ETLA ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY

Keskusteluaiheita
Discussion Papers
19 September 2012

No **1286**

Expectations, Reality and Performance in the Finnish Biotechnology Business

Tuomo Nikulainen (corresponding author)* – Antti-Jussi Tahvanainen** – Martti Kulvik***

* Etlatieto Oy, tuomo.nikulainen@etlatieto.fi
** Etlatieto Oy, antti.tahvanainen@etlatieto.fi
*** Etlatieto Oy, martti.kulvik@etlatieto.fi

Funding by Finnish Funding Agency for Technology and Innovation (Tekes) is kindly acknowledged. The comments of the project steering group have been most valuable in refining the details of the paper. We also wish to acknowledge Mika Pajarinen for his assistance with company financial data.

ISSN 0781–6847

Contents

Abstract

In this paper our aim is to assess the evolution of the Finnish biotechnology sector during the 2000's. Particular focus is given to the growth expectations and realized outcomes of Finnish biotechnology companies, to the evolution of public investments, and to potential determinants of company performance in the sector. The empirical results suggest that there is considerable disparity between the companies' growth expectations and actual performance. Roughly one third of the expected sales have materialized. That being said, it should be noted that the sector has witnessed a significant increase in terms of sales and employment. At the same time, the scale of public funding has dramatically fluctuated during the 2000's in part due to public policy changes and in part due to the financial crisis towards the end of the decade. We also aim to identify where the growth in the sector has come from by discussing company growth and profitability. The findings provide important implications for policy makers regarding the potential evolution paths of the Finnish biotechnology business.

Key words: Biotechnology, industry evolution, growth expectations, public investments, company performance

JEL: O30, M21, L25

Tiivistelmä

Tässä tutkimuksessa on tavoitteena arvioida bioteknologiasektorin kehitystä Suomessa 2000-luvulla. Erityisesti tarkastelussa ovat yritysten kasvuodotukset, näiden odotusten toteutuminen ja julkisen rahoituksen kehitys. Pyritään myös tunnistamaan mahdolliset tekijät yritysten kasvun ja tuloksellisuuden taustalla. Yritysten kasvuodotusten ja realisoituneen kasvun välillä näyttää tutkimuksemme mukaan olevan merkittävä ero. Vain noin kolmannes odotetusta kasvusta toteutui. On kuitenkin huomioitava, että koko sektori on kasvanut merkittävästi niin liikevaihdolla kuin myös henkilöstömäärällä mitattuna. Samaan aikaan julkisen rahoituksen määrä on vaihdellut huomattavissa määrin 2000-luvulla johtuen julkisen rahoituksen uudelleensuuntauksesta sekä viimeaikaisesta talouskriisistä. Tutkimuksen tulokset tuottavat merkittäviä politiikkajohtopäätöksiä liittyen Suomen bioteknologiasektorin mahdollisiin kasvukanaviin.

Asiasanat: Bioteknologia, toimialojen evoluutio, kasvuodotukset, julkiset investoinnit, yritysten tuloksellisuus

1 Introduction

The Finnish biotechnology industry has lived through two eventful decades. It emerged as a science-based technology-intensive industry in the latter half of the 1980s and during the 1990s in the wake of intensified global interest in the promises of the revolutionary nature of biotechnology (Halme, 1994; Luukkonen, Tahvanainen and Hermans, 2004). The generic nature of biotechnology and its wide applicability in a variety of industries led to high growth expectations during the early years of the industry. There was a global demand for biotechnology companies, initiated both by private venture capital and by public policy. In the early years of the 2000s, however, followed by the post-bubble decline of market value of these companies (a phenomenon by no means only related to biotechnology), private investors and public actors were slowly divesting their stakes as only very few investments had resulted in hoped-for outcomes such as licensing of technologies, IPOs or other forms of exits potentially yielding high returns on investment.

Reflecting on these developments, this paper aims to address the evolution of the Finnish biotechnology industry in the 2000s, where during the early years large investments, both private and public, were made based on strategic technology development decisions (Luukkonen, Tahvanainen and Hermans, 2004; Luukkonen and Palmberg, 2004). Already during the first half of the decade investors started to demand results, and the true potential of the industry has repeatedly been questioned since. This highlights the need to understand what has happened in the industry, and leads to the following questions: What were the growth expectations and what has been the actual evolution of the industry in Finland? Has the use of biotechnology spread as widely as expected into a number of new industries or have the industries remained the same over the years? What kind of companies are growing? Are there successes in the Finnish biotechnology business?

By answering to these questions, we hope to not only shed light on the evolution of the industry but to also address its future prospects. In doing so, the current paper addresses a select set of aspects that have been raised in public debate in recent years. The quantitative approach of this study complements another research effort that inspects the Finnish biotechnology sector from a qualitative perspective addressing, among many other aspects, the role of financing and the lack of industrialists in the Finnish biotechnology business (see Kulvik et al. 2011).

The Finnish biotechnology sector has attracted the interest of several scholars over the years. Thus, in this paper some of the earlier findings in the extant body of research are reflected against the findings obtained in this paper. The current paper builds on this body of knowledge and addresses the evolution of the industry, particularly, by looking at specific dimensions of performance. We hope to deepen the understanding of the industry's dynamics from the perspective of the Finnish economy by looking at industry sales, employment, application areas, public funding and company performance. The aim is to provide insights into the past developments and a glance into potential future developments of the industry.

The paper is structured as follows. Section 2 reviews related literature on the Finnish biotechnology industry. Section 3 introduces the data and addresses some methodological aspects that need to be highlighted. Section 4 focuses on the earlier growth expectations of the biotechnology companies and compares them with materialized sales figures, and discusses today's growth expectations of the companies. Section 5 discusses the public investments made

into biotechnology in the 2000s. Section 6 focuses on statistical regression analysis aiming to identify potential determinants of company performance that underlie the growth of the industry. And finally, Section 7 presents a summarizing discussion with conclusions and implications.

2 Prior research on the Finnish biotechnology industry

The Finnish biotechnology sector has been studied throughout the 2000s from various perspectives ranging from qualitative case studies to modelling the evolution of the industry. To establish the premises for the analyses presented in this paper it is worthwhile to look at the most significant empirical contributions in the body of literature and identify (a) aspects that have been highlighted as key areas of interest or (b) themes that have been identified as major obstacles hindering the evolution of the industry.

To start with, Halme (1994) traces the patterns of knowledge spillovers between companies among themselves, on one hand, and between universities and companies on the other. Halme finds that the Finnish biotechnology sector was on the verge of what he called a "biotechnology wave" referring to a strong growth phase that lags a decade behind the leader, namely the USA. One third of approximately 45 biotech companies in 1994 were big diversified corporations and their subsidiaries. New small and medium sized companies focused mainly on diagnostics and enzymes with only a few applying what Halme calls "new biotechnology" (e.g. genetics) and employing 10-20 employees on average. Finnish biotech companies had not lived up to the expectations of investors by the year 1994 having spawned no real success stories by that time.

Halme (1996) follows-up on the matter by depicting basic biotechnological research conducted in Finland, the entities applying this research (companies mainly), the innovations based on it and the biotechnology centres established in Finland. Halme argues that the strong growth of the Finnish biotech sector is a sign of the novelty, generic character and wide applicability of breakthroughs in biotechnological basic research. He adds, however, that the development of commercial applications is primarily a privilege of big corporations, since it is often too complex and expensive to be undertaken by SMEs on a global scale.

Ahola and Kuisma (1998) examine the state of the sector in 1997. The paper identifies companies active in the field, assesses the scale of production and application of biotechnology in Finland, and examines the evolution of sector structure. It also studies network and cooperation patterns in the sector and maps the perceptions of future developments and improvement requirements in the sector from the companies' point of view.

In later studies, Tulkki et al. (2001) use case studies to pay attention to the pharmaceutical industry and expert services in its close proximity. The agro-food sector is dealt with also by introducing the central players. Furthermore, the authors cover topics from research centres to legislation, regulation and quality control as well as education and financing. Some international comparisons are drawn using Germany as the benchmark. In conclusion Tulkki et al. (2001) express their concern about the smallness of companies. Companies need to boost their research capacities. This should be achievable through national and international co-operation and mergers with big global corporations and consolidation in general.

Hermans and Luukkonen (2002) present quantitative results on the evolution of the sector in terms of the number of established companies, their location and difficulties at the start-up phase, funding, customers and markets, R&D-intensity and collaboration, personnel and skills, sources of funding and intellectual property rights (IPRs).

More recent contributions have focused on micro-level analyses. In the light of expressed concern about the allegedly poor output performance of the biotech sector in Finland, Saarinen et al. (2003) study the actual performance of biotech companies as measured by the number of patents filed over the period 1993 to 2002. They find that especially new and small companies are actually performing rather well increasing their share of total patenting in Finland year after year.

