of M&As coming up as a means of consolidation during this timeframe, there was little activity. Thus young biotech firms appear to be particularly inert when it comes to M&As. The reasons for this observation lie in M&A hurdles specific for privately held and VC-backed entrepreneurial ventures, which constitute the major part of German firms. These hurdles include the egos of scientific founders who block negotiations in fear of their position and scientific reputation, valuation problems of the privately held companies, and missing experience with M&As of both, management and investors (Ernst & Young, 2004: 67). These hurdles and were observed for VC-backed biotech ventures before (zu Knyphausen-Aufseß et al., 2005). As a consequence, a number of firms faced insolvency instead of a potentially beneficial M&A. One of the most prominent examples is Axxima, which was guaranteed a 10 million € financing round in 2004 by its investors if the firm succeeded to find an M&A partner. However, negotiations failed and Axxima filed for insolvency in late 2004.

3.5.2 Foundations

Table 2 shows that the number of new biotech firm foundations dropped substantially after the burst of the high-tech bubble in late 2000. In that year, almost 60 biotech ventures were incorporated due to easily available capital, and in 2001 Ernst & Young still counted 44 inceptions. However, during the hostile financing environment in 2002 – 2004, the annual number of foundations was only 25 on average. In contrast to 2000, when 30 newly founded firms received VC, in 2002 and 2003 only 6 and 3, respectively, of the new bioventures were VC-backed. In 2004, none of the newly founded biotech start-ups was financed by VC. All these firms obviously succeeded in finding alternative sources of financing. Intriguingly, the number of 2004 is quite similar to the number of firms started without VC in 2000. Thus, it appears that there is a relatively constant amount of firms started without VC in different financing environments, whereas the number of VC-backed firms heavily depends on the financing situation. This observation is in line with the population ecologist perspective: biotech firms are selected already at the time of inception according to their fit with the financing environment.

Taken together, the population ecology perspective helps to explain the pattern of organisational birth and disappearance in the German biotechnology industry during the hostile financing environment. External adaptation took place through an increasing number of insolvencies and a reduced number of foundations of VC-backed companies.

3.6 Internal adaptation

This section describes how biotechnology firms successfully adapted internally to the hostile financing environment in Germany. I will introduce four case studies of bioventures which changed their strategy and adopted new financing routines as a response to the new context. I will then perform a cross case analysis and discuss whether the strategic changes I identified were more frequently applied in the industry.

3.6.1 Micromet

Micromet was spun-off the University of Munich in 1993 by a team of scientists. The company develops antibodies for treatment of various cancers and other indications. After financing its R&D by government support for three years, Micromet closed its first VC financing round in 1997. Until 2001, Micromet had acquired more than 60 million € of equity investments, primarily as VC. Until the mid of 2005, Micromet had not closed another financing round.

The key for Micromet to ensure a further inflow of cash during the times of tight equity markets was to establish development alliances for its product candidates. In 2000, the company granted a global exclusive license to manufacture, market, and distribute an antibody of its development pipeline for use in cancer diagnosis to ChromaVision Medical Systems. In 2001, Micromet entered into a strategic alliance with Curis covering target research and drug development. Micromet received a 14 million $US upfront payment and a share in profits and revenues. One year later, it formed an alliance with Enzon to jointly develop antibody-based therapeutics, resulting in an 8 million $US equity investment by Enzon and the agreement to share costs and revenues. Another month later, Micromet partnered its clinical lead drug candidate MT201 with Novuspharma. The agreement provided Micromet with another 3.9 million $US upfront fee. Further milestone payments were planned. Moreover, the companies agreed to

share development costs and revenues. Micromet's CEO commented the deals (Wess, 2002b):

> *"With this series of deals we have generated a good cash flow. We are financed through to the end of 2004, maybe until early 2005."*

However, spanning a network of cash-providing alliances was not enough for Micromet to survive in the hostile financing environment. The company also had to restructure its operations. This reaction was partly forced by the acquisition of its alliance partner Novuspharma by Cell Therapeutics in 2004. Mircomet and Cell Therapeutics failed to agree on continuation of the alliance which would have secured Micromet further milestone payments. Therefore, Micromet had to reduce its staff from 135 to 90. The reduction was expected to provide Micromet with enough liquidity to carry out Phase II clinical trials of MT201 themselves (Maggos and Brown, 2004). However, by the end of 2004, Micromet again partnered MT201 with pharmaceutical company Serono. As part of the agreement, Micromet received another 10 million $US upfront fee and will get milestone payments of up to 138 million $US when the product is successfully developed and registered worldwide in three or more indications.

3.6.2 Ingenium

Ingenium is a Munich-based company which develops mouse and rat models for analysis of therapeutically relevant biological pathways. Founded in 1998 as a spin-off of the German Human Genome Project, Ingenium had acquired 60 million € in two VC financing rounds until the end of 2000. Originally, the company planned to compile a catalogue of clinically relevant mouse mutants and offer them to other firms. Besides, Ingenium develops its own portfolio of drug candidates.

Because of its high R&D expenditures and rapid growth to up to 140 employees, Ingenium found itself in mid-2002 with financial resources for only about one more year. This situation was due to the fact that the company had not yet succeeded in finding enough customers for their animal models and had not been able to close a large alliance contract as it had planned. Therefore, in June 2002 Ingenium adopted a more service-oriented strategy. Instead of developing a catalogue with mouse models which

might not meet the requirements of potential customers, the company started to design its models according to the specific customer needs. This strategic change allowed for commercialisation in more flexible partnership structures including upfront funding, milestone payments, royalties, co-development of compounds, and direct fee-for-service agreements. Moreover, as a consequence of its strategic change, Ingenium also reduced its staff to 80 employees. According to the VP finance (Wess, 2002c):

> *"The change of our business model has considerably slowed down our burn rate. We now have enough cash to take us through the signing of our first partnership before we will need to raise more money."*

In the beginning of 2003, Ingenium entered into a collaboration with pharmaceutical company Elan comprising a potential worth of more than 50 million €. Moreover, investors confirmed Ingenium's strategic change and committed another 13.8 million € financing to the company despite of the hostile financing environment at the end of 2003 (Wess, 2002c; Liebl, 2003: 57).

3.6.3 Curacyte

Curacyte was founded in early 2000 in Munich and closed a first round of 7 million € VC financing in the autumn of the same year. The company's initial business concept drew on a drug discovery technology from a Germany university institute. Half a year after Curacyte's foundation it turned out that this technology was invalid and based on a scientific artefact. In the munificent financing environment during the high-tech hype, investors decided to continue the company instead of liquidating it. At that time, Curacyte had more than 5 million € in cash left from its initial investment. Curacyte's management started a business development program based on in-house development and in-licensing of projects. Moreover, Curacyte actively looked for M&A activities.

During the hostile financing environment in 2002, Curacyte faced the challenge to acquire further capital without a robust technology in hand. Therefore, the company decided to merge with another Munich-based firm from the portfolio of its lead investor. The merger partner had a drug candidate in Phase III clinical trials which it developed in its US subsidiary. As a precondition of the merger, Curacyte's

management demanded that shareholders invest another 7 million € in the combined entity in order to facilitate post-merger development. As part of the merger, Curacyte consolidated its portfolio and stopped the less promising projects. Moreover, the company saved costs through release of personnel (Wess, 2002a; Giersiefen, 2003).

By the end of 2004, Curacyte was again in need of financing. Although the company tried to raise funds through partnering of its clinical product candidate with a pharmaceutical firm, negotiations had been unsuccessful so far. Due to the ongoing difficult conditions for VC-backed biotech ventures in Germany, management again decided to merge with another firm in early 2005. On back of the merger, Curacyte secured a 16.5 million € investment. Curacyte's merger partner was based in Leipzig in former Eastern Germany. Since salaries in this part of Germany are significantly below payments in the Munich area, management decided to close its Munich site and move the company's headquarters to Leipzig. Moreover, Eastern Germany is eligible for special funding and other economic benefits for the German accession states. According to the CEO, Curacyte planned further cost reduction and partnering of product candidates which were, after reprioritisation of the combined project portfolio, no more in the focus of the company (Wess, 2005):

> *"We may also lay off some people and seek to partner our oncology compounds, as we want to focus on cardiovascular diseases and inflammation."*

3.6.4 Epidauros

Epidauros is based in Bernried near Munich and was founded in 1997. In 1998, the company closed its first financing round. At that time, Epidauros planned to establish three businesses on the basis of its proprietary pharmacogenetic technology: internal drug development, out-licensing of pharmacogenetic markers for the development of diagnostics, and pharmacogenetic research services for other companies and research institutes. In 2001, Epidauros counted 59 employees and planned an IPO in the near future in order to attract further capital.

However, by the end of 2001 Epidauros had not achieved its R&D goals and therefore was unable to raise further venture capital or go public in the hostile financing environment. The company found itself near insolvency in autumn of 2002. The only

alternative was to completely reorganise its business and become profitable the following year. In early 2003, Epidauros exchanged its complete management team. The company stopped its internal drug development programs and released 50 % of its staff. From that time on, Epidauros focused on its fee-for-service business and, using its proprietary pharmacogenetic technology, conducted genotyping analyses for drug development projects of other biotech and pharma companies. As a second major column of Epidauros' business emerged co-operations with universities and other institutions for building up new Intellectual Property (IP) as well as generating revenues by out-licensing of existing IP. Moreover, Epidauros started to enhance its income by offering pharmacogenetic consulting to other companies and Clinical Research Organisations (CROs). In 2003, Epidauros reached its break even, and the company was also profitable in 2004. As the CEO stated (Zoltobrocki, 2005):

> *"The history of the firm is an example for a turn-around and continuation of a company through fundamental reorganisation of its business."*

3.6.5 Cross case analysis

The case studies I introduced above reveal four major strategies and new routines by which biotechnology firms in the German sector adopted as a response to the hostile financing environment: downsizing of operations, entering into strategic alliances, changing the business model, and engaging in M&A activities. I will now discuss whether the case studies represent exceptions or whether these measures can be viewed as more common strategies in the industry. I will draw on the industry data described in Table 3.

Year	**2000**	**2001**	**2002**	**2003**	**2004**
Industry employees	10673	14408	13400	11535	10089
Employees per company	32	39	37	33	29
Strategic alliances	n.a.	n.a.	100	105	147
Business models (Product/Hybrid/Service in %)	n.a.	45/41/14	46/36/18	33/50/17	31/50/19

Sources: (Ernst & Young, 2002b; Ernst & Young, 2003c; Ernst & Young, 2004; Ernst & Young, 2005)

Table 3: Employees, business models, and strategic alliances in the German biotech industry

Downsizing. Downsizing is "an intentional, permanent, and systematic reduction of an organisation's workforce" (Nixon et al., 2004: 1122). It is a measure of corporations to reduce expenditures and is often followed in times of economic downturns (Cascio, 2002). All four case study companies in the sample downsized their operations in order to survive the scarce availability of capital. Micromet reduced its staff by 33 %, Ingenium by 43 %, and Epidauros by 50 %. Curacyte also laid off personnel after each of its two mergers. Other examples of downsizing measures (either without or in combination with M&A activities) in the German biotech industry include Graffinity, DeveloGen, Morphochem, Morphosys, Biobase, and others. For the industry level, Table 3 shows that not only the total number of employees in the industry dropped by almost 30 % from 2001 to 2004, but that the average number of employees per company also declined by 26 %. It thus appears that downsizing is a common strategy for biotech ventures to adapt to a hostile financing context.

It is important to note that while downsizing allows for a quick cost reduction and thus has a positive effect on a company's financial results on the short term, it always means a loss of human capital which might impact performance on the long run. Nixon et al. (2004), e.g., showed that downsizing measures of large corporations tend to have a negative impact of firm valuation at the stock markets. Market returns are only positive when the company follows a reallocation strategy which ensures that important human capital is kept within the firm. Downsizing may be particularly difficult for biotech

firms because employees carry most of a firm's knowledge, which is one of the most important organisational resources in the biotech industry (Liebeskind, 1996; Zucker et al., 2002). Since existing literature focuses on downsizing of large corporations but provides little insights for small and entrepreneurial firms so far, I suggest that going forward researchers should analyse how bioventures downsize most efficiently, and which impact downsizing has on their long-term performance.

Strategic alliances. Strategic alliances are "voluntary inter-firm agreements aimed at achieving competitive advantage for the partners" (Das and Teng, 2000b: 33). They include in- and out-licensing deals, joint R&D agreements, technology exchange, joint ventures, and minority equity partnerships (Gulati, 1995). Three of the case study firms reacted to the hostile financing environment with an enhanced engagement in strategic alliances with other biotech firms, pharmaceutical corporations, and universities. Micromet's new corporate partners included ChromaVision, Curis, Enzon, Novuspharma, and Serono. These firms paid more than 20 million $US in upfront payments alone, thereby securing Micromet a considerable cash inflow independent of the financing environment. For Ingenium, establishing an alliance with Elan was a major milestone not only to generate revenues, but also to secure support of investors. Epidauros made alliances with universities and research institutions a major part of its business in order to develop new IP, which it then out-licensed to other organisations. Other German biotech companies such as Paion, Morphosys, and Trion Pharma also stressed the importance of strategic alliances to build up and maintain a product portfolio in times of tight equity markets (Ernst & Young, 2004). For the industry as a whole, the number of newly established alliances rose from 100 in 2002 to 147 in 2004 (Table 3). I therefore conclude that strategic alliances are important financing routines for biotech firms in a hostile environment.

This interpretation is further supported by existing literature on strategic alliances and inter-firm co-operations. Besides research that shows that the establishment of an alliance network has a positive effect on the performance of biotech firms in general (George et al., 2002; Baum et al., 2000), scholars also demonstrated that alliances are an appropriate means for bioventures to obtain various resources from a partner, including financing (Shan, 1990; Audretsch and Feldman, 2003). Moreover, Lerner and co-workers (Lerner and Merges, 1998; Lerner and Tsai, 1999) showed that bioventures in

poor cash positions and in hostile financing environments enter into alliances with pharmaceutical firms even when the majority of the alliance control rights is allocated to the incumbent partner.

Change in business model. The term 'business model' refers to the specific information, service, or product that companies exchange and/or the parties that engage in the exchange (Amit and Zott, 2001; Hamel, 2000). In the context of the biotech industry, Ernst & Young distinguish three business models (Section 2.4). Product-oriented companies concentrate on development and commercialisation of biotechnological products such as therapeutics and diagnostics. Service-oriented companies offer the utilisation of their proprietary technology to other companies as a research service. Finally, hybrid companies utilise their proprietary technology for internal product development besides commercialising it. One major difference between these business models is that service-oriented firms create an inflow of cash independent of the capital markets. On the other hand, they do not have the growth- and upside potential of product-oriented companies.

Two of the case study companies in the sample adapted their business model to the hostile financing environment. At inception, Ingenium planned to offer its mouse models from a compiled product catalogue to customers. However, since the company was unable to find customers and got in danger of running out of cash in 2002, it adapted this model towards more service-orientation. Ingenium started to develop its products together with customers according to their specific needs. Similarly, Epidauros changed from a company focusing on the development of products such as drugs and biomarkers for diagnostics towards a service-oriented firm. Since Epidauros was unable to raise funds from investors in 2003, the company focused on its fee-for-service business and became profitable within 12 month. Another example of a company which had to change its business model towards more service-orientation as a response to the hostile capital markets is Cologne-based Amaxa (Ernst & Young, 2003c: 57). Analysis of industry level data reveals that these three firms were no exceptions in the German industry (Table 3). In 2003, 67 % of all companies were service or hybrid firms, whereas one year before these ventures accounted for only 54 % of the total industry. Please note that this increase corresponds to a total number of 28 firms, which is below the number of new firm foundations in 2003 (Table 2). Thus, even if all insolvent firms

in 2003 had been pursuing a product-oriented and all newly founded firms a service-oriented business model, this number can not be fully explained. These findings suggest that bioventures are able to adapt to a hostile financing environment by changing their business model towards more service orientation.

M&A activities. As a final strategy which enabled German biotech companies to adapt to a hostile financing environment emerged M&A activities. Curacyte succeed in closing two VC financing rounds although the company suffered a technology breakdown after its foundation in 2000. Both capital infusions were coupled to the merger with another company. Other examples of bioventures which acquired capital in combination with M&A activities included SiREEN (2004, 20 million €), DeveloGen (2004, 19 million €), Santhera (2004, 14 million €), and others. Obviously, VCs are more willing to support their investees in difficult times if these combine with another firm and create a larger and more robust company. However, due to the hurdles I described above, M&As were a rare strategy for bioventures to achieve financing in the years 2002 – 2004 (Table 2). This contrasts the tendency of large corporations to engage in M&As as a means of consolidation in times of low environmental munificence (e.g., Anand and Singh, 1997). Nevertheless, M&As appear to be a potentially successful strategy for bioentrepreneurial companies as well when it comes to securing support of investors in hostile financing environments.

In summary, the above described case studies in combination with the industry data demonstrate that, despite their high capital intensity and resource constraints, young bioventures are surprisingly flexible organisations with regard to adjusting their financing routines to a hostile environment. A substantial number of firms in the German industry were able to survive during the years 2002 – 2004 through internal adaptation in terms of downsizing, entering into strategic alliances, changing their business models, and engaging in M&A activities.

3.7 Discussion

In this study I analysed how a drop in the munificence of the financing environment influences the development of firms in the biotechnology industry. I drew on the theoretical perspectives of population ecology and evolutionary economics in order to

illustrate both, external adaptation processes at the industry and internal adaptation processes at the firm level. Which contributions do both kinds of processes make to explain the overall industry development I described in Section 3.4?

As Figure 11 shows, VC investment in the German biotechnology industry decreased by more than 50 % in 2002 and the two years following, as compared to the years 2000 and 2001. Interestingly, however, the overall consolidation of the industry was quite moderate since the number of firms only dropped from 365 in 2001 to 346 in 2004, a decrease of just 6%. This number is much lower than predicted by industry experts such as VC managers, executives, and observers of the sector, who were expecting disappearance of up to half of all biotech companies in Germany (Table 4). Based on their knowledge of the firms' cash reserves, revenues, and R&D expenditures, these experts substantially underestimated the potential of young bioventures to adapt internally to the hostile financing context.

Person	**Statement**	**Source**
Helmut Schuehsler, Techno Venture Management TVM	"Only 200 – 250 of about 400 German biotech companies might survive the next two years."	(BioCentury, 2003)
Jörg Neermann, Deutsch Venture Capital DVC	"Many of the about 400 companies in Germany will disappear. At the end of that process, I expect that we will reach a steady state of about 150 biotech companies."	(Wess, 2002b)
BioCentury staff report	"European investors figure that at least a quarter – and maybe more than half – of European companies will not make it through the current selection process, especially those in Germany. Attrition will occur through M&A, trade sales, or simple liquidations."	(BioCentury, 2003)
Mathias Pietras, Zentaris GmbH	"The biotechnology industry will strongly consolidate. Besides insolvencies there will be successful firms which are integrated in pharma companies or acquired by firms from the US."	(Ernst & Young, 2003c: 59)

Peter Stadler, Artemis Pharma GmbH	"Too much money has flown into too many companies while there was too little scrutiny. [...] We are now paying the price and have to digest the insolvency of many companies."	(Wess, 2002b)
Thomas Köhler, Roboscreen GmbH	"There will be a separation of wheat from the chaff. Only those companies will survive that offer a product with a demand based on a proprietary technology platform."	(Ernst & Young, 2003c: 59)

Table 4: Selected statements of experts on the expected development of the German biotechnology industry

The significant role a change in financing routines played for survival of a substantial amount of firms in the sector is also underlined by the fact that, in 2003, 68 % of VC-backed firms (corresponding to 105 companies) reported that they had cash for less than 12 month (Ernst & Young, 2004: 67). However, there were only 34 insolvencies/M&As (Table 2) and 33 VC financing rounds in 2004 (Ernst & Young, 2005), leaving at least 38 of the 105 firms which survived through a change in their financing routines. Thus I conclude that, while external adaptation processes qualitatively describe the patterns of insolvencies and new firm inceptions, internal adaptation and strategic changes of firms prevent a severe consolidation of the sector. A considerable number of bioventures is able to adapt to the hostile financing environment by downsizing, entering into alliances, changing their business model towards more service-orientation, and securing support of investors by entering into M&As. Figure 12 summarises these findings.

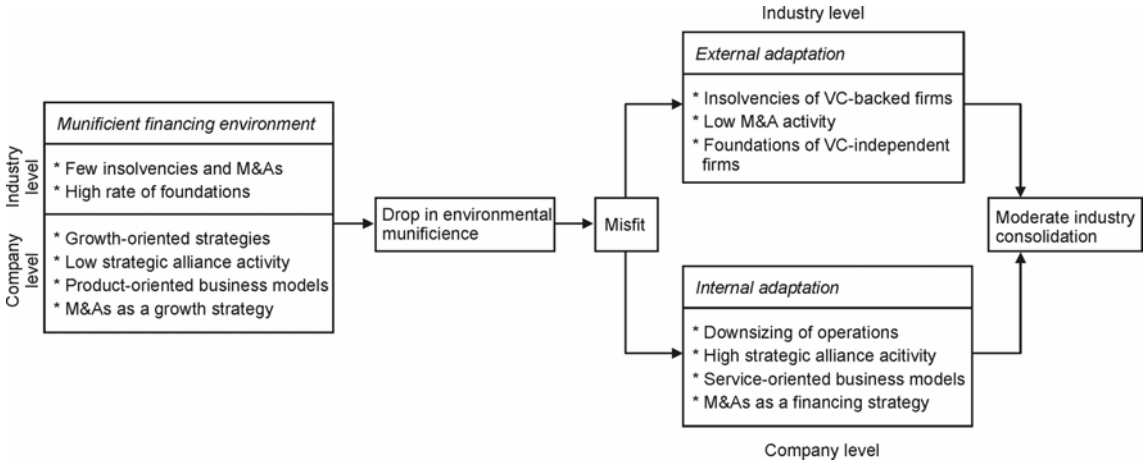


Figure 12: Model for the organisational evolution of a young biotechnology industry in a hostile financing environment

The unit of analysis in this study was the German biotech industry in the timespan 2002 – 2004. Thus, I draw on a single case study, which raises the question of generalisability of the results. Do biotech industries in other countries at other points in time react with a similarly moderate consolidation to a sudden hostility of the financing environment? There is indeed evidence suggesting that a young biotech sector is generally able to cope with a hostile environment for quite some time without severe consolidation. The biotech industry in the USA experienced a similar situation as the German sector twice: after the crash at the stock markets in 1986 and during the recession in 1993 – 1995. In particular the situation in 1986 reminds of the German industry as described in this study, because at that time the US sector was similarly young as the German industry in 2002. Both consisted almost exclusively of entrepreneurial ventures, with many of them depending on capital infusions from VC investors and the stock markets. However, neither in 1986 nor in 1993 – 1995 the US industry consolidated as strongly as expected by industry experts (Ernst & Young, 2003c; zu Knyphausen-Aufseß et al., 2005), suggesting that bioventures are more flexible when it comes to financing than generally assumed. It appears that the findings presented here are at least partially relevant for explaining the development of a young biotech industry in hostile financing environments also in other countries.

For scholars studying the evolution of organisations, the results of this study highlight the need to employ the theoretical perspectives of population ecology and evolutionary economics simultaneously. Whereas the first approach assumes organisational inertness and postulates that organisational evolution takes place through external adaptation (Hannan and Freeman, 1977; Aldrich, 1979), the second perspective emphasises the flexibility of organisations and internal adaptation processes (Nelson and Winter, 1982). So far, there are few studies which draw on both perspectives simultaneously (Valle, 2002) despite their complementary character (Singh, 1990). Although only exploratory and qualitative in nature, the findings I present here contribute to the scarce empirical evidence on this argumentation. The assumption of external adaptation is necessary to explain the rising number of insolvencies and the decreasing number of new firm foundations in the hostile financing environment the German biotech industry experienced. However, it is not sufficient to understand why the consolidation of the sector was much weaker than data on liquidity and cash burn of ventures would have

suggested. This phenomenon can only be explained by assuming a substantial amount of internal adaptation processes and changes in the companies' internal financing routines and strategies. New routines bioventures adopt in hostile financing environments include downsizing activities, new business models, and an enhanced engagement in strategic alliances and M&A activities. For the complete picture of the organisational evolution of the German biotech industry, both external and internal adaptation processes must be considered. This argumentation is in line with recent theoretical work by Valle (2002: 223) who claims that "organisational evolution can be explained on the basis of a combination of [the two] different adaptation mechanisms".

For biotech managers, the findings of this study have important implications. Even if their company was founded in times of a munificent financing environment and pursues a growth-oriented strategy, it appears to have a remarkable potential to adapt this strategy when equity markets become hostile. However, managerial flexibility is essential and drastic measures may be required. These possibly include a significant downsizing of operations, a change in the business model towards more service-orientation, and an enhanced engagement in strategic alliances and M&A activities. Since alliances and M&As often have their origin in the personal networks and informal contacts of management and employees and establishing these networks is a lengthy process, bioventure managers are well advised to build up these contacts already in times of environmental munificence. This provides them with the strategic flexibility required once the equity markets close.

3.8 Limitations and future research

The limitations of this study may be overcome by going forward scholars. As a first avenue for future research I suggest that the alternative financing strategies of bioventures in a hostile financing environment, which I identified from the qualitative case studies in Section 3.6, call for a large scale analysis. It is necessary to corroborate on a statistical basis the impact and importance of downsizing measures, changes in business models, strategic alliances, and M&A activities on bioventure survival and performance under these circumstances. These studies could provide valuable insights for bioentrepreneurs. A particular challenge for researchers may be to build up a

database containing longitudinal data on the financing routines of biotech firms in different environments, which would be necessary for a systematic analysis.

Secondly, it is important to note that the evolutionary path of the biotech sector in times of hostile financing environments may change when the industry becomes older and proceeds in its life cycle. The differences relate, e.g., to the role of M&A activities, as the development of the US biotech sector in the years 2002 – 2004 indicates. In contrast to Germany, the more developed US industry experienced a high M&A activity. One major reason for this difference is that about one quarter of the US biotech firms are mature and publicly traded companies. In case of M&As between these firms, there are little valuation problems because a market valuation is available. Moreover, large and highly profitable firms in the US sector such as Amgen and Genentech have significant cash reserves which enable them to purchase small firms at low valuations in times of closed equity markets. Therefore, at least with regard to M&A activities, the findings I presented here appear to be mainly applicable to biotech industries which are in early life cycle stages like the German sector. Further research is necessary to explore evolutionary adaptation mechanisms not only in relation to the munificence of the financing environment, but in parallel taking into account the effect of different industry life cycle stages.

Finally, by providing some insights into the consequences of the German government policy which promoted the development of the biotech industry in the late 1990s, the results I present also raise important research questions to public policy scholars. Upon initiation of the BioRegio Contest in 1995, the development of the German biotech industry was facilitated in the four winner regions by interventionist policy measures such as providing seed funding for bioventures and building biotech clusters (Dohse, 2000). Existing research suggests that the government "efforts of interventionism were not able to overcome blockages that exist in the German system of biotech innovation. On the contrary, those government strategies have enhanced to a large extend the structural inertia that made the German system inappropriate for biotech development needs" (Giesecke, 2000: 221). However, it is important to note that this study was performed the late 1990s and that, as I showed above, the industry has developed significantly since. Given the fact that the German sector is less than a decade old and that Germany does neither have an established VC industry nor an entrepreneurial

culture like, e.g., the USA, the high number of biotech firms in Germany today may lead one to believe that the interventionist policy was quite successful. This assumption is supported by the fact that, contrary to the expectations of industry experts (Table 4), the number of bioventures remained surprisingly high during the hostile financing environment in the years 2002 – 2004. However, the strategic adaptation of firms towards more service orientation limits their future growth potential and it appears unlikely that large and very successful firms such as Amgen and Genentech, which were all product-oriented firms from their beginning, will emerge in the German sector. Clearly, more research is needed to analyse the impact of policy measures on the development of the biotech industry systematically and over a longer period of time.

4 M&A activities of German biotechnology start-ups

The findings I presented in the preceding chapter show that M&As between bioventures, although they are rare a phenomenon, can contribute to ensure survival of the firms in hostile financing environments. Moreover, these activities are potential measures for bioentrepreneurs to achieve company growth in times of environmental munificence and easily available capital (Ernst & Young, 2002b). However, M&As of small and privately held start-ups are a so far unexplored field in scientific literature. Therefore, in this chapter I will introduce a detailed empirical study on M&A activities of German biotechnology start-up firms. This study is explorative in nature since I do not aim to rigorously develop or test theory, but rather to provide valuable insights for managers. I will illustrate specific motives, benefits and problems that are associated with M&As of new biotech ventures from the start-up management's point of view.[6]

I structure the remainder of this chapter as follows. In the next Section 4.1 I will give a general introduction to the topic and its scholarly relevance. I will then provide an overview of the development of start-up M&A activities in the German biotech industry (Section 4.2). After a brief description of the data sources and methodology (Section 4.3), I will introduce six M&As between privately held biotech start-ups in more detail (Section 4.4). In Sections 4.5 and 4.6, I will discuss benefits and problems, respectively, which arose in the analysed cases. In Section 4.7, I will illustrate implications for biotech start-up managers and the future development of the M&A activities in the German biotechnology industry. I will close in Section 4.8 with pointing to limitations of the study and offering suggestions for more systematic future research.

4.1 Introduction

In research-intensive high-technology industries such as biotechnology, it is a challenging task for start-up company managers to build up a valuable resource platform of their firms in order to gain competitive advantage. The development of complex new technologies does not only require substantial financial resources, but also competencies in different scientific and technological fields (Jones et al., 2000). The

[6] This study profited from discussions with Dr. Lars Schweizer and Prof. Dr. zu Knyphausen-Aufseß, University of Bamberg.

increasing speed of new product development in global markets further complicates the entrepreneurial task (Chatterji and Manuel, 1993). In order to ensure a quick and efficient acquisition of resources, many biotech start-ups share resources with other firms and enter into strategic alliances or mergers and acquisitions.

A substantial body of literature is dedicated to strategic alliances in the biotechnology industry (Audretsch and Feldman, 2003). For young biotech companies, in particular, alliances are essential (Oliver, 2001). The establishment and efficient organisation of an alliance network is linked to the innovative performance of biotech start-ups (Shan et al., 1994) and is a prerequisite to attract investors (Baum and Silverman, 2004). Furthermore, collaborations constitute an important source for learning and, therefore, broaden the biotech start-up's knowledge base (McNamara, 1998; Fildes, 1990; Liebeskind et al., 1996; Powell, 1998).

In contrast to literature on strategic alliances and inter-firm co-operation, work on M&As mainly focuses on large companies. In this context, the desire to obtain valuable resources, including know-how, technologies, and capabilities possessed by the target firms is a driver of M&A activities (Chaudhuri and Tabrizi, 1999; Schweizer, 2005). However, existing literature can not provide research devoted to the study of the acquisition of entrepreneurial firms (Chen and Reuer, 2004) or of the M&A activities between start-up companies. These M&As might differ from deals between large corporations in various aspects. In contrast to large firms, start-up companies follow resource-seeking rather than resource-exploiting strategies (Zaby, 1999), and I therefore would expect different M&A motives. Moreover, start-up companies may achieve other benefits through M&As, e.g., attracting new equity investors as a result of enhanced visibility. Finally, during the M&A process, specific problems for small start-up companies might arise due to missing management experience and the strong impact of investors, such as venture capitalists, on the start-up management (Gompers and Lerner, 1999). Research on M&As between start-up companies is particularly important since an unsuccessful deal might threaten the life of a new venture because of its limited resource base. Therefore, I analyse M&As between start-up companies in the German biotechnology industry.

4.2 M&A activities in the German biotechnology industry

After the burst of the high-tech bubble in the year 2000, many German biotech start-ups were facing serious financing problems (see Chapter 3). Because of the closed IPO window in the years 2002 – 2004, investors lacked their favoured exit option and VC investment in the sector dropped from 525 million € in 2001 to 207 million € in 2002 and 216 million € in 2003, respectively. However, although in 2003 more than half of the German biotech start-ups had cash for less than twelve month, the awaited consolidation of the industry through M&A activities did not materialise. In their annual reports, Ernst & Young listed 38 M&A deals in the years 2000 – 2003, 18 of which took place between two privately held start-up companies (Ernst & Young, 2002b; Ernst & Young, 2003c; Ernst & Young, 2004). In the following, I analyse six of these 18 M&As in more detail.

The development of the financing environment had implications for the M&A activities of biotech start-up companies. There were eight and seven deals between private start-ups in 2000 and 2003, respectively, but only two and one in 2001 and 2002, respectively. In the high-tech hype of the year 2000, when the financing environment was excellent and valuations of biotech start-ups were high, German companies acquired or merged with mostly US-based start-ups in exchange for their expensive stock. In five of the eight M&As in 2000 the target company was from the USA. In 2001, stock markets were declining and the IPO window closed. Thus, valuations of start-ups also dropped and stock-by-stock acquisitions became more expensive for German companies. Consequently, there were only two deals. In 2002, VC investment in the German biotech sector declined more than half as compared to the preceding year, and company valuations were also lower than in 2001. Because investors were not willing to sell or merge their portfolio companies cheaply, low valuations hindered an efficient consolidation of the German industry and there was only one merger of two privately held biotech start-ups. In 2003, the financing environment was still difficult for German bioventures and many of them were in danger of running out of cash. Thus, they were an attractive acquisition target for foreign companies. Of the seven M&As in 2003, four had a foreign bidder, with three of them coming from the USA (Ernst & Young, 2003c; Ernst & Young, 2004).

Depending on the financing environment, motives and general conditions for the M&As mentioned above differed. For example, whereas the overall motif for an M&A in 2000 was to grow and attract new investors in an excellent financing environment, the merger between Curacyte and VitaResc was aimed at consolidating the businesses in order to ensure survival and further growth of both companies in the difficult financing environment of 2002. In the following sections, I introduce examples of both, growth- and consolidation-oriented M&As (Bower, 2001), and benefits and problems associated therewith.

4.3 Methodology and data collection

As mentioned above, this research was not intended for rigorously building or testing theory, but for providing valuable insights for managers. With the aim of demonstrating motives, benefits and problems that are specific for M&A deals between new bioventures, I analyse six M&As within the German biotech industry. Four of these deals took place during the high-tech boom of 2000 and two in the hostile financing environment of the years 2002 and 2003. The cases cover national and international deals and drug development as well as diagnostics companies. Table 5 provides an overview of the analysed M&As.

Case	Year	Countries	Employees	Business area
GPC – Mitotix	2000	G/USA	90/40	drug development
Morphochem – SMT	2000	G/USA	30/28	drug development
DeveloGen – HepaVec	2000	G/G	30/30	drug development
Epigenomics – ORCA	2000	G/USA	50/15	diagnostics
Curacyte – VitaResc	2002	G/G	15/13	drug development
Alnylam – Ribopharma	2003	USA/G	25/25	drug development

Table 5: Overview of M&A cases

A detailed case analysis turned out to be a more difficult task than initially expected. One major reason why there is so little research dealing with M&As of small, privately held companies may be that start-up managers as well as their investors tend to keep the

development of their risky businesses secret until they go public. Consequently, when approaching companies for interviews, I did not manage to talk to the CEOs and/or other executives or investors of all the case companies. Therefore, I also had to rely on secondary sources of information. In two cases, I had the chance to attend conference talks given by the CEOs and reporting on the M&A deals of their company. Furthermore, I talked to independent experts of the German biotech industry to validate the results.

Given the qualitative nature of the data, triangulation was one of the important means of increasing construct validity and substantiating findings (Denzin, 1978). I used archival documents and interview case write-ups. Table 6 presents an overview of the data sources.

