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ACADEMIC SPIN-OFFS IN FINNISH BIOTECHNOLOGY

– A Portrait of Firm Characteristics – **

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ABSTRACT: This paper portrays the characteristics of Finnish biotechnology SMEs that have their origin in academic research conducted in universities or other comparable research institutions. The portrayal facilitates the positioning of these firms within the sector as a whole and, even more importantly, enables the identification of strengths and weaknesses of academic biotechnology spin-offs as well as external factors that either promote or inhibit their prosperity from an entrepreneurial perspective.

Leaning on results of a linear regression analysis based on a sample of 65 companies, it is found that academic biotechnology spin-offs are constraint in several ways. 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 – the concept of the "ivory tower" – 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.

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TIIVISTELMÄ: Tämä tutkimus kuvaa yliopistoissa tai vastaavissa tutkimusinstituutioissa tapahtuvaan akateemiseen tutkimukseen pohjautuvien pienten ja keskisuurten bioteknologiayritysten piirteitä. Kuvaus mahdollistaa yritysten asemoinnin suhteessa koko bioteknologia-alaan. Lisäksi kuvauksen pohjalta voidaan tunnistaa tutkimuksen kohteena olevien yritysten heikkouksia ja vahvuuksia sekä ulkopuoliset tekijät, jotka ovat yritysten kehityksen kannalta hyödyllisiä ja haitallisia.

Tutkimuksessa käytetyn regressioanalyysin tulosten pohjalta voidaan todeta, että akateemiset spin-off-yritykset kärsivät monenlaisista rajoitteista. Ensiksikin heiltä puuttuu usein selkeä markkinaorientoitunut lähestymistapa sekä kaupallinen osaaminen, joita tarvitaan markkinoilla menestymiseen. Tämän lisäksi vallitseva käsitys, jonka mukaan akateemisten instituutioiden rooli ja yhteiskunnallinen tehtävä ovat perinteisiä ja kaupallisesta toiminnasta eristäytyneitä – metafora norsunluutornista – haittaa yritysten kykyä rekrytoida kyvykkäitä työntekijöitä. Ongelmaksi muodostuu myös Suomen pääomamarkkinoiden alikehittyneisyys tietyiltä osin. Tärkeää perustamisvaiheen rahoitusta on vaikea saada kun yksityiset ja ulkomaiset pääomasijoittajat sijoittavat pääasiallisesti yrityksiin, jotka ovat jo hyvin lähellä markkinoita.

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Executive summary

Objectives

This study aims at portraying the characteristics of Finnish entrepreneurial academic biotechnology spin-offs. The underlying assumption is that these firms differ in many ways from biotechnology firms spun off by large corporations and other firms that do not build on academic research. The characterization facilitates the positioning of these firms within the sector as a whole and, even more importantly, enables the identification of strengths and weaknesses of academic biotechnology spin-offs as well as factors that either promote or inhibit their prosperity from an entrepreneurial perspective.

Methods

Leaning on a sample of 65 small and medium sized Finnish biotechnology companies firm characteristics are identified by the means of a probit regression analysis.

Findings

Based on the results one can say that, as opposed to other types of SME level biotechnology companies, academic biotechnology spin-offs in Finland

- are smaller in size and younger in age,
- operate more often in life sciences and process industries than services,
- make relatively smaller losses,
- co-operate less in R&D with other organizations,
- use lead-time more often to protect innovation,
- are more often still primarily owned by the original founder(s) of the company,
- have more often foreign shareholders,
- have less often acquired licenses to produce products or services developed by others,
- have more often problems recruiting skilled work force,
- have more often had difficulties with start-up financing, and
- have more often problems with developing a clear business idea.

Conclusions

Entrepreneurial academic spin-offs are constraint in several ways. 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. They are technology-focused. This is apparent in that there is often no existing business plan, cooperation activities are relatively poor, firms rely heavily on lead-time to protect their innovations and do not utilize alternative business modes – e.g., offering services or acquiring licenses to products – to generate initial revenue that would make them less dependent on financial markets from the beginning of operations.

One could think that business expertise can be recruited from outside of the industry itself. In other European countries managers have been recruited from, e.g., the traditional pharma industry. Also venture capitalists with biotechnology business specific expertise have brought business skills into their portfolio companies. Finland is faced with the problem that it is not endued with a long industrial history in the development of pharmaceuticals or any other branch of industry that requires expertise comparable to the biotechnology business. A large pool of skilled individuals with relevant background which to recruit from is simply non-existent in Finland.