Hermans and Tahvanainen (2002) is a descriptive study on the capital and ownership structure of Finnish biotech SMEs. They find that the debt ratio in the sector is fairly low at 25 per cent. However, they also point out that capital loans, technically a part of equity, constitute over thirty per cent of total funding (31.5%) while conventional equity has a share of 43.6 per cent. Tahvanainen (2003) examines this structure more in-depth in the light of central theoretical frameworks. He concludes that the results of the study do not provide unconditional support for any of the frameworks. The evidence presented is only partially supportive. Reasons for this might be inherent in a too general nature of the theories themselves as well as some unique characteristics of the biotech industry.

Hermans (2003) focuses on the capital structure and other characteristics of business operations of biopharmaceuticals in Finland, while Hermans and Kauranen (2003) relate growth expectations of Finnish biotech companies to intellectual capital residing in them and find a positive relationship between the two.

Tahvanainen (2004) portrays the characteristics of Finnish biotechnology SMEs that have their origin in academic research conducted in universities or other comparable research institutions, and finds that, first, they lack a clear market-oriented focus as well as the commercial sense and skills to strategically direct their organization as a business towards the markets. Second, a very traditional and detached perception and definition of the academia's role and task within society makes it difficult for the companies to attract skilled labour. And last, Finland's equity markets are underdeveloped. New seed capital is next to unavailable, as private and foreign venture capitalists invest only in companies that are already very close to the markets.

Tahvanainen and Hermans (2005), in turn, examine whether and how information asymmetries can explain funding difficulties experienced by small and medium sized biotechnology companies. Indeed, the authors find a relationship between companies' intellectual capital endowments that serve as a proxy for company quality and their capital structures that are indicative of companies' ability to attract funding from different sources. The results suggest that companies of high quality suffer from information asymmetry induced underestimation of capital value most, because they are unable to distinguish themselves from companies of low quality.

In Hermans and Kulvik (2006) the authors establish a national strategy for promoting Finnish biotechnology by identifying sectors in which Finnish biotechnology can be argued to hold comparative advantage. These sectors include healthcare, health promoting food, energy and biomaterials. These four sectors satisfy the criteria that are required of a sustainable technology development environment: they can draw on globally unique factors of production, can ex-

ploit sequential strategies, are networked to internationally competitive support industries in the home country, can utilize a suitable domestic market laboratory, and benefit from a pool of complementary competence bases of business and technology experts. These insights have led to further analyses of the connection between biotechnology-based medical innovation and government intervention (Hermans et al., 2009a).

Both of the latter two works are books that compile a plethora of single studies conducted in the domain of Finnish biotechnology in recent years. In addition to general overviews of the sector's development in light of statistics (Hermans et al., 2006), Hermans and Kulvik (2006) include qualitative analyses on the industry's future prospects (Hussi et al., 2006), patent citation analyses inspecting the relationship between patenting, economic value and technological significance (Nikulainen et al., 2008), and analyses on the regional differences in patterns of collaboration, specialization and performance (Hermans and Tahvanainen, 2006). Hermans et al. (2009) compile studies on knowledge hubs in the global biotechnology industry, price regulation and industry performance in drug development, and effects of technology subsidies on industry strategies and market structure.

Finally, the most recent contributions to the study on the Finnish biotechnology sector include qualitative updates on the prospects of the sector as seen by company representatives (Kulvik et al., 2011) and normative pricing tools that can be employed to identify long-term costs and benefits of single innovations on company and societal levels (Kulvik et al. 2009, Pekkala et al. 2011).

In the current paper we aim to build on the earlier research by i) taking an up-dated bird's eye perspective on the evolution of the Finnish biotechnology business, ii) highlighting the uncertainties both in growth expectations as well as public investments, and finally iii) identifying determinants of growth by analysing the performance of the biotechnology companies. But before going into these discussions it is necessary to bring forth certain aspects of the data and methodology upon which the discussion will build on.

3 Data and methodology

The main data for the current paper stem from two large surveys, the first being performed in 2004 and the second in 2009–2010. The second survey included extensions that were not yet included in the 2004 survey, but in other respects the surveys are identical, thus allowing us to make comparisons over time to provide insights into the evolution of the industry. These surveys are complemented with company level data from Statistics Finland and National Board of Patents and Registration of Finland (NBPR) in order to create longer time-series of sales and employment trends. In addition, Tekes (The Finnish Funding Agency for Technology and Innovation) has kindly provided us with their funding data, allowing us to add a very interesting and relevant dimension to the analysis.

3.1 The survey data

The 2002/2004 biotechnology company survey data (henceforth the 2004 survey) consists of financial and other company level data from two surveys conducted in 2002 and 2004 among Finnish biotechnology companies (for more details see Hermans et al. 2005). The surveys are

based on confidential data collected via telephone questionnaires and supplemented by public financial statement data from The National Board of Patents and Registration of Finland (NBPR).

The 2004 survey covered the majority of companies operating in the Finnish biotechnology sector at that time. As the survey focused on dedicated biotechnology companies, other less biotechnology orientated companies, for example cluster companies specializing solely on distribution, import, consulting, and other support functions, were excluded from the survey. In 2004 there were 123 active biotechnology companies, out of which 111 were identified to be SMEs. The SMEs were defined according to official definitions of the EU excluding companies with over 250 employees. The included companies must also match at least one of the following criteria: annual turnover is no greater than 50 million euros, and the balance sheet total does not exceed 43 million euros. The 2004 survey sample included 87 (out of 123) companies, out of which 79 (out of 111) were SMEs. These numbers translate into a response rate of 71% with respect to both total and SME populations. Partnerships and subsidiaries owned by foreign parent companies were treated as SMEs if they fulfilled the criteria above. Moreover, the partnerships and subsidiaries had to be independently responsible business units in order to be included in the sample as a separate entity; otherwise the data was collected from the parent company and treated as one enterprise.

The 2004 survey covers a variety of topics, ranging from basic characteristics of companies (such as sales, personnel, and finances) to the R&D expenditures as well as to collaboration patterns and purchasing activities. In the survey data, the biotechnology industry was divided into eight subcategories: drug development, diagnostics, biomaterials, enzymes, agricultural applications, forestry, food and feed, and other (see for more details Hermans and Luukkonen 2002; Hermans et al. 2005).

As indicated earlier, the basic content of the 2009/2010 biotechnology company survey (henceforth the 2010 survey data) is identical to the 2004 survey. However, some themes were extended in greater detail, and new themes were added. The 2010 survey data was collected via personal on-site interviews performed in two cycles: the first in August - December 2009, and the second in April - September 2010. The focus was in line with the 2004 survey: dedicated biotechnology SME companies in Finland. We identified in total 107 SMEs active in 2010 of which 71 were interviewed, yielding a total response rate of 66%.

3.2 Tekes funding decisions

In addition to the survey data and supplementary financial data, we have unique access to governmental funding decisions regarding biotechnology dedicated companies. Tekes (The Finnish Funding Agency for Technology and Innovation) is one of the main sources of governmental funding targeted at companies actively pursuing technology development. In the following discussion and analysis we use Tekes funding decisions from the period 2001–2010 to illustrate the scale of public funding directed to biotechnology businesses. Although Tekes funding is only one source of public funding and support, it does constitute a large majority of the investments made by public actors into these companies.

3.3 Methodological considerations

One of the main challenges when discussing a particular industry is how to define it.[1] Biotechnology relates to various different technologies and services, and thus expert opinions are often needed to decide whether a company is involved in biotechnology and, if so, at which intensity. Although similar problems were solved already during the 2004 survey, we needed to come back to the problems as industry dynamics might have had changed. Thus we decided to compile an extensive list of all identifiable companies that might be related to biotechnology and narrow it down through careful assessment until we had a set of companies that could be labelled as biotechnology dedicated SME's.[2] The perspective of the larger, potentially biotechnology-related companies is addressed in Kulvik et al. (2011).

Furthermore, the overlap between the 2004 and 2010 survey data and the two cycles of data collection in 2009 and 2010 should be addressed. While establishing the 2010 company list, we identified that a large share of the companies active in 2004 had exited the markets in one form or another (this aspect of industrial dynamics is discussed in greater detail in the next section). Thus, when comparing the growth expectations in 2004 and the realized growth in 2008 in the next section, we need to take this significant change in the company population into account. As a consequence of this, our sample size is reduced significantly in some of the subsequent analyses.

4 Evolution, expected growth and materialized outcomes in the Finnish biotechnology industry

As mentioned, the Finnish biotechnology industry has had challenging times in the 2000s. The burst of the Dot.com bubble, lack of long-term commitment from some of the national public actors as well as public and private financiers, and challenges in attracting new foreign and domestic financing, both public and private (Hussi et al., 2006), have led to a situation where public debate has often labelled the biotechnology sector a failure and waste of public investments. In the following, we aim to provide a picture of what has really happened in the industry and establish whether the criticism has been warranted.