Case	**Company press releases**	**Biotech press**	**Annual reports**	**Personal interviews/ conversation**	**Printed interviews**	**Executive speech**	**Internal documents**
GPC – Mitotix	X	X			X		
Morphochem – SMT	X	X	X	X			
DeveloGen – HepaVec	X	X		X			
Epigenomics – ORCA	X	X				X	X
Curacyte – VitaResc	X	X	X	X			X
Alnylam – Ribopharma	X	X		X		X	

Table 6: Data sources used in the M&A case studies

4.4 Description of the M&A cases

This section describes the above listed M&As. I will introduce the merging companies and the motives behind the deals. Table 7 shows an overview of M&A motives from the data. This table serves as the basis for the subsequent discussion of benefits and problems in the next sections.

Case	Motives
GPC – Mitotix	"The transatlantic combination of GPC AG and Mitotix will create a unique company which combines broad technological integration from target discovery to the clinic with global access to the world's premier pharmaceutical customers, strategic biotech partners and financial markets." (CEO in company press release in 2000)
Morphochem – SMT	"We are excited about the novel proprietary screening technologies and biology that have been established at SMT." (CSO in company press release in 2000) "Besides an interesting technology, we were also attracted by SMT's strategically favourable location in Princeton." (CFO in biotech press in 2000)
DeveloGen – HepaVec	"We have combined the technological platforms of two individually strong companies to create an organisation poised for significant advancement in its R&D programs." (CEO in company press release in 2000)
Epigenomics – ORCA	"Because ORCA is the only company in the world which is also an DNA methylation specialist, the transaction will create an outstanding force in this exciting market. [...] Through the merger we strengthen our leading position and establish a main pillar in the US." (CEO in conference talk in 2003)
Curacyte – VitaResc	"The merger was part of our strategy to achieve critical mass." (CEO in interview in 2004) "It was clear to us that the pearl of VitaResc was PHP, which was developed in the US." (CFO in interview in 2004)
Alnylam – Ribopharma	"By combining our patent portfolio and scienitific skills we became the major RNAi company and the most attractive partner in the world for pharmaceutical companies aiming to develop RNAi therapeutics." (CSO in interview in 2004) "A major motive for the merger was to get access to Alnylams professional management." (CEO in interview in 2004)

Table 7: M&A motives (examples from the data)

4.4.1 Genome Pharmaceutical Corporation – Mitotix

Genome Pharmaceutical Corporation (GPC) was founded in 1997 in Munich with the aim of becoming a fully integrated drug discovery company. GPC was building up a proprietary technology platform including analysis of protein interaction and gene expression as well as bioinformatics for efficient identification and validation of therapeutically relevant target molecules. Until March 2000, GPC had raised more than 30 million € financing, most of it as VC. At that time, it acquired Mitotix, a company focusing on the development of small molecules as lead drug candidates for cancer diseases. Being five years older than GPC, Boston-based Mitotix had also closed several rounds of VC financing.

The integration of technologies with the potential to cover the whole drug discovery process was the major motif for both companies to combine operations. Mitotix' excellent geographic location at One Kendall Square and the resulting opportunities to establish networks with US companies and universities was another motif for GPC's acquisition.

4.4.2 Morphochem – Small Molecule Therapeutics

The scientists Alexander Dömling and Wolfgang Richter founded Morphochem in 1996 in Munich. As basic technology, the company developed its proprietary "MORE-System", which combines chemical reactions with a bioinformatics platform, thereby allowing an efficient identification and optimisation of lead molecules for drugable targets. Before the acquisition of Princeton-based Small Molecule Therapeutics (SMT) in March 2000, Morphochem had raised about 22 million € in two VC financing rounds. SMT had raised 10 million $US financing but was in serious financial problems and thus an attractive acquisition target. SMT was developing tests for screening the interaction of lead molecules with specific target proteins.

Executives from both companies and main shareholders mentioned the combination of both technologies in order to form a fully integrated drug discovery company as the main deal motif. Further motives for Morphochem's acquisition included the installation of an international presence and the access to SMT's business and scientific network in the USA and Japan.

4.4.3 DeveloGen – HepaVec

A team of three scientists and the serial bioentrepreneur Herbert Stadler founded DeveloGen in 1997 in Goettingen. DeveloGen aimed at developing drugs for metabolic diseases such as obesity and diabetes and focused on the identification and validation of target genes. Until October 2000, when it merged with HepaVec in the first German-German biotech merger, DeveloGen had raised about 10 million € VC financing. Berlin-based HepaVec, which was founded in 1996 also by Herbert Stadler, owned a vector technology for targeting specific genes to pathogenic cells. It already had a gene-therapeutic drug candidate in Phase I/II clinical trial. HepaVec had raised more than 10 million € in two VC financing rounds.

According to Herbert Stadler, CEO of both companies at the time of the merger, growth and the achievement of critical mass was the main motif for the deal. The combination of DeveloGen's and HepaVec's technology should facilitate the targeting of therapeutically relevant genes to damaged cells within the human body.

4.4.4 Epigenomics – ORCA Biosciences

Epigenomics was incorporated in 1998 in Berlin. The company is specialised on DNA-methylation technology, which it uses to develop a new generation of diagnostic products. Until December 2000, when Epigenomics merged with Seattle-based ORCA Biosciences, it had acquired about 7 million € VC. ORCA, founded in 1997, was also focusing on DNA-methylation technology.

Epigenomics founder and CEO Alexander Olek stressed that the extension of a worldwide leading position in DNA-methylation technology and the establishment of a US presence were major motives for the merger with ORCA. He expected a US subsidiary to provide access to qualified senior management, a huge market for diagnostics, co-operations with universities and industry, and an easier listing on the NASDAQ in the future.

4.4.5 Curacyte – VitaResc

Curacyte was founded in 2000 by a team including Helmut Giersiefen (CEO) and Andreas Zaby (CFO) in Munich. Because of a technology breakdown ten month after

its incorporation, Curacyte had to build up a new technology platform by in-house development, in-licensing, and M&A activities. Therefore, the company, which still was in a good cash position from its 7 million € series A financing round, merged with Munich-based VitaResc in 2002. VitaResc, which was founded in 1999, had a wholly-owned subsidiary in Durham, North Carolina. VitaResc was developing PHP, a drug against distributive shock, which was already in Phase III clinical trial. At the time of the merger, VitaResc had already closed two VC financing rounds worth more than 20 million € capital.

Through the merger with VitaResc, Curacyte became, although only two years old, one of the few German biotech companies with a product in Phase III clinical trial. VitaResc, which was a high-risk one-product company, on the other hand gained a proprietary technology with the potential for in-house development of drug candidates. According to Helmut Schuehsler of Techno Venture Management (TVM), the major shareholder of both companies, the merger was a clear win-win situation for all participants.

4.4.6 Alnylam – Ribopharma

Alnylam is a US company founded in 2002 in Boston by a team of reputable scientists and managers including Nobel laureate and Biogen founder Philip Sharp and CEO John Maraganore, previously manager and scientist at two leading US biotech companies. Alnylam develops a new class of pharmaceuticals based on the innovative and very promising RNAi technology. Already in 2002, Alnylam closed two VC financing rounds and acquired 17 million $US. One year later, Alnylam merged with Ribopharma, a company located in Kulmbach, Bavaria. Like Alnylam, Ribopharma were RNAi specialists. The company was headed by two scientists, Roland Kreutzer (CEO) and Stefan Limmer (CSO).

Through combination of their strong IP portfolios, Alnylam and Ribopharma aimed at becoming one of the leading RNAi companies worldwide. For Ribopharma CEO Roland Kreutzer, access to the professional management and the reputable scientists at Alnylam was another main motif for the merger.

4.5 Benefits from the M&As

M&As of biotech start-ups are difficult to evaluate with regard to their overall success. Because the companies are not listed at the stock markets, no market valuation is available. Furthermore, as biotech companies do not generate significant sales in their early development stage, no accounting data can be used to estimate success. Another problem is that some of the deals in this study were successful in the one context, e.g., gaining visibility for investors, and less successful in the other, e.g., integration of technologies. Thus, I could not draw any conclusions with regard to the overall success of the M&A deals analysed.

However, based on the interviews and secondary data sources, I was able to identify specific benefits that arose from the M&As. Given the fact that there is no consensus on a common way of measuring M&A success (Larsson and Finkelstein, 1999), I used the evaluation of managers involved and compared these statements with the evaluations given in other data sources (Datta and Grant, 1990). Table 8 provides examples of benefits from the data. During the analysis it turned out that the benefits can be differentiated according to four main categories: financial, technological, product-oriented, and managerial.

Case	Benefits
GPC – Mitotix	"This [the acquisition of Mitotix] saved us two to three years of work." (CEO in business press in 2004)
Morphochem – SMT	"The purchase may pay dividends after all, as an article in the *Proceedings of the National Academy of Sciences* suggests that the subsidiary's research has produced several early stage cancer compounds." (Biotech press in 2002)
DeveloGen – HepaVec	"Half a year after the merger we closed one of the largest VC financing rounds ever in Germany, which was already planned at the time of the merger. In this sense, the merger was very successful." (CFO in interview in 2004)
Epigenomics – ORCA	"ORCA brought to Epigenomics valuable co-operations and connections with academic institutions in the US." (Biotech press in 2001) "Epigenomics identified several hundred unique markers to allow early detection of colon cancer. [...] Research was carried out at Epigenomics' high throughput discovery facility in Seattle." (Company press release in 2001)

Curacyte – VitaResc	"Despite the hostile financing environment, our shareholders decided on a bridge financing round on the back of the merger to provide ample time to implement the merger. [...] With an ongoing Phase III clinical trial, Curacyte is one of the most advanced biotech companies in Germany [in 2004]." (CFO in interview in 2004)
Alnylam – Ribopharma	"The excellent contacts of our professional management in the US with banks and investors were a prerequisite to go public in 2003, when the IPO window was closed in Germany." (CSO in interview in 2004)

Table 8: M&A benefits (examples from the data)

4.5.1 Financial benefits

All M&A deals cited above were accompanied by significant capital infusions for the biotech start-ups. By far the largest amount was raised by GPC two month after the acquisition of Mitotix. Due to enhanced visibility for investors through the international expansion and the excellent financing environment of the year 2000, GPC was able to acquire 188 million € through its IPO, one of the largest amounts ever raised by a German biotech company.

Morphochem and DeveloGen both raised more than 40 million € VC financing in connection with their M&As. Those rounds were among the largest ever in Europe. Epigenomics raised 28 million € and Alnylam 25 million $US. The least money was raised by Curacyte (7 million €). However, given the technology breakdown one and a half years before and the harsh financing environment of the year 2002, without the merger further financing might have been very difficult for Curacyte. From VitaResc's point of view, the merger with Curacyte did not only provide access to new capital, but also to Curacyte's financial resources from its last financing round. Furthermore, Curacyte benefited financially from cost savings through release of personnel.

Taken together, for the biotech start-ups in the case studies M&As were an option to acquire financial resources by attracting new equity investors, combining with a company which is in a good cash position, or by reducing costs in the combined entity.

4.5.2 Technological benefits

In five of the six cases in this study combination of technologies was mentioned as one of the major deal motives. Four of these five companies retrospectively claim that this combination indeed paid off. GPC significantly speeded up its drug discovery process. Similarly, Morphochem reported the identification of small molecule inhibitors for therapeutically relevant cancer targets due to SMT's screening technology. The CEOs of Epigenomics and Ribopharma mentioned benefits in technology development resulting from the scientific discussions with their respective M&A partners.

4.5.3 Product-oriented benefits

GPC and Morphochem both claim that their M&As have advanced their drug discovery process and led to identification of lead compounds. However, until the end of 2004, none of these drug candidates had advanced to the clinic, which makes it difficult to judge final benefits. Similarly, all projects at Alnylam were preclinical at that time. DeveloGen acquired one clinical product in Phase I/II, which failed to complete clinical development. The only company making a large step along the pharmaceutical value chain was Curacyte. VitaResc's lead product PHP was already in Phase III clinical trials with indication distributive shock at the time of the merger with Curacyte. The study was ongoing by the end of 2004. Additionally, PHP entered Phase II studies for two further indications.

4.5.4 Managerial benefits

In three of the six M&As under study the combined company was obviously headed by a stronger management than the individual entities. Firstly, before the merger, Herbert Stadler had to spend his time on heading two companies, DeveloGen and HepaVec, as CEO and without any further top management support. After the merger, he could not only focus on one company, but was soon complemented by CFO Carsten Dehning. Secondly, Curacyte's M&A partner VitaResc was headed by an interim CEO since the original CEO left the company one year before the merger. After the deal, the experienced Curacyte management took over the combined company and soon supplemented the top management team by a Chief Development Officer leading their

US-operations. Thirdly, Ribopharma, which was headed by two scientists, gained management experience by merging with Alnylam, the top management team of which consisted of well-known and previously successful bioentrepreneurs.

4.6 Problems in the M&A process

Although start-up managers as well as investors in the interviews and in the literature more stressed the benefits that arose from the described M&As, they also mentioned some problems associated therewith. Those occurred in the pre-merger negotiation phase or during post-merger integration. Table 9 illustrates examples from the data that form the basis for the following discussion.

Case	Problems
GPC – Mitotix	n.a.
Morphochem – SMT	"We added 35 people when we bought SMT. However, it took us until recently to understand what we did. [...] Cultures were different and there was no homogeneous growth. Looking from today's perspective, it would have been necessary to have one board executive in the US all the time. [...] US companies are very difficult to integrate, and today, I would rather do it in Europe." (CEO in biotech press in 2002)
DeveloGen – HepaVec	"[By using HepaVecs vectors to deliver the Pax-4 gene] we plan to take gene therapy into a new direction" (COO in biotech press in 2000); "We do not follow any gene-therapeutic projects anymore, but rather focus on small molecules." (CFO in interview in 2004)
Epigenomics – ORCA	"We learned that there are real cultural differences between the US and Europe. [...] Financial controlling and planning issues differ a lot. So, it became necessary to keep tight control from Germany. [...] Frequent and direct interaction with the people in the US is essential." (CEO in conference talk in 2003)
Curacyte – VitaResc	"Before entering into negotiations with VitaResc, we evaluated three other merger candidates. However, all were rejected on the basis of either scientific concerns or the problem that the candidates' projects were even at earlier development stages than Curacyte's new project portfolio and, thus, hardly qualified for creating a more robust company." (CFO in interview in 2004)

Alnylam – Ribopharma	"We had problems to ensure employment in Germany because Americans do not like long-term agreements [...] In the end, we had the largest problems with minority equity holders who tried to get the absolute maximum out of the deal." (CSO in interview in 2004)

Table 9: M&A problems (examples from the data)

4.6.1 Pre-merger negotiation phase

In many M&As, the pre-merger negotiation phase is an exhausting and time-consuming process which costs the participating managers a lot of energy. This became particularly obvious in the case of Curacyte. Since the company was missing a robust technology platform, it was actively looking for M&A opportunities. Before getting in contact with VitaResc, it had already entered into negotiations with three other companies. These negotiations failed for different reasons. In one case, Curacyte's and the potential partner's technologies were missing the desired compatibility, in the second case the cash-burn of the combined entity would have been too high, and in the third case, shortly before closing the deal, Curacyte's candidate closed another VC financing round and decided to continue on its own. Therefore, the negotiations occupied significant managerial capacity, which was missing in daily business.

Ribopharma only entered into negotiations with Alnylam and successfully completed them. In this case, the major problem arose during negotiations with shareholders. In particular the "stille Gesellschafter", a special form of shareholders only incorporated in the German but not in the US-American law, were difficult to persuade and almost stopped the deal. Because Ribopharma is now part of the US-American Alnylam Holding, these shareholders could not continue their status after the merger and had to be paid out. Since they believed in a successful IPO of Ribopharma even without the merger, negotiations were difficult and, in the end, costly. In contrast, in the case of Curacyte, where both merger partners had a significantly overlapping shareholder base, full support of all shareholders facilitated pre-merger negotiations.

Another difficult task reported by the interview partners at Alnylam and Curacyte were decisions about the future of employees. Ribopharma, which was in the comfortable position of having the opportunity to close another financing round with existing and new investors instead of merging with Alnylam, made it as a precondition of the deal to

guarantee maintenance of a German site of comparable size and staff for a certain time. Since US business philosophy does not like long-term agreements, it was difficult to achieve mutual consent. The Curacyte management, which was in a less comfortable situation than Ribopharma, had the opposite problem: they had to decide which people to lay off and which ones to keep. Since Curacyte's management worked out a complete post-merger integration plan already in the pre-merger phase, these decisions had to be drawn already before the closing of the merger. In particular in a small company, where everybody knows everyone, this is a difficult task. As Andreas Zaby, Curacyte's CFO, commented: "It was not easy on a personal level. We were not in the year 2000 when money was pouring in and positions could be double-staffed. Our situation was different. These decisions were no fun."

4.6.2 Post-merger integration phase

It is a well-known fact that M&As, as good as the perspectives at the time of the merger may be, often fail (Sirower, 1997) because an efficient post-merger integration of the companies is not achieved (Haspeslagh and Jemison, 1991). In the cases of this study, interviewees as well as literature articles reported several problems during this difficult task.

In a conference talk, Epigenomics CEO Alexander Olek stressed that the overcoming of cultural differences between Germans and Americans was a serious challenge after the merger with ORCA. Staff at the Berlin site had to be trained to interact with personnel at the new US subsidiary and to get to know and respect the US social rules. Furthermore, it was important to keep all contacts as direct as possible and to use the phone for the tiniest issues instead of relying on e-mailing. Olek and his top management team members spent a lot time in the US and even built up a social life there including membership in fitness studios and participating at social events. On the other hand, the US management was invited as often as possible to come to Germany in order to ensure that they identify themselves with the whole company.

The requirement for a steady and regular presence of top management team members at US operations was also reported by other companies. Four years after the acquisition of Mitotix, GPC's CEO Bernd Seizinger still shuttled in a three-week period between

Munich and the USA. Curacyte instead, although not planned initially, shortly after the merger turned the head of their US operations into a top management team member and hence ensured better identification with the merged company. Furthermore, to support scientific exchange and communication between both sites, Curacyte organised the company by projects and, if possible, distributed project team members among the two sites. Morphochem also reported that permanent presence of a top management team member at their acquired US operations would have been necessary for efficient integration, but did not achieve it. In 2002, Morphochem laid off 27 of their 32 US employees and today would prefer acquiring a European company due to its integration problems.

Moreover, financial planning and controlling were sources of post-merger integration problems. Epigenomics CEO Alexander Olek stressed that these practices differ significantly between Germany and the USA. Hence, Epigenomics introduced tight and central control from the German headquarters.

Finally, combination of technologies may also cause difficulties post-merger. When merging with HepaVec, DeveloGen aimed to use HepaVec's technology for development of a "regenerative gene therapy". In the years after the merger, however, DeveloGen turned into a small molecule company and does not follow gene-therapeutic projects any more indicating that technological integration was not possible as initially planned.

4.7 Implications and conclusions

Table 10 summarises the main motives, benefits and problems associated with M&As between biotech start-up companies in the case studies. The findings have several implications for biotech start-up managers. Furthermore, they offer the opportunity to discuss some potential implications and development paths of the future M&A and consolidation activities within the German biotech industry.

Case	Main motives	Main benefits	Main problems
GPC – Mitotix	Integration of technologies Access to networks in US	Visibility for investors at IPO Faster product development	n.a.
Morphochem – SMT	Integration of technologies Access to networks in US	Visibility for VC investors Identification of lead compounds	Post-merger integration of US subsidiary
DeveloGen – HepaVec	Achieve critical mass Integration of technologies	Visibility for VC investors Management capacity	Integration of technologies
Epigenomics – ORCA	Leading position in technology Presence in US	Visibility for VC investors Scientific knowledge	Cultural differences Financial planning and controlling issues
Curacyte – VitaResc	Extend product pipeline Achieve critical mass	VC financing in hostile environment Extension of product pipeline	Find the right merger partner
Alnylam – Ribopharma	Leading position in technology Access to management skills	Visibility for VC investors Professional management Escape hostile financing environment	Negotiations with shareholders Ensure employment

Table 10: Summary of main M&A case findings

4.7.1 Implications for biotech start-up managers

Managers of biotechnology start-up companies can learn a number of lessons from the case studies. Before deciding to look for an M&A opportunity of their company, they should be aware that not only the process of searching and negotiating with possible partners can be exhausting and time-consuming, but also the post-merger integration phase. Pre-merger, sources of frustration may be the vain attempts to find the right partner and lacking support of investors. Furthermore, as demonstrated by the Curacyte case, negotiations may fail at any time, even shortly before signing contracts. Painful decisions like the lay-off of personnel or the restructuring of the project portfolio might cause sleepless nights to some managers. Post-merger integration problems may arise particularly in trans-national deals and will demand a high level of personal effort of the

top management team members. Successful integration can only be achieved if the managers are willing to spend a significant amount of time at the new site of the company. Financial controlling issues and cultural differences should be considered as well.

However, the energy invested in an M&A deal can yield several benefits which a biotechnology start-up company can hardly achieve on its own. Firstly, M&As provide an important opportunity for biotech start-ups to acquire financial resources. All of the analysed deals were accompanied by capital infusions. Other examples of successful VC financing rounds in combination with an M&A include the mergers of Cardion with the US company Cardiogene in 2000 (42 million €) and SiREEN with NADAG, both located in Munich, at the beginning of 2004 (20 million €). Particularly in a hostile financing environment, however, the M&A should be a clear signal to investors that the companies are willing to reduce costs and to restructure their project portfolio, as both done by the Curacyte management. If the participating companies are in serious financial trouble and not willing to cut operations, investors will likely not support the deal by further capital infusion. As one VC manager commented: "We do not bind together sinking stones, which afterwards sink even quicker".

A merger with a foreign company may be a possibility for biotech start-ups to escape the hostile financing environment of their home country. One year after its merger with Ribopharma, US-company Alnylam went public at the NASDAQ and acquired about 30 million $US. With the closed IPO window of the years 2002 – 2004, it would have been impossible for Ribopharma to issue shares and raise capital at the German stock market at that time. Besides equity financing, start-ups can benefit financially from an M&A through cost savings or combination of complementary cash positions.

Secondly, integration of technologies through M&A can save time and costs in comparison to building up the resources internally. However, it might also turn out post-merger that technologies do not combine as initially thought, like in the case of DeveloGen and HepaVec. Ongoing co-operation of the potential merger partners before the deal in order to ensure technological compatibility might reduce the risk of technology integration failure.

M&As are an opportunity for biotech start-ups to expand their pipeline of clinical products. Through the merger with VitaResc, Curacyte gained a significant product pipeline including a product in Phase III clinical trials. In 2004, DeveloGen strengthened its product pipeline by merging with Peptor, an Israeli company, which has a product in Phase II clinical trial. However, as DeveloGen's first merger with HepaVec demonstrates, there is still the risk of failure of the product during clinical development. Merging with a company just with the aim of getting access to a single, early-stage clinical product might therefore be a risky strategy. The product should either be advanced or approved for clinical trials in further indications. Ideally, not only the product pipelines of the companies but also their technologies are compatible and complementary.

Finally, managerial benefits can be achieved through M&As, if one company is lacking management experience which the other company offers. A prerequisite for full exploitation of this potential synergy source is that the inexperienced management is aware of its shortcomings and willing to hand over the CEO position to the experienced management of the M&A partner. If this is the case, competition with a firm led by superior management can be avoided and, as shown by Alnylams successful IPO a few month after the merger with Ribopharma, both companies can profit in the long run.

4.7.2 Implications for the development of the German biotech industry

In their biotech report of the year 2004, Ernst & Young list a number of reasons why the awaited wave of M&A and consolidation activities in the German biotech industry did not happen in the years 2002 and 2003 (Ernst & Young, 2004: 67). I analysed two M&As (Curacyte – VitaResc and Alnylam – Ribopharma) in this timeframe. How do the M&A hurdles described by Ernst & Young compare to the case studies?

According to Ernst & Young, hurdles of M&As have their roots in the attitudes of the investors and the management. With regard to investors, these are not willing to sell or merge their companies cheaply in hostile financing environments, when valuations of private companies are low. If two companies from portfolios of different investors merge, there will be a dilution of the shares one investor holds in his portfolio company. Furthermore, valuation of biotech companies is always a difficult task (Remer et al.,

2001). Dilution and valuation problems did not arise in the Curacyte – VitaResc merger, because both companies were from the portfolio of the same lead investor. Alnylam and Ribopharma, however, had a different shareholder base. Negotiations between shareholders were indeed a problem and almost stopped the deal. The perspective to escape the difficult situation at the German stock markets and to exit their investment by an IPO at the NASDAQ might have contributed to convince the Ribopharma shareholders. However, the case findings illustrate that consolidation within one investor portfolio is achieved easier than between portfolios of different investors. There are only a few investors in Germany like TVM, Curacyte's and VitaResc's main shareholder, which hold a portfolio large enough that CEOs can look for a merger partner within. Therefore, I doubt that within-portfolio consolidation will be an option for the majority of biotech start-ups in Germany in the future.

As a further M&A hurdle, Ernst & Young list a lack of experience of both, management and investors, with M&A deals. Inexperienced managers would like their investors to actively support M&As pre-merger as well as during post-merger integration. Abingworth, the lead investor of Ribopharma, indeed orchestrated the pre-merger negotiations with Alnylam. Abingworth is an experienced VC company with a great reputation within the life science industry, but it is located in the UK and only has a few investments in Germany. Of the German VC firms, only TVM has experience with a significant number of M&A deals within the biotech industry. TVM offers active support for M&A activities to their portfolio companies. However, they are an exception in Germany and, thus, missing experience of management and investors will probably remain a hurdle for M&As in the future.

Finally, Ernst & Young mention egos of biotech CEOs as a major M&A hurdle in the German biotech industry. Two of the six cases analysed in this paper had a special constellation of top management teams of the M&A partners. DeveloGen and HepaVec were both headed by the same CEO, Herbert Stadler, and VitaResc had one of its board members as interim CEO when merging with Curacyte. Thus, CEO egos were no hurdle in these exceptional cases. The CEO and CSO of Ribopharma, Roland Kreutzer and Stefan Limmer, demonstrate that there are indeed some managers who rank the wealth of their company higher than their own egos. When they approached Alnylam for merger negotiations, they were aware that they had to step down from their leading

positions of the company and other, more experienced managers will take over. However, the Alnylam – Ribopharma merger was the only one of the case studies with a CEO consciously handing over the leading position in favour of the wealth of his company. Hence, I speculate that egos of many CEOs will continue to be a major M&A hurdle in the German biotechnology industry.

In summary, the case studies of this study are largely in line with the hurdles for efficient consolidation through M&As in the German biotech industry as described by Ernst & Young. However, they demonstrate that these hurdles can be overcome given the willingness of both, managers and investors.

4.8 Limitations and future research

The exploratory work of this study has limitations which offer avenues for future systematic research. Firstly, the generalisability of the findings is limited by the number of cases analysed. Large scale studies are necessary to corroborate the findings. Since M&As of biotech start-ups are rare events, an international study might be necessary to achieve a sufficient sample size.

Secondly, I did not analyse in detail how the resource endowment of a biotech start-up before an M&A determines its strategy of external resource acquisition. Money, organisational resources, patents, products in development, and scientific and managerial knowledge are crucial resources for a biotech start-up's success (Deeds et al., 1997; Deeds et al., 1998; Zucker et al., 2002). The case studies in this research indicate that biotech managers do indeed seek to acquire these resources through M&As. But, which of these resources should biotech start-ups better acquire through M&A activities and which ones better through alternative strategies such as in-licensing and strategic alliances? More systematic research is necessary to link the resource base of a biotech start-up to its external resource acquisition strategy, and, finally, to its success.

Finally, the findings indicate that post-merger integration is not only a challenging task for large corporations, but also for small start-ups. However, the sources of post-merger integration problems are not so much cultural differences as in the case of M&As between large corporations (Nahavandi and Malekzadeh, 1988; Cartwright and Cooper,

1993), but missing experience and capacity of the start-up management. The impact of investors such as VC firms, which actively support management of start-up companies (Gompers and Lerner, 1999), in the integration process might be substantial. Further research could provide insights how these factors influence different tasks of post-merger integration.

5 To ally or not ally that is the question – an analysis of biotech managers' decision policies to seek a new alliance

The study I introduced in the preceding chapter has demonstrated that M&As are an appropriate means for biotech start-ups to acquire important resources such as technologies, product candidates, and access to networks and management skills. However, the Chapters 3 and 4 also showed that in the biotechnology industry M&As are a rare phenomenon because specific hurdles for these kinds of transactions exist. Thus, young biotech firms much more often gain access to missing resources via entering into strategic alliances with other companies. Therefore, the study I will introduce below deals with resource acquisition of bioventures via strategic alliances. Specifically, I will investigate from a decision-making perspective how a biotech firm's endowment of resources and capabilities motivates its managers to seek new strategic alliance partners.

Conceptually, this study builds the theoretical and empirical heart of this thesis. I build on and extend a theoretical model by Gomes-Casseres (1996) and subsequently test it empirically employing an experimental design and conjoint analysis. The study makes several contributions to the management and entrepreneurship literature and has valuable implications for practitioners.[7]

I structure this chapter as follows. First, I will give a brief introduction which places the study in the context of existing literature and highlights its contributions (Section 5.1). In the following Section 5.2, I will formulate the theory and hypotheses. I will then describe the research method and sample frame (Section 5.3) before presenting and discussing the results (Sections 5.4 and 5.5, respectively). Finally, I will point to limitations of the study and suggest avenues for further research in Section 5.6.

5.1 Introduction

This study seeks to assess whether the factors that the literature on strategic alliances proposes as motivating a bioventure to seek to enter an alliance are in fact considered in its managers' decision policies. Are managers primarily driven by a need to find

[7] I am indebted to Prof. Dr. Dean Shepherd, University of Indiana at Bloomington, and Prof. Dr. David Deeds, University of Texas at Dallas, for their help with this study.

complementary assets to leverage their firms' capabilities? Are the primary considerations those of their environment, such as the competitive environment or the environment for financing technology ventures? How does their perceived ability to control and protect their key knowledge assets impact their decision to seek a new alliance?

Gomes-Casseres (1996) postulated that these factors – capabilities, governance and context – determine when constellations of alliances arise and the shape of those constellations. This study builds on these ideas and tests whether capabilities, governance and context are considered in the decision policies of bioventure managers. Drawing on Gomes-Casseres' (1996) work I define capabilities as the set of tangible and intangible assets that enable an organisation to develop, make, and market goods and services. It should be noted that this is a broad definition of capabilities and incorporates what has traditionally been termed 'resources' by the resource-based view of strategy (Wernerfelt, 1984; Barney, 1991). Control is defined as the ability of a decision maker to maintain ownership of, and appropriate the value created from the deployment of, these capabilities. Finally, context refers to the environment that places demands and creates opportunities for the organisation (Gomes-Casseres, 1996). These factors are consistent with the work of Kogut (1988) and Teece (1988), which have been influential in the development of the strategic alliance literature. In fact, while these factors have been widely accepted in the literature on alliances, surprisingly, no one has directly assessed whether they are part of managers' decision policies and how these factors interrelate in that decision policy. The current study is an attempt to remedy this by employing an experimental design to shed light on how capabilities, governance and context interact to influence the decision by managers of bioventures to seek out new alliance partners.

Using conjoint analysis, I collect and analyse 1532 decisions, nested within 51 managers of entrepreneurial biotech firms. Specifically, I investigate the impact of the level of five different internal firm capabilities, the ability of the firm's managers to govern these capabilities, as well of the nature of the firm's financing and competitive environment on managers' assessments of the likelihood of seeking an alliance. I take the analysis a step further by examining how the financial resources of the firm moderate the relationship between the other variables and the likelihood of seeking a

new alliance. By directly assessing the impact of these factors on managers' decision policies I make a number of contributions.

Firstly, by examining the capabilities, governance and context of the firm as antecedents of the alliance formation process I am filling a gap in the existing literature on strategic alliances. Existing theoretical work suggests only how general properties of resources might trigger alliance formation (Das and Teng, 2000b) without taking the specific perspective of the alliance-seeker into account. Moreover, most empirical studies on motives for strategic alliance formation have distinct shortcomings due to their focus on established alliances. That is, to a certain extent, these studies are sampling on their dependent variable since they are examining the motives of those firms that have been successful in their quest for an alliance while ignoring all those who are seeking but have not yet acquired an alliance partner. The examination of existing alliances also does not consider the resource heterogeneities of firms before an alliance is formed which might influence the decision of managers (Barney, 1991; Conner, 1991) to seek a partner.

Secondly, this study will add to the understanding of previous findings on alliances that indicate that some biotechnology ventures enter too many alliances (Deeds and Hill, 1996; Rothaermel and Deeds, 2004). Specifically, the results suggest that the differences in alliance formation activities between firms are partially due to managers' reactions to heterogeneous endowments of resources, particularly liquidity. Thus, I provide an explanation for why many young firms form either too few or too many alliances in order to achieve an optimal rate of product development.

Thirdly, the findings also extend the literature on resources and capabilities. I not only add to the so far scarce empirical evidence that a firm's capabilities are fundamental for managerial decision-making (Barney, 1991; Conner, 1991), but, more importantly, show that managers' decision policies are complex and take into account interactions between different types of capabilities. I therefore address a recent critique of scholars which claim that most resources or capabilities-based studies treat these factors independently without investigating possible contingency relationships (Priem and Butler, 2001; Heirman and Clarysse, 2004).

5.2 A capabilities view of strategic alliances

Strategic alliances have become an essential part of business for young biotechnology ventures over the last few decades. Since these firms develop complex products and face a highly dynamic and hypercompetitive environment, alliances are an important strategy to share risks (Hamel et al., 1989), gain market power (Hagedoorn, 1993), and enhance legitimacy (Baum and Oliver, 1991). In the European biotechnology industry, for example, the number of strategic alliances between firms rose from 179 in 1997 to 538 in 2001 (Ernst & Young, 2002a). Fisher (1996) reports that 20,000 alliances were formed in the US biotech sector between 1988 and 1996. Given these numbers, it is not surprising that strategic alliances have attracted considerable scholarly attention. Research has, for example, investigated the effect of alliances on firm performance (George et al., 2002; Baum et al., 2000), the choice of governance structures (e.g., Chen and Chen, 2003), the role of trust and commitment of parties (Cullen et al., 2000), and opportunistic behaviour (Deeds and Hill, 1998).

Acquiring resources or capabilities has been one of the primary theoretical motivations for alliance formation. The existing literature provides insights into the type of capabilities firms may acquire through alliances. Knowledge resources (Chi, 1994; Leonard-Barton, 1995; Zahra and Bogner, 2000), access to customer networks (Beamish, 1994; Kauser and Shaw, 2004), financial capital (DeCarolis and Deeds, 1999), and manufacturing and marketing capabilities (Hagedoorn, 1993; Audretsch and Feldman, 2003) have all been shown as capabilities which can be acquired through strategic alliance formation. However, while there has been significant study of the capabilities that are accessed via alliances, little empirical evidence is available about how the internal resource endowment of a firm before alliance formation influences the decision of its managers to seek out an alliance. Such an investigation is, however, of utmost importance since it represents a primary and fundamental step of the alliance formation process. Technology ventures are characterised by high resource needs and minimal resource endowments (Katz and Gartner, 1988), and because they are often new and/or small they lack an established customer base, distribution channels, reputation, and often have insufficient resource slack for further product development (Shepherd et al., 2000; Thornhill and Amit, 2003). Acquisition of these resources is one of the primary tasks of managers in entrepreneurial firms (Brush et al., 2001). These

tasks are particularly challenging in research-intensive biotechnology ventures, because product development is an expensive and time consuming process. To obtain the resources that they need, some biotech ventures seek alliance partners (Deeds and Hill, 1996; Deeds et al., 1998; Rothaermel and Deeds, 2004), while others do not. What makes an alliance attractive to the managers of some ventures but not for others? It appears that the managerial decision to seek strategic alliance partners at least partially depends on the firm's endowment of resources and capabilities.