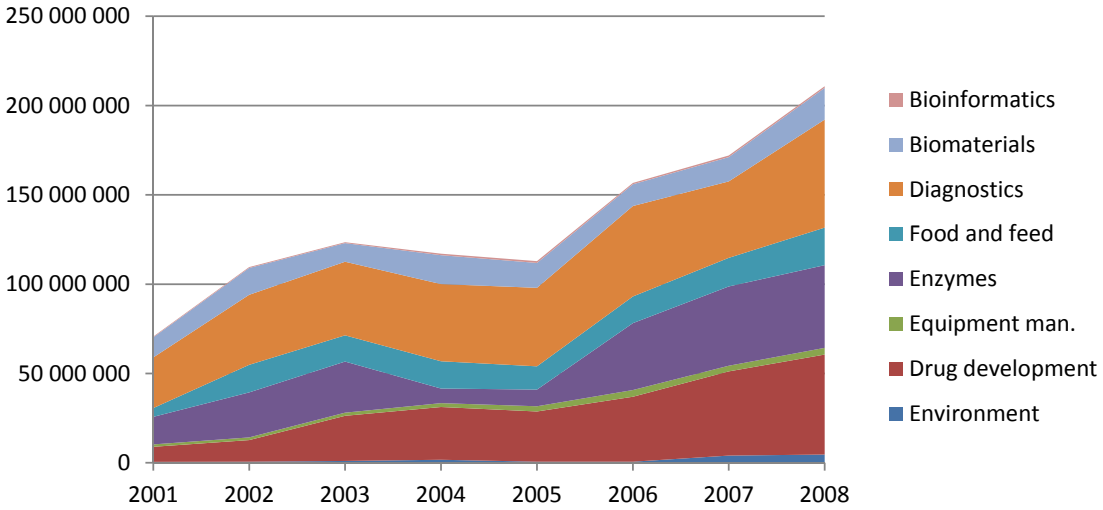
4.1 The development of the biotechnology industry in Finland

One of the key aspects of a growth industry is that it grows both in terms of sales and employment. In Figure 1 we illustrate the trend of sales for the biotechnology-dedicated SME's in Finland. What should be noted when interpreting the results is that, as we have two main data collection points (2004 and 2010), companies that entered the industry in 2004 or later but made

[1] Throughout all surveys and reports, we have used the OECD definition for biotechnology: "The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services." (OECD, 2005). For life science we use the definition: "Any science that deals with living organisms, their life processes, and their interrelationships, as biology, medicine, or ecology" (R.H. Unabridged dictionary, 1987).

[2] The unabridged list included any company that was listed in the data banks of ETLA (including all potential companies for the 2004 survey), Finnish Bio Industries' (FIB) list from 2006, bioindustry list of Culminatum Ltd, and the FIB list of 2011 where companies were asked to identify themselves if they see themselves as related to biotechnology. This yielded a total of 394 companies, which were then assessed individually for e.g. in-depth classification, performance analysis, business history and ownership.

Figure 1 The biotechnology industry sales in Finland 2001–2008 (€; SME's; based on primary business area)

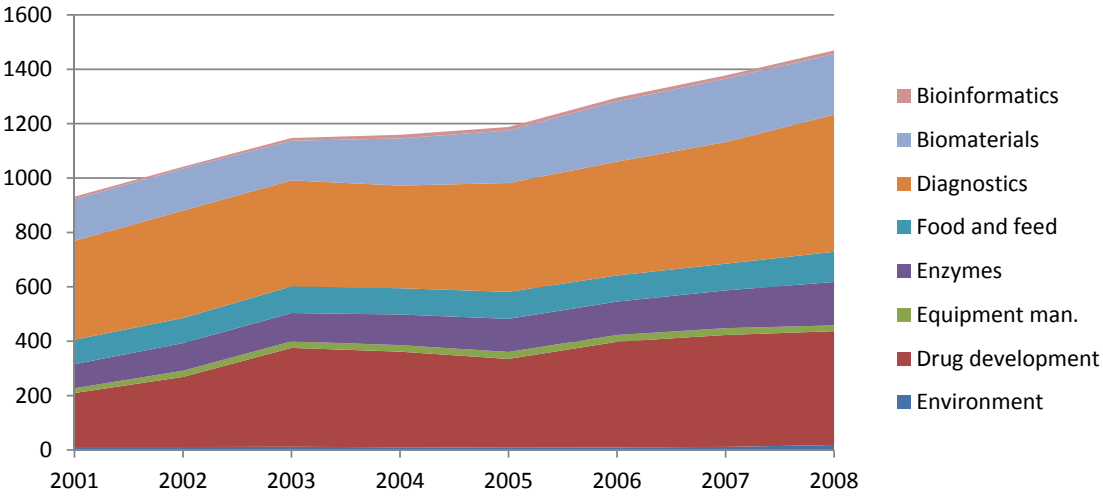


Note 1: The number of companies varies on yearly basis due to entry and exit (50–82 companies).
Note 2: The data does not include all of the companies as financial data was not available (mostly very small companies).

an exit before 2009 might be missing from our data. This may partially explain the slight drop in industry sales for the years 2004 and 2005.

We can see that the industry's sales have grown fast. In 2001 the sales totalled about 70€ million and in 2008 they accumulated to 210€ million. This means that, in seven years, the industry has tripled its sales (overall growth of 199%). Similar developments can be observed when looking at the employment in the industry for the same time period in Figure 2.

Figure 2 The biotechnology industry employment in Finland 2001–2008 (# of employees in Finland; SME's; Based on primary business area)



Note 1: The number of companies varies on yearly basis due to entry and exit (50–82 companies).
Note 2: The data does not include all of the companies as financial data was not available (mostly very small companies).

The biotechnology dedicated SME industry employed 932 employees in 2001, and in 2008 the employment had risen to 1472 employees, yielding an overall growth of 58%; the annual growth rate is a fair 6.8%. While both sales and employment have increased, the key attribute is growth in sales per capita, rising from €75,856 in 2001 to €143,470 in 2008; overall growth is 89%. One interpretation of this development could be that the industry is becoming more mature, and companies pay more attention to the business logic to generate stable sales.

4.2 The evolution of the sector population

As mentioned earlier in the discussion on data, the number of companies active in biotechnology has changed over time. For this reason, Table 1 provides some insight into the development of the industry based on the number of companies active in particular years. To make company data fully comparable, we re-analysed the year 2004 data with similar criteria used for the 2010 data, yielding for 2004 a total of 99 SME biotechnology dedicated companies; in this report we use the re-analysed data only.

Table 1 Number of biotechnology dedicated companies in Finland

# of companies	*Year – 2002*	*Year – 2004*	*Year – 2010*
All	116	123	n.a.
SMEs	n.a.	99	107

From Table 1 we can infer that the number of biotechnology companies in Finland has not changed significantly over time. However, a deeper look into the dynamics of the industry reveals a rather different view:

Table 2 Entry and exit in the Finnish biotechnology industry from 2004 to 2010 (only SMEs)

# of SME companies 2004	*99*
Exit between 2004 and 2010	
Bankruptcy	11
Not operating	9
No official data	7
Sold abroad	7
Sold/merged in Finland	9
Total exit	**43**
# of SME companies 2010	**107**
Entry from 2004 to 2010	**51** (new or missing from old lists)

From companies active in 2004 around 43% exited (43 companies out of 99, Table 2). If this is translated into an annual exit rate, we estimate it to be around 7% per year. The overall annual exit rate of manufacturing sector companies in Finland is around 7% (OECD, 2010). Looking at the situation in 2010, we can see that 48% of companies are new (51 companies out of 107). If this is translated into an annual entry rate, we estimate it to be around 8% per year. As a benchmark, the overall annual entry rate of manufacturing companies in Finland is around 8% (OECD, 2010).

These findings suggest that the biotechnology-dedicated SME sector seems to conform to the overall entry/exit trends of more conventional industries. This raises the question should the trends be so similar? Considering that the biotechnology business is often perceived to be a science-based, technology-driven, high-risk, bankruptcy- and entry-prone sector, should we expect significantly higher entry and exit rates? It may be that the current business environment, bad reputation and lack of funding (particularly private equity) have resulted in a situation where potential entrants are quite hesitant to enter the market.

4.3 The evolution of application sectors in Finland

We have established that the Finnish biotechnology industry seems to renew itself in a similar fashion and rate as do other industries. What we have not addressed is whether the structure of the industry has changed from the perspective of sectors which the companies are involved in. In Table 3 we show the composition of the industry in 2004 and in 2010.

It seems that between 2004 and 2010 the composition of the Finnish biotechnology industry has remained remarkably stable. Even though the role of drug development has diminished somewhat, it remains the most populated sector, followed by diagnostics and food and feed.

In the light of the current findings, it seems to be surprising that the industry has been publicly considered a failure. In contrast to the prevailing public opinion, these results provide evidence of strong sector growth, healthy entry and exit rates, and a stable sectoral composi-

Table 3 Number of companies in different biotechnology sectors

Sector	*2004*	*2010*
Drug development, oncolytic therapies	27 %	32 %
Diagnostics	20 %	19 %
Biomaterial	13 %	12 %
Bioinformatics	8 %	7 %
Argobiotechnology	2 %	2 %
Equipment/manufacturing	9 %	9 %
Environment	2 %	3 %
Enzymes	5 %	3 %
Food and feed	16 %	14 %
Total	**100 %**	**100 %**

Note: In 2010 23 companies represented two or more sectors, in line with 16 companies in 2004.

tion of the industry. Pessimistic views of the industry might relate to the tempting, immediate comparisons to ICT, which not only is one of the current pillars of the Finnish economy, but also experienced a very rapid growth period in the 1990s and 2000s. In an earlier comparison between biotechnology and the major pillars of the Finnish economy (Hermans et al 2004), it became evident that biotechnology lags ICT by about 30 years. In other words, we should reflect on the situation of biotechnology today in the context of ICT in the early 1980s. In this context, the differences between the industries are still there, but we begin to understand that ICT did not emerge as a global paradigm shift overnight. In place of direct comparisons, one should ask how Finnish biotechnology looks like in 2040.

What, then, are the potential growth paths of biotechnology in Finland, and does it have the potential to scale up rapidly? Although we cannot provide a direct answer, we do have information on the companies' own views on how they expect to grow in the near future.

4.4 Expectations and reality

When discussing the growth of the biotechnology business in Finland, the main source of data on the potential future growth prospects are the companies themselves. This owes to the fact that the average company history in the industry is still very short. In an earlier study, it has been established that companies base their future growth expectations on the science-driven technological base rather than market-demand (Nikulainen et al. 2008). Building on this finding, it is interesting to identify whether this strategy actually worked and what the realized outcomes were in terms of sales.

As the companies in Finland were targeted with very similar surveys in 2004 and 2010, we have a unique opportunity to analyse expectations as expressed in 2004 and actual, materialized performance in later periods. In the following, we reflect whether earlier growth expectations of the companies actually became reality. We achieve this objective by comparing sales expectations for 2008 as reported in 2004, and the realisation of the expectations in 2008 as reported in 2010. In addition, we have reported growth expectations (from the 2010 survey) until 2013. Based on these data, we can establish how well the companies can predict their future growth and what may be the growth path in the near future.

When discussing these growth expectations one has to remember that they are subjective, survey-based estimates that were made ad hoc during the interview, and, most importantly, represent expected sales figures in the case that everything goes according to plans. Based on these considerations, we expect that, for most companies, the expectations clearly exceed the materialized sales due to unaccounted technological and economic risks that, most probably, have not been integrated into the interviewees' responses.

These risks relate directly to the nature of the business. The biotechnology business is strongly dichotomous: when a company succeeds in developing a marketable product the pay-offs are often very substantial. In case of failure, companies often face bankruptcy. If the interviewees did not believe in the success of their business, they would arguably not be in the business in the first place. Thus, given that the interviewees' responses are expected to reflect a bias towards the more optimistic outcomes, we readily expect to find a fairly large margin between expectations and materialized sales. The more interesting question is by what margin expec-

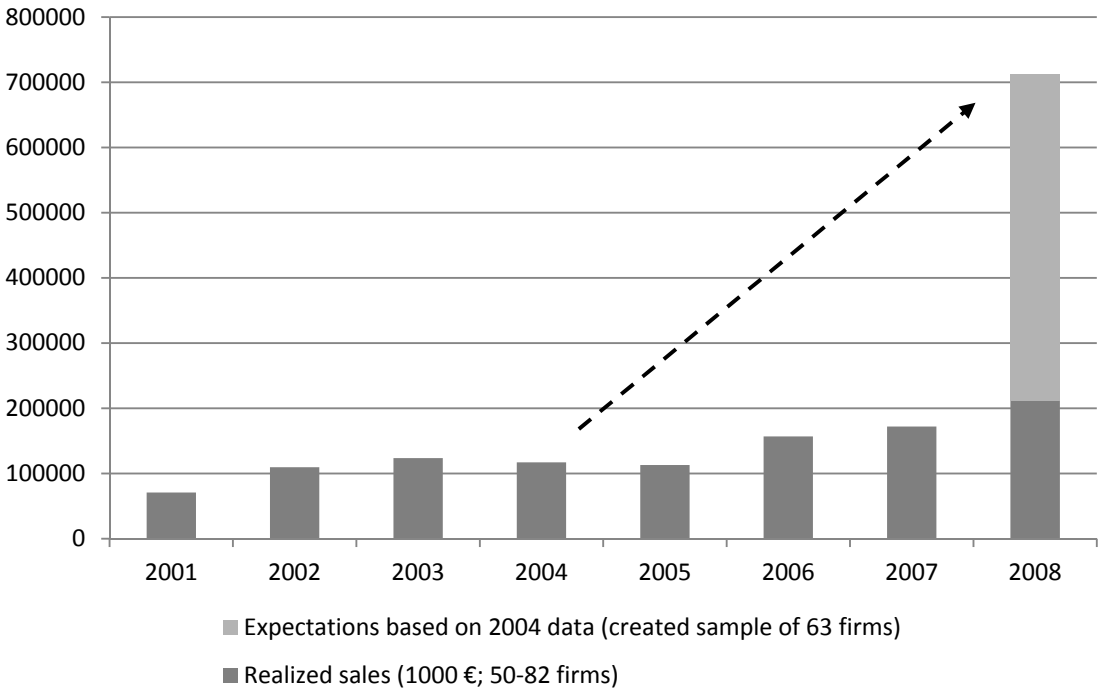
tations exceed sales, and whether there are any companies that, in fact, surpass their original expectations.

To shed light on differences between expectations and materialized outcomes, Figure 3 shows both the realized sales (dark grey) and the corresponding expectations (light grey), highlighting a clear discrepancy. When interpreting the figure and its data, it should be noted that the number of companies/observations for the actual sales varies year by year, and that the expectations disclosed by the companies by nature reflect the most optimistic scenarios.

We can see that actual sales have not seen an exponential growth but follow a linear, increasing trend. The total sales in 2008 were slightly over 200€ million whereas the expected sales were slightly over 700€ million; roughly 3.5 times the actual sales. However, the projected sales do not reflect the option of failure – a risk that is particularly significant in high technology sectors. Hence, we need to take a more in-depth view reflecting not only returns but also risks.

Hermans et al. (2004) presented a growth forecast of the entire Finnish biotechnology sector based on interviews performed in 2001. The risk-corrected model forecasted for 2006 a value added between 850 and 1 200 million euros for the entire Finnish biotechnology industry, corresponding to a yearly growth of 10–18% from the 2001 starting point of 500 million (Hermans, Kulvik and Ylä-Anttila 2004).

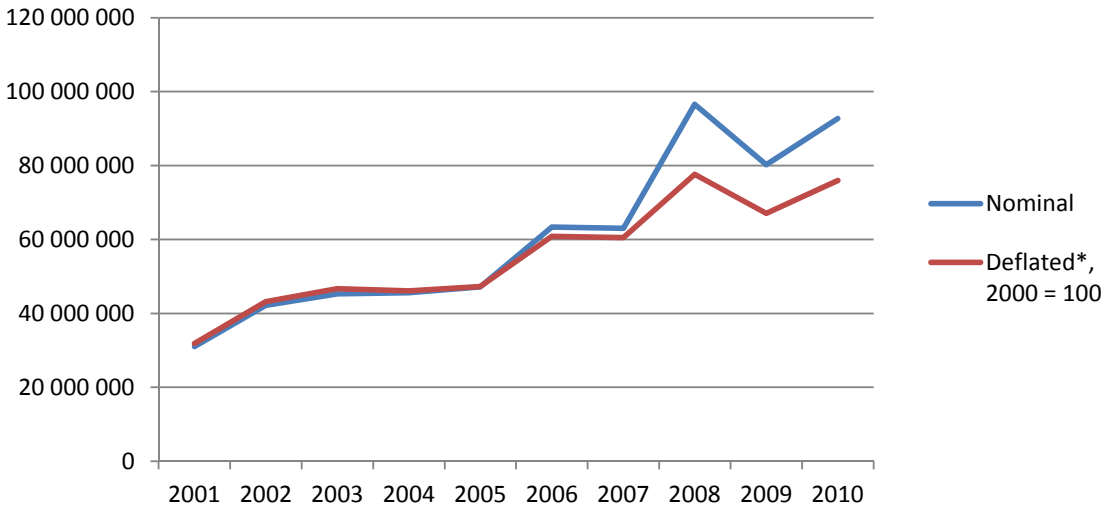
Figure 3 The realized and expected sales in Finnish biotechnology business from 2001 to 2008



Note 1: The collected data on expected sales in the 2004 survey concerns the year 2008.
Note 2: The data regarding expectations has been derived from a sample of 21 companies for which we had survey and official data. The sample of 63, thus, has been obtained by multiplying the original sample by a factor of three. This is a conservative approximation of the actual situation.