5.2.1 Capabilities and strategic alliances

Strategic alliances are "voluntary inter-firm agreements aimed at achieving competitive advantage for the partners" (Das and Teng, 2000b: 33). They cover a wide variety of contractual arrangements including licensing, joint R&D agreements, technology exchange, joint ventures, and minority equity partnerships (Gulati, 1995). All forms of alliances have in common that firms pool some of their resources and capabilities and therefore generate new combinations with the aim of achieving sustained competitive advantage (Hamel et al., 1989). By application of the RBV framework to formation of strategic alliances, Eisenhardt and Schoonhoven (1996: 137) argue that alliances are driven by "a logic of strategic resource needs and social resource opportunities" in order to gain competitive advantage.

Das and Teng (2000b) state that two distinct capabilities-based rationales may trigger strategic alliance formation: obtaining and retaining valuable resources. Retaining resources becomes particularly important for those firms that currently have excess resources (resources not being fully used) but want to maintain them for future utilisation (Kogut, 1988). Strategic alliances allow a temporary usage of these resources in combination with the resources of another firm (Das and Teng, 2000b). In contrast, obtaining resources from a strategic alliance represents an extension of a firm's resource base with the aim of filling gaps in its resource endowment (Das and Teng, 2000b). In technology-based industries, firms may lack technological know-how and scientific knowledge for further product development and therefore decide to access these capabilities from an alliance partner (Hagedoorn, 1993; Chi, 1994; Leonard-Barton, 1995). Even after completion of the development process, firms may lack the necessary resources and capabilities to efficiently and effectively manufacture and market their

new products and therefore enter into alliances with established incumbent firms to access these resources (Hagedoorn, 1993; Audretsch and Feldman, 2003). In any case, a lack of valuable resources and capabilities, which cannot be purchased efficiently at the factor markets, triggers the decisions of managers to seek an alliance partner in order to obtain the missing resources and gain competitive advantage.

Existing literature identified a number of different resources and capabilities which contribute to success of biotech ventures and can be acquired by strategic alliance formation. Firstly, financial resources are particularly valuable for new firms because these resources are fungible and excess liquidity may allow the venture to purchase required other resources and capabilities through factor markets (Dollinger, 1995). Particularly in the biotechnology industry, where product development is accompanied by high uncertainty and long development cycles, firms need to spend large sums of money before they generate revenues. As demonstrated in Chapter 2, biopharmaceuticals, for example, require more than 100 million $US of R&D expenditure before they enter the market (DiMasi et al., 2003). Sufficient liquidity is thus a necessary condition for the continued existence of the biotechnology venture. Since alliances with corporate partners frequently include research funding, equity investments or other types of direct cash payments to the venture by the partner (DeCarolis and Deeds, 1999), these alliances are a favoured means to enhance the firm's liquidity.

Secondly, as many young biotech firms do not yet have a product on the market, their valuation is substantially based on the product candidates they have under development, often referred to as their "pipeline" (Kellog and Charnes, 2000; Deeds et al., 1997; Deeds et al., 1998). As noted by Rothaermel and Deeds (2004), these products in development are the embodied capabilities of the venture. The development of biopharmaceuticals, for example, is a 12-year multi-step process and drug candidates can fail at any stage of development with only about 6 % of initial candidates reaching the market (see Chapter 2). The value of a product candidate thus significantly increases with its development stage since the probability to achieve market launch becomes higher and the company needs to spend less time and money on further development. Managers of biotech firms must seek to build up a risk-adjusted pipeline which contains products in late development stages, and a sufficient number of early stage follow-ups

in order to compensate for late stage failures. A deficiency in either will likely encourage managers to seek alternatives to enhance product development such as strategic alliances (Deeds and Hill, 1996; Gulati, 1998).

Thirdly, scholars have also stressed the importance of human resources in terms of excellent scientists and research team capabilities for the success of biotechnology firms (Zucker et al., 1998; Deeds et al., 1999). Scientists create and conserve over time knowledge, expertise, and skills, which are essential intangible resources (Liebeskind et al., 1996; DeCarolis and Deeds, 1999). Deeds et al. (1997) found that the publication record of a biotech firm's scientific team is related to the money they raise at IPO. Moreover, since new product development in high tech industries essentially depends on basic scientific research (Dasgupta and David, 1994), highly reputable scientists provide the firm with links to universities and research institutes, which contribute to firm performance (Liebeskind et al., 1996). If a biotech venture does not possess a high quality scientific team, managers are likely to draw on the experience, skills, and knowledge of other organisations through alliance formation (Liebeskind et al., 1996; Das and Teng, 2000b; Zucker et al., 2002).

Finally, the existing network of a biotechnology firm is an important and valuable resource (Estades and Ramani, 1998). Consistent with previous literature, I understand a biotech venture's network as the sum of alliances and non-formal contacts with other firms, universities, research institutions, and investors (Estades and Ramani, 1998; Powell et al., 1996). Networks are tightly linked to the firm and highly immobile (Das and Teng, 2000b). For biotech ventures, they are a crucial source of learning, flexibility and technological competence (Estades and Ramani, 1998; Zucker et al., 2002). University linkages provide a firm with contacts to top scientists that possess valuable scientific knowledge (Liebeskind et al., 1996) which enhances innovative output (George et al., 2002). Entering into a strategic alliance with another firm does not only extend the network of a firm by one new contact, rather there appears to be a multiplying effect since the access to potential network partners depends on the number of previously established alliances (Gulati, 1995).

H1: The level of internal capabilities available to the biotechnology venture (liquidity, early products, late products, scientific team, and/or contact network) will be negatively related to the likelihood of the venture's manager seeking an alliance partner.

5.2.2 Governance and strategic alliances

As Teece (1988) notes, the benefits to innovation are distributed among innovators, imitators, suppliers and customers based on the ability of the innovator to protect and appropriate the value of the innovation. Biotechnology ventures' primary function and means of creating wealth is to bring innovative new products or services to market. In these conditions the key determinant of their ability to benefit and their choice of the mode of bringing the innovation to market is the strength of their property rights protection (governance) for their key intellectual property. As we know from the cases of EMI and Bowmar, being the innovator is clearly not in itself sufficient to assure success (Teece, 1988). The ability to appropriate the value of the innovation is substantially determined by whether the innovator has strong or weak protections on its intellectual property. If the innovator has a strong intellectual property position, this buys the innovator time and competitive space needed to continue to develop the innovation, which places little pressure on the innovator to immediately seek an alliance partner to expedite the development process. Thus, a high patenting activity is often seen as an indicator of a high tech venture's innovative activity (Acs and Audretsch, 1989), and has an important signalling effect for investors (Shan and Song, 1997). In contrast, if the innovator is operating with weak intellectual property protection he or she is in a race to capture the value from the innovation before it can be imitated by competitors. The race to market places a premium on rapid access to complementary assets and will therefore focus managers of these innovating ventures on seeking a new alliance. Granted, the risks of opportunistic action by the partner are also higher with weak intellectual property protection. However, the drive to be first to market to gain any benefit from the innovation will take priority in the managers' decision policies, since the alliance contract will at least provide some level of protection and recourse to opportunistic action by the partner.

H2: The strength of the biotechnology venture's governance over its intellectual assets will be negatively related to the likelihood of the venture's manager seeking an alliance partner.

5.2.3 Context and strategic alliances

The environmental context in which a biotechnology venture operates will play a significant role in the decision of the venture's manager to seek a new alliance. In this particular study I focus on two critical elements of a bioventure's context – the munificence of the competitive and financing environment. I have chosen to limit the research to these two elements, since they are both critical determinants in the success and failure of new biotech ventures (Fildes, 1990; Zahra and Bogner, 2000).

The competitive context likely plays a critical role in the decision policies of high technology venture's managers, since being first to market with an innovative product or service is crucial to the success or failure of the venture (Schoonhoven et al., 1990; Stalk et al., 1992). Eisenhardt and Schoonhoven (1996) argued that the more vulnerable the strategic position of a firm, the more it will seek to enter into strategic alliances. The strategic position of a firm is particularly vulnerable when its environment is highly competitive, as it is the case for many biotech ventures (Fildes, 1990; Zucker et al., 2002). Therefore the strength of the venture's competitors will influence the managers' view of the need to access complementary assets in order to speed the venture's products towards the market. In contrast, in situations in which the venture does not feel substantial competitive pressure, its managers will not feel as compelled to immediately seek an alliance partner to bring the product to market as quickly as possible. Instead, they will seek to advance their internal development efforts in order to both move the product towards market and enhance their negotiating position in the event they decide to enter an alliance in the future.

Since most biotechnology ventures do not earn significant revenues yet, they essentially depend on the infusion of capital from investors. Raising money at the capital markets is thus one of the main tasks of biotech managers (Fildes, 1990). However, the availability of money at capital markets changes over time. In particular the market for venture capital, the main financing source for young technology ventures, is highly cyclical

(Gompers and Lerner, 1999). Similarly, the possibility to acquire capital from equity markets through an IPO changes in simultaneous cycles (Lerner, 1994). As demonstrated in Chapter 3, young biotech firms in the German industry faced a highly munificent financing environment during the high tech hype in 2000 and acquired 565 million € capital in VC financing and 655 million € through IPOs (Ernst & Young, 2002b). In contrast, when stock markets were declining in 2002, the financing environment became considerably less munificent for biotech start-ups. The total amount of VC invested was only 207 million €, and no firm went public during that time (Ernst & Young, 2003c). Consequently, firms will face a higher need to employ strategic alliances as an alternative to the capital markets in a less munificent financing environment since alliances "can replace financing because they enable the firm to meet its goals without additional investment by piggy-backing on the investment of another firm" (Dollinger, 1995: 36). Moreover, acquiring an alliance partner serves as a powerful signal to the financial markets, which enhances a firm's access to both the private and public financial markets (Stuart, 1998), particularly in times of a less munificent environment (Lerner and Tsai, 1999).

Given the benefits in terms of both speed to market and access to capital I expect biotech managers to be more interested in seeking an alliance when their venture is operating in a context with low munificence. Alliances become in many ways an attractive alternative or substitute to the challenges being created for the firm by the context in which it operates.

H3: The munificence of the context (competitive and/or financing) in which the biotechnology venture operates will be negatively related to the likelihood of the venture's manager seeking an alliance partner.

5.2.4 The moderating impact of firm liquidity

Success in a high technology environment requires creating access to a complex bundle of complementary capabilities. Some of these capabilities will be developed internally, some acquired via the markets, and some accessed through alliances. As I hypothesised earlier, low levels of internal capabilities will focus management on seeking new alliances to compensate for these weaknesses and access capabilities from an alliance

partner. However, a firm's liquidity might moderate the impact of the firm's other internal capabilities on this decision. Specifically, I propose that managers believe that a firm needs to be sufficiently liquid to efficiently exploit existing capabilities on its own without an alliance partner.

As stated above, the development of biotech products such as biopharmaceuticals is a long and complex process which demands large sums of money. Thus, product candidates can only be considered as valuable resources if the firms developing these candidates have sufficient liquidity to fund the whole development process. Imagine, for example, a biopharmaceutical venture with a product pipeline containing products in early preclinical development. Further advancement of these products is only possible when the firm is sufficiently liquid to finance the expensive subsequent clinical trials (DiMasi et al., 2003), otherwise it will need to form alliances with other corporations. Similarly, if a venture has products in late Phase III clinical trials, it needs access to production and marketing facilities which it can only build up internally if it is sufficiently liquid. Otherwise, it must enter into strategic alliances with large pharmaceutical firms to access these required capabilities (Rothaermel, 2001b; Audretsch and Feldman, 2003). Moreover, consider a biotechnology venture whose team consists of top scientists. These scientists are only able to fully exploit their knowledge and skills if they have access to modern devices and research facilities. In addition, a high salary may be necessary to motivate these people and keep them with the firm (Pfeffer, 1998). If the firm is insufficiently liquid to equip and pay its high quality scientific team, managers need to seek strategic alliances to acquire these resources. Finally, I expect that liquidity will also moderate the effect of a biotech venture's network capabilities on the propensity of its managers to seek an alliance. In order to efficiently source capabilities via its network, a firm needs to monitor its network partners and establish contractual control mechanisms in order to protect itself from opportunistic behaviour of the partners (Williamson, 1985). These monitoring and contracting costs can be substantial (Gulati et al., 2000). Moreover, since in networks resources and capabilities are acquired from multiple partners, coordination costs arise (Gulati et al., 2000). Thus, efficient exploitation of network contacts is only possible if the firm has sufficient liquidity at hand. In the case of low liquidity, sourcing of

resources and capabilities becomes inefficient and entering into new alliances is a more attractive means for the firm to acquire the desired resources and capabilities.

In summary, liquidity is essential for a biotech venture to efficiently exploit its existing capabilities by acquisition of complementary assets. If firms are insufficiently liquid, managers face a high need to acquire these complementary assets via alliance formation. Therefore, the liquidity of a biotechnology venture will moderate the negative relationship between the firm's capabilities and the likelihood that its managers will seek an alliance particularly for ventures with high levels of existing capabilities.

H4: The liquidity of a biotechnology venture will moderate the negative relationship between a venture's capabilities (early products, late products, scientific team, and/or contact network) and the likelihood of its manager seeking an alliance partner such that the relationship is more negative for managers of firms with high liquidity than for managers of firms with low liquidity.

In situations in which the governance over the biotech venture's intellectual property is weak I expect those with lower liquidity to be more likely to seek out an alliance partner than those more liquid ventures. The cost and complexity of defending a patent, particularly one that is of questionable strength, will be daunting to a venture with little cash on hand (Lerner, 1995a). Also the costs of defending poorly protected intellectual property against infringement are likely higher than intellectual property protected by a strong appropriability regime increasing the need for venture liquidity. The costs and complexity of defending intellectual property and the benefits of deep pockets is evidenced by Amgen's 17 year legal battle with pharmaceutical company Johnson & Johnson. Hence, the combination of these two forces is likely to increase the desire of managers of biotechnology ventures with weak cash positions to seek an alliance in circumstances in which they perceive the firm has weak governance over its intellectual assets.

H5: The liquidity of a biotechnology venture will moderate the negative relationship between a venture's governance over its intellectual assets and the likelihood of its manager seeking an alliance partner such that the relationship is more negative for managers of firms with low liquidity than for managers of firms with high liquidity.

In a highly competitive context a biotechnology venture will need to increase its speed to market to gain the benefits of being a first mover and avoid being locked out of the market (Lieberman, 1989). The venture will therefore need to reach out and access additional resources to compete and win via the strategic factor or labour markets. Under these circumstances a firm with high levels of liquidity will be able to leverage its capital to gain access to the resources they need to respond to the competition, since financial resources are fungible and allow the firm to access the strategic factor market or the labour market to enhance low levels of a specific capability. In contrast, when the firm's liquidity is low, it will not have the opportunity to supplement its capabilities via the market in order to respond to competitive challenges, nor will it be able to increase its rate of internal development, since it will not have additional resources to commit to the project. Thus, low liquidity biotech ventures likely turn to an alliance to help competitive challenges.

In some ways alliances and accessing the capital markets can be viewed as substitutes for one another. Recent research by Lerner and Tsai (1999) supports this contention by finding that in a less munificent financing environment young biotech companies seek alliances with large incumbent firms even if the bulk of alliance control rights are allocated to the incumbent. In other words, the price of an alliance goes up when financial markets become more difficult. A firm's dependence on the capital markets is low when it is still sufficiently liquid from its last financing event (Wasserman, 2003). In this case, there is no need for short-term financing, and the firm may be able to 'wait out' a less munificent financing environment without entering into an alliance. However, managers of low liquidity biotech ventures will likely turn to alliances as a substitute for the capital markets. In addition, existing literature indicates that a low munificent funding environment is less onerous for firms with high liquidity since a strong financial position enhances the possibility of attracting investors under any circumstances (Audretsch and Lehmann, 2004).

H6: The liquidity of a biotechnology venture will moderate the negative relationship between the munificence of a venture's context (competitive and/or financing) and the likelihood of its manager seeking an alliance partner such that the relationship is more negative for managers of firms with low liquidity than for managers of firms with high liquidity.

Figure 13 illustrates the decision model for managers of biotechnology ventures to seek strategic alliances, i.e., the impact of the firm's capabilities, governance and context on managers' decisions and the moderating role of a firm's liquidity on these relationships.

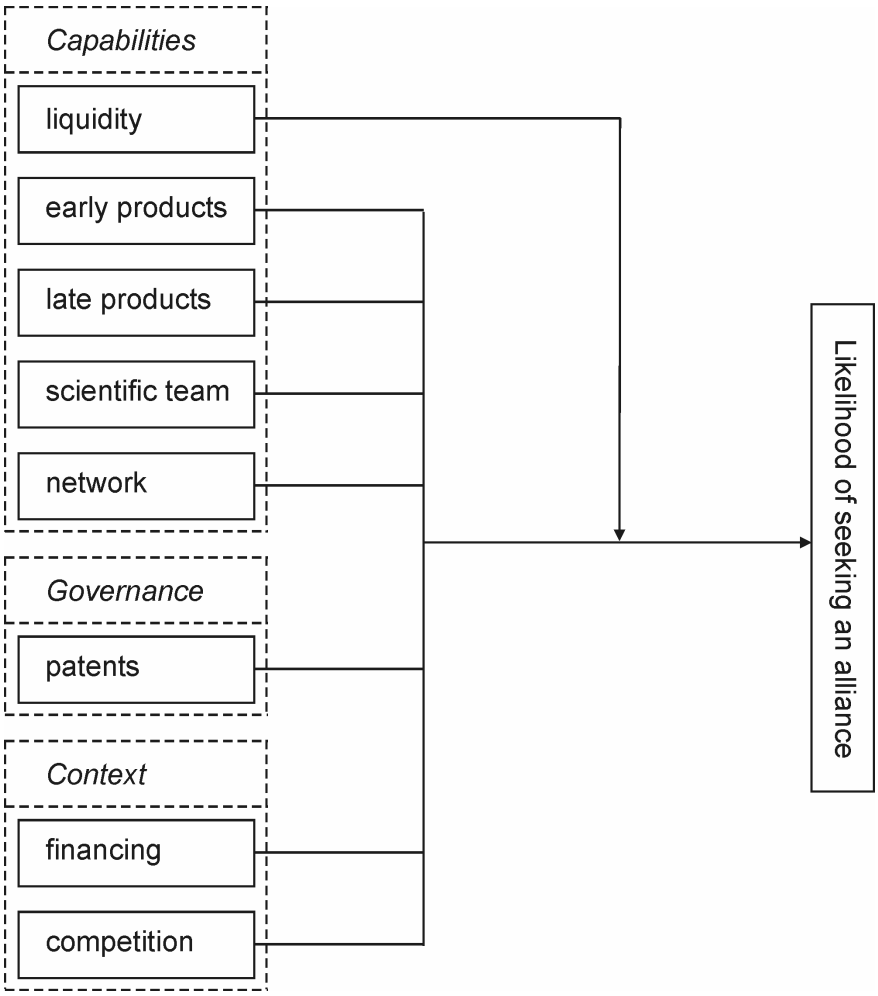


Figure 13: Model for biotech managers' decision to seek a new strategic alliance

5.3 Methodology and data collection

5.3.1 Sample characteristics

The sample frame is managers of entrepreneurial firms in the German biotechnology industry. In combination with their biotechnology industry report 2003, Ernst & Young released a list of their 212 industry survey participants. However, since biotechnology is a heterogeneous field ranging from development of biopharmaceuticals to

manufacturing of enzymes and the supply of laboratory material, the firms in Germany's biotechnology industry vary substantially in their financing, business strategies, and revenue perspectives. I therefore followed previous studies (Deeds and Hill, 1996; Deeds et al., 1998; George et al., 2001) and included in the sample only firms developing biotherapeutics and biodiagnostics. These firms are known to be engaged widely in alliance formations. This left 99 biopharmaceutical firms, of which twelve had gone out of business since the publication of the Ernst & Young list.

I contacted all 87 firms by telephone and asked for at least one top management team member to participate in the study. I defined a top management team member as any person at the top executive and vice president level (Deeds et al., 1999). Moreover, I included leading business development managers because they were responsible for seeking and negotiating strategic alliances in the sample firms. From the telephone contacts, individuals in 68 firms agreed to participate.

Except for the first six firms, which conducted the experiment in my presence (see below), a survey booklet and a cover letter was mailed to these firms. The mailing also contained a self-addressed, postage paid envelope for returning the experiment to me. If I did not receive the experiment within four weeks, I again called the firms asking whether they had received the letter and reminding them to participate. I finally received usable experiments from 51 managers of entrepreneurial biotechnology firms.[8] This response rate (51% in terms of firms contacted) is relatively high. Moreover, the number of participants is consistent with other conjoint studies. Shepherd (1999a) analysed decision policies of 66 venture capitalists within 47 venture capital firms and Hitt and Tyler (1991) had a sample of 65 managers. Although for survey-based research this sample size looks small, there are 32 decisions nested within each of these individuals and therefore the sample consists of a total of 1632 decisions (I account for the nested nature of the data using hierarchical linear modelling HLM, described below).

Table 11 summarises the characteristics of participating managers and their respective entrepreneurial biotech firms. On average, participants were 41.6 years old (standard

[8] These 51 managers came from 44 firms. In the analyses that follow I found that results did not differ substantially when only one representative from each firm was used. Therefore, I report only the analysis of the full sample.

deviation 6.9 years), had 8.0 years experience in the biotech industry (std. dev. 6.4 years), 3.7 years experience in the pharmaceutical industry (std. dev. 5.1 years), and 5.7 years experience in top management team (TMT) positions (std. dev. 4.1 years). Moreover, they had worked on average in 1.6 firms before their current firm (std. dev. 1.2 firms), had a tenure in their current firm of 4.3 years (std. dev. 3.2 years), and were involved in the top management of their present firm for 3.7 years (std. dev. 3.1 years). Sixty-seven percent of participants held positions at the CEO/CFO/CSO level, 82% had an education in natural sciences (biology, chemistry, medicine, the remaining 18% had educations in management), and 37% were founders of their current firms (all were managers). These firms were on average 6.7 years old (std. dev. 2.8 years) and employed 50 people (std. dev. 46).

Demographic	Mean	Std. Dev.
Age	41.6	6.9
Total biotech experience	8.0	6.4
Total pharma experience	3.7	5.1
Total TMT experience	5.7	4.1
Number of previous firms	1.6	1.2
Firm tenure	4.3	3.2
Firm tenure TMT	3.7	3.1
Percentage CEO/CFO/CSO	67	n.d.
Percentage nat. sci. education	82	n.d.
Percentage founders	37	n.d.
Firm age	6.7	2.8
Firm employees	50	46

Table 11: Characteristics of experiment participants

5.3.2 Conjoint analysis

I used a conjoint experiment to collect data on the decisions of managers of entrepreneurial biotech firms in their assessments of the likelihood of entering into a strategic alliance. Conjoint analysis is a technique that allows researchers to decompose an individual's decisions into its underlying structure (Green, 2001). It has been applied in marketing research, psychology research, strategic management research, and other disciplines (Green and Srinivasan, 1990; Wittink and Cattin, 1989). Conjoint analysis has also been used in research on strategic alliances, specifically on evaluation of desired partner properties (Tyler and Steensma, 1995; Dollinger et al., 1997). The particular strength of conjoint analysis is that it enables researchers to obtain real time data about the decision maker's decisions. In contrast to retrospective methods such as questionnaires, interviews or surveys, this method is not biased due to the mistaken or missing introspection of decision makers (Shepherd and Zacharakis, 1997). This bias can be substantial (Fischhoff, 1988; Zacharakis and Meyer, 1998). Moreover, conjoint analysis enables the researcher to analyse contingent relationships (two-way interactions) between variables (Hitt and Barr, 1989). Since the theory above suggests several interactions between research variables and thus a contingent decision policy of managers, conjoint analysis is the appropriate method for this research.

5.3.3 Research instrument

Conjoint experiments require decision makers to make assessments based on a number of attributes. These attributes are described by different levels (e.g., high and low). Several different attributes with predetermined levels constitute a profile to which the decision maker assigns her/his judgement.

Dependent variable. The dependent variable of this study is the manager's likelihood of seeking a strategic alliance partner. I defined strategic alliance as any type of "corporate relationship between firms to develop new products", consistent with previous studies (George et al., 2001; Deeds and Hill, 1996). I asked managers to assess the attractiveness of seeking an alliance partner on a seven-point Likert-type scale anchored by the end points "very unattractive" and "very attractive".

Independent variables. The scenarios in the experiment are described by eight attributes, each of which is described by two levels. These attributes are split among five that describe the internal capabilities of the venture (Liquidity, Early, Late, Team and Network), one that describes the ability of the venture to govern its intellectual property assets (Governance) and two that describe the context in which the firm operates (Financial Environment and Competitive Environment). *Liquidity* of the firm ranges from high (considerable liquidity which guarantees growth of the firm for the next years) to low (limited liquidity which will ensure survival for less than one year). *Early* means the number of products in early development stages and ranges from high (considerable number of early products in the firm's pipeline) to low (few early products in the firm's pipeline). *Late* stands for the number of products in late development stages and ranges from high (considerable number of late products in the firm's pipeline) to low (few late products in the firm's pipeline). *Team* means the quality of the firm's scientific team and ranges from high (team consists of well-known and reputable specialists) to low (team consists of only average scientists). *Network* is the size of the firm's existing network and ranges from extended (many contacts to universities, research institutes, and other firms) to limited (few contacts to universities, research institutes, and other firms). *Governance* ranges from high (broad portfolio of secure patents) to low (few patents, insecure due to pending law suits). *Finance* stands for the description of the firm's financial environment and ranges from attractive (good possibilities to acquire venture capital or file for IPO) to unattractive (only limited possibilities to acquire venture capital, closed IPO window). *Competition,* which describes the competitive environment of the firm, ranges from high (very competitive projects and direct competition with other firms) to low (little competitive projects and no direct competitors).

5.3.4 Experimental design, reliability and external validity

Profiles of the experimental design consist of the eight attributes, each of which is represented by two levels, yielding 2^8=256 possible combinations. Since evaluation of 256 profiles is not an easily manageable task for participants in this study, I applied an orthogonal factorial design to reduce the number of attribute combinations to 16 (Hahn and Shapiro, 1966). In an orthogonal design inter-correlations between attributes are

zero, which eliminates issues of multicolinearity and increases the robustness of experimental results (Huber, 1987). I chose a fractional factorial design which confounded main effects and all two-way interactions of most interest (involving the liquidity of the firm) with other two-way and higher order interactions (which are of least interest). It is therefore unlikely that the latter will bias the results of this study (Louviere, 1988; Green and Srinivasan, 1990).

Reliability is a necessary condition for the validity of measures in general (Carmines and Zeller, 1979). In conjoint experiments, reliability of decision makers' judgements is tested by replicating profiles and performing test-retest checks (Karren and Barringer, 2002; Shepherd and Zacharakis, 1997). Full replication of all 16 attribute combinations of the experimental design resulted in 32 profiles. In order to control for effects resulting from the specific order of the profiles and/or the specific order of attributes within each profile, I randomly assigned the 32 profiles as well as the attributes in two ways each resulting in four versions of the experiment. I distributed the versions randomly among participants. Since I found no significant difference across versions, I conclude that order effects had little impact on the results. Moreover, I included a 'practice' profile as a first evaluation task, which I excluded from the statistical analysis, in order to make participants familiar with the decision situation before entering into the experiment. Thus, the final experimental design consisted of 33 profiles.

One possible criticism conjoint analysis faces is that these kind of 'paper and pencil' experiments do not represent real decision situations and therefore lack external validity. However, scholars have shown that conjoint analyses significantly reflect decision policies employed by individuals (Brown, 1972; Hammond and Adelman, 1976). External validity can be enhanced by not only deriving judgement attributes from theory, but by in addition interviewing or surveying potential study participants with regard to relevance of the decision attributes (Shepherd and Zacharakis, 1997; Karren and Barringer, 2002). I therefore conducted four in-depth interviews with managers of entrepreneurial biotech firms before I approached possible participants. In addition, the first six of the experiments were performed in my presence in order to obtain feedback on the design of the experiment. All interviewees and participants confirmed that the decision attributes are relevant and that the decision profiles are realistic.

5.3.5 Post-experiment questionnaire

The research instrument also contained a post-experiment questionnaire where I asked participants to provide demographic information including the variables described in Table 11. I applied HLM to test whether these variables explained variance in decision policies across managers. I did not find any statistically significant associations. Moreover, I asked participants to self-report the importance of the decision criteria when evaluating the likelihood of seeking a strategic alliance partner on a seven-point Likert-type scale anchored by the end points "very unimportant" and "very important". Participants reported the following average values: liquidity 6.3, early 4.4, late 5.8, team 4.3, network 3.1, governance 4.4, finance 5.8 and competition 4.4. All criteria had some self-reported importance with emphasis on financial resources (liquidity) and access to them (financing environment).

5.4 Results

Eighty percent of the individual decision policies were statistically significant ($p<0.05$), consistent with previous research (Shepherd, 1999a). The mean R^2 of these models was 0.79 (Choi and Shepherd, 2004: 0.72; Shepherd, 1999a: 0.78). Seventy-eight percent of managers were significantly reliable ($p<0.05$), which is slightly below the 92% value found by Shepherd (1999a). However, the mean test-retest correlation was 0.66, again in line with previous studies (Shepherd, 1999a: 0.69). This indicates that the managers in the sample of entrepreneurial biotech firms consistently performed the conjoint experiment. For the sample as a whole, 91 % of the variance in decisions is within individual variance, that is, only 9 % of the variance in decisions is from individual differences. 68.3 % of the true within individual variance is accounted for by the variables of this study.

The statistical analysis draws on 32 decisions from 51 individuals, thus yielding a total of 1632 data points. However, these data points are not independent since each set of 32 observations is nested within an individual manager. I therefore applied HLM, which takes into account nested decisions within individuals. I did not use hierarchical linear regression analysis as earlier policy capturing studies had done (Hitt and Tyler, 1991) and report only full model results since orthogonal fractional design assures zero

correlation between independent variables (Priem and Rosenstein, 2000). Table 12 presents the results. I report for each decision criterion the standardised coefficient, the corresponding standard error, the t-ratio as well as the level of significance, indicated by the asterisks.

Evaluation criteria	**Coefficient**	**Standard error**	**t-ratio**
Intercept	4.647	0.089	52.424***
Capabilities			
Liquidity	-1.377	0.187	-7.382***
Early	-0.387	0.092	-4.217***
Late	-0.522	0.140	-3.725***
Team	-0.140	0.056	-2.495*
Network	0.039	0.055	0.720
Governance			
Patents	-0.277	0.069	-4.023***
Context			
Finance	-1.000	0.114	-8.770***
Competition	0.213	0.064	3.321**
Interactions			
Liquidity x Early	-0.078	0.130	-0.602
Liquidity x Late	-0.358	0.120	-2.975**
Liquidity x Team	-0.279	0.150	-1.857
Liquidity x Network	-0.324	0.120	-2.703**
Liquidity x Patents	-0.162	0.121	-1.340
Liquidity x Finance	0.422	0.119	3.554**
Liquidity x Competition	-0.162	0.117	-1.374

*p<.05; **p<.01; ***p<.001; n=1632 decisions nested within 51 managers

Table 12: Results of the conjoint analysis

Results show that all main effects except for network are significantly used by bioventure managers in assessing the likelihood of entering into a strategic alliance. Specifically, managers' likelihood of seeking strategic alliance partners increases with (a) lower liquidity, (b) a lower number of early stage products in the firm's pipeline, (c) a lower number of late stage products in the firm's pipeline, (d) a lower quality scientific team, (e) weaker governance over intellectual property, (f) a less attractive financing environment, and (g) a more competitive environment. In terms of the first three Hypotheses #2 and #3 receive strong support. In testing Hypothesis #1, which links capabilities to the propensity to enter an alliance, I find a strong relationship in the hypothesised direction for liquidity, early stage products, late stage products and the quality of the team, but no independent relationship between the venture's network and the propensity to ally. However, the interaction between network and liquidity is significant. Thus, I conclude that there is strong overall support for the hypothesised link between capabilities and the likelihood that managers will seek strategic alliances (Hypothesis #1).

However, managers' decision policy was more complex than analysis of only the main effects would lead one to believe. Table 12 shows that three out of seven interactions of liquidity with other attributes are significant. Specifically two interactions between liquidity and capabilities measures – late stage products and network – are significant and the interaction between one of the context measures, the financing environment, and liquidity is significant. Since I find no significance for the interaction between liquidity and governance I conclude that Hypothesis #5 is not supported.

In order to understand the significant interaction effects in more detail, I plot each research variable (x-axis) which interacts with liquidity against the managers' evaluation of the likelihood of seeking alliance partners (y-axis). I plot separate lines for low and high liquidity (Figure 14, Figure 15, Figure 16).

Figure 14 demonstrates that, based on their decision policy, biotechnology venture managers are more likely to seek a strategic alliance when there are fewer late stage products in the venture's pipeline and this negative relationship is more negative for those whose firms have higher liquidity. The nature of this significant interaction provides support for Hypothesis #4.

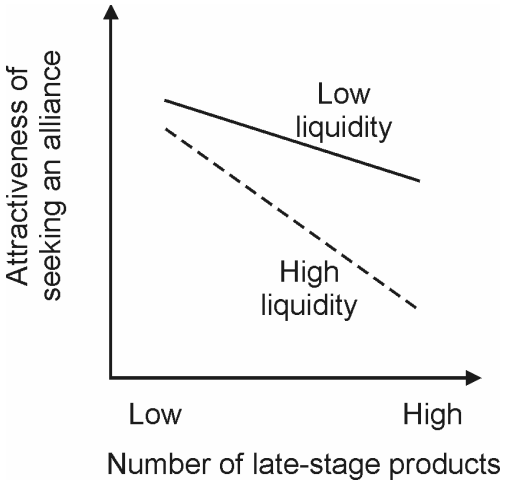


Figure 14: Interaction effect between the firm's liquidity and the number of late stage products.

Figure 15 demonstrates that, based on their decision policy, biotechnology venture managers are more likely to seek a strategic alliance when their venture has a smaller network and this negative relationship is more negative for those whose firms have higher liquidity. The nature of this significant interaction provides support for Hypothesis #4.

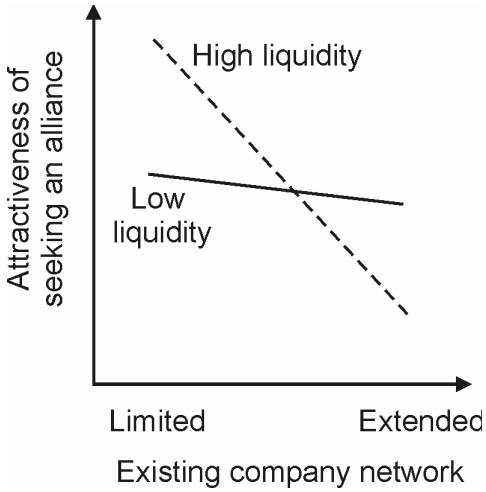


Figure 15: Interaction effect between the firm's liquidity and the size of the firm's network.

Figure 16 illustrates that, based on their decision policy, biotechnology venture managers are more likely to seek a strategic alliance when the funding environment is less munificent and this negative relationship is more negative for those whose firms have lower liquidity. The nature of this significant interaction provides support for Hypothesis #6.