In follow-up ETLA studies of 2005 and 2010 the focus has been narrowed to so called dedicated biotechnology companies, as the line between biotechnology and other fields has with the development of biotechnologies become very elusive: a significant part of companies within the food, brewery, cosmetics, drug and even pulp and paper industry rely on biotechnological applications in their production. Figure 4 shows the realized value added of dedicated biotechnology SME companies between years 2001 and 2010, which gives comparability to the forecast of 2004. Between years 2001 to 2006 the deflated added value approximately doubled, corresponding to an annual growth of 13 percent. This can favourably be compared to the risk-adjusted forecast of 10–18% annual growth. The average yearly growth of value added for the entire time period (2001 to 2010) was 10%, and the total amount of active companies varied between 75 and 103.

Figure 4 Value added from year 2001 to year 2010 (SMEs, deflated, sales in euro)



* Deflated by producer price index, branch of activity at 2-number level, year 2000 = 100. Source: Mika Pajarinen/ETLA 2012.

One additional way of looking at the gap between a single company's projected sales *vs.* realized sales is through the distribution of the ratio between expected sales per actual sales (Table 4). An index higher than one indicates that the company overestimated it sales, and, vice versa, an index lower than one indicates that the company had higher than expected sales. Again we need to remember that a company looking for funding has strong incentives to avoid underestimating it's future sales, as such an underestimation not only tends to make the company less interesting for any funding, but also diminishes the company's pre-value and hence increases potential ownership dilution.

The data shows that only one company exceeded its sales expectations. Most of the others were less successful. Four companies reported 1–3 times higher sales expectations than accrual sales. The distribution is quite even over the categories, but it should be noted that the last category (50+) includes two companies that had very high index values; two had several hundreds and one almost four thousand. The results clearly show that companies perform very

Table 4 Companies and their expectation indexes

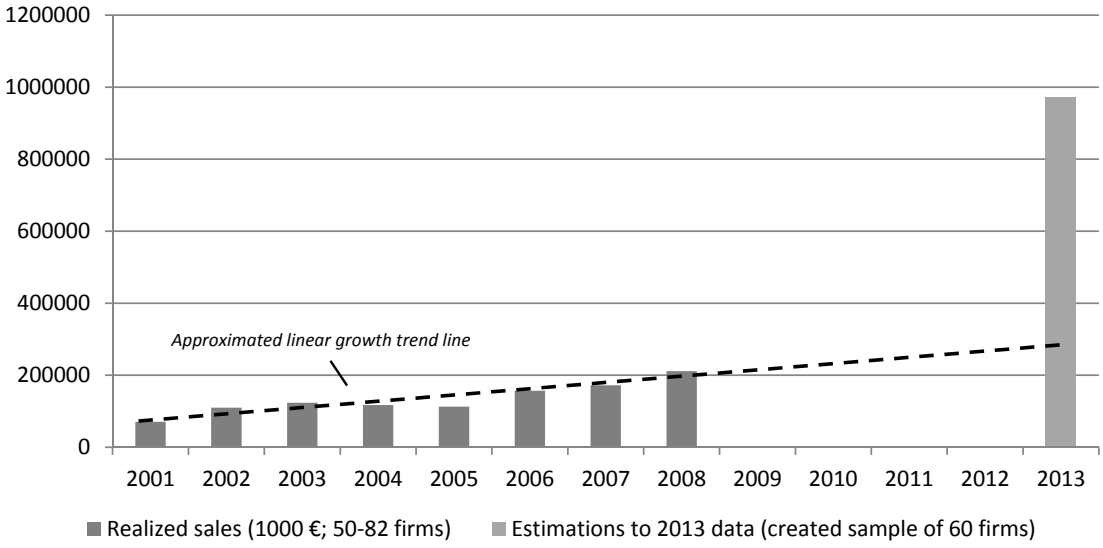
Index	*# of companies*
<1	1
1– <3	4
3– <5	4
5– <10	4
10– <20	4
20– <50	0
50+	4
Total	**21**

differently in making valid predictions about their future growth, and heavy underperformance relative to the respective predictions can be a reflection of high growth potential associated with equally high risks (Hermans and Kulvik, 2009).

For comparison we show sales predictions for 2013 of SME biotechnology companies participating in the ETLA 2010 survey (Figure 5).

We see a very similar pattern as with companies participating in the 2004 survey. The disclosed growth expectations are high, suggesting an exponential growth. As we have discussed above, the companies do understandably not include the option of failure in their disclosed earnings projections.

Figure 5 The expected sales in 2013



Note 1: The collected data in the 2010 survey concerns 2013.
Note 2: The expected data has been derived from a sample of 20 companies for which we had survey data (2010 survey). The sample of 63, thus, has been obtained by multiplying the original sample by a factor of three. This is a conservative approximation of the actual situation.

The companies estimate that the compound sales in 2013 would total almost 1000€ million. An alternative, mechanistic way of looking at the development is to expect a more linear growth. A conservative annual growth of €20 million would yield total sales of €310 million for 2013. If one looks at the development of employment and using the linear growth assumption, we can project that the small and medium sized biotechnology industry potentially employs slightly over 1800 persons in 2013.

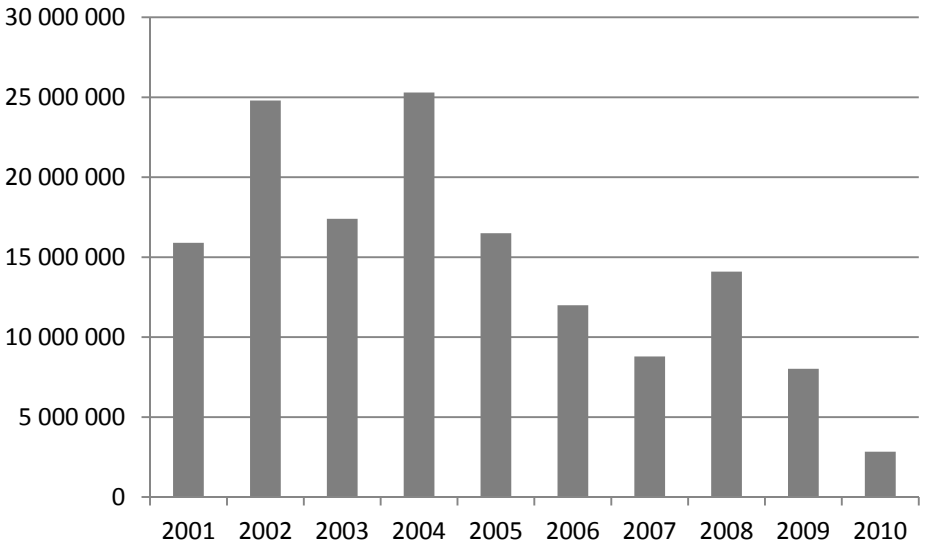
As a conclusion of these exercises on growth expectations and the materialised sales, we can say that the industry growth has been surprisingly strong, but that it fails to show signs of the exponential growth indicated in industry policy goals set for the Finnish biotechnology industry around the millennium shift.

If the development of Finnish biotechnology has experienced strong linear growth, why, then, is the industry often labelled a failure and a harvester of public R&D investments? To answer this question, the next section addresses the public investments made to the biotechnology companies in Finland.

5 Changing tides in Finnish public investments to biotechnology business

One of the most common perceptions is that the Finnish biotechnology industry has received more than its share of public R&D subsidies. To shed some light on this, in the following we will discuss these investments and, later on in Section 6, we will address whether they have a connection to company performance. The trend of all Tekes' investments (grants and loans) to small and medium sized biotechnology companies is illustrated in Figure 6. The figures are

Figure 6 Public investments made by Tekes to SME biotechnology companies (€)



Note: Represents the public investments made to the companies identified in the 2004 and 2010 biotechnology company lists.
Data source: Tekes.

based on company-specific data, and the companies represent dedicated SME biotechnology companies only.

In the beginning of the 2000s, public investments made by Tekes have increased quite significantly, but during the latter half of the decade they have almost as sharply decreased again. Reasons for this development are somewhat unclear but one of the reasons may be the relatively high investments with respect to the total budget of Tekes (Table 5).

Table 5 Share of biotechnology investments of total Tekes budget

2001	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
4.1 %	6.5 %	4.5 %	6.2 %	3.8 %	2.6 %	1.9 %	2.8 %	1.3 %	0.5 %

Data source: Tekes.

What is evident from Table 5 above is that the share of biotechnology investments made by Tekes increased substantially in the mid-2000s followed by steep decline. Based on commentaries from Tekes, there was a policy shift as it became evident that biotechnology was consistently allocated quite a large share of Tekes' total funding. In addition, the financial crisis has most likely had an impact on funding as the funding instruments reported here do usually require a 50% match from private funding sources (for example venture capitalists).

After discussing the various trends in the Finnish biotechnology business, such as sales, employment, industry composition, expected and realised sales, and public investments, it is worthwhile to address the performance of biotechnology companies in greater detail. We know from earlier research that the industry does have a high level of heterogeneity among the companies and particularly in their performance (Hermans and Kulvik, 2006).

6 Company performance in the Finnish biotechnology business

In the following we will assess the Finnish biotechnology dedicated SMEs by looking at two performance indicators: growth and profitability. We will not try to identify the causality between the performance indicators and suitable explanatory variables, as this would require larger and time-series-based data sets allowing more thorough statistical analyses. We merely hope to identify typical company characteristics and their connection with performance.

6.1 Indicators for company performance

The first performance indicator is the average growth rate of sales and employment of a biotechnology SME in Finland during the years available for each company. As the term high-growth-firm is quite established, we need to make a difference between the standard use of high-growth-firm and our definition of a "growth" company used in the present paper. The OECD proposes the following definition of a high growth firm: 'All enterprises with average

annualised growth in employees or turnover greater than 20% per annum, over a three year period, and with more than 10 employees in the beginning of the observation period, should be considered as high growth enterprises' (OECD, 2007). If this definition would be used, only very of the Finnish biotechnology companies would be classified as high-growth-firms. Therefore, we use a slightly modified definition of a growth company: 'All enterprises with average annualised growth in turnover and/or in employment greater than 20% per annum, over the available observation period, will be considered as growth companies'. Our definition aims to take into account the sometimes very volatile changes in annual sales and employment in the biotechnology business.

The second performance indicator is the profitability of the biotechnology companies. We divide the companies into three subgroups: i) companies that have never been profitable (at least during our observation period 2001-2008), ii) companies that have irregularly been profitable (at least once during 2001-2008), and iii) companies that have been profitable throughout the observation period.

Before going into the analysis, an important aspect should be highlighted. The data used in the subsequent analysis is largely based on the 2010 survey data, which is supplemented by data from Statistics Finland and National Board of Patents and Registration of Finland (financial data) and Tekes (funding data). In some cases we lacked data for some of the companies in a variety of variables. In such cases, we resorted to statistical imputation methods to ensure that we maintained a consistent number of observations in the analyses. The imputed data points were approximated based on other variables thus creating an intact data set. While the imputation usually does not have significant impact on the outcomes of a statistical analysis, it should be acknowledged when interpreting the results.

For the analysis we selected a small number of relevant variables from the 2010 survey. The industry variables represent the main sectors of activity of the biotechnology SMEs and only sectors in which more than 10% of companies were active were included. The other sectors of the industry are used as the reference group. Variables capturing company characteristics include the age of the company (approximated through the year of foundation), size (approximated through the size of personnel), research intensity (approximated through a ratio of PhD's per total personnel), and the role of public funding (approximated through the Tekes funding per personnel; 1000€). We also took into account the background of the company by identifying whether it is a spin-off from another company, whether one of its founders has founded companies before (approximating serial entrepreneurship), and whether the company has links to the original research upon which their current technologies build upon (approximating the closeness to science). Finally, we have the dependent variables which were already discussed farther above.

Table 6 presents the summary statistics for these variables. The first columns describe the data as a whole and in the following it is stratified based on the performance indicators.

It is evident that differences can be seen between the different groups. Although some interpretations could already be drawn based on the summary statistics alone, we prefer to statistically control for the interaction between the different variables and highlight their statistical significance. Therefore, in the following, we will analyse the dependent variables using regression analysis.

Table 6 Summary statistics

OBS / *Variable*	*ALL* 63 Mean	*Growth company: Yes* 20 Mean	*Growth company: No* 43 Mean	*Profitable: Never* 33 Mean	*Profitable: Sometimes* 20 Mean	*Profitable: Always* 10 Mean
Industry (%)						
Drug development	44.4 %	45.0 %	44.2 %	42.4 %	35.0 %	70.0 %
Diagnostics	27.0 %	35.0 %	23.3 %	21.2 %	20.0 %	60.0 %
Biomaterials	23.8 %	15.0 %	27.9 %	36.4 %	15.0 %	0.0 %
Manufacturing	17.5 %	5.0 %	23.3 %	21.2 %	15.0 %	10.0 %
Enzymes	11.1 %	15.0 %	9.3 %	0.0 %	10.0 %	50.0 %
Food and feed	12.7 %	10.0 %	14.0 %	6.1 %	15.0 %	30.0 %
R&D services	25.4 %	40.0 %	18.6 %	18.2 %	35.0 %	30.0 %
Consulting	12.7 %	10.0 %	14.0 %	9.1 %	20.0 %	10.0 %
Company characteristics						
Founding year	1998.4	1999.1	1998.1	2002.5	1993.6	1994.9
Personnel (# of employees)	19.3	27.0	15.7	13.8	23.2	29.6
PhD per personnel (%)	36.5 %	40.0 %	34.9 %	45.5 %	25.0 %	30.0 %
Funding per personnel (1000€)	86.2	136.8	62.7	130.3	34.5	44.0
Origin of company (%)						
Spin-off	15.9 %	20.0 %	14.0 %	15.2 %	10.0 %	30.0 %
Serial entrepreneur	11.1 %	10.0 %	11.6 %	15.2 %	0.0 %	20.0 %
No link to original research	9.5 %	10.0 %	9.3 %	6.1 %	15.0 %	10.0 %
Company performance (%)						
Growth company	31.7 %	100.0 %	0.0 %	24.2 %	40.0 %	40.0 %
Never profitable	52.4 %	40.0 %	58.1 %	100.0 %	0.0 %	0.0 %
Sometimes profitable	31.7 %	40.0 %	27.9 %	0.0 %	100.0 %	0.0 %
Always profitable	15.9 %	20.0 %	14.0 %	0.0 %	0.0 %	100.0 %

6.2 Company performance in statistical analysis

Although the distributions between the different strata above does illustrate some basic differences between the companies, more detailed analysis is needed to understand which companies really are growth companies and which of them can turn a profit. For this reason, we resort to regression analysis where both of the performance indicators are taken into account as dependent variables.

The results (in Table 7) from the regression analysis provide very interesting insights into the Finnish biotechnology business. Looking first at the probability of a company being a growth company, we can make several findings. When controlling for industry sector effects, we can see that companies reporting their main activities relating to manufacturing and consulting are less likely to be growth companies. In contrast, if a company is actively involved in research and development activities, it is more likely to be a growth company. The growth companies are also more likely to be younger, larger and having received more public funding from Tekes

Table 7 The probit regression results for company performance indicators (with robust standard errors)

Variable	*Growth company: Yes = 1* Coef.	P>|z|	*Profitable: Never Yes = 1* Coef.	P>|z|	*Profitable: Sometimes Yes = 1* Coef.	P>|z|	*Profitable: Always Yes = 1* Coef.	P>|z|
Industry								
Drug development	-0.499		-0.579		-0.065		0.698	*
Diagnostics	0.716		0.168		-1.043	*	1.091	*
Biomaterials	0.265		4.177	***	-0.981	+	(omitted)	
Manufacturing	-1.302	**	0.871		0.303		-0.897	+
Enzymes	0.077		(omitted)		-1.138	+	1.790	**
Food and feed	0.229		0.665		-0.969		0.991	
R&D services	0.996	*	2.824	***	0.534		-0.421	
Consulting	-1.673	***	-3.698	***	1.582	**	-0.986	*
Company characteristics								
Founding year	0.095	**	0.332	***	-0.140	***	0.015	
Personnel	0.027	***	-0.024		-0.004		0.008	
PhD per personnel	0.609		2.307	***	0.114		-0.104	
Funding per personnel	0.003	**	0.015	***	-0.004	**	-0.004	**
Background of company								
Spin-off	-0.522		-1.485	*	-0.081		-0.108	
Serial entrepreneur	0.656		4.082	***	(omitted)		0.788	
No link to orig. research	-0.011		-1.339	**	0.556		-1.247	
Company performance								
Never profitable	-1.691	**						
Always profitable	-0.761							
Growth company			-2.134	**	1.074	**	0.243	
Constant	-189.8	**	-665.7	***	279.73	***	-33.24	
Number of obs	**63**		**63**		**63**		**63**	
Wald chi2	32.15		47.21		31.8		50.48	
Prob > chi2	0.014		0.000		0.007		0.000	
Pseudo R2	0.330		0.656		0.414		0.435	
Log pseudolikelihood	-26.39		-15.00		-23.06		-15.57	

+ p<0.15, * p<0.10, ** p<0.05, *** p<0.01
Note: (omitted) indicates that in this category no companies belonged to the industry/background indicated. This leads to a situation where no variance exists and, thus, the variable cannot be included in the regression.

than low-growth companies. Furthermore, growth companies are less likely to have made consistent losses during the observation period. We do not find that the growth is related to R&D intensity (approximated through PhD per personnel ratio) or background of the company. To sum up, it could be said that growth companies in the Finnish biotechnology business are more likely to be involved actively in research and development, they are younger and larger and have received more public funding, but they are less likely to be involved in manufacturing and consulting, and are not making consistent losses.