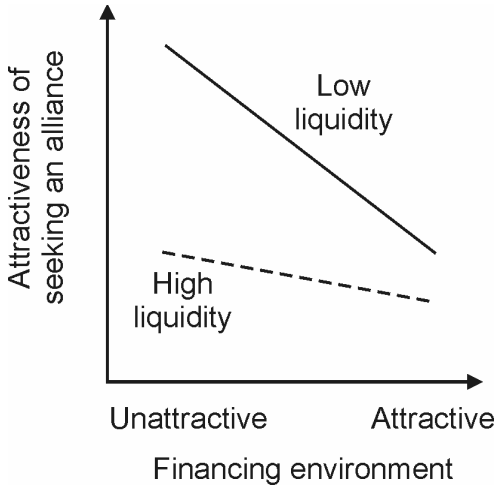


Figure 16: Interaction effect between the firm's liquidity and the attractiveness of the financing environment.

In summary, I find strong support for the hypothesised direct effects. Moreover, I find that liquidity moderates the impact of two capabilities (late products, network) on the likelihood of biotechnology venture managers to seek an alliance. I find partial support for the hypothesised moderating effect of liquidity on the relationship between the munificence of the context and the propensity to ally. The findings for the munificence of the funding environment are strong and in the expected direction, but there is no moderation of the competitive context. Further, I do not find support for any moderation of the governance relationship.

5.5 Discussion

In this study I introduced a model for biotechnology venture managers' decision to seek strategic alliance partners. The model is based on the framework developed by Gomes-Casseres (1996) and is consistent with the resourced-based theory and the work of Kogut (1988) and Teece (1988). The model describes how the capabilities, governance over knowledge assets, and the context in which the venture operates influence the managers' decision to seek a new alliance. By testing this model via an experimental design and conjoint analysis I was able to compare the decision policy of bioventure managers with the theoretical models developed by management scholars.

The findings of this research suggest that the internal resource position of biotech ventures influences the decision of managers to engage in strategic alliances. If their

venture lacks important resources and capabilities such as cash, products in early or late development stages, a high quality scientific team, or an extended contact network with other firms, they will aim to complement this deficit by seeking alliance partners. Managers also take into account the environmental situation of their firm with regard to the competitive situation and financing opportunities. Moreover, managers consider the strength of their governance of the intellectual property in deciding whether to seek an alliance. All these findings are in line with the resource-based rationale of strategic alliance formation to obtain resources from alliance partners (Das and Teng, 2000b) and gaining competitive advantage in strategic vulnerable resource positions (Eisenhardt and Schoonhoven, 1996).

Whereas previous literature offered insights into which capabilities of potential target firms might trigger alliance formation (Kauser and Shaw, 2004; Chi, 1994), this analysis provides empirical evidence that internal capabilities are an important antecedent which determines if a firm will likely engage in alliance formation. If the necessary capabilities are present in the firm, managers will not be as likely to seek an alliance partner (Kogut, 1988). This does, of course, not exclude the possibility that they might enter into an alliance if they come across an attractive opportunity. They will, however, not actively seek to attract alliance partners by themselves.

First and foremost the results highlight that the decision to seek an alliance appears to be viewed in light of the financial needs of the firm and the environment in which it operates before anything else. I find that the most powerful driver in the managers' decision model is the firm's liquidity and the financing environment. In examining the coefficients in Table 12, the paramount importance of firm finances in their decision becomes obvious, with firm liquidity having a coefficient (-1.377) twice as large as any other variables except munificence of the funding context (-1.000). The importance of cash is further highlighted by the contingent nature of the relationship between liquidity and the munificence of the financial markets which highlights the preference of managers of bioventures for using internal funds first, followed by equity capital and finally alliances.

The results of this study indicate that managers of bioventures are much more likely to seek an alliance when their firm has lots of late stage products but low liquidity than

when their firm has lots of late stage products and high liquidity. In fact, the slope of the lines in Figure 14 indicates that managers prefer to use internal resources when available to further develop the products. The tendency to substitute internal resources for external ones is supported by the theoretical predictions of the optimal capital structure model (Myers, 1984; Myers and Majluf, 1984). The strength of the preference for internal resources is based on the costs associated with information asymmetries between the firm and external resource providers (Myers and Majluf, 1984; Shyam-Sunder and Myers, 1999) and the risks of expropriation of knowledge due to opportunistic actions on the part of partners (Williamson, 1985). Taken together the results for the moderating role of liquidity in bioventure managers' decision models help explain earlier findings by Lerner and Merges (1998) and Rothaermel and Deeds (2004). It appears that managers are responding to the critical need to maintain their venture's liquidity and are willing to over commit to alliances when necessary to maintain cash flows.

An interesting result of the analysis is how the liquidity of an entrepreneurial biotech firm moderates the effect of the firm's network size on the motivation of managers to seek alliance partners. As I expected, if the firm has already an extended network, managers are less likely to further expand it if the firm also possesses financial resources. In this case, managers will focus on internal processes in order to advance product development rather than acquiring additional resources by further expanding the network. At low liquidity, however, firms are more likely to acquire resources through further expansion of their already extended network, maybe partially with the aim of accessing new investors. Unexpectedly, the results are opposite when the firm does not yet have an extended network. In this case, managers are more likely to seek alliance partners when the firm has a high amount of cash available. One possible explanation might be that when their firms are highly liquid, managers are in a more comfortable position to engage in network extension activities than when the firm is short of money. Whereas in the latter case managers might employ alliances as a pure means to save costs for further product development (Eisenhardt and Schoonhoven, 1996), in case that their firm possesses high liquidity they may even invest money in growing their network with the aim of building up visibility, reputation, and legitimacy,

which contribute to performance in the long run (Baum et al., 2000; Zimmerman and Zeitz, 2002).

This study also contributes to the understanding of previous empirical research on strategic alliance formation in the biotechnology industry. Specifically, Deeds and Hill (1996) and Rothaermel (2001a) found that there is an optimal number of alliances for biotechnology ventures with regard to their rate of product development. However, many biotech firms in their samples had too few or too many alliances. The authors speculated that "like all human decision makers, managers may be intendedly rational, but because of the constraints imposed by cognitive limits, uncertainty, complexity, and ambiguity, their rationality is bounded" (Deeds and Hill, 1996: 54). The results above provide evidence that biotech managers' decision policies are, even if they were purely rational, complex and take into account more than just the firm's current rate of product development. Instead, they depend on the firm's endowment of a variety of different resources and interactions between them. Given the death sentence that a cash crisis represents to many biotech ventures, over committing to alliances at the expense of productivity may be rational if the alternative is dissolution of the firm due to a cash shortage.

The results of this work may also shed some light on the current debate about the benefits of alliances for new ventures offered by Alvarez and Barney (2001). The short term decision making forced on venture managers by a low liquidity position may lead them to negotiate an alliance from a position of weakness and give away much of the firm's future. Under these circumstances entering into alliances could quite conceivably have detrimental impacts on the venture's future rents and survival. However, when alliances are entered into from positions of strength such as high liquidity, venture managers are in a position to negotiate stronger alliances and be selective in the alliances in which they engage the firm (Lerner and Merges, 1998). In high liquidity conditions venture managers will choose those alliances which have the greatest potential benefit to the firm in the long run and be in a position to negotiate better terms making it much more likely that these alliances will enhance the venture's productivity and odds of survival. It appears that the old adage that the rich get richer applies to alliances. Understanding the biotechnology venture managers' decision policies and the circumstances under which they are likely to enter alliances which are beneficial, in

contrast to seeking any alliance including those which are likely to be detrimental, may help to resolve the debate about the value of alliances to biotech ventures.

Finally, this study contributes to existing literature on the RBV framework. Although several scholars have suggested that managers' decision policies are central to resource-based strategies (Barney, 1991; Conner, 1991; Alvarez and Busenitz, 2001), empirical support for this hypothesis has been scarce. In the context of one specific strategy – formation of strategic alliances – I provide evidence that managers' decisions do indeed depend on their firm's endowment of resources that are valuable, rare, and difficult to imitate and substitute. Moreover, I show that their decision policies and thus the firm's strategy does depend on contingent relationships between resources rather than their additive effect, as many previous studies applying the RBV framework suggest. In line with other scholars (Priem and Butler, 2001; Heirman and Clarysse, 2004) I therefore call for a more sophisticated application of the RBV in future research which views the firm as a complex "bundle of resources" (Penrose, 1959) and explicitly takes into account possible resource interactions (Black and Boal, 1994).

The findings have value for practitioners. From the perspective of the alliance-seeking firm, understanding their decision policies might help venture managers to make better and more accurate decisions. Since alliances are long-term agreements between firms which bind resources of each of them for a significant amount of time (Das and Teng, 2000b), managers should think deeply about the decision to seek an alliance partner. The results above suggest that in situations where their firm has low liquidity and the financing environment is less munificent, biotech managers have a strong motivation to seek alliances with other firms. However, employing alliances only as a means of short-term financing might be a dangerous strategy since alliance success crucially depends on the commitment both parties bring to the agreement over the long-run (Cullen et al., 2000), and unsuccessful alliances have been shown to be potentially devastating to a venture's future (Alvarez and Barney, 2001). Indeed, many alliances fail (Das and Teng, 2000a; Dyer et al., 2001), and inappropriate motivations such as short-term financing might be one such reason. Consistently, managers in this study reported that on average only 56% of the alliances they negotiated turned out to be successful in the end. From the perspective of the alliance target firm, it is also important to understand the motives why they are approached for alliance formation. In line with previous

research by Lerner and colleagues (Lerner and Tsai, 1999; Lerner and Merges, 1998), this study suggests that, when the approaching firm has little cash and the financing environment is less munificent and thus the need for seeking an alliance is high, the target firm is in a strong position for negotiating the alliance conditions in their interest. There is, however, the danger that the approaching partner will act opportunistically by not living up to commitments or failing to bring enough resources to the table to make the alliance successful, or (perhaps most threatening) seeking only to learn and appropriate the knowledge base of the venture through the alliance.

5.6 Limitations and future research

As all studies, this one has limitations which I have attempted to minimise in the design of the study. Firstly, in this article I focus on the decision of biotechnology venture managers to seek any type of product development alliance with another company based on the resource endowment of their firm. In order to understand the fundamental motivation for formation of strategic alliances, I followed existing literature (e.g., Deeds and Hill, 1996) and did not distinguish between different contractual types of alliances (e.g., licensing deals, joint ventures, minority equity participations). This choice might also depend on the firm's resource endowment (Das and Teng, 2000b). I suggest it as a fruitful avenue for further research to investigate this effect. An experimental design as I employ here might serve as an appropriate method.

Secondly, the theoretical justification of the decision model I develop and its subsequent empirical test is focused on one specific context, entrepreneurial biotechnology firms. Strategic alliances are, however, a ubiquitous phenomenon in many industries (Hagedoorn, 1993), which are characterised by specific resource needs. The application of the model is thus limited and future research might well shed light on how a firm's endowment of resources in other sectors and in established firms influences the managers' decision policies to seek a strategic alliance partner.

Finally, as a unit of analysis I draw on decisions made by individuals. In entrepreneurial high technology firms, however, decisions are often made by the top management team and might differ from individuals' decision policies (Eisenhardt and Bourgeois, 1988). I

suggest that future research might analyse decision policies of complete teams, possibly by employing a similar experimental design as this study.

6 Crisis management in entrepreneurial biotechnology companies

The preceding Chapters 4 and 5 investigated two important strategies for bioventures to build up a competitive resource base: M&A activities and strategic alliances with other firms. I showed that biotech start-ups use both strategies to get, among other resources, access to patented technologies. These technologies constitute the economics basis of every bioventure. Thus, a breakdown of their proprietary technology means a major crisis for these firms and severely threatens their survival. How can bioentrepreneurs manage such a crisis successfully? Are M&As and/or strategic alliances an appropriate way to escape this difficult situation? The study I present in this chapter seeks to answer these questions.[9]

I will introduce an explorative case study of Curacyte, a biopharmaceutical start-up firms which escaped a major technological breakdown crisis. The work is practitioner-oriented and aimed to provide valuable insights for start-up managers in similar crisis situations. After the following introduction (Section 6.1), I will describe a framework for analysis of the crisis management process (Section 6.2). I will then introduce the methodology and data collection process (Section 6.3), followed by the results (Section 6.4). In the subsequent discussion (Section 6.5) I will highlight implications for practitioners. Finally, in Section 6.6 I will describe the limitations of the study and suggest how they might be overcome by scholars in future research.

6.1 Introduction

The discovery of a new and exciting technology is often the starting point for formation of a biotechnology venture. Genentech, for example, one of the first and most successful biotech companies in the world, was founded upon the discovery of rDNA technology in the late 1970s. Genentech utilised this technology for production of human somatotropin and human insulin, two therapeutic proteins which formed the basis of its later economic success. In the years following the discovery of rDNA

[9] I would like to thank Dr. Andreas Zaby, CFO of Curacyte, for his support, and Prof. Dr. Dodo zu Knyphausen-Aufseß, University of Bamberg, for providing me with archival interview material.

technology, many other biotechnological techniques and methods emerged and often led to foundation of a new biotech venture.

Given the importance of an exciting technology for new biotech ventures, a sudden breakdown of the technology means a severe crisis for the firm. In contrast to large and established corporations, which usually have a broad technological basis and can thus overcome the loss of one technology, for entrepreneurial firms this situation is always life-threatening. Antisense and gene therapy are examples for promising technologies, which did often not fulfil the expectations of biotech investors at foundation. Several biotech start-ups building on these technologies were discontinued due to missing economic perspectives.

Yet, a few biotech start-ups escape a technology breakdown crisis. To date, existing literature can not provide any insight on the successful crisis management strategies of these firms. One reason for lack of research in this area might be that managers and investors are not willing to release information on the crises of their firms to the public, a research hurdle described in crisis management literature (Pearson and Clair, 1998). However, I consider research on technology breakdown crisis management in entrepreneurial biotech ventures as particularly important since, as discussed above, these crises lead to organisational death for the majority of the firms.

In order to fill this research gap, I introduce an exploratory case study of Curacyte, a biopharmaceutical start-up company. Curacyte is one of the rare examples of a new biotech venture escaping a technology breakdown crisis six month after its foundation. I demonstrate Curacyte's successful crisis management strategy enabling them to build up a new technological platform.

6.2 Framework of analysis

Scholars have not yet succeeded to find an unifying definition of organisational crisis (King, 2002). In this study, I follow Weick (1988: 305) and define crisis as "low probability/high consequence event that threatens the most fundamental goals of an organisation". In this sense, the unexpected breakdown of a biotech start-up's technology, which constitutes its economic basis, doubtlessly means a major crisis for the new venture. Consequently, I consider the crisis as ongoing as long as the firm has,

in the eyes of the management, not yet succeeded in building up a new technological basis. My aim is to illustrate managerial challenges within this timeframe in order to gain useful insights for bioentrepreneurs in similar crisis situations.

As a framework for the analysis I draw on the resource-based view of the firm. Since all new ventures have a limited resource base, acquisition of resources is the main task of entrepreneurs (Brush et al., 2001; Zaby, 1999). Many studies in the entrepreneurship literature therefore draw on the resource-based view as the theoretical perspective for analysis (e.g., Bruton and Rubanik, 2002; Choi and Shepherd, 2004). According to this perspective, firms are bundles of resources (Penrose, 1959), and the accumulation of a unique resource base is a prerequisite for firms to gain competitive advantage (Wernerfelt, 1984; Barney, 1991). Resources must be valuable (contribute to value creation of the firm), rare (not available to competitors), non-imitable (difficult to copy), and non-substitutable by other resources which can easily be acquired (Barney, 1991). Several studies describe categories of resources essential for entrepreneurial firms (e.g., Greene et al., 1997; Dollinger, 1995). I distinguish financial, organisational, human, social, and technological resources. Efficient management of these resources turned out to be crucial for a new biotech venture suffering technological breakdown during the course of the analysis.

Financial resources are the funds to start, operate and grow a business and central for the development of every firm (Bygrave, 1992; Dollinger, 1995). In particular in the field of biotechnology, which is by its nature a research-intensive industry, development of products is an expensive and risky process. As demonstrated in Chapter 2, biotherapeutics, e.g., demand more than 100 million $US R&D expenditure and only few initial product candidates reach market launch. Therefore, financial resources are of utmost importance for successful development of new biotech ventures.

Organisational resources include organisational relationships, structures, routines, culture, and knowledge (Greene et al., 1997). Whereas in very young biotech firms internal relationships, structures, routines and organisational culture might not yet have evolved in a way that they are different from competitors and thus a source of competitive advantage, the continual accumulation of organisational knowledge is a prerequisite for biotechnology firms to succeed (Liebeskind et al., 1996; DeCarolis and

Deeds, 1999). Scientific knowledge is the basis for a biotech start-up's research capabilities, which are the precondition to develop new products (DeCarolis and Deeds, 1999; McNamara, 1998). Since knowledge is particularly hard to imitate and substitute, it constitutes one of the most important resources of a biotech company.

Scholars have also noted the central role of human resources for development of biotech ventures. Two types of human resources are of particular importance. Firstly, managerial resources are often missing in start-ups where scientific founders are heading the company (Ernst & Young, 2003c). These managers have former careers as, e.g., university professors, positions in which they are free to focus on science rather than financial issues and acquisition of capital. Consequently, start-ups led by inexperienced managers have a much harder time to get funding (Zacharakis and Meyer, 2000) and are more likely to fail. Secondly, scientists in biotech start-ups represent an important human resource. Zucker et al. (1998) show that the founding of new biotech ventures is tightly connected to the presence of "star scientists". A highly motivated and qualified scientific team is an essential resource for biotech start-ups (Baum and Silverman, 2004).

Social resources of a company refer to its relationships and networks (Bourdieu, 1983). They are tightly linked to the firm and thus immobile and a source of competitive advantage. For a biotech start-up company, an extended contact network is crucial for performance (Estades and Ramani, 1998; Baum et al., 2000). Networks cover contacts to other companies, universities and investors, and are a source of learning, flexibility and technological competence (Estades and Ramani, 1998; Powell, 1998; Zucker et al., 2002). They lower R&D costs and enhance innovative output (Zucker et al., 2002; George et al., 2002). Investors such as VCs also provide access to their network, which is often widely spread (Fried and Hisrich, 1995; Bygrave, 1988). Social resources are thus crucial for young biotech ventures.

Finally, technological resources are of central importance. In general, technological resources of a firm "are made up of processes, systems, or physical transformations" (Dollinger, 1995: 37) and include laboratories, R&D facilities, and other technologies valuable for the company. As demonstrated in the introduction, an exciting, cutting-edge technology with either a great commercialisation potential itself, or the potential to

contribute to the development of revenue-promising products in the future, is often the starting-point for foundation of new biotechnology ventures. It is important that extensive patent rights secure an exclusive use of the technology to the start-up company for a certain amount of time (Dollinger, 1995). Otherwise, competitors will imitate the technology and it is no longer a source of competitive advantage. For potential investors, the patent position of a biotech start-up firm is an important factor influencing their investment decision (Stuart et al., 1999; Baum and Silverman, 2004). In summary, a strong patented technology is essential for successful development of biotechnology firms (Lerner, 1995a; Powell et al., 1996; Deeds et al., 1998).

Given the importance of technological resources for new biotech ventures and the fact that these ventures are often built on one single technology, a breakdown of the technology will lead to a severe and life-threatening crisis for the new firm. A breakdown may, e.g., occur because (i) patent protection is not as complete as initially assumed, (ii) it turns out that the technology is not easily commercialisable, or (iii) the technology is based on a scientific artefact which was discovered after foundation of the firm. In the latter case, patents covering the technology are useless for economic purposes and the firm looses its economic basis. Thus, the fast build-up or acquisition of a new technology must be the primary goal of a crisis management strategy in a new biotech venture suffering technological breakdown.

However, crisis management also requires secondary strategic actions of biotech managers since other resources of the company are affected in this situation, too. With respect to financial resources, e.g., managers must reallocate R&D expenditures and may even face the challenge to acquire new capital without a robust technology in hand. Organisational and human resources are affected when scientists leave the company due to its uncertain future and take scientific knowledge with them. Furthermore, future uncertainty may influence the overall motivation of staff and management. With regard to social resources, leaving personnel might take contacts to stakeholders like university scientists with them. A particular challenge may be to keep support of investors after a technology breakdown.

The discussion above suggests the framework depicted in Figure 17 for this study. I will demonstrate a biotech start-up's technology acquisition strategy as a primary crisis

management reaction in response to the technology breakdown. I also analyse the effect of the technology breakdown on management of financial, organisational, human and social resources of the company.

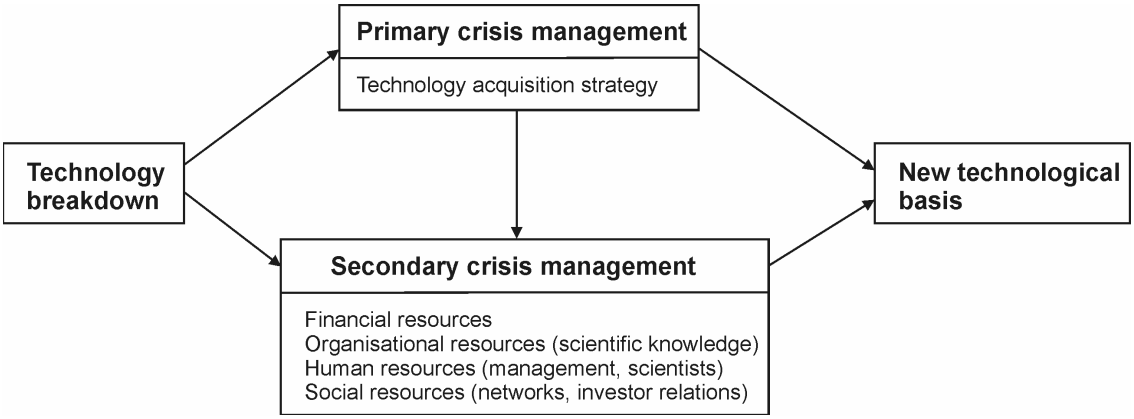


Figure 17: Framework of analysis

6.3 Methodology and data collection

The main objective of this research is to conduct an examination of the crisis management process of an entrepreneurial biotechnology firm following a technology breakdown. In order to achieve this, I use an exploratory case study research approach (Yin, 1994). Yin suggests a case study methodology when "a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control" (Yin, 1994: 9). Because I aim to investigate the crisis management process from a management perspective, I need to identify 'how' managers reacted in the given situation and 'why' they did so. Therefore, a case study approach is most useful for this purpose. Moreover, since crises are very diverse in nature and by definition rare (Weick, 1988; Pearson and Clair, 1998), case studies are the method of choice in most research on crisis management (e.g., Ulmer, 2001; Simon and Pauchant, 2000).

One major hurdle for crisis management research is to obtain data about organisational crises since firms are often not willing to make the circumstances of a crisis public (Pearson and Clair, 1998). For small entrepreneurial companies it is particularly dangerous to release information on a crisis because investors may be warned off and not willing to participate in further financing rounds. The missing readiness of entrepreneurs to report about crises in their companies may thus be the major obstacle for crisis management research on entrepreneurial firms. In this study, I circumvent the

problem of limited data access by exploiting personal relationships to a manager of a bioventure which escaped a major crisis. Specifically, the CFO of Curacyte, the case study company, besides serving as an interview partner, provided me with information from business plans, proposals, press releases and other internal documents. In order to validate and extend the data, I also interviewed Curacyte's CEO. Moreover, I draw on archival data containing interviews with managers of two shareholder VC firms. All interviews lasted between 60 and 90 minutes, were semi-structured, and recorded and transcribed. Data from different sources were triangulated (Denzin, 1978), coded and analysed according to the framework presented in Section 6.2.

6.4 Case study findings

In this section I will first describe Curacyte's history before it suffered the technology breakdown crisis (Section 6.4.1). I will then illustrate Curacyte's technology acquisition strategy (Section 6.4.2) and its management of financial (Section 6.4.3), organisational (Section 6.4.4), human (Section 6.4.5), and social resources (Section 6.4.6) during the crisis management process.

6.4.1 Curacyte's history before the technology breakdown

Curacyte is a German company and was founded in March 2000 in Munich. In June of the same year the company closed its first financing round. A consortium of European venture capital firms lead by Techno Venture Management TVM committed itself to invest 7 million € under the condition that the founders agree to the hiring of an executive management team to take the positions of the CEO and CFO rather than holding these positions themselves. Curacyte's lead investor identified two individuals who had worked together for a management consulting firm, primarily for pharmaceutical clients – the designated CEO being a chemist with significant experience in the pharmaceutical industry and a track record of founding and managing a successful biotechnology company in the USA, the designated CFO with a background in management consulting and incubation of start-up companies. The two individuals acquired Curacyte shares prior to the closing of the financing round and

joined the company as executive managers and non-scientific founders subsequent to the closing.

Two key technologies which originated from an university institute led by Curacyte's scientific founder, a professor of medicine, formed the basis of Curacyte's business plan. These technologies were promising early-stage targets in the fields of oncology and immunology, respectively. In preparation of the planned target validation and drug discovery work, Curacyte's management recruited a team of scientists and technicians and set up the laboratory infrastructure immediately after the closing. Curacyte became fully operational in fall of 2000 with a staff of ten people.

Curacyte's scientists began the technology transfer process from the university institute by replicating key experiments. However, after a six month transfer period marked by numerous replication failures, it had become evident that the key technologies were seriously flawed and lacked commercial viability. The university research team had been misled by intricate scientific artefacts, which were impossible to be discovered in a pre-investment due diligence.

Curacyte's executive management team presented the bad news of the technology breakdown to the board of directors on a board meeting in January 2001, six months after begin of the technology transfer. As a consequence, Curacyte's scientific founder, who was a shareholder and served as a non-executive member on the board of directors, but was not involved in daily business, as well as the head of research, immediately left the company. Intensive discussions ensued between management, board of directors, and shareholders about the strategic implications for the young company, which counted 15 employees at that time. The obvious alternatives were that Curacyte would have to receive a new technological basis or be liquidated. Based on the value of the experienced management team, the human resources and the available infrastructure, shareholders decided against liquidation. Management and Curacyte's lead investor convinced the other shareholders that under a joint business development effort it would be feasible to escape the technology breakdown crisis and acquire the necessary critical mass of projects.

Curacyte's CFO summed up the situation of his company after the technology breakdown as follows:

"We had an experienced management team, a team of scientists and technicians, state-of-the-art laboratories, more than five million € in cash, but – apart from a minor project – no technology."

I now discuss how Curacyte managed to establish a new technological basis and coped with the management of other critical resources during the crisis management process.

6.4.2 Technology acquisition strategy

Curacyte's primary crisis management effort aimed at acquisition of a new technology. The strategy consisted of three approaches. Firstly, Curacyte's scientists would generate project proposals from in-house know-how. Secondly, Curacyte would scout, evaluate, and eventually acquire attractive technologies from German academia, and thirdly, with the support of its main shareholders, Curacyte would source technologies from other biotechnology companies under potential deal structures ranging from in-licensing of selected intellectual property to M&A activity.

Within few months after the technology breakdown, Curacyte's scientists came forward with several proposals for new project opportunities, two of which were eventually pursued. Building on the only remaining project, a 'hit to lead' project for an oncological target (project P1), the company's scientists developed a broader program encompassing novel approaches in computational chemistry. In addition, the in-house team proposed a new project with the aim of discovering inhibitors of a target enzyme with cardiovascular indication (P2), thus leveraging the computational chemistry resources. After board approval, laboratory staff was fully allocated on these projects for several months until the second approach of the business development effort, i.e., the acquisition of new technologies from academia yielded further opportunities.

Based on the personal network of its management, Curacyte reviewed numerous technologies from German universities and research institutes. Moreover, the company hired a scientist particularly for screening yearly reports from German academia in order to discover interesting technology candidates. Opportunities were evaluated along the parameters of fit with the company's core competencies, scientific and economic feasibility, and intellectual property protection. Also, the willingness of the respective research group to out-license their technology while co-operating in some form of

continued support had to be assessed. Because of their previous experience with invalid technology, Curacyte's scientists were extremely critical about all the project candidates. In order to get external validation, Curacyte employed university professors as consultants for project evaluations. As the management states:

> *"It may sound sad, but our philosophy is to try to scientifically destroy any new project. It is better to ask the critical questions, which stop the projects, at the beginning, rather than messing around with them." (CEO)*

> *"An incredibly high portion of what you get offered from academia is economically useless. Mostly this refers to the intellectual property protection of the projects, which professors often do not know. You must evaluate it yourself the hard way and give it back to them with the bad news." (CFO)*

Although Curacyte rejected a number of project candidates – sometimes after evaluating them in their own laboratories for several month – the strategy was successful in two cases. The company acquired patents from a renowned research group at the university of Jena in two transactions. These patents were related to novel small molecule inhibitors of two target proteins with oncological and cardiovascular indication (P3 and P4), respectively. During negotiations, Curacyte particularly emphasised that they were interested in a long-term relationship with the research groups.

> *"The key to success of these transactions was – apart from the necessary level of personal trust and the administrative support by the university's patent office – that they contractually coupled the purchase of the intellectual property to a long-term commitment by our company and the research groups to contribute to the progress of the projects." (CFO)*

Following project budgeting and board approval, Curacyte's work on the two projects began in summer of 2001. At that time, the board conceded that Curacyte had regained a technology base that at least matched the position of many of its peers. Yet, management was convinced that the company still lacked a robust and sustainable technological basis that would adequately address the risk of inevitable future project

failures. Therefore, the company also screened project opportunities from other biotech firms.

While attempts to in-license projects failed due to the fact that none of the very few opportunities offered measured up to scientific and economic scrutiny, with the support from key shareholders Curacyte identified four merger candidates on the basis of their fit with the newly positioned company. One of the main aspects in defining 'fit' was that

> *"... the merger candidates were focused on either up- or downstream activities in the drug development process and would potentially benefit from Curacyte's expertise in hit identification and lead optimisation and vice-versa." (CFO)*

By late 2001, Curacyte's management had evaluated three of the four merger candidates. In one case evaluation had advanced to the stage of joint budgeting and the calculation of post-merger financing needs. However, all three deals were eventually rejected on the basis of either scientific concerns or the problem that the merger candidates' projects were even at earlier development stages than Curacyte's new project portfolio and thus, in the eyes of the management, hardly qualified for creating a more robust company. In November of 2001 Curacyte started discussions with VitaResc, another German portfolio company of Curacyte's lead investor, about a potential fit of the two firms. Being one year older than Curacyte, VitaResc had acquired a US biotech venture which was developing a therapeutic compound with a cardiovascular indication in clinical Phase III, the final phase prior to filing for regulatory marketing approval (P5). The compound had also received authorisation to enter into clinical trials in another oncological indication. So while Curacyte had several early stage projects with about two years to go until the first one might reach clinical development, VitaResc had one late stage project with no significant early stage follow-ups. Thus Curacyte was not going to generate revenues for many years, and VitaResc was a high-risk one-product company. Moreover, VitaResc was headed by an interim CEO who did not want to continue after the merger, which avoided conflicts about the composition of management in the combined company. Curacyte's CEO described the motives behind the merger as follows:

"The merger was part of our strategy to re-gain critical mass. We still needed an attractive main project. Here we had the chance to get something clinical. We were particularly attracted by the main product, which was developed in the USA. This demonstrated to us the quality of the work that was done there over years."

Within a period of six months the management teams designed an integration plan as well as an outline of the business plan of the combined entity. As part of post-merger integration all projects of the combined company were reprioritised and a number of them were stopped. After shareholders had agreed to these plans and the issues of valuation were settled, the two companies were merged in late May of 2002 under the name of Curacyte.

In summary, during the 16 month from the technology breakdown in January 2001 to the closing of the merger with VitaResc in May 2002, Curacyte had built up a project pipeline containing one clinical product with two indications, as well as four projects in the R&D stage. Figure 18 summarises the project acquisition process and shows Curacyte's project pipeline by May 2002 as described in the business plan of the merged company.

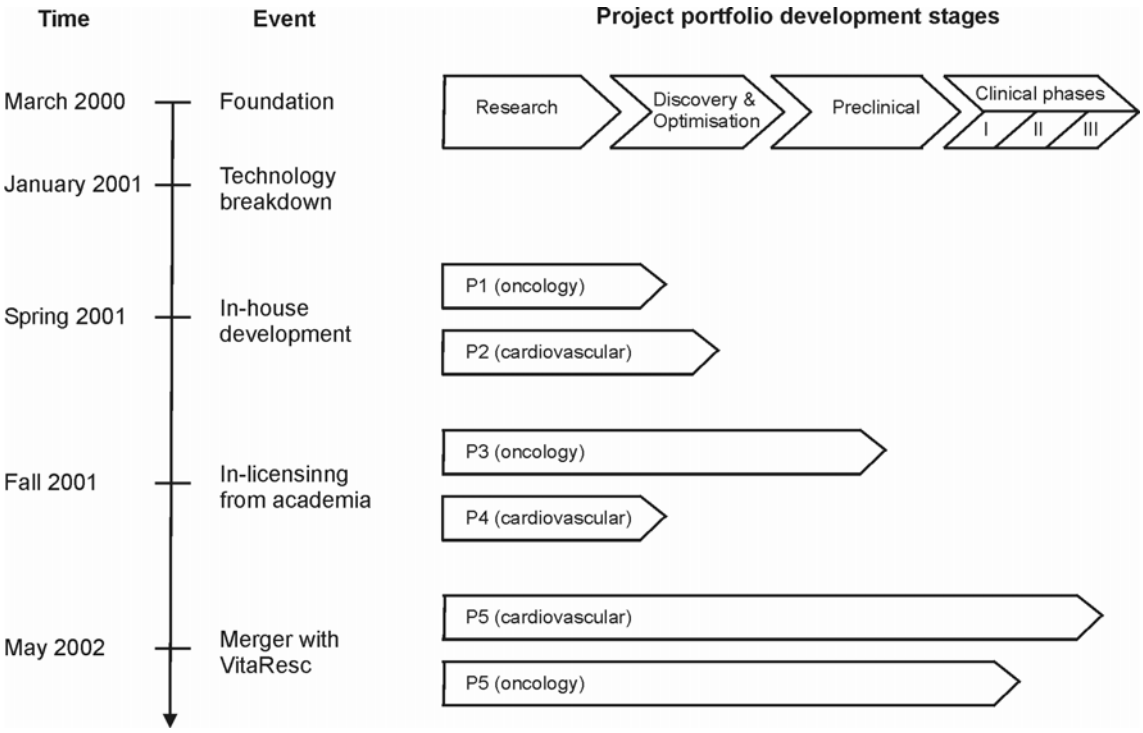


Figure 18: Curacyte's technology acquisition process and project portfolio

6.4.3 Financial resources

Efficient and careful management of financial resources before and after the technology breakdown was essential for Curacyte to survive the crisis. As the basis for continuation of the company, Curacyte had about 5 million € in liquidity when presenting the breakdown to the board of directors in January 2001. This comfortable cash position resulted from the management's quick decision to concentrate all resources on corroborating the invalidity of the technology. After shareholders decided to continue the company, Curacyte's management could focus on acquisition of technologies after the breakdown rather than finding new investors, which might have been impossible in view of the missing technological basis. However, despite of Curacyte's considerable liquidity, management tried to minimise costs and acquire new capital during the entire crisis management process.

Whereas the technologies Curacyte purchased from university were "attractive projects for which we did not pay much" (CEO), financial issues became more critical during Curacyte's evaluation of merger candidates. One of the candidates, which showed a good fit with Curacyte in terms of scientific projects and human resources, was rejected because the cash-burn of the combined entity would have been too high. When merging with VitaResc, Curacyte saved costs through release of personnel. Additionally, the management made it as a precondition to shareholders that they would provide Curacyte further financing for development of the enlarged project portfolio. Shareholders decided on a bridge financing round of 7 million € on the back of the merger to guarantee ample time for implementing the merger and finalising the new business in preparation for a large financing round that would enable the company to advance its projects. According to the management, the fact that Curacyte and VitaResc had an overlapping shareholder base facilitated negotiations. Given the hostile financing environment for biotech start-ups in Germany in 2002 and the early development stage of Curacyte's project portfolio before the merger, it would have been very difficult for the company to raise money without the deal.