Turning the attention to the profitability in the Finnish biotechnology business, we can make several revealing findings. When looking at the binary variable that indicates whether companies have never made profits, we can see that negative profitability relates to companies that have activities in biomaterials, are younger, have a serial entrepreneur as a founder, and have received more Tekes funding. The consistent negative profitability is less likely related to companies that have no links to the original academic research activities or being a growth company.

As we turn to the binary variable identifying companies with inconsistent profit performance, we can see that this type of company is more likely to be involved in consulting and is more likely to be a growth company. These companies are less likely to be involved in activities related to diagnostics, they are older, and they have received less per capita funding from Tekes.

The final regression model analyses the binary variable that indicates whether companies have consistently made profits during the observation period. The results suggest that consistent profitability is related to activities in drug development, diagnostics and enzymes. The consistent profitability is less likely to relate to activities in consulting and to the reception of funding from Tekes.

To summarize the regression results, we can say that when looking at the industry controls it seems that higher growth is related to activities in R&D services. R&D service activities are interestingly also related to never making a profits. Lower growth seems to be related to activities in manufacturing and consulting. Both industries are also negatively related to the probability of displaying consistent profitability, and the latter seems to be more related to inconsistent profitability. Companies active in biomaterials are more likely to have never made profits, whereas companies active in enzymes are more likely to be consistently profitable.

Unsurprisingly, younger companies are more likely to have higher growth and inconsistent profits, which is typical in most technology-based companies that are starting their operations. The size of the company does matter for being a growth company which suggests that critical mass in size may be a determinant in becoming a growth-oriented company.

The variables on the serial entrepreneurship seem to relate to loss-making. This finding is somewhat contradictory to the findings in the broader literature of entrepreneurship. Interestingly, companies that have no ties to the original research upon which the company's technologies build on are also less likely to belong to the group of companies that makes consistent losses. This may confirm earlier findings that companies in which the original innovators are still involved may in fact perform more poorly in the markets. This finding is somewhat contradictory to the extant literature that highlights the positive role of including the original inventor(s) in subsequent research activities (Murray, 2004). It maybe that letting go of own one's research is a particular challenge in the Finnish biotechnology business and results in lower company performance.

Tekes' funding does have a connection to the growth of companies, and to all of the profitability categories. In case growth companies and never making profits, the connections is positive suggesting that public funding has particularly targeted growing companies that typically make losses during their growth phase. The negative connection between public funding and making a profit sometimes or consistently suggests that these companies are in a phase were public funding has a lesser role to play.

7 Concluding discussion

In this paper we address the evolution of the Finnish biotechnology industry focusing on the activities of its SME sector. The sector has been said to perform poorly compared to the public investments made into it. In the current paper we aimed to shed light on this aspect by looking at the development of the sector from various perspectives. We discussed the trends in sales and employment, the evolution of company population both in terms of size and composition, the entry and exit rates in the sector, the expected and realized growth paths of the industry, the evolution of public investments to the Finnish biotechnology business, and company performance by analysing company growth and profitability. The paper addresses specific, although interrelated, aspects of the Finnish biotechnology business, we can draw some overarching conclusions based on the empirical findings.

Despite its poor reputation, the biotechnology sector has grown significantly. We identified that the sector has grown rapidly during the 2000s both in terms of sales and employment. This may suggest that the biotechnology business is slowly beginning to emerge as a viable sector. Naturally, every industry has companies that perform poorly and others that do well, but in Finland some of the cases in biotechnology may have received more unwarranted critical attention than in other industries. To support this argument, we also showed that the entry and exit rates of companies in the biotechnology sector do not significantly differ from the average rates of other industries. In addition, the composition of biotechnology sectors has remained very stable indeed. The fact that half of the companies are new suggests that the Finnish biotechnology industry as a whole has found its position in the global industry, maybe reflecting the specific strengths and the knowledge pool vested within the sector.

When discussing the future evolution of the biotechnology industry in Finland, one has to mostly rely on the companies' self-reported perspectives, as they can be assumed to have a deeper understanding of the technological and economic potential of their company assets. Interestingly, we found that companies are not very good in making reliable predictions of their future. This type of overestimation of performance is typical when discussing a company's future development as companies would report the anticipated growth based on the assumption that everything goes in accordance with their best case scenarios. Based on the predictions of the companies and the realised actual growth we could still argue that the Finnish biotechnology sector will most likely still grow linearly, although there is always a small possibility for rapid exponential growth.

The biotechnology sector in Finland has received significant public investments, as is the case also in many other countries, raising the question what has been achieved with the funding and how it has related to companies' performance. We identified that public funding, in this paper synonymous with Tekes funding, rapidly grew in the early 2000s, peaked in the middle of the decade, and, by the end of the decade, had dwindled down to only a fraction of the funding provided in the peak years. What we know is that this trend has been affected by policy changes that have resulted in a situation where biotechnology is strategically not seen as an equally important technology area as before. The decreasing funding trend has also been related to the financial crisis that virtually stopped the flow of private equity, which is a requirement for receiving public funding.

We also addressed the question of performance in the Finnish biotechnology business. We used two indicators, growth and profitability, to understand the heterogeneity of the companies as well as to identify the source of the significant growth of the sector. We identified that growth is most related to younger and larger companies, suggesting that critical mass in terms of size seems to be relevant for rapid growth. However, this growth is not always profitable. Looking at the profitability dimension of performance, we identified significant differences across the different sectors of biotechnology. Based on these findings we can argue that the biotechnology sector consists of a very heterogeneous group of companies.

The empirical analysis presented in this paper makes a contribution to the extant literature by focusing on perspectives that have largely been left outside the research scope in previous efforts. In addition, implications for public policy can be drawn. First, the Finnish biotechnology sector consists of a heterogeneous group of companies. Having a single policy instrument to fit all their needs may not be sufficient. Companies that are entering markets with developed technologies require a different type of support than companies that focus on R&D activities. To a large extent, this situation is considered in current and in future activities by the public actors (see for example Tekes strategy, 2011). We wish to emphasize that this change is warranted and necessary.

The second policy implication relates to the stability of both public and private funding. As we showed, the public funding has fluctuated significantly during the 2000s; not only that from Tekes, but also from the funding provided by Sitra (The Finnish Innovation Fund), which has been making its exit from biotechnology related investments actively during the latter part of the decade. While public policy has only limited ways of affecting the availability of private equity (excluding Sitra's activities), promotion of tax incentives for venture capital might be an option as suggested for example in the recent Evaluation of the National Innovation System (Reinhilde et al. 2009).

With this paper we hope to provide more understanding on the recent developments in the Finnish biotechnology business focusing on the activities of the SMEs in this industry. Only a limited number of perspectives could be explored in this paper, thus leaving significant room for further research. This growing sector does have potential, but it is still unclear when and if it will experience a rapid growth phase.

References

Ahola, E. – Kuisma, M. (1998): "Biotekniikkasektori Suomessa – Laboratoriosta lupausten lunastajaksi", Teknologiakatsaus 61/98, Teknologian Kehittämiskeskus, Helsinki.

Halme, K. (1994): "Uudet yritykset biotekniikkasektorilla 1994", Working Papers, No 11/94, VTT, Espoo.

Halme, K. (1996): "Biotekniikka uusien yritysten toimialana", Working papers, No 24/96, VTT, Espoo.

Hermans, R. (2003): "Lääkealan biotekniikkayritysten rahoitusrakenteet ja liiketoiminnan ominaispiirteet", DOSIS. Farmaseuttinen aikakauskirja 2003:3, p. 133–145.

Hermans, Raine – Kamien, Morton – Kulvik, Martti – Löffler, Alicia – Shalowitz, Joel (2009a): Medical innovation and government intervention. The Research Institute of the Finnish Economy (ETLA), B series 236, Helsinki.

Hermans, Raine – Kamien, Morton – Kulvik, Martti – Tahvanainen, Antti-Jussi (2009b): The effect of technology subsidies on industry strategies and market structure. In Hermans, Raine – Kamien, Morton – Kulvik, Martti – Löffler, Alicia – Shalowitz, Joel (eds.): Medical innovation and government intervention. The Research Institute of the Finnish Economy (ETLA), B series 236, Helsinki.

Hermans, R. – Kauranen, I. (2003): "Intellectual Capital and Anticipated Future Sales in Small and Medium-sized Biotechnology Companies", Discussion Papers, No 856, ETLA, Helsinki.

Hermans, Raine – Kulvik, Martti (2006): Sustainable Biotechnology Development – New Insights into Finland. The Research Institute of the Finnish Economy (ETLA), B series 217, Helsinki.

Hermans, Raine – Kulvik, Martti – Tahvanainen, Antti-Jussi (2006): The Biotechnology Industry in Finland. In Hermans, Raine and Kulvik, Martti (ed.): Sustainable Biotechnology Development – New Insights into Finland. The Research Institute of the Finnish Economy (ETLA), B series 217, Helsinki.