6.4.4 Organisational resources

As discussed above, in the context of new biotech firms organisational resources mostly refer to scientific knowledge present within the firm. Since Curacyte acquired new technologies in response to its technological breakdown, management had to guarantee that knowledge necessary for further development of these projects was also built up.

Knowledge acquisition was no major problem for the two projects Curacyte developed in-house since they emerged from the firm's scientific core competencies. These core competencies were based on computational chemistry, biochemistry, and molecular and cell biology. Thus, the knowledge required for development of early stage drug candidates was present within the firm. Missing parts were built up internally by the respective project teams as part of the R&D process. No specific managerial actions were necessary in these cases to ensure knowledge acquisition and integration.

When merging with VitaResc, Curacyte expanded its knowledge base significantly and gained core competencies related to clinical development of products. P5 was already in Phase III clinical trial and developed at VitaResc's site in the US from the beginning. Besides acquisition of a clinical product, the chance to get access to clinical expertise as a new core competency was a major driver for the merger.

> *"Before the merger we did not have any clinical expertise. Thus VitaResc's site in the USA supplemented well our core competencies. The people there are very experienced clinical developers. Their expertise at this part of the pharmaceutical value chain particularly attracted us." (CFO)*

In order to ensure that the knowledge necessary for further clinical development of P5 was kept within the company, Curacyte's management decided to continue operations in the USA and keep key personnel there after the merger. As a long-term strategy, Curacyte planned to conduct clinical development of all drug candidates in the USA.

The main challenge in building up and acquiring knowledge was related to the projects Curacyte acquired from the university of Jena. Simply purchasing the intellectual property associated with the projects would have left Curacyte without the necessary knowledge base for further project development. Thus, as a short-term strategy, Curacyte's management made it as a precondition for the technology purchase that

contractual long-term relationships with the respective research groups would guarantee Curacyte the opportunity to draw on the knowledge of the scientists which originally developed the technologies. Frequent interactions of Curacyte's management with the university researchers ensured commitment of both sides to project development. On the long run, Curacyte planned to fully integrate the knowledge into the operations of the company. In order to achieve this, Curacyte aimed to employ the three key technology developers. Since not all of them wanted to move to Curacyte's headquarters in Munich, the management decided to open a new subsidiary (Curacyte Chemistry) near the university in Jena. This decision was aided by the fact that the new subsidiary would be located in Eastern Germany facilitating acquisition of public financial support such as research grants and government financing for regional development. The knowledge Curacyte incorporated in its new site again led to an extension of core competencies. Specifically, it was related to efficiently perform optimisation of early lead drug candidates by chemical modifications.

> *"We were suddenly a company doing chemistry. We did not make it before and did not want to. But we then also started employing people bringing in knowledge in fields we did not intend to enter when we started the company." (CEO)*

A main challenge for Curacyte's management was to efficiently integrate and coordinate the acquired knowledge since it was located at three different sites. Curacyte's computational chemistry and biology resources were located at its headquarters in Munich, its chemistry facilities at the new site in Jena, and its clinical expertise in the USA. However, management felt that for an efficient R&D process it was necessary to encourage cross-site communication and ensure, e.g., that the clinical developers located in the USA also contribute their expertise to preclinical projects because they were expected to take over these projects for clinical development in the future. Thus, in order to achieve this efficient knowledge integration, after its merger with VitaResc Curacyte's management structured the entire company by interdisciplinary project teams and selected the team members in a way that they were distributed among different sites. Depending on the development stage, projects were headed from Germany (if at the R&D or preclinical stage) or from Curacyte's newly acquired subsidiary in the USA (clinical projects). Through this interdisciplinary cross-

site project organisation Curacyte did not only realise scientific synergies, but also ensured post-merger integration of its US subsidiary.

In summary, Curacyte significantly expanded its knowledge base and core competencies during the crisis management process as a result of its external technology acquisition strategy. The loss of scientific knowledge due to leaving personnel turned out to be no major problem for the company, since this knowledge was mostly related to the invalid and discontinued technology.

6.4.5 Human resources

Human resource management was a major challenge for Curacyte's management after the technology breakdown. In order to gain support for their decisions during the crisis management process, communication with employees was as open as possible.

> *"We always had employee meetings, in which we told the people how the company developed. I think, we were very open, although I am not sure now whether it was always the best." (CEO)*

Despite open communication, however, Curacyte's management did not gain support from all employees and a turnover of staff, including scientists and technicians, was unavoidable. The failure of the company's main project due to scientific invalidity led to suspension of the head of research. Staff loyal to him did not understand this management decision. Others had problems with the management style of the CEO, who temporary took over the position. Uncertainty about future development of the company and job security led to anxiety and interpersonal conflicts.

> *"We had a turnover resulting from dissatisfaction, wrong expectations, and maybe missing confidence in the drastic management decisions. It did not help the climate within the company. We had real problems in tightening the team together. [...] I was really distressed and often swamped with the situation, although we tried everything." (CEO)*

However, management understood that it would not help and make sense to keep all the people.

"Sometimes we had to say to someone: now it is a different job, and if you do not accept, leave the company!" (CEO)

"We did not do everything to keep the people. Some were so agitated that you realised after a few conversations that it would not change and that it was best for them to leave. And so it happened." (CFO)

Instead of convincing all staff to stay, Curacyte soon started recruiting new people. The management did not pay particular attention on "crisis experience" or "stress resistance" of the candidates, but on their scientific qualification. As mentioned above, one strategy was to employ the people who developed Curacyte's newly purchased projects at university. Others were acquired by advertisements in journals and newspapers.

As a result of the dissatisfaction of employees, Curacyte's management introduced periodical surveys among staff about job satisfaction, career advancement, and suggestions of improvement. These surveys were taken very seriously and still done four years after the breakdown. Several employee suggestions were implemented. These measures in combination with integration of new people and the leave of the most dissatisfied finally led to an "acceptable climate in the company" (CEO).

With regard to managerial resources of Curacyte, it is obvious that the past experience of the CEO and the CFO as consultants and managers of pharmaceutical projects was crucial for successful crisis management. In contrast to many young biotech firms, which are spun-off universities and headed by former professors and scientists, both managers did not have any emotional relationships to Curacyte's projects but instead viewed failure as intrinsic to drug development. They accepted the breakdown and quickly looked out for new opportunities.

"I learned in pharmaceutical industry that it is the art of drug development to early enough identify projects with prospect of success. All others must be eliminated as soon as possible. Ninety percent of funds in the pharmaceutical industry are invested in drug candidates which never reach the market. This is the nature of drug development, although many believe that they can change it by messing around with projects." (CEO)

6.4.6 Social resources

Two kinds of social resources were particularly affected during Curacyte's crisis management process: investor relations and Curacyte's contact network to universities and research institutions.

Support of investors was a prerequisite for Curacyte's successful crisis management. Particularly their main VC shareholder TVM, who selected the CEO and CFO at foundation of the company, encouraged management to continue the firm despite of the breakdown.

> *"I remember a business dinner I had with the chairwoman of our board shortly before the board meeting. I gave her some hints about our situation and asked what if we found out that our technology is invalid? She answered that this would be no catastrophe and we would have to find something new." (CEO)*

It is important to note that the personal relationship between the CEO of Curacyte and TVM extends until before the company was founded. VC managers at TVM and the CEO knew each other from common years they spent at a major pharmaceutical company. The shareholder was thus aware of the managerial skills and personal integrity of the CEO which certainly facilitated their decision to continue Curacyte instead of liquidating it after the technology breakdown.

As in the context of employees, open communication was essential for building up an atmosphere of trust, in particular with other shareholders than TVM which had no personal relationship to the management before company formation. Management was commended by shareholders for the rapid and unbiased recommendation to discontinue work on the main technology, although, in the eyes of the management, the opposite would have secured the future of the company for the short term.

> *"We could easily have continued with the project for two more years and showed the board fishy results which can be interpreted in one way or another. Many do it like this. [...] But in the end, we would have reached no milestone to raise money again." (CEO)*

As a result of their openness, Curacyte's management received a mandate from the board of directors to initiate the business development program with the goal of establishing a new technological basis. Shareholder support continued during the entire technology acquisition process. According to the management, it was a precondition for quick technology acquisition that the shareholders backed all major management decisions.

Shareholder support for Curacyte was also crucial during its merger with VitaResc. Although the deal was initiated by the management and not, as it is often the case with underperforming VC portfolio firms, forced by the main shareholders, the lead investor TVM played a crucial role. First, they suggested to the Curacyte management to evaluate VitaResc as a potential merger candidate. Since TVM was also the main shareholder of VitaResc, they were aware that VitaResc lacked a senior management as well as valuable potential follow-up projects for its main clinical product thus providing a good fit with Curacyte's project portfolio (see above). Moreover, the fact that both firms had the same lead investor facilitated valuation negotiations, a major problem for private biotech ventures and a hurdle for many biotech-biotech M&As (Ernst & Young, 2004). Finally, although shareholders played no active role in the post-merger integration process, they contributed valuable practical suggestions during this phase ranging from how to sell free office space to how to efficiently cancel unnecessary contracts which had no value for Curacyte after the merger.

The external project acquisition strategy provided Curacyte with additional contacts to universities and research institutes. Particularly the contact to the university research group in Jena where Curacyte purchased two projects from turned out to be valuable. The contact had its roots in the personal network of Curacyte's management. Specifically, when looking for new project opportunities, the management contacted a scientist with whom they used to work at the consulting company before founding Curacyte. This scientist contacted his PhD supervisor, a professor at the Max-Planck-Institute for Biochemistry in Munich, who in turn recommended the research group at the university of Jena as potential source of attractive projects. After the management visited the professor who led the research group in Jena and both parties got to know each other, he offered Curacyte to purchase the projects. In 2004, Curacyte was still in close contact with this professor. Besides ongoing scientific collaboration, he served as

an external scientific consultant for Curacyte during evaluation of new project opportunities. By the merger with VitaResc, Curacyte acquired a subsidiary in the USA, where experienced scientists with contacts to universities, research institutes, and CROs were working on the development of P5. As the CFO summed up:

> *"We are still in close collaboration with the university institute and recruited a number of people from there. [...] It is a big advantage to have the excellent universities around in the USA, and also the biotech companies and CROs. Because of these structures the USA are a much better place for clinical studies than Germany. We are also doing animal models in the USA together with a university research group which our scientists there know." (CFO)*

6.5 Discussion

In this article, I demonstrated how an entrepreneurial biotechnology firm escaped a technology breakdown crisis. Table 13 summarises the results.

Resources	**Main challenges**	**Important management reactions**
Technological	Acquisition of new technology	Three-way strategy: in-house development, in-licensing from academia, M&A
		Expansion of core competencies
Financial	Financing for continuation of company	Remaining cash through concentration on quick corroboration of technology breakdown
	Financing in times of tight equity markets	Bridge financing round as precondition of M&A deal
Organisational	Acquisition of new knowledge	Contractual long-term relationships to research groups, employment of scientists from purchased and acquired projects
	Integration of new US subsidiary	Organisation of company by cross-site projects
Human	Motivate and keep people	Accept staff turnover, employee surveys
	Acquisition of new personnel	Employ people from purchased projects

Social	Keep investor relations	Open and honest communication before and after the technology breakdown

Table 13: Crisis management case study results

The main aim of this study was to gain valuable insights for bioentrepreneurs. Results show that the breakdown of a bioventure's technology does not necessarily lead to failure of the company. I illustrated that a loss of technological resources has important implications for the management of other resources as well. The following discussion may help bioentrepreneurs with this difficult task.

Firstly, bioentrepreneurs should be aware that, although a new technology might look very promising at foundation of a company, there is still the possibility of technological breakdown for whatever reason. Scientific invalidity, as in the case of Curacyte, is only one example. Others may include incomplete intellectual property protection or missing commercialisability. The limited resource base of a new venture will probably not allow for extensive proactive crisis preparation, e.g., by developing scenarios of alternative strategies in case of a crisis, as done by some large corporations (Mitroff et al., 1987). The only proactive strategy bioentrepreneurs may follow is to be highly critical about the technology and sensible with regard to a possible breakdown. A critical attitude of management and scientists is a prerequisite for early signal detection, which is essential for successful management of every crisis (D'Aveni and MacMillan, 1990; Pearson and Mitroff, 1993; Pearson and Clair, 1998). Particularly scientific founders of a company should ask themselves whether they are critical enough about the technology they developed, or whether their emotional link to the technology perturbs their objectivity. Supplementation of the management team by external managers or non-scientific founders like the CEO and CFO of Curacyte might be a way to enhance sensibility of the management with regard to technological invalidity.

In case of any indication of a technology breakdown, bioentrepreneurs are well advised to concentrate resources on corroborating these results instead of spending further money on the project despite of uncertain validity. This strategy limits financial damage to the new venture. It ensured Curacyte a maximum of financial resources for acquisition of a new technological basis after the breakdown was presented to the board

of directors. The findings are in line with existing crisis management literature, where general damage limitation in case of an upcoming crisis is seen as a crucial step in an efficient crisis management process (Pearson and Mitroff, 1993).

Already during the process of detection and corroboration of a possible technological breakdown, investor relations are an important social resource bioentrepreneurs should pay attention on. Shareholder communication should be open and honest in order to create an atmosphere of trust and enhance the probability that they will decide on continuation of the company after technological failure instead of liquidation. This view is supported by Ulmer (2001), who finds that strong communication channels and positive value positions with stakeholders well before organisational crises erupt are important preconditions for successful crisis management. Excellent investor relations will also be valuable during the build-up of a new technological basis after the breakdown event. Curacyte, e.g., was supported by its shareholders not only in terms of access to investor networks and suggestions of potential deals, but also with regard to freedom and support for managerial decisions. The latter is a prerequisite for the management to react with the necessary speed and flexibility required during all crisis management processes (Pearson and Clair, 1998).

Once technological breakdown is corroborated and board approval for continuation of the company is achieved, management needs to follow an aggressive project acquisition strategy. This strategy may consist, as in the case of Curacyte, of three approaches in parallel: in-house development, purchase or licensing of patents from academia, and deals with other biotech companies including in-licensing, joint ventures, or M&A activities. During project acquisition, which corresponds to the "recovery" phase described by crisis management researchers (Pearson and Mitroff, 1993), bioentrepreneurs should again be very critical with project opportunities with a focus on scientific and economic feasibility, and, equally important, intellectual property protection. As in the case of Curacyte, external consultants may assist in evaluation of project candidates. Furthermore, managers should pay particular attention on organisational resources, i.e., the attraction of knowledge related to the acquired technologies, since, in the best case, newly acquired projects should not only fit the core competencies of the firm but expand them. Curacyte, e.g., built up a chemistry facility and clinical expertise and acquired the corresponding knowledge by employing the

technology developers. Moreover, an aggressive strategy of external technology acquisition may provide a new biotech venture with additional contacts to universities and research institutions, an important social resource for these firms (Powell, 1998; Zucker et al., 2002).

Lastly, bioentrepreneurs should be aware that, as during most crisis management processes (Pearson and Clair, 1998), a major challenge after a technology breakdown is the management of human resources. For Curacyte, turnover of staff was unavoidable. The overall climate in the company suffered and social structures eroded, consistent with observations of other crisis management scholars (Pearson and Clair, 1998). I suggest that bioentrepreneurs should follow Curacyte's strategy to let go people willing to leave the firm instead of keeping them for any price. Acquisition of new staff should start as soon as possible. Moreover, human resource management practices like staff surveys can contribute to uncover sources of dissatisfaction and may, as in the case of Curacyte, help entrepreneurs to reintroduce an acceptable climate in the company.

In summary, this research demonstrates that many aspects described as critical for successful crisis management in large organisations are also important in the context of a technology breakdown within a bioentrepreneurial firm. However, there are major differences due to the limited resource base of the venture. In contrast to large corporations, where often specialised crisis management teams deal with certain aspects of organisational crises (Podolak, 2002), in case of a new firm it is the entrepreneurial team themselves who must manage all kinds of resources during the crisis management process. They can neither establish a formalised signal detection process before the crisis occurs nor a specialised crisis management team afterwards. Moreover, in contrast to large corporations, lack of financial resources does not enable entrepreneurial firms to engage crisis management specialists from outside as consultants for certain aspects of the crisis. Instead, the whole organisation is affected by the crisis and it is the entrepreneurial team who must find a way out.

Although one might consider Curacyte's case as quite unique, it shows interesting similarities with a case study on the corporate renewal process of Celltech, one of the largest biotech firms in Europe (McNamara and Baden-Fuller, 1999). Founded in 1980, Celltech suffered a severe corporate crisis and found itself near bankruptcy in 1990. At

that time, a new, external top management team entered the company and initiated its transformation from a contract R&D firm and manufacturer of biologics to a modern biopharmaceutical company. As in the case of Curacyte, the fact that the new management was not emotionally attached to previous and ongoing projects facilitated this transformation. Furthermore, Celltech's management experienced strong support by shareholders, again reminding of the relationship between the Curacyte management and TVM. The analogies also extend into management of financial, human, and organisational resources. As Curacyte, Celltech followed a strict cost reduction strategy and experienced a staff turnover. Since Celltech had to build up new knowledge related to development of therapeutics, management decided to hire thirty medicinal chemists to extend its knowledge base, a strategy similar to Curacyte's hiring of scientists from the university research group it purchased projects from. Intriguingly, although Celltech was 10 years older and had considerably more employees than Curacyte, in both cases management decided to restructure the company by interdisciplinary project teams. Finally, collaborations with other organisations played a key role in Celltech's as well as Curacyte's strategy of new technology and knowledge acquisition. These similarities do not only suggest that many of the findings presented here are generalisable to other, even more established biotech companies in similar crisis situations as Curacyte, but they suggest that the literature of corporate renewal might provide an appropriate theoretical lens for future researchers studying crisis management in entrepreneurial firms.

6.6 Limitations and future research

This research is a first step to understand how entrepreneurial firms can survive life-threatening crises. The specific focus on the technological breakdown of a new biotech venture allowed me to derive helpful insights for bioentrepreneurs. I would like to motivate researchers to extend this stream of research in several directions.

Firstly, this work draws on a single case study and may thus, as all case studies, be of limited generalisability. Due to the similarities with the Celltech case described above, I consider it as likely that some of the findings might well be applicable to other cases. However, some biotech start-ups may escape a technology breakdown by a different

strategy, e.g., exclusive in-house development or acquisition of a new technology which has nothing to do with the core competencies of the firm. I speculate that management of other resources would be different in these cases. Moreover, it would also be interesting to analyse cases of non-successful crisis management in situations similar to the one of Curacyte. A comparison might reveal critical issues during the process more systematically.

Finally, I would like to encourage managers as well as investors of biotechnology start-ups to try to overcome organisational crises in a joint effort instead of quickly liquidating the company. Crises also offer chances to a firm (Hurst, 1995; Nathan, 1998). Young ventures can, e.g., build up a "history" in quite a short time, which can tie the team together and enhance identification with the company, an experience made by the case study company Curacyte. Therefore, although conceding that the crisis management process was exhausting and often frustrating, in an interview Curacyte's CFO referred to it as "good old times".

7 How do venture capitalists spread risk by diversification within specialised life science portfolios?

Bioventures are risky businesses. In Chapter 3 I illustrated that a downturn at the capital markets often leads to insolvencies because the firms fail to acquire the capital necessary to finance their expensive product development processes. Moreover, as the case study I introduced in the previous Chapter 6 demonstrates, the technological uncertainty of bioventures is high and there is always the danger that the firms will loose their economic basis because of a technological breakdown. From the perspective of biotech investors such as VCs, which often invest tens of millions of Euros in these risky firms, insolvencies usually mean a complete loss of their investments. How do these investors deal with the considerable risk inherent in their investees?

The purpose of the study in this chapter is to analyse portfolio and risk reduction strategies of specialised life science VC firms. It is important to note that the term "life sciences", which I will use below, refers to what I described as "biotechnology" in Chapter 2, but also covers "medical technology", which I will introduce in more detail in the following sections. Since VCs often include both technologies in their portfolio of investees, this extension turned out to be necessary during the course of the analysis.[10]

This study contributes to VC literature by extending the concept of VC portfolio diversification to industry specialised portfolios. In the introduction in Section 7.1, I will illustrate how the study relates to existing literature on diversification of non-industry specialised portfolios. In Section 7.2, I will introduce a theoretical framework for analysis of life science portfolios. I will then describe the methodology chosen and the data sources (Section 7.3). In Section 7.4, I will apply the framework to the portfolios of seven VC firms and describe the results. In the following Section 7.5 I will discuss the results and compare and extend them with rich interview data. Finally, in Section 7.6, I will point to limitations of this work which might be overcome by going forward scholars.

[10] I would like to thank Prof. Dr. Dodo zu Knyphausen-Aufseß, University of Bamberg, for providing me with archival interview material and critical comments and discussions. I am indebted to Ilona Arnoldt, University of Bamberg, for her help with data collection.

7.1 Introduction

Venture capitalists invest large amounts of money in a portfolio of start-up companies. Due to their liabilities of newness (Stinchcombe, 1965), many of these start-ups fail during the first years of their lifetime. They therefore comprise a high risk for their investors. Investment risk in the VC market is particularly high since portfolio firms are not traded at public stock markets and therefore do neither have to publish detailed financial reports and inform their investors about company development, nor are they subject to monitoring by qualified analysts of institutional investors (Sanders and Biovie, 2004). Moreover, VC portfolio ventures often operate in new industries such as life sciences and employ new business models, where only scarce knowledge and experience is available to investors (Sanders and Biovie, 2004). Since many start-up managers tend to keep the use of their limited financial resources and operational problems secret (Mitchell et al., 1995), significant informational asymmetries arise between VC firms and their investees. Finally, in contrast to investors of public firms, VCs can not exit their investments at any point in time because valuation of early stage, non-public companies, which do often not yet have a product on the market, is difficult and VCs might not succeed in finding a buyer willing to pay their charged price. Therefore, in order to reduce future uncertainty and facilitate valuation and exit from their investments, VCs need to grow their portfolio firms to a certain size, which typically demands several rounds of capital infusion and takes about 5 years (Sahlman, 1990).

VCs can reduce their investment risk on the level of individual portfolio companies ("micro risk") and on the level of the overall portfolio ("macro risk") (Norton and Tenenbaum, 1993). It is well studied in the literature how VCs minimise their micro risk. Firstly, VCs carefully select their portfolio companies according to criteria such as quality and experience of the management, product differentiation, market potential and financial perspectives (Wright et al., 1997; Tyebjee and Bruno, 1984; MacMillan et al., 1985; Shepherd, 1999b). Moreover, during the time of investment, VCs thoroughly monitor and control the management of their portfolio start-ups through participation in the board of directors (Gorman and Sahlman, 1989; Lerner, 1995b). Sophisticated contracting constructs ensure the VC firm substantial rights to achieve their interests in case of agency conflicts with their portfolio start-up management (Kaplan and

Strömberg, 2001). VCs also provide not only financial support but add value to their portfolio companies by assisting the management in daily business, personnel management, selection of executives, strategic analysis, and financial issues (MacMillan et al., 1988; Sapienza, 1992; Hellmann and Puri, 2000; Fried and Hisrich, 1995). Finally, VCs syndicate in financing rounds with other VC firms which allows them to draw on the experience of their syndication partners when selecting investees and supporting them in management (Bygrave, 1987; Lockett and Wright, 2001).

In contrast to micro risk reduction strategies, much less attention has been paid in the literature on how VCs reduce their risk by diversifying their portfolio among markets and industries (macro risk). Whereas the systematic component of the macro risk, which arises from market-wide effects, remains unaffected, diversification of a portfolio can well reduce the unsystematic risk component arising from firm and industry-specific variations. According to financial theory, VCs should thus invest in a well-diversified portfolio of start-up companies (Markowitz, 1967). However, diversification of a portfolio of private firms is more difficult than diversification in public stock markets for two reasons. Firstly, VC investments usually demand a relatively high percentage of the total fund the VC firms have under management (Robinson, 1987), which limits diversification opportunities and drives syndication of investments (Lockett and Wright, 2001). Secondly, the information asymmetries associated with their investments make it difficult for VCs to obtain sufficient information required for efficient diversification (Sahlman, 1990). Previous research has shown that these high information costs lead to specialisation rather than diversification of VC portfolios across industries. Accumulation of industry-specific knowledge, networks, and reputation enhances the probability that VCs will select successful portfolio companies which finally yield high returns (Bygrave, 1987; Sahlman, 1990; Norton and Tenenbaum, 1993).

The development of the VC industry in the last decade provided further support for the industry specialisation hypothesis. An increasing number of VC firms raised funds dedicated to one promising high technology industry such as information technology or life sciences. Many VC companies even exclusively focus on one industry. According to previous studies, portfolios of these VC firms would be classified as undiversified (Norton and Tenenbaum, 1993). Industry-specialised VCs would not have the chance

and necessity to build up a risk-adjusted portfolio with regard to diversification of their portfolio firms among technologies and product markets.

In this study, I argue that diversification of their portfolio is an important strategy also for industry-specialised VC firms to reduce their macro risk. I illustrate within-industry portfolio diversification in the context of the life science industry, one of the most promising sectors of the 21st century. Modern biotechnological methods like genetic engineering and large-scale production of biomolecules such as proteins and antibodies facilitate the development of drugs and diagnostics for unmet clinical needs (e.g., cancer, Alzheimer's disease) and have a huge economic potential. However, the development of biotechnological products is research-intensive and risky and requires large amounts of capital before the firms generate revenues. Therefore, most life science start-up companies essentially depend on VC financing (Prevezer, 2001). The high return potential of biotechnological products makes the life science industry particularly interesting for VC investments, and many dedicated life science VC firms have emerged during the last years. Meanwhile life science firms comprise a significant amount of total VC investment. In Germany, e.g., almost one third of total VC investment in 2003 was in the life science sector. Table 14 provides an overview of life science and other VC investments in Germany.

Year	Total VC investment	Life science VC investment	Life science of total
1997	990	65	7 %
1998	1250	140	11 %
1999	2450	180	7 %
2000	3700	565	15 %
2001	2800	525	19 %
2002	1450	210	15 %
2003	700	225	32 %

Source: (BVK, 2004; Ernst & Young, 2004)

Table 14: VC investment in life sciences in Germany in million €.

During the hostile financing environment of the years 2002 to 2004 many German life science firms did not succeed in closing another VC financing round necessary for further company development. Moreover, they could not raise money through an IPO since the German stock markets are less developed than, e.g., the markets in the USA or the UK, and the IPO window was closed. The German life science industry suffered painful insolvencies including even established companies which had received significant VC investment before like Axxima (64 million €), Munich Biotech (40 million €), Apovia (29 million €), and Xerion (26 million €). There is thus an essential need for life science VC firms to build up a risk-adjusted portfolio in order to compensate for these large potential losses.

The purpose of this paper is to analyse which contribution (if any) to VC's risk reduction strategies diversification can make when their portfolio is specialised on one industry. I will conclude that, in contrast to non-industry specialised portfolios, where specialisation rather than diversification contributes to risk reduction (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993), the opposite is true in the context of industry-specialised portfolios. Specialisation below industry level on technologies or product markets does not seem to be a favoured means for VCs to reduce their investment risk. Industry-specialised VC portfolios are well-diversified among markets and technologies.

7.2 Framework for the analysis of diversification within life science portfolios

Since the goal of this study is to analyse how diversification within industry-specialised portfolios can contribute to reduction of VCs' investment risk, I first need to define the understanding of risk and the unit of analysis in this study. Consistent with existing VC literature (e.g., Ruhnka and Young, 1991; Norton and Tenenbaum, 1993), I conceptualise risk as the probability that an investment will fail before the VC generates a profitable exit. A portfolio is the riskier the more firms face a high individual failure risk, i.e., the lower the number of profitable exits the VC will probably generate. VCs will accept investments with higher risk (at the individual or the portfolio level) because they have a higher chance for large returns (Ruhnka and Young, 1991; Gupta and Sapienza, 1992). Based on this conceptualisation, the investment risk of a VC firm at

the portfolio level is, at any point in time, described by the portfolio companies it currently holds. It is therefore independent of profitable exits the VC had in the past. Moreover, it does not depend on the number of funds the VC has under management, since every failed investment will mean a loss for the VC. It also does not depend on whether funds have been fully invested or not, since non-invested money does not comprise risk according to this conceptualisation. The unit of analysis are thus the current portfolios of VC firms.

As demonstrated in Chapter 2, biotechnology and life sciences are a heterogeneous field with various definitions existing in the literature. I draw on the definition of Ernst & Young who understand as life science firms "companies that use modern techniques to develop products or services to serve the needs of human healthcare or animal health, agricultural productivity, food processing, renewable resources or environmental affairs" (Ernst & Young, 2000a). Since by far most of these firms focus on development of products for human healthcare (Ernst & Young, 2000a), in the context of this analysis I will only refer to these firms. However, even these companies develop very different technologies and serve different markets. Classical industry categorisations such as the Standard Industry Classification (SIC) do not cover this substantial within-industry diversity (zu Knyphausen-Aufseß et al., 2005). Thus, I use the categories below for life science companies active in human healthcare.

I distinguish between firms that develop medical technology (medtech), drugs and diagnostics, and firms offering services and supply of laboratory material. Medtech companies, for example, develop technologies for tissue and organ transplantation. Drug development firms use modern biotechnological methods to develop biopharmaceuticals. Diagnostics companies employ modern biotechnology (e.g., gene and protein analysis) to produce a new generation of diagnostic tests for humans. Service/supply firms offer, e.g., DNA sequencing services or laboratory equipment like protein or DNA purification kits for daily research in industry and research institutes. I summarise these categories under the term "business areas". This expression is loosely defined in the literature and often used to describe different product markets firms serve (e.g., Frumau, 1992). Thus, it is an appropriate summarising term for this study.

Of the life science business areas described, drug development is by far the most risky and money-consuming one. As illustrated in Chapter 2 , it takes about 100 million $US to bring a drug to market (DiMasi et al., 2003), and the probability that an initial drug candidate will reach the market is only about 6 % (Kellog and Charnes, 2000). Therefore, drug development companies are particularly likely to fail. Despite this high risk, drug development firms comprise the largest fraction of VC-backed life science companies, since they have the greatest potential for high returns. In contrast, medtech, diagnostics and service/supply firms are often profitable a few years after foundation and face a much lower failure risk. However, they do not generate comparable revenues. In the framework of this study, I use the fraction of drug development companies in the portfolio as an indicator of its business area risk.

VC firms can also spread risk within their sub-portfolio of drug development firms. VCs can invest in start-ups developing drugs for different therapeutic markets (e.g., cancer, cardiovascular diseases), and drugs belonging to different lead compound technologies (e.g., small molecules, antibodies). From a start-up's perspective, significant synergies arise between projects focusing on the same therapeutic area or the same lead compound class since know-how and technologies are overlapping. Therefore, many drug development start-up firms are, e.g., "cancer companies" or "small molecule companies", or focus on both and, for example, develop small molecules for cancer diseases. However, there is the possibility that a novel technology of lead compounds might not be as easily applicable as initially thought. Antisense and gene therapy are examples from the past. Similarly, there might arise more problems in developing drugs for a certain therapeutic market than expected at foundation of a company, as it is the case for some neurological diseases. Thus, VCs ought to diversify their drug development sub-portfolio with regard to different lead compound classes and therapeutic areas in order to keep their risk low. I measure diversification of the sub-portfolio by its entropy S (Palepu, 1985) according to $S = S_{th} + S_{lc} = - \Sigma p_{i, th} \ln p_{i, th} - \Sigma p_{i, lc} \ln p_{i, lc}$, with $p_{i, th}$ and $p_{i, lc}$ representing the fractions of firms developing drugs for different therapeutic markets and belonging to different lead compound technologies, respectively. According to portfolio theory, the drug development sub-portfolio risk decreases with increasing diversification and hence increasing entropy (Markowitz, 1967).

VCs investing in a large portion of risky drug development companies and/or with a non-diversified drug development sub-portfolio might reduce their macro risk in another way. In the framework of this study I analyse two possibilities of risk reduction which potentially interplay with the life science portfolio design of VC firms. Firstly, VCs might invest in companies in late development stages (Elango et al., 1995; Sapienza and Gupta, 1994). Early stage ventures are particular risky investments since they face the liabilities of newness (Stinchcombe, 1965) and therefore a high failure risk for a number of reasons. Firstly, technological uncertainty is usually high for young ventures since their technologies are new and not yet established. Secondly, the long product development cycles make market projections difficult, in particular in the hypercompetitive environment of the life science industry. Finally, at early stages life science start-ups are often led by inexperienced academic founders and thus face a high risk of management failure (Ruhnka and Young, 1991; Sapienza and Gupta, 1994).

VCs can also reduce macro risk by diversifying their portfolio investments among different countries and thus capital markets (Meyer and Shao, 1995; Gupta and Sapienza, 1992). This possibility is particularly important for VCs active in less developed equity markets like, e.g., Continental Europe. European investors are less experienced and much more hesitant to invest in risky start-up firms than their counterparts in the USA or the UK. This effect multiplies once a market downturn occurs. For example, whereas only one life science firm went public in Germany in 2004, 30 firms had their IPOs in the US market raising a total of 2.5 billion $US (BioCentury, 2005). German VCs can thus more easily achieve exits and reduce their macro risk when diversifying their portfolio into the US market. Moreover, these VCs may also have better chances to find syndication partners in the USA with more liquidity than German VCs, which enhances the probability that their portfolio start-ups will finally achieve an IPO. US VCs invested more than 4 billion € in life science firms in 2004, as compared to 0.2 billion € of German VCs (BioCentury, 2005). In summary, international diversification into more developed and liquid capital markets such as the USA is an efficient means for VCs in Continental Europe to reduce their macro risk.

Figure 19 summarises the framework of this analysis. I analyse the interplay of a VC's focus on geographic scope/development stage of investment, and diversification of the life science portfolio with regard to different business areas. I also investigate the

relationship between geographic/investment stage focus and diversification within drug development sub-portfolios. Finally, I elucidate whether risk of the overall portfolio and the drug development sub-portfolio are correlated.

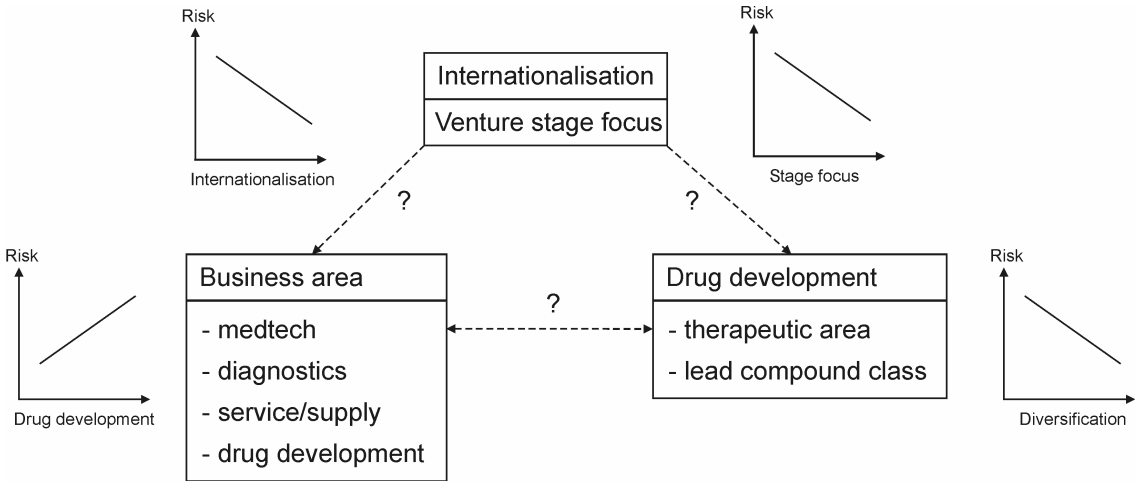


Figure 19: Framework for analysis of life science portfolios

7.3 Methodology and data collection

The main objective of this research is to conduct an examination of the diversification strategies of industry-specialised life science VC firms. In order to achieve this, I use an exploratory case study research approach (Yin, 1994). Yin suggests a case study methodology when "a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control" (Yin, 1994: 9). Because I aim to analyse 'how' VCs diversify their life science portfolios and 'why' they do so, a case study approach is most useful for this purpose. Case studies have been used successfully before in VC and Management Buy-In/Management Buy-Out (MBI/MBO) research (e.g., Robbie and Wright, 1995; Kollmann and Kuckertz, 2004).

In order to select the cases, I identified VC firms with investments in the German life science industry from industry reports (mostly those by Ernst & Young), life science firm press releases, industry press, and online sources. From this initial list of 46 firms, I theoretically derived the sample. Since many variables might influence VC's risk attitude and diversification strategy, it was impossible to analyse the effect of all of them simultaneously. I therefore aimed to hold some of the variables constant across cases while covering a possibly wide range of others ("polar types") (Eisenhardt, 1989).

I aimed at achieving homogeneity with regard to VC experience, location of the VC's headquarters, syndication strategy, and stage focus in a wider sense (including MBO/MBI firms), which are known to impact VC's risk attitude and investment behaviour (Lockett and Wright, 2001; Manigart et al., 2002). Therefore, I first excluded all VCs which had less than ten life science investments and were active for less than six years in the sector in order to take into account only VCs with significant experience.[11] Secondly, I included only VCs which either have their headquarters in German-speaking countries or have a subsidiary in Germany and their headquarters in a neighbouring country. Moreover, I selected only VCs which prefer acting as a lead investor according to their own announcements, which controls for different syndication strategies to a certain extent. I also excluded MBI/MBO specialists. All VCs in the sample have at least some early stage lead investments in Germany (for examples see Table 15). Finally, I did not include corporate VCs since these might follow different diversification strategies with the aim to integrate their portfolio ventures later.[12]

From the remaining list of 17 firms I selected seven VCs – a number consistent with recommendations for case study research (Eisenhardt, 1989) – with the aim of covering maximum heterogeneity with regard to the two variables geographic scope of investees and stage focus in a narrow sense (non-MBO/MBI firms) of the framework. I decided to analyse portfolios of Techno Venture Management TVM (Germany), HBM Bioventures (Switzerland), Deutsche Venture Capital DVC (Germany), Life Science Partners LSP (Netherlands), Global Life Science Ventures GLSV (Germany), Heidelberg Innovation HI (Germany), and BioM (Germany) (Table 15). Please note that the VCs systematically differ in amount of capital under management since VCs with a small fund invest in early stage ventures with narrow geographic scope. Small VCs should, according to the framework of analysis, thus have a much higher need of risk reduction

[11] Please note that the German VC and life science industry, both of which mainly arouse in the mid-1990s, are much younger than the sectors in the USA and the UK. Therefore six years do mean above-average experience in the German context, whereas in the USA and the UK these VCs might be classified as young and unexperienced.

[12] One might also argue that syndicate partners which are either corporates (e.g., pharma firms) or corporate VCs influence the strategy of portfolio firms, e.g., regarding choice of therapeutic area, which in turn might influece diversification strategies of VCs in the sample. In the framework of this study I can not account for this effect explicitly. However, I do not expect it to significantly influence the results since (i) none of the portfolio firms in the sample had a corporate as lead investor in any financing round, and (ii) corporate life science VCs such as Novartis Venture Fund, the most prominent syndication partner and lead investor in some cases of the sample, claim that "entrepreneurial freedom of funded companies is ensured; no formal ties with Novartis are implied" (www.venturefund.novartis.com).

by portfolio diversification. Moreover, the two smallest VCs in the sample (BioM and HI) were founded as public VCs with the aim of supporting regional development of the life science industry in the Munich and Rhine-Neckar region, respectively, by providing seed and early stage financing to start-up firms. Meanwhile both firms also have private investors and started investing in other regions. Since existing literature is inconsistent and suggests that either there is no effect on diversification and VC's risk attitude (Gupta and Sapienza, 1992), or that independent VCs have a higher need to reduce risk (Manigart et al., 2002), I included both in order to elucidate possible effects. Finally, two of the larger VCs in the sample (TVM, DVC) also have non-life science investees in less risky industries such as information technology, which might allow them to follow a more risky strategy with regard to diversification within the life science portfolio. I analyse this issue below.

The seven life science VC firms invested in a total of 156 portfolio companies (some of which are in the portfolio of more than one VC firm), and are described in Table 15. Their age ranges from six to 21 years (average 10 years), and the number of life science portfolio companies from 11 to 35 (average 22). Their total capital under management varies from 11.2 to 918 million € (average 319 million €). As compared to the overall German VC industry, these companies have thus a similar portfolio size (industry average 22 firms), but more money under management (industry average 120 million €) (BVK, 2004) due to the capital intensity of life science investments.

Name	Year founded	Head-quarters	Capital (million €)	Pf-firms	Geogr. focus	Stage focus	Early stage lead investments (examples)	Inter-view
TVM	1983	G	918	35	EU, NA	e/l	Curacyte, Morphochem	X
HBM	2001[13]	Sw	588	32	EU, NA	e/l	TeGenero, Arpida	
DVC	1998	G	300	11	EU	e/l	elbion, 4SC	X
LSP	1988	NL	170	17	EU	e	Neuronova, Kiadis	X

[13] Please note that HBM merged in 2003 with New Medical Technologies NMT, which was incorporated in 1997 and was the first Swiss VC firm exclusively focusing on life science investments. Therefore HBM has significantly more experience than its date of foundation indicates.

GLSV	1996	G	143	18	EU	e	Apovia, DeveloGen	
HI	1997	G	103	21	G	e	mtm laboratories, Cenix	
BioM	1997	G	11.2	22	G	s/e	Icon Genetics, PIERIS	X

NA: North America = US, Canada; G: Germany; Sw: Switzerland; NL: Netherlands; s: seed; e: early, l: late

Table 15: Characteristics of analysed VC firms

Investigation of portfolio diversification is only possible if I cover the complete set of companies in the portfolios of the sample. I think that the coverage is complete for the following reasons. Firstly, I used multiple data sources from the present and the past including the internet, online publications (e.g., BioCentury), public data base material (e.g., biospace), printed industry reports (e.g., Ernst & Young) and journals (e.g. |transkript), and press releases of both, VC firms and portfolio companies. I triangulated all of these data to perform the analysis and draw conclusions. Secondly, I included archival interview data with VC managers of four of the case study firms (see below), all of which confirmed completeness of the coverage. Thirdly, one would assume that VCs will preferentially keep information on badly-performing portfolio companies secret. However, during the course of this analysis several firms which had received extensive financing by the sample VCs filed for insolvency (Axxima (TVM, BioM, HI, GLSV, HBM), Munich Biotech (HI, GLSV), Apovia (GLSV, HI), Xerion (BioM, HI)). All these firms were listed on the web pages of their VCs until their insolvency was publicly announced, which suggests that VCs in the sample do not systematically hide their badly-performing investees.

Whereas I will draw the main conclusions from application of the framework and the descriptive statistical analysis in the next section, I also rely on archival interviews with managers of VC firms. Questions asked in the interviews included, e.g., “How do you diversify your portfolio?”, “How important are synergies between firms?”, and “Which factors influence diversification?”. Unfortunately, I was only able to get interview data from managers of four of the sample firms (TVM, DVC, LSP, BioM), since European VCs are generally very reluctant to participate in academic research (Muzyka et al., 1996). However, these represent well the polar types I analysed (Table 15). To further substantiate and extend the results, I also draw on data from archival interviews with

four VC managers of firms which I excluded from the sample because they either had their headquarters in the UK (Apax, 3i), syndicated preferentially as a non-lead investor (Industriekreditbank IKB), or did not support enough life science portfolio companies (Earlybird, IKB).

7.4 Results

In this section I present the results of the descriptive statistical analysis of life science portfolios. I will first illustrate the VCs' internationalisation and investment stage strategies (Section 7.4.1). I will then analyse the portfolios with regard to business area diversification (Section 7.4.2) and diversification of the drug development sub-portfolio (Section 7.4.3). In Section 7.4.4 I will investigate the risk distribution between the overall portfolio and the drug development sub-portfolio.

7.4.1 Geographic scope and venture development stage

In order to get an impression how self-reported internationalisation and investment stage strategies of the VC firms are quantitatively reflected in the distribution of portfolio companies, I analysed the portfolios with regard to these two variables. I distinguish between geographic distribution in the home country of the VC firm (Germany, Switzerland or the Netherlands), the rest of Europe, and the more developed equity markets in North America (USA, Canada). As an indicator of venture development stages I use their latest financing rounds, which I categorise as A, B, C, and D+ rounds.[14] Since venture stages change over time, VC firms with a seed and early stage focus will also have late stage companies in their portfolio, although their shares are diluted.

Not surprisingly, the findings largely reflect the investment strategies of the VC firms as described in Table 15. Figure 20 shows that large VC firms like TVM and HBM do significantly reduce risk by diversifying their investments into other countries, in

[14] I was not able to determine the last financing round with certainty for all portfolio firms. The percentages of firms I gathered this information for ranges from 71 % (BioM) to 96 % (DVC). Numbers in Figure 21 only refer to this percentage. Please note that Figure 21 is only a quantitative illustration of self-reported investment strategies described in Table 15. Therefore, incomplete information does not influence the conclusions I draw.

particular into the more developed capital markets in North America (more than 60 % of investments).

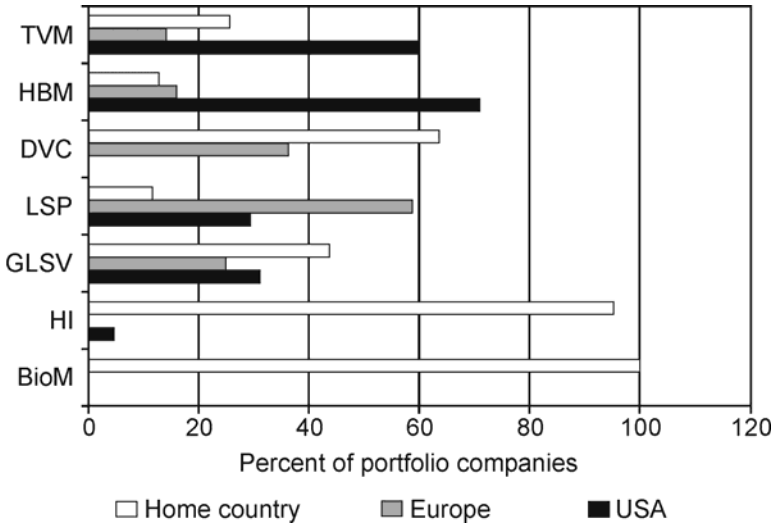


Figure 20: Geographic scope of life science portfolio companies

With regard to risk reduction by selecting late stage investees, Figure 21 demonstrates that primarily the large VCs in the sample follow this strategy. At least half of TVM's and HBM's portfolio companies are in C or D+ financing rounds, which are for many firms the last rounds before an IPO. In contrast, smaller firms do not have this opportunities of risk reduction to the same extent. In the portfolios of BioM and HI, basically all firms are German and most of them have only completed A and B financing rounds, respectively.

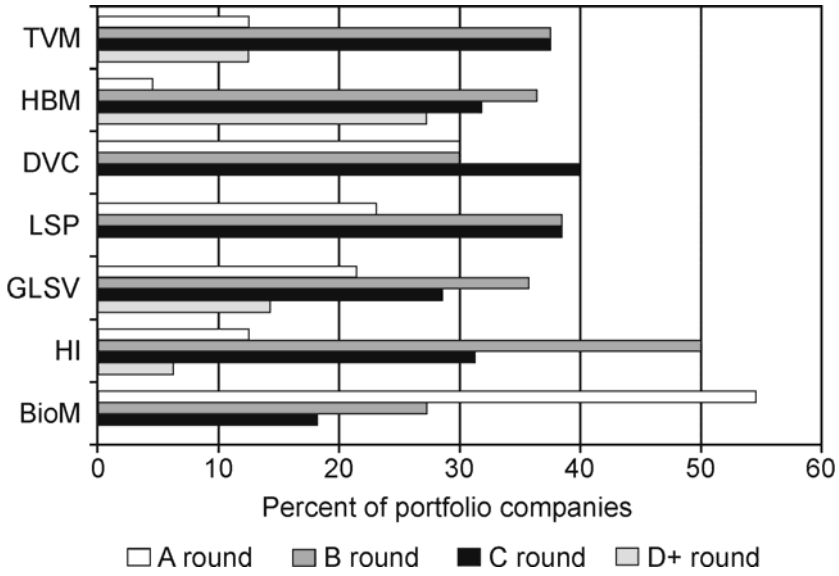


Figure 21: Development stages of life science portfolio companies

In summary, Figure 20 and Figure 21 illustrate that the portfolios of VC firms with small funds in the sample comprise substantially more risk concerning geographic scope and investment stage focus.

7.4.2 Business areas of life science portfolio companies

The following Figure 22 displays the distribution of portfolio companies among the business areas diagnostics, drug development, medtech and service/supply.

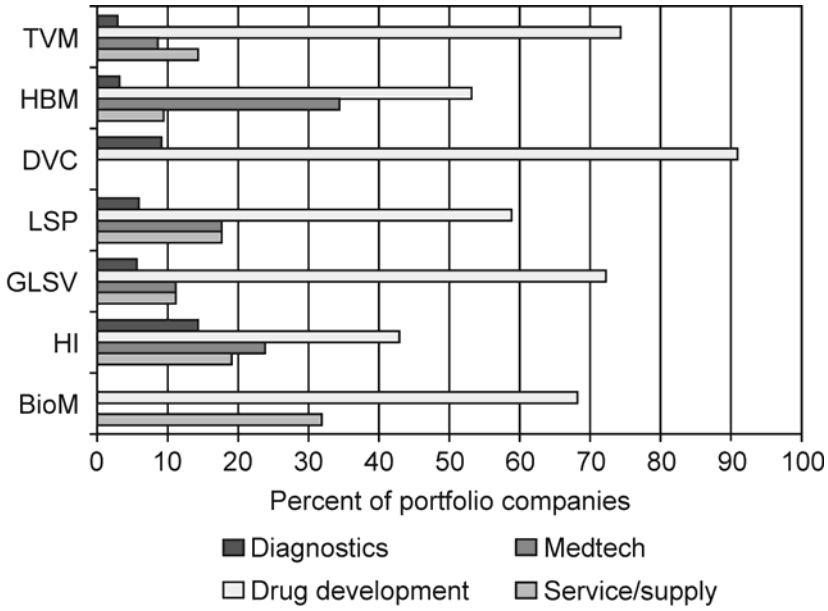


Figure 22: Business areas of life science portfolio companies

Results illustrate that drug development companies comprise by far the largest fraction in each of the VC portfolios analysed. Percentages, however, differ substantially and range form 42 (HI) to 91 (DVC) percent. Please note that DVC, which has no specialised life science fund, comprises the highest business area risk. TVM, which has dedicated life science funds but also invests in other technology funds, ranges second (72 %), followed by all the firms which exclusively invest in life science companies.

Another striking result is that the portion of drug development portfolio companies and thus the business area risk of the portfolio is not correlated to the size of the VC firm, although smaller VC companies in the sample do not spread risk by internationalisation and late stage investment strategies.

7.4.3 Drug development sub-portfolio

Figure 23 displays the distribution of drug development portfolio firms among therapeutic markets. I distinguish therapeutic areas cancer, neurology, infection, inflammation, metabolic, cardiovascular, and others.

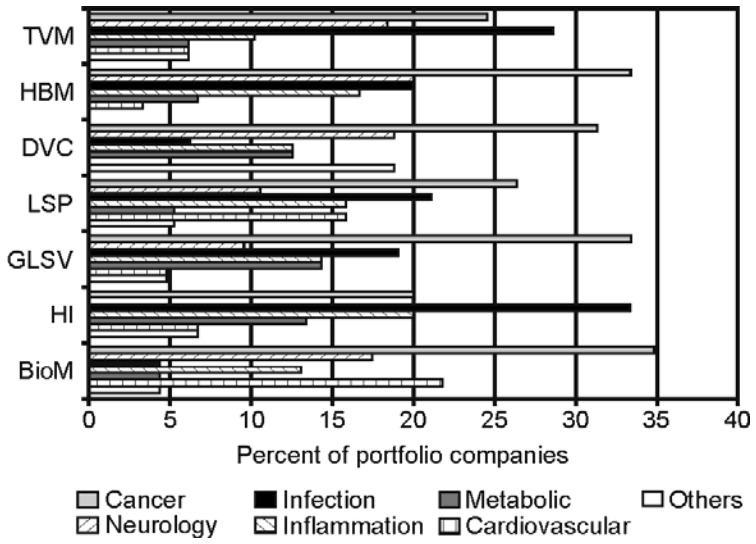


Figure 23: Therapeutic areas the drug development sub-portfolios

The results shown in Figure 23 reveal that cancer and infectious diseases are the dominant therapeutic areas of drug development companies in the portfolios analysed with five of seven VC firms focusing on cancer and two on infection. However, they only comprise about one third of all sub-portfolio firms in each case. Since the rest is widely spread among all other areas, VCs in the analysed sample do not seem to have a strong preference for one particular therapeutic market.

With regard to lead compound classes I use the categories small molecule, antibody, protein/peptide, vaccine, and others. Figure 24 shows the results.

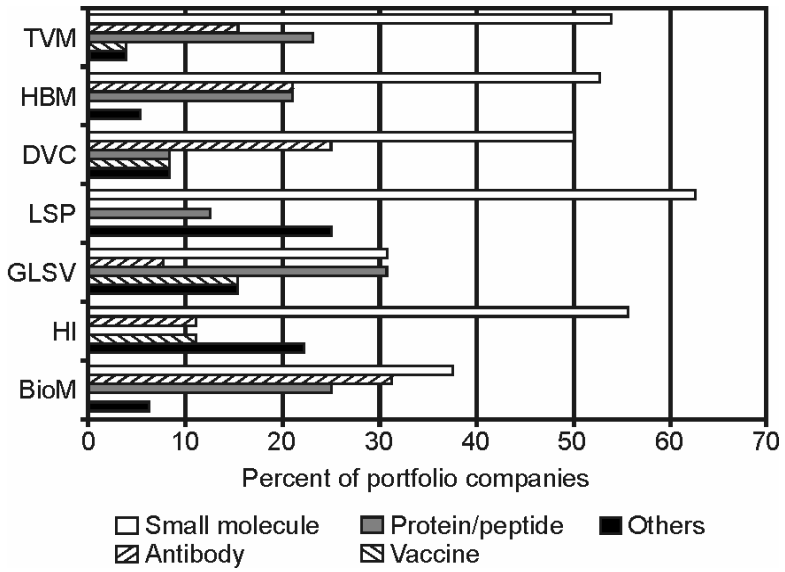


Figure 24: Lead compound classes of the drug development sub-portfolios

Analysis of the lead compound classes of drug development companies reveals that, although most companies in all portfolios develop small molecules, some VCs are much more specialised than others (Figure 24). In case of LSP, e.g., almost two third of portfolio firms are small molecule companies, whereas in the GLSV portfolio they comprise less than one third. I conclude that some but not all VCs have a preference for a particular lead compound technology.

For quantification of diversification of the drug development sub-portfolios, I calculated their entropy (Figure 25). Values range from 2.58 (HI) to 3.02 (GLSV), meaning that HI has the least diversified and GLSV the most diversified drug development sub-portfolio with regard to therapeutic markets and lead compound technologies of the portfolio companies. Thus, the GLSV sub-portfolio is the less and the HI sub-portfolio the most risky one. I do not find any correlation between size of the VC firms and risk of the drug development sub-portfolio.

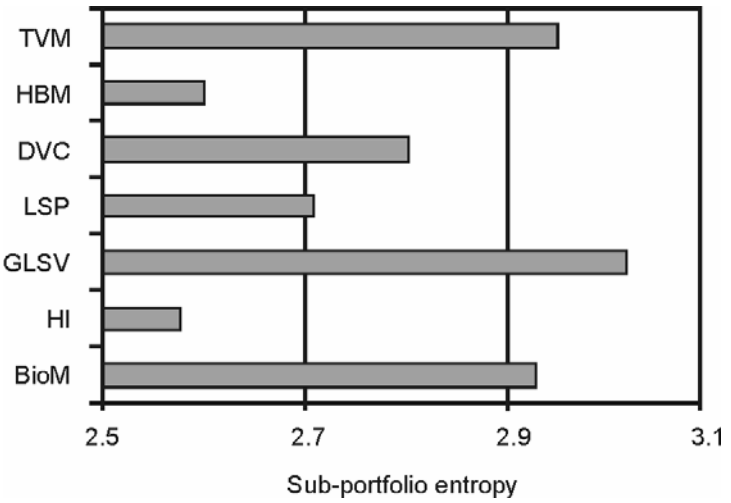


Figure 25: Entropies of drug development sub-portfolios

7.4.4 Risk distribution between overall portfolio and drug development sub-portfolio

I finally analysed whether the overall business area risk and the risk within the drug development sub-portfolio of the VC firms are correlated. Since I cannot explicitly quantify risk, as an approximation I categorise business area risk as high or low, depending on whether the portion of drug development companies is above or below average of all VC portfolios. Similarly, I distinguish high and low risk of drug development sub-portfolios depending on whether the entropy of the sub-portfolio is below or above average of all portfolios analysed. The matrix in Figure 26 summarises the results.

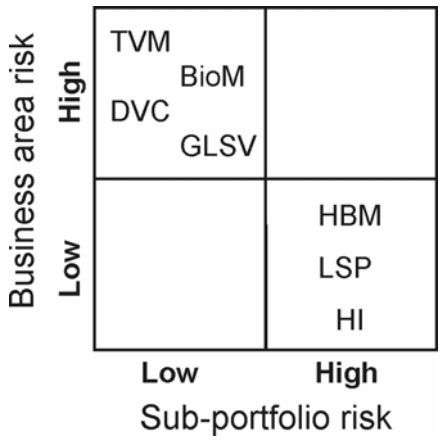


Figure 26: Distribution of risk between business areas of portfolio firms and drug development sub-portfolio

Only the quadrants on the upper left and the lower right in the matrix are occupied. Life science portfolios with a larger portion of drug development firms and thus a higher business area risk have a more diversified drug development sub-portfolio and vice versa. These results suggest that VCs in the sample systematically balance risk between the business areas they invest in and therapeutic areas/lead compound classes of their drug development firms. Low or high risk in both at the same time is obviously not an investment strategy these VCs prefer. The strategy chosen is independent of the size of the VC firm and thus the risk reduction strategy with regard to geographic scope and and development stage focus of the portfolio companies.

7.5 Discussion

In this study I introduced a framework for the analysis of investment strategies of life science VC firms and applied it to seven VC portfolios. Below I discuss the validity of the framework (Section 7.5.1) and the findings I gained by its application (Sections 7.5.2) and compare both to the interview data (Table 16). I also comment on factors which were not part of the applied framework but turned out to influence portfolio diversification according to the interview data (Sections 7.5.3 and 7.5.4, Table 17 and Table 18).

7.5.1 Validity and relevance of the framework

The theoretical framework of this study framework draws on the assumption that VCs spread their risk in industry-specialised life science portfolios along the dimensions of business areas drug development (high risk) vs. diagnostics, medtech, and service/supply firms (low risk). Moreover, I propose that diversification of drug development firms among different lead compound technologies and different therapeutic markets is a possibility for VCs to reduce investment risk according to modern portfolio theory (Markowitz, 1967). Application of portfolio theory is not self-evident because it assumes a passive investor and does not take synergies between investments into account (Lubatkin and Chatterjee, 1994). Since VCs have substantial influence on the management of their portfolio firms, one could argue that they are active investors. In this case corporate diversification theory would apply and

diversification and risk would be related in a U-shaped manner with minimal risk at a medium degree of diversification (Lubatkin and Chatterjee, 1994).

As the quotations in Table 16 show, VCs do indeed aim to diversify their portfolio according to the categories of the framework. Moreover, the statements of the VCs demonstrate that the framework largely reflects their understanding of risk regarding investment stage and internationalisation. The quotations also illustrate that application of portfolio theory is valid since VC managers stress the importance of the "stand alone" criteria for selection of portfolio firms. Synergies are only relevant as investment criteria for large VCs like TVM, which selects investments within "topic clusters". Of the VC firms interviewed which are not parts of the sample, only the manager of 3i, a large and publicly traded UK-based company, claimed that potential synergies between portfolio companies contribute to their investment decision (Table 16). These findings are consistent with previous research showing that fit with other portfolio investees is important for only a very minor amount of VCs (Muzyka et al., 1996).

VC firm	**Quotations (examples)**
DVC	"We invest in three big areas: service/tools, diagnostics and therapeutics. Another one would be medtech, but this is not our focus. [...] The chances to get a therapeutic product through the clinic are minimal. Service companies comprise much less risk for investors. [...] You need to balance the risk between the therapeutics companies. You need to invest in different [lead compound] technologies and address different markets [therapeutic areas]. [...] In early investment phases, risk is enormous and you only do it because you get a large portion of the company for little money."
Apax	"We do not invest with the aim to merge companies afterwards within the portfolio. They must be able to survive alone. You will never have enough firms to follow this strategy of within-portfolio consolidation from the beginning. [...] Besides the therapeutics, diagnostics, and service firms we invest in medtech with a focus on mature companies."

LSP	"We invest our money according to three dimensions: business areas of the companies (therapeutics, diagnostics, supply, medtech), investment stage (mostly early), and geographic scope – America and Europe. In this pattern we like to have at least one investment in each field to spread our risk. We try to avoid investing in firms doing more or less the same. [...] I do not think that, from a risk perspective, it makes sense to focus on one particular technology. If I now like RNAi and do it only and at another point in time I follow another hype – this will never work out well and I consider it as very problematic."
TVM	"Real VC business has to do with high risk and therefore early stage investments. [...] We manage our risk by diversification according to geographic scope, investment phases, and what the firms do [business areas]. [...] We usually invest in different "topic cluster" where we aim to have more than one investment. "
Earlybird	"It is our philosophy to diversify broadly. [...] We have a small fund, and we need to spread our risk."
3i	"We analyse potential investments with regard to their stand alone capability or whether they are a potential donor or acceptor firm in M&As with other portfolio firms."

Table 16: Examples from interview data illustrating framework validity and investment strategies

7.5.2 Geographic scope and investment stage focus

The framework of this analysis suggests that, in order to reduce their risk arising from a focus on narrow geographic scope and early stage investments, the small VCs of the sample should invest less in drug development firms and spread these more across different lead compound technologies and therapeutic markets than the large firms, which invest with a broader geographic scope and more in late-stage investees. However, I do not find systematic differences in diversification strategies. As Figure 26 demonstrates, BioM and TVM, the smallest and largest firm in the sample, follow a similar diversification strategy. HI and HBM, the second smallest and second largest firm, also apply a similar strategy, which differs from the one of BioM/TVM. I conclude that diversification within the life science portfolio is important for any VC, regardless of size, geographic scope and investment stage focus. This interpretation is in line with the interview data. Interviewees at TVM, DVC, LSP, and BioM all state in a similar manner the importance of diversification between lead compound technologies/therapeutic markets and/or the need to invest in business areas medtech,

diagnostics, and service/supply as a means to reduce investment risk (Table 16, Table 17).

VC firm	Quotations (examples)
BioM	"We do not invest in any company. Our aim is to select the good ones – although with a regional and very early stage focus – and finally get a profitable exit. This is what all is about, also for us."
TVM	"We introduced specialised life science funds only upon request of our investors because they wanted more opportunities to diversify their risk."
Apax	"We do not diversify our risk systematically within healthcare, because we have one large fund comprising six industries. Therefore, it would not make sense. We view any portfolio company as sole standing and try to promote it."
IKB	"We invest 70% in [non-life science] established companies and do only about 30% venture capital. This is our way of risk diversification since we can transfer revenues between both. [...] Our portfolio consists only of drug development firms including one company doing cell therapy. We have a strong focus on cardiovascular and cancer, we do not invest in, e.g., CNS at the moment."

Table 17: Examples from interview data illustrating the effect of geographic scope, stage focus, investor base and non-life science investments on diversification of life science portfolios

The findings of this study are in contrast to existing literature on non-industry specialised VCs. Specifically, Gupta and Sapienza (1992) found that large firms invest more across different industries. Moreover, VC literature claims that non-industry specialised VCs that focus on risky early stage ventures tend to have a narrower industry focus (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993) because industry specialisation allows VCs to build up a knowledge base including technological, market, and product expertise, as a means to control risk when judging new investments. Although these studies were done in the USA where VCs invest more in early stage ventures and have a need for higher returns on investments as compared to Continental Europe (Manigart et al., 2002), which in turn might demand a higher degree of specialisation than for firms in the sample of this study, these differences between industry- and non-industry specialised VCs suggest an interesting interpretation. Specifically, specialisation of the VCs' know-how within the one industry on, for example, one business area or one particular technology would not contribute to risk reduction. This conclusion is supported by the interview data (Table 16). Obviously, VCs with experience in the life science field can similarly well select

and, after investment, add value to portfolio firms developing diagnostics, drugs, medtech, and firms offering service/supply. It appears that specialisation on the industry level is the optimum for VCs to build up specific know-how, networks, and reputation.

7.5.3 Investor base and non-life science investments

The sample of this study included both, independent VCs as well as VC firms which have a mixed investor base of public and private investors (BioM, HI). Existing literature is inconsistent with regard to the effect a differing investor base has on risk reduction strategies of the companies. Manigart et al. (2002) found that independent VCs have a higher required return per investment than public VCs because the latter ones might have 'unlimited access' to finance and therefore a different risk perception. In contrast, Gupta and Sapienza (1992) found no difference between public and independent VCs with regard to across-industry diversification. The findings presented here are consistent with the latter study. BioM and HI do not follow portfolio diversification and risk reduction strategies different from the independent VCs (Figure 26). Specifically, they do not invest in a riskier portfolio by choosing a strategy comprising high business area and high drug development sub-portfolio risk. The interviewee at BioM supported the view that risk reduction is crucial for partially public VCs as well (Table 17).

The analysis revealed that the two VC firms which do not only focus on life sciences (TVM, DVC) have the highest fractions of drug development firms in their portfolios which thus comprise the highest business area risks in the sample of this study. This suggests that diversification into industries which are less capital-intensive and risky (such as information technology) enables VCs to follow a riskier strategy within their life science portfolio.[15] The conclusion is supported by VC managers of firms which were not part of the portfolio analysis. For example, the interviewee at Apax, a large and established VC firm based in the UK, stressed that the company does not follow any systematic risk reduction strategy within its life science investments since it has the possibility to spread risk between industries (Table 17). Similarly, the interviewee at

[15] Please note that this conclusion only holds true under the assumption that diversification within versus across funds does only impact the investment risk of VC investors, but not the risk of the VC firm itself, which is the focus of this study. The assumption is fundamental and discussed in detail at the beginning of Section 7.2.

IKB, a German investment bank doing only 30% VC investments (remaining 70% silent partnerships in larger firms and MBI/MBOs), mentioned that the possibility to spread risk among other industries allows the firm to pick only the life science investees which they view as most promising regardless of their specific business area (Table 17).

7.5.4 Other variables influencing diversification of life science VCs

The theoretical sampling of this study allowed to control – to a certain extent – for other strategies that VCs use for reducing investment risk, which might interfere with their diversification strategy. From the interview data with managers of VC firms outside the sample, I am able to shed some light on these effects.

In the sample I included only VCs which prefer investing as a syndicate leader. I gained some insight on the effect of syndication strategy on life science VCs' risk attitude by drawing on interview data with a manager at IKB, which prefers to invest as a syndicate follower. The life science portfolio of IKB consists of nine firms (overall VC portfolio 22 firms), all of which focus on biotherapeutics. Additionally, the portfolio has a strong cancer and cardiovascular focus. According to the theoretical framework, it would thus represent both, high business area risk and high risk within the drug development sub-portfolio, in contrast to the investment strategies followed by VC firms in the sample of this study. The IKB interviewee confirmed that, in addition to investing in more mature firms with a non-life science focus, IKB's syndicate follower strategy aims at risk reduction (Table 18). IKB therefore can focus on risky investments with high revenue potential. However, also the interviewee at LSP, which does primarily lead investments, stressed the importance of syndication in general due to the risky nature of life science investments (Table 18). Since there is, to my knowledge, no literature available so far which analyses the effect of syndication strategies on portfolio diversification across or within industries in detail, I encourage scholars to follow this avenue in future research.

VC firm	Quotations (examples)
IKB	"In VC, we mainly do co-investments. This allows us to draw on the experience of the lead investor. [...] For each investment, we outsource an additional technical due diligence to specialists in the field. [...] We try to minimise risk for each investment."
LSP	"The size of syndicates significantly increased over the last years, particularly in the risky life sciences field. There is basically no VC who does not try to acquire as many syndication partners as possible."
TVM	"We use our expertise to identify potential projects in different areas. And we expand it to new areas like RNAi recently. However, we also have consultants from industry which we meet regularly to discuss these potential investments."
Earlybird	"Although if we have gained expertise in one area, we only do two or three investments there."
BioM	"Sometimes you would indeed prefer the one or the other technology to supplement the portfolio. But it is just not always possible to get the right company."
DVC	"You are not always able to get what you want and what would theoretically fit best. [...] There are always certain phases. At the moment, most VCs invest in firms which develop therapeutics. But there were also phases in which basic technologies and tools were the centre of interest. It changes. [...] Of course we try to get a balanced portfolio, but it also depends on the opportunities you get."
Apax	"There are meanwhile therapeutic areas which are overcrowded. For example, I would not invest in an early stage cancer venture at the moment. [...] However, CNS is very interesting, which was different a few years ago. On the other hand, gene therapy is out. [...] All fields are so complex that you will never have experience in detail. You always need to draw on the opinion of external experts. Your own knowledge is only sufficient for initial [technology] selection."

Table 18: Examples from interview data illustrating the effect of syndication, expertise, deal flow generation, and technological trends on diversification of life science portfolios

Another variable which I aimed at controlling for by theoretical sampling is the difference in experience and expertise of VC firms. I only included firms with significant experience in the Continental European market. One might assume that VCs only invest in technologies they have knowledge and expertise in and that thus diversification among technologies is more limited for inexperienced VCs. However, the interview data indicate that inexperienced VCs such as IKB as well as experienced VCs such as TVM are not capable of gaining expertise in every technology, in

particular when it is new on the market (Table 18). Similarly, the interviewee at Apax, a well established VC firm from the UK, claimed that inclusion of external experts is essential because of the technological complexity (Table 18). The interviews thus suggest that missing expertise in a technological field does not severely limit VC's opportunities of portfolio diversification since this expertise has to be acquired from outside even by experienced firms.

In contrast, a limitation of portfolio diversification mentioned by the interviewees was the inability to generate the desired deal flow. Efficient diversification as a means to reduce risk is only possible when VCs are able to select life science investments in business areas and lead compound technologies/therapeutic markets from a broad pool of capital-seeking start-ups. However, two interviewees stressed that it is often impossible to get an investment with significant potential in their area of interest. Interestingly, one interviewee was from the smallest firm of the sample with regional and early stage focus (BioM), whereas the other was from a large VC firm with investees in all development stages spread across Europe (DVC) (Table 18). This suggests that deal flow generation might be a factor influencing the diversification strategies of most VC firms, in particular when focused on one industry. Due to the limited research on this issue (Wright and Robbie, 1998), I encourage scholars to analyse the variables impacting deal flow generation more systematically.