Hermans, R. – Luukkonen, T. (2002): "Findings of the ETLA Survey on Finnish Biotechnology Firms", Discussion Papers, No 819, ETLA, Helsinki.

Hermans, Raine – Linnosmaa, Ismo (2009): Price regulation and industry performance. In Hermans, Raine – Kamien, Morton – Kulvik, Martti – Löffler, Alicia – Shalowitz, Joel (eds.): Medical innovation and government intervention. The Research Institute of the Finnish Economy (ETLA), B series 236, Helsinki.

Hermans, Raine – Löffler, Alicia – Stern, Scott (2009): Knowledge hubs in the global biotechnology industry. In Hermans, Raine – Kamien, Morton – Kulvik, Martti – Löffler, Alicia – Shalowitz, Joel (eds.): Medical innovation and government intervention. The Research Institute of the Finnish Economy (ETLA), B series 236, Helsinki.

Hermans, R. – Tahvanainen, A.-J. (2002): "Ownership and Financial Structure of Biotechnology SMEs: Evidence from Finland", Discussion Papers, No 835, ETLA, Helsinki.

Hermans, Raine – Tahvanainen, Antti-Jussi (2006): Regional differences in patterns of collaboration, specialisation and performance. In Hermans, Raine and Kulvik, Martti (ed.): Sustainable Biotechnology Development – New Insights into Finland. The Research Institute of the Finnish Economy (ETLA), B series 217, Helsinki.

Hussi, Tomi – Hermans, Raine – Kulvik, Martti – Tahvanainen, Antti-Jussi (2006): How Do You See the Future Prospects of the Finnish Biotechnology Industry? Interviewing 89 Business Leaders. In Hermans, Raine and Kulvik, Martti (ed.): Sustainable Biotechnology Development – New Insights into Finland. The Research Institute of the Finnish Economy (ETLA), B series 217, Helsinki.

Kulvik, M. – Peltonen, I. – Tahvanainen, A. (2011). Insights Into the Finnish Biotechnology Companies – Interviews of 70 Industry Leaders. ETLA DP *nnn*.

Kulvik, M – Linnosmaa, I – Shalowitz, J. – Hermans, R. (2009): *Promoting Efficient Treatment: New Technology and Health Care Costs.* In: Hermans, R – Kamien, M – Kulvik, M – Löffler, A – Shalowitz, J (eds.) (2009): *Medical Innovation and Government Intervention*, Kellogg School of Management and ETLA, ETLA series B236, Helsinki.

Pekkala, A. – Pouru, V. – Kulvik, I. – Taskinen, J. – Kulvik, M. (2011): Vaikuttavuus-kustannus-mallin käytettävyystutkimus, väliraportti.

Luukkonen, T. – Palmberg, C. (2004): "Suomen teollisuuden seuraava läpimurto? Uuden biotekniikan vertailu tietotekniikka-alaan" (The next breakthrough of the Finnish industry? A comparison of new biotechnology to information- and communication technology). In Luukkonen, Terttu (ed.): Biotechnology – Knowledge Based Business. The Research Institute of the Finnish Economy (ETLA), B series 207, Helsinki.

Luukkonen, T. – Tahvanainen, A. – Hermans, R.(2004): "Suomen biotekninen teollisuus – yleiskatsaus" (The Finnish Biotechnology Industry – An Overview). In Luukkonen, Terttu (ed.): Biotechnology – Knowledge Based Business. The Research Institute of the Finnish Economy (ETLA), B series 207, Helsinki.

Murray, F. (2004): "The role of academic inventors in entrepreneurial firms: sharing the laboratory life", Research Policy, Vol. 33 (4), pp. 643–659.

Nikulainen, T. – Kulvik, M. – Hermans, R. (2008): "Patent citations indicating present value of the biotechnology business", International Journal of Innovation and Technology Management, Vol. 5(3), pp. 279–301.

OECD (2009): "OECD Biotechnology Statistics – 2009", OECD, Paris.

OECD (2007): "High growth enterprises and gazelles", OECD, Paris.

OECD (2010): "Measuring innovation: A new perspective", OECD, Paris.

Random House (1993): "Random House Unabridged Dictionary", Second edition. Random House, New York.

Saarinen, J. – Ebersberger, B. – Rantanen, M. (2003): "Expectations in biotechnology: From optimism to pessimism – and back to optimism? ", Kemia – Kemi, Vol. 30, No: 6.

Tahvanainen, A.-J. (2003): "The Capital Structure of Finnish Biotechnology SMEs - An empirical analysis", Discussion Papers, No 864, ETLA, Helsinki.

Tahvanainen, Antti-Jussi (2004): Growth Inhibitors of Entrepreneurial Academic Spin-offs: The Case of Finnish Biotechnology. International Journal of Innovation and Technology Management, No 4, VOL 1.

Tahvanainen, Antti-Jussi – Hermans, Raine (2005): Funding Intellectual-Capital-Abundant Technology Development: Empirical Evidence from the Finnish Biotechnology Business. Knowledge Management Research & Practice, No. 3, pp. 69–86.

Tulkki, P. – Järvensivu, A. – Lyytinen, A. (2001): "The emergence of Finnish Life Sciences industries", Sitra Reports series 12, p. 10–79.

Veugelers, R. et al. (2009): "The Evaluation of the Finnish National Innovation System – Full Report", TEM.

Aikaisemmin ilmestynyt ETLAn Keskusteluaiheita-sarjassa

Previously published in the ETLA Discussion Papers Series

No 1270 *Hannu Hernesniemi*, Merenkulun toimintaedellytykset, kilpailukyky ja julkisen talouden sopeuttamistoimet. Taustaselvitys valtiovarainministeriölle. 18.4.2012. 53 s.

No 1271 *Petri Böckerman – Mika Maliranta*, Outsourcing, Occupational Restructuring, and Employee Well-being. Is There a Silver Lining? 11.4.2012. 28 p.

No 1272 *Heli Koski*, The Role of Data and Knowledge in Firms' Service and Product Innovation. 24.5.2012. 18 p.

No 1273 *Pekka Ylä-Anttila*, Sähkö-, elektroniikka- ja tietotekniikka-ala. Tuotantoketjut hajautuvat, osaamistarpeet muuttuvat. 29.5.2012. 16 s.

No 1274 *Timo Harakka*, A New Narrative for Europe? Summary of a BRIE-ETLA Seminar. 31.5.2012. 10 p.

No 1275 *Marcel Veenswijk – Henk Koerten – Jaap Poot*, Unravelling Organizational Consequences of PSI Reform. An In-depth Study of the Organizational Impact of the Reuse of Public Sector Data. 18.6.2012. 56 p.

No 1276 *Heli Koski – Pertti Kiuru – Jaana Mäkelä – Marjut Salokannel*, Julkinen tieto käyttöön. 19.6.2012. 9 s.

No 1277 *Marjut Salokannel*, Julkisesta datasta avoimeen dataan. Julkisen datan lisensiointi. 16.8.2012. 36 s.

No 1278 *Matias Kalm*, The Impact of Networking on Firm Performance. Evidence from Small and Medium-Sized Firms in Emerging Technology Areas. 31.8.2012. 78 p.

No 1280 *Hannu Hernesniemi*, Kone- ja metallialan koulutuksen laadullinen ennakointi. 31.8.2012. 40 s.

No 1281 *Hannu Hernesniemi – Martti Kulvik – Pekka Ylä-Anttila*, Pohjois-Savon kilpailukyky ja tulevaisuuden haasteet. Selvitys Pohjois-Savon liitolle. 7.9.2012. 87 s.

No 1282 *Kari E.O. Alho*, Targets, Models and Policies: A Quantitative Approach to Raising the EU Employment Rate. 29.8.2012. 18 p.

No 1283 *Stefanie A. Haller – Jože Damijan – Ville Kaitila – Črt Kostevc – Mika Maliranta – Emmanuel Milet – Daniel Mirza – Matija Rojec*, A Portrait of Trading Firms in the Services Sectors – Comparable Evidence from Four EU Countries. 6.9.2012. 33 p.

No 1284 *Jože Damijan – Stefanie A. Haller – Ville Kaitila – Mika Maliranta – Emmanuel Milet – Matija Rojec*, The Performance of Trading Firms in the Services Sectors – Comparable Evidence from Four EU Countries. 6.9.2012. 40 p.

No 1285 *Tuomo Nikulainen – Julia Salmi*, Uudistaminen ja yhteistyöverkostot Suomen teollisuudessa. Havaintoja yrityskyselystä. 14.9.2012. 23 s.

ETLA
Elinkeinoelämän Tutkimuslaitos
The Research Institute of the Finnish Economy
Lönnrotinkatu 4 B
00120 Helsinki

Puh. 09-609 900
Fax 09-601 753
www.etla.fi
etunimi.sukunimi@etla.fi

ISSN 0781–6847