Finally, several of the interviewees pointed to the fact that the current development of technology has a major influence on diversification of their portfolio. In particular in the dynamic life science field new, "disruptive technologies" (DVC), are not seldom. One recent example is RNAi technology, which was mainly developed in 2002 and entitled as "billion dollar breakthrough" by the *Fortune Magazine* in 2003. With these technologies, VCs need to be quick in capturing the chance to get pioneering investees. On the other hand, interviewees also reported that some technologies and markets such as cancer become overcrowded and that they would therefore not invest in them again at the moment (Table 17, Table 18).

7.6 Limitations and future research

This study is a first step to understand how diversification of industry-specialised portfolios can contribute to macro risk reduction strategies of VC firms, and which factors might influence portfolio diversification. As all studies, it has limitations which suggest avenues for further research.

Firstly, the generalisability of the findings is limited due to the sample size of only seven firms. Large scale studies are necessary to corroborate the findings presented here. The framework might also be useful for analysis of a large number of portfolios and subsequent statistical data evaluation. Since there is only a limited amount of VCs in each country holding a significant number of life science investments, an international effort as pursued in previous studies (e.g., Sapienza et al., 1994; Sapienza et al., 1995; Manigart et al., 2002) might be necessary.

Secondly, I investigate only VC firms based in Continental Europe. The largest VC companies, however, are located in the USA and the UK. Some of these firms have much larger funds than the ones in the sample of this study and hold portfolios with more than 100 companies spread all over the world. Risk within these portfolios might be balanced differently than in the sample I used, for example with more emphasis on potential synergies between the portfolio companies. Moreover, the VC markets in the UK and the US are more developed and more liquid than the markets in Continental Europe, which might also impact diversification strategies as discussed above. It will be interesting to apply the framework of this study to large VC firms from the USA and the UK in order to reveal differences to the results presented here.

Finally, the interview data unravelled a number of possible antecedents of portfolio diversification such as syndication, deal flow generation, and technological trends. To my knowledge, so far no literature is available on how these factor influence diversification of non-industry specialised as well as industry-specialised portfolios. Future research might shed light on these certainly interesting issues.

8 Conclusions and new avenues of bioentrepreneurship research

In this thesis I introduced five empirical studies all of which investigated important and cutting-edge issues of bioentrepreneurship research. I employed qualitative case studies as well as a large-scale experimental design, and addressed the studies to practitioners as well as management and entrepreneurship scholars. Moreover, I took into account perspectives of the industry, bioentrepreneurs, and biotech venture capital investors. In the following Section 8.1, I conclude this thesis by briefly summarising the results I obtained and the contributions I made. I will close with suggesting new avenues for bioentrepreneurship research in Section 8.2.

8.1 Summary of results and contributions

In the first of the empirical studies in Chapter 3 I analysed the development of the German biotechnology industry during the hostile financing environment in the years 2002 – 2004. I employed the theoretical perspectives of population ecology and evolutionary economics. One of my key findings is that the development of the sector is best explained by application of both theoretical lenses in parallel, in agreement with recent theoretical work on the evolution of organisations (Valle, 2002). Whereas most existing work offers and tests competing hypotheses derived from both approaches (e.g., Shane and Kolvereid, 1995), I show that the assumption of external adaptation mechanisms (insolvencies and M&As) as postulated by population ecologists, as well as internal adaptation mechanisms (changes in organisational routines and strategies) according to the predictions of evolutionary economics scholars are necessary to understand why the German biotech industry experienced a much weaker consolidation in the years 2002 – 2004 than assumed by industry experts. Drawing on in-depth case studies of bioventures which successfully adapted their financing routines to the new environmental context, I also add to the literature on strategies of entrepreneurial firms. I demonstrate that young biotech firms show considerable strategic flexibility and are, in times of tight equity markets, able to achieve substantial financing through partnering of product candidates in strategic alliances and changing their business model towards more service orientation. Biotech ventures also have a remarkable cost saving potential

through downsizing of their operations. Finally, M&As with other bioentrepreneurial firms may contribute to secure support of investors and lead to further capital infusion in difficult environments. These findings do not only extend scientific literature, but constitute a valuable agenda for bioentrepreneurs demonstrating how to ensure survival of their companies in a hostile financing context.

In Chapter 4 I introduced a practitioner-oriented empirical study which was addressed to managers of bioentrepreneurial firms. This study is one of the first to analyse M&A deals between small and young firms. This is particularly important in the bioentrepreneurial context, because a failed M&A may severely threaten the life of a bioventure due to its limited resource base. By drawing on a comparative case study approach, I illustrated motives, benefits, and problems which may arise when two entrepreneurial biotech firms decide to merge. I identified several M&A motives specific for the bioentrepreneurial context such as the integration of the partners' technologies, the desire to gain a critical mass of projects, and the access to the partner's networks and experienced management team. Among the main benefits were an enhanced visibility for investors, a faster rate of product development, an extension of the venture's product pipeline, and the possibility to escape a hostile financing environment through an international M&A. Moreover, I was able to unravel major problems which may arise when two bioventures merge. In contrast to the majority of existing studies, I also analysed problems which arise before the M&A deal such as the inability to find the right partner and the opposition of shareholders. Problems that occur during post-merger integration include the incompatibility of the partners' technologies and the difficulty to control financial issues in a subsidiary abroad. Besides providing valuable insights for bioentrepreneurs which consider an M&A as a strategic option for their company, the results also indicate possible future development paths of M&A activities in the German biotech industry. In line with industry experts (Ernst & Young, 2004) I concluded that M&A hurdles which have their roots in the behaviour of management as well as investors will probably continue to exist in the future.

The scope of the study I introduced in Chapter 5 was to develop and empirically test management and entrepreneurship theory. I investigated the motivation of biotech managers to seek new alliances with other firms from an ex ante perspective. Specifically, I analysed how the situation of a biotech venture before alliance formation

influences the decision of its managers to look for new alliance partners. Using an experimental design and conjoint analysis, I found that the answer to the question "to ally or not to ally" from bioventure managers appears to depend on the capabilities, governance, and context of their firm. The decision is complex since these factors interact. This finding on its own is remarkable because it provides the tangible evidence that resources/capabilities are crucial in the decision policies of managers that the capabilities/RBV school of thought requires. Moreover, the results stress the necessity for RBV scholars to take into account possible interactions between resources and capabilities rather than treating them independently. However, the implications for the growing literature on strategic alliances are even more important. Of particular value is the illumination of the decision policies venture managers use to consider whether to ally. The findings on the centrality of considerations of venture liquidity in biotech managers' decision policies help to explain prior results that find over commitment to alliances (Deeds and Hill, 1996), higher rates of renegotiation for alliances entered during poor funding environments (Lerner and Tsai, 1999), and that alliances are in fact detrimental to venture survival (Alvarez and Barney, 2001). Prior explanations have relied primarily on the bounded rationality, hubris, and other non-rational explanations for these outcomes. But when the decisions are placed in the context of low levels of firm liquidity and the threat this poses to the venture's survival, biotech managers' decision policies appear to be a rational attempt to make the best of bad circumstances. Venture managers seem to prefer internally controlled resources and funds raised via the capital markets to those accessed via alliances, which indicates that they recognise the risks of alliances and may in fact view entering an alliance as "making a deal with the devil". An important implication for going forward researchers examining alliance performance and their impact on firm performance is that they need to assess the condition of the venture at the time in which it entered the alliance. This condition appears to play a major role in the motivation for the alliance and will quite possibly have significant explanatory power for alliance performance and venture survival.

Chapter 6 was again addressed to biotech practitioners and illustrated how a bioentrepreneurial venture can successfully escape a technology breakdown. Because young biotech firms are, in contrast to large corporations, often built on one single technology, a breakdown means a life-threatening crisis for most of the ventures.

Therefore, it is important for bioentrepreneurs to provide insights how to escape such a crisis. I introduced an exploratory case study of Curacyte, a German biotech firm which suffered technological breakdown half a year after its foundation and successfully managed this situation. I demonstrated that an aggressive business development and project acquisition strategy consisting of in-house technology development, in-licensing activities, and M&As may enable a bioventure to build up a new technological basis and keep support of investors. Since this strategy might be associated with a shift or an extension of the venture's core competencies, managerial flexibility is essential. Moreover, I showed that efficient management of financial, organisational, human, and social resources is crucial for successful crisis management. In case that a technological breakdown is detected, financial resources should be concentrated on corroborating the findings in order to ensure a maximum of liquidity for acquisition of the new technology. Entering into an M&A with another company may not only contribute to technology acquisition, but also to raise further capital from VC investors. Knowledge related to the new technology may be integrated in the firm by employing key technology developers and entering into long-term collaborations with the institutions where the projects are acquired from. I also demonstrated that, in line with literature on crisis management in large corporations (Pearson and Mitroff, 1993; Pearson and Clair, 1998), management of human resources is crucial. Bioentrepreneurs are well advised to accept staff turnover and concentrate on hiring of new personnel. Finally, I showed that an open and honest communication contributed to keep support of both, employees as well as investors, during the crisis management process. The findings of this study may not only be interesting for managers of bioentrepreneurial firms but also of larger biotech companies as many similarities with the corporate renewal process of Celltech, a large UK-based biotech firm, suggest (McNamara and Baden-Fuller, 1999).

In the final empirical study in Chapter 7 I switched to the perspective of biotech investors. The focus of analysis were portfolio diversification strategies of VCs active in the biotechnology and life science industry. The study's aim was to contribute to VC literature and extend the concept of portfolio diversification and risk reduction to industry-specialised portfolios. As a first contribution to the literature, I introduced a theoretical framework for analysis of risk distribution within life science portfolios. This framework was derived from practitioner-oriented literature and interviews with

VC managers and distinguished between investees active in business areas drug development (high risk), and diagnostics, service/supply, and medical technology (low risk). Moreover, VCs may reduce their investment risk by distributing their drug development investees among different therapeutic markets and lead compound technologies. Drawing on a comparative case study approach, I applied this framework to the life science portfolios of seven Central European VC firms. One finding was that the small VC firms in the sample did not reduce their risk more than the large firms by investing in less risky business areas or diversifying their drug development sub-portfolio more among different therapeutic markets and/or lead compound technologies. This was surprising since the small firms invested with a narrower geographic scope and focused more on early stage investees and thus had a much riskier portfolio with regard to these two variables than the large firms. Instead, two dominant diversification strategies emerged from the analysis regardless of the VC firms' size. VCs invested either with a focus on risky drug development firms and distributed these more among markets and technologies, or they diversified their drug development sub-portfolio less but then invested more in less risky business areas diagnostics, service/supply, and medtech. These findings in combination with interview data led to the conclusion that, in contrast to non-industry specialised VC portfolios where specialisation rather than diversification contributes to reduction of the investment risk (Gupta and Sapienza, 1992; Norton and Tenenbaum, 1993), the opposite appears to be true in the context of industry-specialised portfolios. The latter are well diversified among technologies and markets. Thus, specialisation on the industry level is probably the optimum for VCs to reduce their investment risk by accumulation of specific knowledge, networks, and reputation. Besides this interesting finding, interview data allowed me to unravel some determinants of portfolio diversification such as the inability to create the desired deal flow or the necessity to follow technological trends, which were undescribed in VC literature so far.

8.2 The road ahead

At the beginning of this thesis I demonstrated that the biotechnology industry has gained significant economic importance over the last two decades and nowadays has a significant impact on our everyday life. It is a common opinion that this influence will

keep growing over the next decades because the biotech sector is still young and entrepreneurial and growing globally (Rifkin, 1999). New technologies are emerging continuously and promise not only to contribute to wealth of humankind in the future by, e.g., enabling the development of new drugs for so far unmet clinical needs, but also to offer plenty of opportunities for bioentrepreneurs to found and grow new ventures. Thus, it is important that the literature of bioentrepreneurship, which is even younger than the industry it explores, continues to grow as well.

In this thesis, I contributed to bioentrepreneurship literature with studies in the fields of organisational evolution, M&As, strategic alliances, crisis management, and venture capital financing. Whereas each of these empirical studies has by itself limitations which suggest avenues for future research as I described in the respective chapters, there is also a need for scholars to explore other fields. I will close this thesis by suggesting roads for researchers which are underexplored in bioentrepreneurship literature so far.

Firstly, an interesting stream of research could focus on project management in bioentrepreneurial firms. As I described in Chapter 2, biotechnological R&D projects are characterised by enormous capital intensity on the one hand and a high failure risk on the other hand. Thus, it is a particular challenge for biotech managers to build up a substantial pipeline of product candidates under development. The Curacyte case study I introduced in Chapter 6 demonstrated that the management is continuously confronted with the decision to continue or stop projects, even if these are in advanced development stages and thus have required significant R&D expenditures so far. How many R&D projects should a bioventure follow in order to compensate for inevitable failures? How related or diversified should the project portfolio be among markets and technologies? Do the considerable sunk costs delay the decision of bioentrepreneurs to stop an underperforming R&D project and lead to escalating commitment as postulated by project management scholars (Garland, 1990)? The last one of these research questions appears to be particularly suited for an experimental design as I employed in Chapter 5, since conjoint analysis has been used in studies on escalating commitment of software projects before (Keil et al., 2000; Sabherwal et al., 2003).

A second stream of literature might explore the impact of human capital in bioentrepreneurial firms. Since bioventures are research-intensive and have a very limited resource base, it is at the same time challenging and important to guarantee the acquisition of top scientists and top management. Zucker et al. (1998) showed that local proximity to top scientists at universities and research institutes is a precondition for a high foundation rate of biotech firms. However, so far little is known about the optimal configuration of a research team in a bioventure. Are interdisciplinary teams more successful than homogeneous ones? Which team size is the optimum? And how do group processes influence the scientific output of the team? Answering these questions may enable bioentrepreneurial firms to establish a more efficient and successful R&D process and enhance innovative output. With regard to managerial capital, it is known that managers' characteristics and strategic choices are crucial for the performance of every corporation (Hambrick and Mason, 1984; Carpenter et al., 2004). So far research has mostly analysed the characteristics of management teams in large firms (e.g., Hambrick et al., 1996; Pegels et al., 2000; Knight et al., 1999). However, in entrepreneurial firms the impact of the management team on firm performance is particularly high (Reich, 1987; Gersick, 1994). The Curacyte case study I introduced in Chapter 6 demonstrated the importance of management skills for survival and success of bioventures. Moreover, it is a frequent problem for young biotech firms that they are led by scientists who developed the company's technology, but have no management experience (Ernst & Young, 2000b). Replacing these scientists by professional outside management may lead to a loss of essential knowledge related to the technology. Furthermore, the egos of the scientists may make it difficult to engage outside management to take the leading position of the company. Should scientific founders continue as part of the top management team or even as CEO? If not, when is the optimal time point for succession? How should the other members of the TMT be constituted? Which impact does the educational background of team members have on the success of the bioventure? It would not only be important for biotech firms to explore the impact of TMT characteristics on the company's success, but also for VC investors which often contribute to selection of TMT members in their portfolio firms (Hellmann and Puri, 2002).

Thirdly, there is also a considerable need to study bioentrepreneurship from the perspective of investors. In this thesis, I analysed how VCs active in the biotechnology and life science field can reduce their investment risk by portfolio diversification among different markets and technologies (Chapter 7). However, as described above, bioventures have themselves the possibility to diversify their project portfolio according to these two variables. Exploratory work by zu Knyphausen-Aufseß et al. (2005) suggests that portfolio diversification of biotech VC investors and project diversification of their investees may not be independent since VCs are active investors with considerable influence on their investees (Sapienza et al., 1994; Lerner, 1995b). This influence may enable them to transfer projects between firms, e.g. by M&A activities among investees, with the aim of creating more robust companies within their portfolio. Moreover, investment strategies of VC fund investors may also influence VC portfolio diversification, thus creating a complex, interdependent three-level phenomenon (zu Knyphausen-Aufseß et al., 2005) which is so far unexplored in the literature.

Another stream of research on biotech investors may analyse the active role VCs play in bioventure development. VCs are known to monitor and control their investees through participation in the board of directors, contractual covenants, and other mechanisms (Barney, 1994; Lerner, 1995b). Furthermore, they add value to their investees by assisting the management in daily business, personnel management, selection of executives, strategic analysis, and financial issues (MacMillan et al., 1988; Sapienza, 1992; Hellmann and Puri, 2000; Fried and Hisrich, 1995). The need for control and active involvement appears to be particularly high in bioentrepreneurial firms since these demand large amounts of capital and are often led by inexperienced scientific founders. However, too tight control may lead to demotivation of the scientists and cause a staff turnover. Because biotechnology is knowledge-intensive and the knowledge of a firm is mainly embedded in its human capital (Barney and Wright, 1998), a turnover can lead to the loss of the bioventure's most important resource. Thus, there appears to be a trade-off for VCs in controlling and influencing their high-risk investees on the one hand and guaranteeing enough freedom for sustaining motivation of staff on the other hand. To my knowledge, little is known on the optimal level of VC control and involvement in their portfolio companies. Due to the reasons I mentioned

above, the biotechnology industry may constitute an optimal context to address this important topic.

Finally, there are also opportunities for economists to contribute to the understanding of processes in the entrepreneurial biotechnology industry. An important and still underexplored issue is the role public policy plays in industry development. In Germany, an aggressive interventionist government policy (BioRegio Contest) promoted the formation of a large number of bioventures in the late 1990s, e.g. by providing seed capital to firms and establishing biotech clusters (Dohse, 2000). Existing research suggests that the government "efforts of interventionism were not able to overcome blockages that exist in the German system of biotech innovation. On the contrary, those government strategies have enhanced to a large extent the structural inertia that made the German system inappropriate for biotech development needs" (Giesecke, 2000: 221). However, it is important to note that this study was performed in the late 1990s and that the industry has developed significantly since. Given the fact that the German industry is less than a decade old and that Germany does neither have an established VC industry nor an entrepreneurial culture like, e.g., the USA, the high number of biotech firms in Germany today may lead one to believe that the interventionist policy was quite successful. This assumption is supported by the fact that the number of bioventures remained surprisingly high during the hostile financing environment in the years 2002 – 2004 (Chapter 3). Clearly, more research is needed to analyse the impact of policy measures on the development of the biotech industry more systematically and over a longer period of time. A new methodological approach may be an experimental design as I employed in Chapter 5. Different profiles could describe different hypothetical policy programs, and bioentrepreneurs may assess whether these programs would meet their needs and facilitate development of their company. These studies could provide important insights for both bioentrepreneurs as well as policy makers.

In summary, the discussion above illustrates that, as the biotechnology industry itself, bioentrepreneurship research is still an underexplored field with plenty of opportunities for researchers. Although we have yet learned a lot, we still know little. This thesis is an attempt to further advance our limited understanding of different phenomena in the

bioentrepreneurial context. In the future, scholars from different disciplines need to explore further issues along the exciting road ahead.

9 References

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10 Summary in German

Die vorliegende Arbeit trägt den Titel “Bioentrepreneurship in Germany” und beschäftigt sich mit unterschiedlichen Themengebieten, die alle im Bereich Gründungsforschung an jungen Biotechnologieunternehmen angesiedelt sind. Dieser Forschungszweig ist aus mehreren Gründen von Bedeutung. Zum einen zählt die Biotechnologie zu den vielversprechendsten Technologiezweigen des 21. Jahrhunderts. Moderne biotechnologische Produkte und Verfahren ermöglichen die Erforschung molekularer Prozesse in menschlichen, tierischen, pflanzlichen und bakteriellen Organismen, wodurch z. B. die Entwicklung neuer Therapeutika und Diagnostika ermöglicht wird. Diese tragen nicht nur zum Wohle der Menschheit bei, sondern besitzen auch ein enormes Marktpotential. Zum anderen ist die Biotechnologiebranche vor allem in Deutschland noch jung und besteht vorwiegend aus Startup-Firmen. Die spezifischen Charakteristika der biotechnologischen Produktentwicklung wie lange Entwicklungszyklen, hohe technologische und marktseitige Unsicherheiten und ein hoher Kapitalbedarf führen dazu, dass Forschungsergebnisse aus anderen Branchen nur bedingt auf die Biotechnologiebranche übertragbar sind. Dies macht industriespezifische Forschung wie in der vorliegenden Arbeit notwendig.

Die Arbeit besteht aus fünf empirischen Studien, die sich im biotechnologischen Kontext mit den Themen Finanzierungsstrategien, M&A-Aktivitäten, strategischen Allianzen, Krisenmanagement und Venture Capital(VC)-Finanzierung auseinandersetzen. Die Untersuchungen sind sowohl praxis- als auch theorieorientiert und beinhalten die Perspektive der Manager von Biotechnologieunternehmen sowie die Perspektive ihrer Investoren. Methodisch wird sowohl auf qualitative Fallstudien als auch auf einen großzahligen experimentellen Ansatz zurückgegriffen.

Die erste der Studien stellt eine detaillierte und theoretisch fundierte Analyse der Entwicklung der deutschen Biotechnologieindustrie unter den Bedingungen rückläufiger Kapitalmärkte in den Jahren 2002 – 2004 dar. Dabei wird unter den theoretischen Blickwinkeln der Populationsökologie und der Evolutionsökonomie untersucht, wie organisationsexterne und -interne Anpassungsmechanismen die Entwicklung der Branche erklären. Externe Anpassung findet durch eine steigende Zahl an Insolvenzen und eine sinkende Anzahl an Gründungen VC-finanzierter Unternehmen

statt. Allerdings ist die beobachtete Branchenkonsolidierung deutlich schwächer als von Industrieexperten erwartet, da sich viele Biotechnologiefirmen intern an das schwierige Finanzierungsumfeld anpassen. Vergleichende Fallstudien von Firmen zeigen, dass eine Schrumpfung des Unternehmens, ein Wechsel des Geschäftsmodells hin zu mehr Serviceorientierung, sowie ein verstärktes Engagement in strategischen Allianzen und M&A-Aktivitäten mit anderen Firmen zum Überleben der Firmen unter diesen Bedingungen beitragen können.

Gegenstand der zweiten empirischen Studie der Arbeit sind M&A-Aktivitäten junger Biotechnologie-Startups. Adressaten der Studie sind Manager dieser Unternehmen. Unter Verwendung vergleichender Fallstudien werden für den untersuchten Kontext spezifische Motive sowie potentielle Vorteile und Probleme von M&A-Transaktionen analysiert. Zu den identifizierten Motiven zählen die Integration der Technologien der M&A-Partner, das Streben nach einer „kritischen“ Unternehmensmasse und der Zugang zu dem Kontaktnetzwerk und den Managementressourcen des Partners. Als mögliche Vorteile sind eine erhöhte Sichtbarkeit für Investoren, ein Ausbau der Produkt-Pipeline, und der Zugang zu internationalen Kapitalmärkten im Falle eines internationalen M&As zu nennen. Probleme können bereits vor der Transaktion auftreten, wenn ein Unternehmen nicht den richtigen Partner findet oder keine Unterstützung von seinen Investoren erhält. Während der Post-Merger-Integration können sich zudem Schwierigkeiten bei der Integration der Technologien oder bei der Kontrolle über die Geschäftstätigkeit am neuen Standort ergeben, insbesondere wenn sich dieser im Ausland befindet. Neben diesen wichtigen Erkenntnissen für Gründer und Manager junger Biotechnologiefirmen unterstützen die Ergebnisse zudem die von Industrieexperten vertretene Meinung, dass auch in Zukunft eine effiziente Konsolidierung der deutschen Branche über M&A-Aktivitäten auf für viele Unternehmen unüberwindbare Hürden stößt.

Ziel der dritten Studie, die das Kernstück der vorliegenden Arbeit darstellt, ist die Erweiterung und empirische Überprüfung von Management- und Entrepreneurship-Theorie. Hierzu wird ein in der Literatur beschriebenes konzeptionelles Modell für die Entstehung strategischer Allianzen für den spezifischen Kontext junger Biotechnologieunternehmen operationalisiert und erweitert. Mit einem experimentellen Ansatz werden die Entscheidungen von 51 Top-Managern der deutschen

Biotechnologiebranche, neue Partner für strategische Allianzen zu suchen, analysiert. Dabei zeigt sich, dass diese Entscheidung von der Ressourcenposition, der Verfügungsgewalt über intellektuelles Eigentum und von der Umwelt der Firma abhängt. Damit trägt die Studie zu den bislang spärlichen empirischen Evidenzen zum Einfluss der Ressourcenbasis eines Unternehmens auf strategische Entscheidungen der Manager bei, wie sie nach dem ressourcenbasierten Ansatz postuliert wird. Zudem wird gezeigt, dass diese Entscheidungen komplex sind und mögliche Interaktionen zwischen Ressourcen von Managern berücksichtigt werden. Noch wichtiger jedoch sind die Beiträge der Studie zur Literatur über strategische Allianzen. Insbesondere das Ergebnis, dass eine geringe Liquidität der Firma und ein rückläufiger Kapitalmarkt die Haupttriebkräfte hinter Allianzentscheidungen sind, lassen die Ergebnisse vorhergehender Studien anderer Autoren in neuem Licht erscheinen. Diese Autoren betonen vor allem mangelnde Rationalität und das Machtstreben der Manager als Gründe für ein zu starkes Engagement vieler Firmen in Allianzen. Wird jedoch davon ausgegangen, dass viele Manager aufgrund mangelnder Liquidität und drohender Firmeninsolvenz Allianzen mit anderen Unternehmen suchen, erscheint diese Entscheidung als ein rationaler Versuch, das Beste aus einer schlechten Situation zu machen. Zu bezweifeln ist allerdings, dass diese Firmen die nötigen Ressourcen für eine erfolgreiche Abwicklung der Allianz besitzen, womit sich zumindest ein Teil des oftmals beschriebenen hohen Anteils nicht erfolgreicher Allianzen erklären lässt. Für zukünftige Forschungsarbeiten, die sich auf die Untersuchung des Erfolges strategischer Allianzen sowie den Beitrag dieser Allianzen zum Unternehmenserfolg konzentrieren, lässt sich folgern, dass die Situation der Partner bei Abschluss der Allianz ein wichtiger Parameter ist, der in den Studien berücksichtigt werden muss.

Die vierte empirische Studie dieser Arbeit ist wiederum praxisorientiert und an Manager und Gründer von Biotechnologieunternehmen adressiert. Sie zeigt anhand einer explorativen Fallstudie, wie eine junge Biotechnologiefirma auch nach dem Zusammenbruch ihrer Technologie überleben und weiter wachsen kann. Grundlage des erfolgreichen Krisenmanagements des Fallstudienunternehmens ist eine aggressive Geschäftsentwicklungs- und Projektakquisitionsstrategie, die aus der Eigenentwicklung und Einlizensierung neuer Technologien sowie einer Akquisition über M&A-Aktivitäten besteht. Daneben erweist sich auch ein effizientes Management von

finanziellen, organisatorischen, humanen und sozialen Ressourcen als essentiell für ein erfolgreiches Krisenmanagement. Um maximale Liquidität für den Krisenmanagementprozess zu garantieren, sollten im Falle eines Verdachts technologischer Invalidität alle finanziellen Mittel auf die schnelle Bestätigung dieses Verdachts konzentriert werden. Zudem kann ein M&A mit einer anderen Firma die weitere Kapitalakquisition von Investoren in dieser Zeit erleichtern. Eine Herausforderung für Manager ist die effiziente Integration des Wissens, das der neu akquirierten Technologie zugrunde liegt. Dieser Herausforderung kann entweder dadurch begegnet werden, dass die ursprünglichen Technologieentwickler in der Firma angestellt werden, oder über eine vertraglich vereinbarte, langfristig ausgerichtete Zusammenarbeit mit den Institutionen, die die Technologie ursprünglich entwickelt haben. Im Bezug auf das Humanressourcenmanagement zeigt sich, dass ein schnelles Akzeptieren einer unvermeidlichen Personalfluktuation und die Konzentration auf die Beschaffung neuen Personals während des Krisenmanagementprozesses förderlich sind. Die Kommunikation mit dem Personal sollte ebenso wie die mit den Investoren offen und ehrlich sein. Ein Vergleich mit existierender Literatur zum Krisenmanagement eines großen, englischen Biotechnologieunternehmens zeigt viele Parallelen auf und deutet an, dass die Ergebnisse der untersuchten Fallstudie auch auf größere Firmen übertragbar sind.

Die fünfte und letzte empirische Studie der vorliegenden Arbeit nimmt schließlich die Perspektive von VC-Investoren in der Biotechnologie- und Life Science-Branche ein und untersucht, inwiefern eine Diversifikation eines industriespezialisierten Investitionsportfolios zur Risikoreduzierung beitragen kann. Ziel der Studie ist ein Beitrag zur wissenschaftlichen VC-Literatur. Dieser besteht zum einen aus der Einführung eines theoretischen Analyserahmens für die Risikoverteilung in Life Science-Portfolios. Ausgehend von praxisorientierter Literatur und Interviews mit VC-Managern unterscheidet dieser Rahmen zwischen dem Life Science-Geschäftsfeld Therapeutikaentwicklung (hohes Risiko) einerseits und den Feldern Diagnostika, Auftragsforschung und Medizintechnik (niedriges Risiko) andererseits. Darüber hinaus können VCs das Risiko ihres Sub-Portfolios der Therapeutikafirmen durch eine Diversifizierung zwischen unterschiedlichen therapeutischen Märkten und Technologien (Substanzklassen) erzielen. Eine Anwendung dieses Analyserahmens im

Rahmen einer vergleichenden Fallstudienanalyse auf die Portfolios von sieben VC-Firmen zeigt, dass kleine Firmen (gemessen an dem von ihnen insgesamt verwalteten Kapital) ihr Risiko nicht mehr durch eine verstärkte Investition in risikoarme Geschäftsfelder oder eine höhere Diversifizierung ihres Sub-Portfolios der Therapeutikafirmen reduzieren als große VCs. Dies ist insofern überraschend, als dass die kleinen VC-Firmen der untersuchten Stichprobe ein höheres Investitionsrisiko durch eine regionale Fokussierung und eine Spezialisierung auf Frühphaseninvestitionen ausweisen. Stattdessen können zwei archetypische Portfoliostrategien unabhängig von der VC-Firmengröße identifiziert werden. VCs investieren entweder mit einem Fokus auf die riskanten Therapeutikaentwickler und diversifizieren dieses Sub-Portfolio dann mehr im Bezug auf Märkte und Technologien, oder sie fokussieren dieses Sub-Portfolio und investieren dafür verstärkt in weniger risikoreiche Geschäftszweige. In Kombination mit Daten aus Interviews mit VC-Managern ergibt sich somit die Schlussfolgerung, dass – im Gegensatz zu nicht-industriespezialisierten Portfolios – eine Spezialisierung auf bestimmte Märkte und Technologien nicht zu einer Risikoreduzierung des VC-Portfolios beiträgt. Spezialisierung auf Industrieebene scheint für VCs das Optimum zur Akkumulation spezifischen Wissens und zum Aufbau von Netzwerken und Reputation. Neben diesem interessanten Ergebnis zeigt die Studie, dass die Diversifikation von VC-Portfolios durch unterschiedliche, in der Literatur bislang nicht beschriebene Einflussfaktoren, wie z. B. einem mangelnden Deal-Flow oder einer Notwendigkeit zur Verfolgung technologischer Trends, beeinflusst wird.

11 Appendix

The appendix contains original data related to the empirical conjoint study in Chapter 5. All material is provided in its original language German.

11.1 Cover letter for the conjoint experiment

eXIST
Ein Programm des Bundesministeriums für Bildung und Forschung

EXIST-High Technology Entrepreneurship Postgraduate Program (EXIST-HighTEPP) Universität Bamberg

Dr. Holger Patzelt EXIST-HighTEPP Universität Bamberg
Jäckstr. 3 96052 Bamberg Tel.: 0951 863 2799 holger.patzelt@exist-hightepp.de

XXX Bioscience AG
z. Hd. XXX
Musterstrasse
Musterstadt

Bamberg, 9.2.2005

Teilnahme am Experiment

Sehr geehrter Herr Dr. XXX,

vielen Dank für Ihre Bereitschaft, an unserer Studie mitzuarbeiten. Wie telefonisch besprochen erhalten Sie anbei das Experiment und einen Rücksendeumschlag.
Ziel der Studie ist es, herauszufinden, wie Resourcen- und Umweltsituation eines Biotechstartups die Manager dazu bewegen, Partner für strategische Allianzen zu suchen. Dazu habe ich in Kollaboration mit Prof. Dean Shepherd, einem weltweit führenden Entrepreneurship-Forscher an der Leeds Business School in Boulder, Colorado, beiliegendes Experiment entwickelt. Dieses besteht aus Szenarien, die verschiedene Situationen eines hypothetischen Unternehmens beschreiben. Sie sollen nun für jede Situation den Anreiz, einen Partner für eine Allianz zu suchen, einschätzen. Die statistische Auswertung, die ich in den Monaten März bis Juni zusammen mit Prof. Shepherd in Colorado durchführen werde, ermöglicht so eine Extraktion und ein Ranking der treibenden Kräfte hinter Allianzentscheidungen.
Bitte erschrecken Sie nicht über die Dicke der Studie. Der Umfang dient lediglich der Übersichtlichkeit und damit der schnelleren Bearbeitbarkeit. Da Sie pro Seite nur ein Kreuz machen müssen, nimmt die komplette Bearbeitung nach unseren bisherigen Erfahrungen nicht mehr als 15-25 Minuten in Anspruch. Sollten Sie eine Auswertung Ihres individuellen Entscheidungsverhaltens wünschen, teilen Sie mir dies bitte mit, indem Sie Ihren Namen auf der ersten Seite der Studie vermerken.
Über das Ergebnis werde ich Sie selbstverständlich informieren. Zudem ist eine Präsentation (natürlich nur in statistisch aggregierter und damit anonymisierter Form) auf der EGOSNET Conference on Organizational Science im Juni in Berlin und anschliessende Publikation in einem internationalen Fachjournal vorgesehen.
Für eine Zusendung bis Fr., 27. Februar 2005, wäre ich Ihnen dankbar. Für weitere Fragen bzw. eine telefonische Anleitung stehe ich Ihnen jederzeit zur Verfügung.

Besten Dank für Ihre Kooperation.

Mit freundlichen Grüssen

Dr. Holger Patzelt

11.2 Introduction of the conjoint experiment

Warum gehen Biotechnologie-Start-ups Strategische Allianzen ein?

von
Dr. Holger Patzelt

EXIST-HighTEPP
Universität Bamberg
Jäckstr. 3
96052 Bamberg
Tel.: 0951 863 2799
Fax: 0951 863 1198
holger.patzelt@exist-hightepp.de

Version 4

ZWECK DER STUDIE

Die vorliegenden Studie untersucht, in welchen Unternehmenssituationen und unter welchen Umweltbedingungen Top-Manager von Biotechnologie-Start-ups Partner für Strategische Allianzen suchen.

WICHTIGE INFORMATIONEN

Bitte beantworten Sie alle Fragen der Studie, da nicht vollständig ausgefüllte Fragebögen nicht in der statistischen Analyse berücksichtigt werden können.
Vorausgehende Tests haben ergeben, dass die meisten Teilnehmer nicht mehr als **20-25 Minuten** für eine komplette Bearbeitung benötigen. Sie brauchen pro Seite des Bogens nur eine Beurteilung abzugeben. Normalerweise nimmt die Zeit für die Beurteilung einer Situation mit der Zahl der bereits bearbeiteten Situationen ab.

Alle Informationen der Studie sind streng vertraulich und werden nur in einer Form berichtet, in der keine Rückschlüsse auf Ihr individuelles Entscheidungsverhalten gezogen werden können.

Vielen Dank für Ihre Kooperation!

ANLEITUNG

Stellen Sie sich vor, Sie sind CEO der hypothetischen Firma MegaBio, die biotechnologische Produkte entwickelt. Der Sitz der Firma befindet sich in einem Biotech-Cluster in Nachbarschaft zu anderen Biotech-Firmen, Universitäten und Forschungseinrichtungen. MegaBio beschäftigt 30 Angestellte und besitzt eine proprietäre Technologie zur Produktentwicklung, die jedoch nicht kommerzialisiert wird. MegaBio's hauptsächliche Finanzierungsquelle ist Risikokapital; Umsätze durch die Vermarktung von Produkten werden noch nicht erzielt.

Sie werden nun gebeten, für die auf den folgenden Seiten dargestellten Situationen von MegaBio den Anreiz, sich nach einer Strategischen Allianz mit irgendeinem anderen Unternehmen (das hier NICHT näher beschrieben wird) umzusehen, zu beurteilen. Unter strategischer Allianz wird dabei jede Art von Partnering verstanden, also z. B. Lizenzierungen, Joint Ventures oder Minderheitsbeteiligungen. Bitte beziehen Sie sich bei Ihren Beurteilungen auf die Definitionen auf der folgenden Seite.

Bitte antworten Sie für jedes Szenario, indem Sie die Zahl auf der folgenden Skala ankreuzen, die Ihrer Beurteilung am nächsten kommt. Auf der nachfolgenden Beispielskala ist die 2 angekreuzt, um zu demonstrieren, dass Sie den Anreiz für MegaBio, einen Partner für eine Strategische Allianz zu suchen, in der vorgegebenen Situation als gering einschätzen (aber nicht sehr gering).

Sehr geringer Anreiz, eine Strategische Allianz zu suchen						**Sehr hoher Anreiz, eine Strategische Allianz zu suchen**
1	X 2	3	4	5	6	7

Manche der Situationen auf den folgenden Seiten werden Ihnen vertraut vorkommen, andere eher unwahrscheinlich erscheinen. Bitte treffen Sie Ihre Entscheidungen bestmöglich anhand der zur Verfügung gestellten Informationen für **alle** Situationen und gehen Sie davon aus, dass nicht beschriebene Unternehmens- und Umweltparameter sowie andere Faktoren für alle Situationen **konstant** sind.

Bitte trennen Sie dieses und Blatt ab und beziehen Sie sich während Ihrer Beurteilungen auf den folgenden Seiten darauf

Situationsparameter

Parameter	Ausprägung	Beschreibung
Kontakt-Netzwerk	**Ausgedehnt**	MegaBio verfügt über ein ausgedehntes Kontaktnetzwerk mit anderen Firmen, Universitäten und Forschungseinrichtungen.
	Beschränkt	MegaBio unterhält nur wenige Kontakte zu anderen Firmen, Universitäten und Forschungseinrichtungen.
Kompetition	**Hoch**	MegaBio verfolgt sehr kompetitive Projekte und befindet sich zu mehreren Firmen in unmittelbarer Konkurrenz.
	Niedrig	MegaBio verfolgt wenig kompetitive Projekte. Unmittelbare Konkurrenz zu anderen Firmen besteht nicht.
Liquidität	**Hoch**	MegaBio besitzt beachtliche Liquiditätsreserven für Fortbestand und Wachstum in den nächsten Jahren.
	Niedrig	MegaBio besitzt beschränkte Liquiditätsreserven, die voraussichtlich binnen Jahresfrist erschöpft sind.
Qualität des wissen-schaftlichen Teams	**Hoch**	Das wissenschaftliche Team von MegaBio besteht aus herausragenden und renommierten Spezialisten.
	Niedrig	Das wissenschaftliche Team von MegaBio besteht aus nur durchschnittlichen Wissenschaftlern.
Anzahl der Patente	**Hoch**	MegaBio besitzt ein breites Portfolio an gesicherten Patenten.
	Niedrig	MegaBio besitzt nur ein beschränktes Portfolio an Patenten, die zudem durch Patentstreitigkeiten unsicher sind.
Finanzierungs-umfeld	**Attraktiv**	Es bestehen momentan gute Möglichkeiten für MegaBio, Risikokapital zu akquirieren oder an die Börse zu gehen.
	Unattraktiv	Es bestehen nur beschränkte Möglichkeiten für MegaBio, Risikokapital zu akquirieren; das Börsenfenster ist geschlossen.
Anzahl der frühen Produkte	**Hoch**	MegaBio's Entwicklungspipeline weist eine beachtliche Anzahl an Produkten in frühen Entwicklungsphasen auf.
	Niedrig	MegaBio's Entwicklungspipeline weist nur wenige Produkte in frühen Entwicklungsphasen auf.
Anzahl der späten Produkte	**Hoch**	MegaBio's Entwicklungspipeline weist eine beachtliche Anzahl an Produkten in späten Entwicklungsphasen auf.
	Niedrig	MegoBio's Entwicklungspipeline weist nur wenige Produkte in späten Entwicklungsphasen auf.

Bitte betrachten Sie jede der folgenden Beschreibungen als separate Situation von MegaBio, **unabhängig** von allen anderen. Die Eigenschaften eines potentiellen Partnerunternehmens werden, wie bereits beschrieben, nicht spezifiziert.

Bitte blättern Sie **nicht** zu bereits beurteilten Situationen zurück.

11.3 Example scenario of the conjoint experiment

Situation 1: dxo

1. **Kontaktnetzwerk** von MegaBio	Ausgedehnt	Viele Kontakte zu anderen Firmen, Universitäten und Forschungseinrichtungen
2. **Kompetition**	Niedrig	Wenig kompetitive Projekte, keine direkte Konkurrenz
3. **Liquidität** von MegaBio	Hoch	Beachtliche Liquiditätsreserven (mehrere Jahre)
4. Qualität **wissenschaftliches Team**	Hoch	Herausragende und renommierte Spezialisten
5. Anzahl der **Patente** von MegaBio	Niedrig	Beschränktes Portfolio an unsicheren Patenten
6. **Finanzierungsumfeld**	Attraktiv	Gute Möglichkeiten für Risiko-kapitalakquisition oder Börsengang
7. Anzahl **frühe** Produkte	Niedrig	Wenige Produkte in frühen Entwicklungsphasen
8. Anzahl **späte** Produkte	Niedrig	Wenige Produkte in späten Entwicklungsphasen

Beurteilung

Wenn Sie CEO von MegaBio wären, wie beurteilten Sie in der oben geschilderten Situation den Anreiz, eine andere Firma als Partner für eine Strategische Allianz zu suchen?

Bitte kreuzen Sie Ihre Antwort auf folgender Skala an.

Sehr geringer Anreiz, eine Strategische Allianz zu suchen						**Sehr hoher Anreiz, eine Strategische Allianz zu suchen**
1	2	3	4	5	6	7

11.4 Design of the four experiment versions

Version 1

Nr	Situation	patents	early	late	network	liquidity	compn	team	finance
1	dxo	low	low	low	high	high	low	high	high
2	piu	low	high	low	high	high	low	low	high
3	gnz	high	low	high	high	high	low	low	low
4	hae	low	low	low	low	low	low	low	low
5	pdp	high	low	low	high	low	high	low	high
6	rkw	low	low	low	high	high	high	high	low
7	bgm	low	high	high	high	low	high	low	low
8	kjl	high	low	low	low	high	low	high	high
9	whl	high	low	high	low	low	high	high	low
10	smq	low	high	high	low	high	low	high	low
11	wer	low	low	high	high	low	low	high	high
12	xpv	high	high	high	high	high	high	high	high
13	hfa	high	high	high	low	low	low	low	high
14	tbd	high	high	low	high	low	low	high	low
15	hlv	high	high	low	low	high	high	low	low
16	tcy	low	high	low	low	low	high	high	high
17	lop	low	low	high	low	high	high	low	high
18	whl	high	low	high	low	low	high	high	low
19	xpv	high	high	high	high	high	high	high	high
20	bgm	low	high	high	high	low	high	low	low
21	kjl	high	low	low	low	high	low	high	high
22	tbd	high	high	low	high	low	low	high	low
23	rkw	low	low	low	high	high	high	high	low
24	pdp	high	low	low	high	low	high	low	high
25	hae	low	low	low	low	low	low	low	low
26	tcy	low	high	low	low	low	high	high	high
27	hlv	high	high	low	low	high	high	low	low
28	smq	low	high	high	low	high	low	high	low
29	piu	low	high	low	high	high	low	low	high
30	wer	low	low	high	high	low	low	high	high
31	lop	low	low	high	low	high	high	low	high
32	hfa	high	high	high	low	low	low	low	high
33	gnz	high	low	high	high	high	low	low	low

Table 19: Conjoint experiment version 1

Version 2

Nr	Situation	network	compn	liquidity	team	patents	finance	early	late
1	dxo	high	low	high	high	low	high	low	low
2	piu	high	low	high	low	low	high	high	low
3	gnz	high	low	high	low	high	low	low	high
4	hae	low	low	low	low	low	low	low	low
5	pdp	high	high	low	low	high	high	low	low
6	rkw	high	high	high	high	low	low	low	low
7	bgm	high	high	low	low	low	low	high	high
8	kjl	low	low	high	high	high	high	low	low
9	whl	low	high	low	high	high	low	low	high
10	smq	low	low	high	high	low	low	high	high
11	wer	high	low	low	high	low	high	low	high
12	xpv	high	high	high	high	high	high	high	high
13	hfa	low	low	low	low	high	high	high	high
14	tbd	high	low	low	high	high	low	high	low
15	hlv	low	high	high	low	high	low	high	low
16	tcy	low	high	low	high	low	high	high	low
17	lop	low	high	high	low	low	high	low	high
18	whl	low	high	low	high	high	low	low	high
19	xpv	high	high	high	high	high	high	high	high
20	bgm	high	high	low	low	low	low	high	high
21	kjl	low	low	high	high	high	high	low	low
22	tbd	high	low	low	high	high	low	high	low
23	rkw	high	high	high	high	low	low	low	low
24	pdp	high	high	low	low	high	high	low	low
25	hae	low	low	low	low	low	low	low	low
26	tcy	low	high	low	high	low	high	high	low
27	hlv	low	high	high	low	high	low	high	low
28	smq	low	low	high	high	low	low	high	high
29	piu	high	low	high	low	low	high	high	low
30	wer	high	low	low	high	low	high	low	high
31	lop	low	high	high	low	low	high	low	high
32	hfa	low	low	low	low	high	high	high	high
33	gnz	high	low	high	low	high	low	low	high

Table 20: Conjoint experiment version 2

Version 3

Nr	Situation	patents	early	late	network	liquidity	compn	team	finance
1	dxo	low	low	low	high	high	low	high	high
2	bgm	low	high	high	high	low	high	low	low
3	xpv	high	high	high	high	high	high	high	high
4	hae	low	low	low	low	low	low	low	low
5	tcy	low	high	low	low	low	high	high	high
6	smq	low	high	high	low	high	low	high	low
7	hfa	high	high	high	low	low	low	low	high
8	kjl	high	low	low	low	high	low	high	high
9	pdp	high	low	low	high	low	high	low	high
10	piu	low	high	low	high	high	low	low	high
11	lop	low	low	high	low	high	high	low	high
12	wer	low	low	high	high	low	low	high	high
13	whl	high	low	high	low	low	high	high	low
14	gnz	high	low	high	high	high	low	low	low
15	rkw	low	low	low	high	high	high	high	low
16	tbd	high	high	low	high	low	low	high	low
17	hlv	high	high	low	low	high	high	low	low
18	smq	low	high	high	low	high	low	high	low
19	hfa	high	high	high	low	low	low	low	high
20	xpv	high	high	high	high	high	high	high	high
21	pdp	high	low	low	high	low	high	low	high
22	hae	low	low	low	low	low	low	low	low
23	wer	low	low	high	high	low	low	high	high
24	tbd	high	high	low	high	low	low	high	low
25	bgm	low	high	high	high	low	high	low	low
26	lop	low	low	high	low	high	high	low	high
27	gnz	high	low	high	high	high	low	low	low
28	whl	high	low	high	low	low	high	high	low
29	kjl	high	low	low	low	high	low	high	high
30	piu	low	high	low	high	high	low	low	high
31	rkw	low	low	low	high	high	high	high	low
32	hlv	high	high	low	low	high	high	low	low
33	tcy	low	high	low	low	low	high	high	high

Table 21: Conjoint experiment version 3

Version 4

Nr	Situation	network	compn	liquidity	team	patents	finance	early	late
1	dxo	high	low	high	high	low	high	low	low
2	bgm	high	high	low	low	low	low	high	high
3	xpv	high	high	high	high	high	high	high	high
4	hae	low	low	low	low	low	low	low	low
5	tcy	low	high	low	high	low	high	high	low
6	smq	low	low	high	high	low	low	high	high
7	hfa	low	low	low	low	high	high	high	high
8	kjl	low	low	high	high	high	high	low	low
9	pdp	high	high	low	low	high	high	low	low
10	piu	high	low	high	low	low	high	high	low
11	lop	low	high	high	low	low	high	low	high
12	wer	high	low	low	high	low	high	low	high
13	whl	low	high	low	high	high	low	low	high
14	gnz	high	low	high	low	high	low	low	high
15	rkw	high	high	high	high	low	low	low	low
16	tbd	high	low	low	high	high	low	high	low
17	hlv	low	high	high	low	high	low	high	low
18	smq	low	low	high	high	low	low	high	high
19	hfa	low	low	low	low	high	high	high	high
20	xpv	high	high	high	high	high	high	high	high
21	pdp	high	high	low	low	high	high	low	low
22	hae	low	low	low	low	low	low	low	low
23	wer	high	low	low	high	low	high	low	high
24	tbd	high	low	low	high	high	low	high	low
25	bgm	high	high	low	low	low	low	high	high
26	lop	low	high	high	low	low	high	low	high
27	gnz	high	low	high	low	high	low	low	high
28	whl	low	high	low	high	high	low	low	high
29	kjl	low	low	high	high	high	high	low	low
30	piu	high	low	high	low	low	high	high	low
31	rkw	high	high	high	high	low	low	low	low
32	hlv	low	high	high	low	high	low	high	low
33	tcy	low	high	low	high	low	high	high	low

Table 22: Conjoint experiment version 4

11.5 Post-experiment questionnaire

Anleitung: Bitte geben Sie im Folgenden die Wichtigkeit der Kriterien bei ihrer Beurteilung des Anreizes, eine Strategische Allianz zu suchen, an.

(Bitte kreuzen Sie die Nummer an, die Ihrer Beurteilung am nächsten kommt).

A) Anzahl der Patente der Firma

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

B) Anzahl der Produkte in frühen Entwicklungsphasen

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

C) Anzahl der Produkte in späten Entwicklungsphasen

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

D) Kontaktnetzwerk der Firma

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

E) Liquidität der Firma

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

F) Kompetition

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

G) Qualität des wissenschaftlichen Teams

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

H) Finanzierungsumfeld

Sehr unwichtig 1 2 3 4 5 6 7 Sehr wichtig

Erfahrung und persönlicher Hintergrund (vertraulich)

1. Bitte geben Sie Ihr aktuelles Alter an _____

2. Bitte geben Sie die Fachrichtung Ihres höchsten Abschlusses an

a) Chemie ( ) b) Biologie ( ) c) Wirtschaft ( ) d) Medizin ( ) e) Sonstiges ( )

3. Welche Position besetzen Sie im Moment in Ihrer aktuellen Firma?

a) CEO ( ) b) CFO/CSO ( ) c) Vice Precident ( ) d) BD Manager ( ) e) Sonstige ( )

4. Sind Sie (wissenschaftlicher) Gründer Ihrer aktuellen Firma?

a) Wissenschaftl. Gründer ( ) b) Nicht-wissenschaftl. Gründer ( ) c) kein Gründer ( )

5. In welchem Jahr wurde Ihre aktuelle Firma gegründet? _____

6. Wie viele Mitarbeiter hat Ihre aktuelle Firma? _____

7. Welches Geschäftsmodell verfolgt Ihre aktuelle Firma?

a) Reine Produktentwicklung ( ) b) Reine Dienstleistung ( ) c) Beides (Hybridstrategie) ( )

8. Wie viele Jahre waren Sie insgesamt in der Biotechbranche tätig? _____

9. Wie viele Jahre waren Sie insgesamt in der Pharmabranche tätig? _____

10. Wie viele Jahre sind Sie in Ihrer aktuellen Firma tätig? _____

11. Wie viele Jahre waren Sie insgesamt in Top-Management-Positionen tätig? _____

12. Wie viele Jahre sind Sie in einer Top-Management-Position in Ihrer aktuellen Firma? ____

13. In wie vielen Firmen waren Sie schon tätig? _____

14. Wie viele Strategische Allianzen haben Sie schon verhandelt (Verhdl. abgeschlossen) ____

15. Wie viele dieser Strategischen Allianzen würden Sie als erfolgreich bezeichnen? _____

16. Wie viele strategische Allianzen hat Ihre momentane Firma mit

a) Universitäten _____ b) Biotechnologiefirmen _____ c) Pharmafirmen _____

Ende der Studie. Vielen Dank für Ihre Mithilfe!

11.6 Conjoint experiment data

Version 1

	Participant number												
Situation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
dxo	4	2	2	6	2	2	6	4	2	3	6	2	3
bgm	5	2	4	7	2	2	6	2	2	4	6	3	3
xpv	5	4	6	7	5	3	2	4	1	5	6	4	5
hae	7	7	1	1	7	6	7	7	7	6	6	7	7
tcy	6	5	2	2	4	4	2	7	7	4	6	5	5
smq	6	4	3	6	2	3	6	5	6	6	6	5	6
hfa	6	7	5	7	7	5	7	7	6	7	6	6	5
kjl	6	2	7	6	2	2	2	3	6	3	6	2	3
pdp	6	7	5	6	7	5	7	7	6	6	6	6	6
piu	4	5	6	7	5	1	3	6	1	5	4	3	5
lop	5	6	4	7	5	3	2	4	5	6	4	4	4
wer	2	3	2	7	5	2	1	2	1	4	2	1	2
whl	4	5	5	7	6	2	2	4	4	5	5	3	4
gnz	6	7	2	7	7	7	7	7	6	5	6	6	6
rkw	5	5	5	7	6	5	5	5	5	6	4	3	5
tbd	6	5	2	7	5	4	2	6	6	4	5	3	5
hlv	6	2	6	7	5	2	2	4	4	5	3	3	4
smq	6	6	2	7	7	5	6	7	5	6	6	6	6
hfa	1	5	1	7	4	2	1	2	1	3	2	1	2
xpv	6	7	6	7	7	5	6	7	6	6	6	7	6
pdp	5	4	6	5	2	2	1	2	3	3	6	2	5
hae	6	7	6	7	7	7	7	6	5	3	6	5	6
wer	6	6	6	2	5	3	7	6	6	4	7	4	5
tbd	6	7	2	3	5	4	6	6	7	4	6	3	5
bgm	7	7	7	1	7	6	7	7	7	3	7	7	7
lop	6	4	2	7	4	4	2	5	6	4	6	3	6
gnz	6	4	5	7	6	5	4	5	3	4	7	3	6
whl	6	5	6	7	5	1	5	3	2	4	3	5	5
kjl	6	3	3	7	3	2	2	4	4	4	3	3	4
piu	6	6	2	7	3	3	2	4	6	4	4	5	5
rkw	6	4	6	7	4	2	3	3	5	3	5	2	3

Table 23: Conjoint data version 1

Version 2

	Participant number											
Situation	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**[16]	**24**	**25**
dxo	6	2	7	5	7	6	6	4	4	6	7	1
bgm	5	4	2	5	3	4	6	5	6	6	6	1
xpv	4	2	3	6	5	2	5	7	2	4	4	2
hae	1	7	6	1	4	7	7	5	6	7	7	6
tcy	5	7	6	2	5	6	4	3	6	6	7	4
smq	4	6	6	3	7	6	7	5	6	6	5	3
hfa	3	7	6	4	3	3	4	6	6	3	7	7
kjl	5	2	7	4	5	3	6	2	2	6	5	1
pdp	3	6	7	5	3	5	4	7	6	2	7	7
piu	4	2	4	6	1	2	5	4	3	3	5	5
lop	2	2	5	6	3	2	5	6	6	4	6	4
wer	5	2	1	6	1	2	2	2	2	4	4	1
whl	3	5	3	6	1	5	3	2	4	4	6	5
gnz	2	7	6	4	3	6	4	5	6	6	7	7
rkw	4	5	3	4	3	3	5	4	4	6	5	6
tbd	2	7	3	4	3	5	5	4	6	6	6	6
hlv	4	3	5	5	5	2	6	5	3	4	4	2
smq	2	7	6	5	3	3	4	5	7	4	7	7
hfa	6	1	1	6	1	1	2	2	2	2	1	1
xpv	2	7	6	5	5	4	4	6	6	4	7	7
pdp	4	1	5	5	5	4	6	2	3	6	5	2
hae	2	7	6	5	2	6	4	5	6	6	7	6
wer	4	5	6	4	7	5	7	5	4	7	5	5
tbd	2	7	6	4	6	5	5	3	5	7	6	5
bgm	1	7	6	2	4	6	5	6	7	7	7	7
lop	2	7	4	4	3	4	4	4	6	6	5	4
gnz	4	7	2	4	5	3	5	4	4	5	5	5
whl	5	3	2	5	2	1	5	5	4	6	3	3
kjl	5	5	5	5	5	2	6	4	2	3	5	2
piu	2	1	6	5	4	4	4	6	4	5	4	4
rkw	5	2	4	5	4	3	5	6	2	3	5	2

Table 24: Conjoint data version 2

[16] I excluded participant Nr. 23 from the statistical analysis since s/he did not provide any data in the post-experiment questionnaire

Version 3

	Participant number												
Situation	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
dxo	2	7	6	2	5	1	6	1	1	2	6	7	7
bgm	7	6	7	5	6	7	7	7	7	4	6	6	4
xpv	2	1	2	4	2	6	5	1	1	5	4	5	3
hae	7	7	7	6	6	7	7	7	7	6	5	7	7
tcy	3	3	5	4	6	2	6	4	6	5	4	6	6
smq	2	2	6	2	2	4	7	2	2	3	5	5	3
hfa	5	2	5	5	6	6	4	4	2	2	3	5	4
kjl	1	1	6	4	6	1	7	1	4	7	4	5	7
pdp	3	5	7	2	5	6	6	5	6	4	5	7	6
piu	2	6	6	2	5	4	4	1	2	6	5	6	6
lop	6	2	3	3	2	7	6	2	5	3	5	4	3
wer	6	6	6	6	5	5	6	5	6	4	5	5	4
whl	7	6	7	7	5	6	7	7	6	4	4	7	4
gnz	6	1	5	5	4	2	6	3	3	6	4	4	3
rkw	5	6	7	6	5	7	5	1	6	5	4	5	7
tbd	6	7	7	3	5	6	6	6	6	2	3	6	6
hlv	4	2	5	4	5	3	7	3	6	1	5	5	6
smq	6	4	5	2	4	5	7	2	3	1	4	5	3
hfa	5	2	3	7	5	2	6	4	2	2	3	5	4
xpv	1	1	2	5	1	1	7	1	1	4	4	4	2
pdp	2	6	6	4	7	7	5	5	5	5	5	7	6
hae	4	7	7	6	7	7	6	7	7	6	6	7	7
wer	2	6	5	3	6	5	7	5	6	5	6	6	6
tbd	6	6	7	4	6	7	6	7	6	4	5	7	6
bgm	7	6	7	6	6	7	6	7	6	3	5	7	4
lop	1	2	2	4	3	2	5	2	6	3	3	4	2
gnz	3	2	4	2	2	6	5	3	4	4	4	4	2
whl	7	6	7	5	4	7	7	7	6	5	4	6	3
kjl	2	5	5	2	6	6	4	1	3	5	6	5	7
piu	2	2	3	2	6	1	4	1	4	4	6	6	6
rkw	5	6	6	4	6	5	6	4	6	6	6	5	7

Table 25: Conjoint data version 3

Version 4

	Participant number													
Situation	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**
dxo	6	4	1	5	1	5	2	2	1	2	2	7	4	1
bgm	6	5	7	7	7	7	3	7	7	6	6	7	6	7
xpv	2	2	1	4	7	1	6	6	2	1	5	5	6	1
hae	7	6	7	7	7	7	7	6	6	7	7	6	6	7
tcy	5	6	2	7	7	4	4	6	4	7	6	6	7	6
smq	6	3	2	5	2	5	2	6	5	3	3	5	7	1
hfa	3	2	1	4	2	3	5	3	4	2	2	6	6	6
kjl	6	2	2	5	2	4	2	5	2	1	1	6	6	1
pdp	6	6	7	5	6	6	5	6	7	7	5	5	7	7
piu	5	3	3	6	2	5	3	3	4	6	7	4	5	1
lop	6	4	2	4	1	5	4	6	5	7	3	5	7	1
wer	6	6	1	4	4	3	6	6	6	4	7	6	4	7
whl	5	6	7	7	7	6	6	7	7	6	7	7	7	7
gnz	4	6	1	4	4	5	1	7	5	3	4	6	7	1
rkw	6	6	2	5	3	6	2	3	2	5	2	5	7	6
tbd	6	4	7	7	7	7	5	6	6	7	5	5	7	7
hlv	6	4	2	6	6	6	5	6	4	3	5	4	7	2
smq	3	2	1	3	2	6	2	6	4	1	1	7	6	4
hfa	2	2	1	5	3	5	6	5	5	2	7	7	7	7
xpv	3	7	1	2	1	2	1	2	2	1	1	6	2	1
pdp	7	6	6	6	6	5	6	6	5	5	5	5	7	4
hae	7	6	7	7	7	7	7	6	7	7	7	3	7	7
wer	5	7	1	5	5	6	5	6	6	6	6	5	4	7
tbd	6	7	7	7	7	6	6	6	6	7	6	5	6	7
bgm	6	6	6	7	5	6	6	6	7	7	5	5	7	7
lop	5	4	1	3	3	5	2	6	3	4	3	6	5	2
gnz	4	5	1	5	3	5	2	4	4	3	2	6	6	1
whl	5	6	6	7	6	6	5	6	7	6	7	6	7	7
kjl	6	4	5	6	4	4	3	6	1	2	1	4	5	1
piu	4	5	2	5	2	5	3	2	3	4	4	4	5	1
rkw	4	6	5	6	1	6	4	5	1	5	2	5	7	2

Table 26: Conjoint data version 4

11.7 Post-experiment questionnaire data

	Participant number												
Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
A)	6	2	5	4	5	6	3	5	6	4	5	5	4
B)	5	3	5	7	2	3	3	5	5	6	4	4	5
C)	4	5	6	7	5	5	6	6	6	7	6	6	6
D)	5	2	5	1	2	2	2	3	5	5	4	4	2
E)	6	7	7	6	7	7	7	7	7	6	6	6	5
F)	5	3	6	2	3	5	2	5	4	6	3	5	5
G)	5	3	4	7	4	3	6	4	4	5	5	5	3
H)	6	7	6	1	7	7	7	7	2	6	6	6	6
1.	53	40	36	29	45	34	41	40	52	42	n.a.	50	37
2.	a	c	b	b	a	a	a	b	a	a	b	b	b
3.	b	b	a	a	a	d	b	a	a	c	d	b	a
4.	a	b	a	c	a	c	c	b	a	c	c	c	a
5.	2000	2000	2000	1997	1992	2000	1998	2000	1988	1994	1997	1999	2001
6.	38	18	16	22	132	50	80	29	200	125	180	57	2
7.	n.a.	n.a.	n.a.	n.a.	c	c	a	c	n.a.	a	a	c	n.a.
8.	4,5	4	7	12	18	5	2	9	16	5	6	3	4
9.	0	0	0	0	0	0	15	4	n.a.	10	0	16	n.a.
10.	4,5	4	4	2	15	5	2	4	16	1	4	3	4
11.	4,5	8	4	11	15	1	4,5	9	3	5	n.a.	10	4
12.	4,5	4	4	2	15	1	2	4	16	1	n.a.	3	4
13.	0	4	1	2	1	0	3	2	1	4	1	2	0
14.	15	2	10	3	n.a.	2	5	5	2	4	2	5	1
15.	2	2	2	3	n.a.	1	3	4	1	n.a.	2	2	1
16 a)	n.a.	n.a.	n.a.	n.a.	4	4	2	3	n.a.	4	n.a.	n.a.	n.a.
16 b)	n.a.	n.a.	n.a.	n.a.	2	3	2	5	n.a.	1	n.a.	1	n.a.
16 c)	n.a.	n.a.	n.a.	n.a.	2	0	1	5	n.a.	1	n.a.	n.a.	n.a.

n.a. = not available

Table 27: Post-experiment questionnaire data

	Participant number												
Item	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**[17]	**24**	**25**	**26**
A)	4	4	3	5	4	3	6	4	4	n.a.	5	2	5
B)	2	7	4	4	6	4	6	5	3	n.a.	6	4	2
C)	5	7	6	7	6	5	7	5	6	n.a.	7	6	7
D)	1	4	5	3	7	6	1	3	4	n.a.	3	1	4
E)	7	7	7	6	5	7	7	7	7	n.a.	7	7	6
F)	4	7	5	5	5	7	1	4	4	n.a.	5	2	5
G)	3	4	5	5	5	4	3	5	6	n.a.	5	4	3
H)	2	7	6	6	3	6	6	6	7	n.a.	7	7	6
1.	50	31	45	42	35	40	33	33	41	n.a.	55	36	45
2.	a	c	d	b	b	c	b	c	b	n.a.	d	a	b
3.	a	e	c	d	d	a	d	b	c	n.a.	a	d	a
4.	a	c	c	c	c	c	c	c	c	n.a.	a	c	a
5.	1996	1996	1999	1998	1997	2000	1997	2000	1994	n.a.	1997	1997	2000
6.	65	64	42	80	35	10	180	20	100	n.a.	23	58	38
7.	n.a.	n.a.	a	a	c	a	a	c	c	n.a.	a	c	n.a.
8.	17	4	4	5	7	3	4	2	12	n.a.	30	6	4
9.	0	0	20	n.a.	0	0	0	0	0	n.a.	7	n.a.	0
10.	8	4	3	5	7	1	1	2	2	n.a.	7	3	4
11.	12	2	7	2	0	8	0	2	6	n.a.	19	3	4
12.	8	2	3	2	0	1	0	2	2	n.a.	7	3	4
13.	2	1	3	0	0	4	1	2	2	n.a.	1	1	0
14.	5	n.a.	n.a.	n.a.	n.a.	2	n.a.	2	20	n.a.	14	n.a.	5
15.	4	n.a.	n.a.	n.a.	n.a.	1	n.a.	2	14	n.a.	10	n.a.	1
16 a)	n.a.	n.a.	n.a.	2	5	3	n.a.	2	0	n.a.	5	n.a.	n.a.
16 b)	n.a.	n.a.	n.a.	2	n.a.	1	n.a.	0	0	n.a.	1	n.a.	n.a.
16 c)	n.a.	n.a.	n.a.	1	n.a.	0	1	0	3	n.a.	3	n.a.	n.a.

n.a. = not available

Table 28: Post-experiment questionnaire data (continued)

[17] Participant number 23 did not provide any information on the post-experiment questionnaire

	Participant number												
Item	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
A)	6	2	5	5	2	5	3	5	4	6	5	2	6
B)	2	6	5	5	7	6	3	5	5	6	6	3	6
C)	6	6	5	5	7	7	6	5	7	4	7	7	6
D)	1	2	1	3	2	6	3	4	2	4	3	1	3
E)	7	7	5	6	7	4	7	6	5	6	7	4	6
F)	5	5	4	4	6	7	4	3	5	6	5	1	5
G)	3	4	1	5	5	4	5	4	6	5	5	1	5
H)	4	7	5	5	7	7	6	5	5	6	7	6	7
1.	45	36	36	37	37	43	51	44	43	42	55	37	35
2.	c	c	b	b	a	a	a	b	b	a	d	a	b
3.	c	b	d	a	a	d	a	e	b	a	a	a	d
4.	c	b	c	b	a	c	c	c	c	c	a	a	c
5.	1995	2000	1993	2002	2003	2002	1995	1995	1998	1994	1997	2000	1995
6.	38	25	40	5	9	29	35	42	25	7	23	15	38
7.	n.a.	n.a.	a	c	c	c	c	c	b	c	a	c	n.a.
8.	3	4	3	7	4,5	8	20	9	5	3	30	8	6
9.	0	6	6	0	0	n.a.	1	0	10	0	7	0	0
10.	3	4	3	3	1,5	1	1	9	1	3	7	5	2
11.	14	4	3	5	4,5	7	5	6	5	3	19	5	2
12.	3	4	3	3	1,5	1	1	6	1	3	7	5	2
13.	1	1	2	3	2	2	2	1	2	0	1	3,5	1
14.	n.a.	3	3	5	6	2	5	10	19	4	14	4	4
15.	n.a.	2	2	5	2	1	5	10	18	n.a.	10	2	1
16 a)	n.a.	n.a.	0	0	0	2	2	5	5	2	5	1	n.a.
16 b)	n.a.	n.a.	1	5	4	0	0	5	2	2	1	0	n.a.
16 c)	n.a.	n.a.	1	0	0	4	0	5	4	0	3	0	n.a.

n.a. = not available

Table 29: Post-experiment questionnaire data (continued)

	Participant number												
Item	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**
A)	4	5	3	5	5	2	3	2	5	5	6	7	7
B)	6	4	5	4	2	2	3	2	3	4	6	7	1
C)	2	7	2	4	5	3	6	7	5	7	7	7	7
D)	3	1	3	2	3	3	6	1	5	4	5	1	1
E)	6	7	7	5	6	2	6	7	7	6	5	7	7
F)	6	5	3	n.a.	5	6	6	5	3	3	6	2	4
G)	4	4	3	3	5	4	6	5	5	6	5	2	4
H)	4	7	7	6	7	6	6	6	7	6	5	7	4
1.	40	33	38	32	42	49	38	37	48	52	42	35	46
2.	b	c	c	b	b	b	b	b	b	a	b	c	b
3.	a	b	b	b	a	b	a	c	a	b	d	c	d
4.	a	c	b	a	c	a	c	c	c	a	c	c	c
5.	2001	1999	2000	2000	1999	1999	2000	1994	1999	2002	2000	1998	1997
6.	18	22	45	25	22	23	17	90	22	114	35	75	60
7.	n.a.	a	c	c	c	c	n.a.	a	a	a	c	c	a
8.	10	2,5	4	5	10	20	8	4	5	10	4	11	8
9.	0	2,5	0	1	10	4	0	0	10	15	12	0	8
10.	3	2,5	4	4	3	4	5	4	1,5	12	4	4	8
11.	4	3,5	4	4	3	4	5	1	6	4	8	7	8
12.	3	2,5	4	4	3	4	5	1	1,5	4	4	4	8
13.	3	2	4	1	2	1	1	0	4	1	2	2	0
14.	1	n.a.	n.a.	7	17,5	n.a.	n.a.	4	50	1	15	1	1
15.	1	n.a.	n.a.	5	8	n.a.	n.a.	4	n.a.	1	10	1	1
16 a)	n.a.	0	n.a.	6	5	n.a.	n.a.	0	4	n.a.	0	20	n.a.
16 b)	n.a.	1	n.a.	0	3	n.a.	n.a.	6	3	n.a.	30	6	n.a.
16 c)	n.a.	0	n.a.	1	0	n.a.	n.a.	0	0	1	5	4	1

n.a. = not available

Table 30: Post-experiment questionnaire data (continued)