Second, a very traditional and detached perception and definition of the academia's role and task within society – the concept of the "ivory tower" – as well as high income tax regimes in Finland make it difficult for the academic entrepreneur to attract skilled labour, the most important resource in R&D-intensive industries. Potential employees, mostly researchers themselves, are reluctant to abandon a promising academic career for the "filthy" business world stained by commercialisation, as they perceive it. The exposure of scientific research to commerciality is perceived to distort the ultimate purpose of science, namely the quest for truth. Scientists leaving the academia are quickly marked as mavericks and traitors of the cause and are put in negative light. Additionally, academic entrepreneurs used to an academic income are unwilling – if not unable due to lack of resources – to pay market prices for skilled employees, be they scientists or business experts.

And last, with only one true seed stage risk capital provider, Sitra, Finland’s equity markets are underdeveloped. With a full portfolio of companies, that Sitra is unable to exit from at this point of time, new seed capital is next to unavailable, as private and foreign VCs invest only in companies that are already very close to the markets and have established a viable business.

For the situation to improve, measures have to be designed and applied actively not only on firm but also on the national level. On firm level, the greatest challenge is to divert from a technology-driven mode towards a strongly market-oriented mode. This calls for educational services focusing on processes of commercialisation, strategic thinking, project and technology management as well as the role of immaterial property rights and the importance of cooperation. On the national level, the definitions of the role and task of the academia require expansion aiming at the disintegration of the “ivory tower” in order to unchain academics from a purely science- and technology-focused view of the world.

1 Introduction

This paper portrays the characteristics of Finnish biotechnology SMEs[1] that have their origin in academic research conducted in universities or other comparable research institutions. In order to emphasize the entrepreneurial aspects and background of the research targets, academic spin-offs are defined to comprise of firms that were founded or at least co-founded by the originator of the academic research that the particular firm is trying to commercialise. The focus on entrepreneurial academic spin-offs is justified by the fact that the majority of biotechnology start-ups in Finland have this kind of a background. The underlying assumption is that these firms, from this point on designated “entrepreneurial academic spin-offs”, differ in many ways from biotechnology firms spun off by large corporations and other firms that do not build on academic research[2].

Based on unique and proprietary data the portrayal contributes to existing literature by providing a first-time look at Finnish academic biotechnology spin-off firms in detail. It facilitates the positioning of these firms within the sector as a whole and, even more importantly, enables the identification of strengths and weaknesses of academic biotechnology spin-offs as well as factors that either promote or inhibit their prosperity from an entrepreneurial perspective. Furthermore, findings have implications on in-depth studies that aim at generating (a) knowledge on entrepreneurship that is rooted in academic research, on one hand, and (b) advise for policy making concerning the promotion of the Finnish biotechnology sector on the other.

1.1 Background

The motivation for studying entrepreneurship in a sector that is still regarded to be in an infant state of development and of small significance at the present from the perspective of the Finnish economy can be traced back to a much broader framework

[1] SMEs in this paper are defined according to official definitions of the EU excluding firms that match at least two of the following criteria: (i) Annual turnover < 40 mill. EUR, (ii) Number of employees < 250, (iii) balance sheet total < 27 mill. EUR.

[2] Large biotech corporations are excluded from the analysis due to inconsistencies in the data and because one could assume that larger and more mature companies resemble those in other sectors in terms of firm characteristics relatively more than small and medium sized companies due to the more consolidated state of business. Thus, the inclusion of large sized firms might have diluted findings stemming from characteristics distinctive for biotechnology businesses. The question whether this assumption holds true stands open for further research and is not answered to in this paper.

that is actually in the very core of discussions about Finland's future and survival in the global economy.

According to the principle of comparative advantage, Finland has to focus on generating technological innovations in order to protect its competitiveness, as competition based on cheap mass production and economies of scale are ruled out due to small domestic markets and a high cost level. In the 1990s, the ICT sector bore the function of being the locomotive of innovation and exports growth. As the sector matures and markets saturate fast due to harsh global competition, Finland has to map and develop new sectors that (a) form a strong platform for technological innovation activities and (b) are of significance on the global scale. Biotechnology is one of the potential candidates that fit both criteria. Understanding the nature of the biotechnology business and its requirements posed to the operational, political and social environment become crucial, if one aims at an efficient and effective support of the sector. This in turn necessitates profound research, as the sector seems to differ in many ways from more traditional ones [3].

At the heart of sector growth are start-ups and, in more general terms, entrepreneurship. Growth can certainly be achieved through expansion of existent organizations, but the critical mass of players that can form a well-functioning and self-nurturing network generating sustainable growth through complementary diversity of operations can only be provided by an expansion of the company base through start-ups, entrants to the sector, which not only increase the sector in terms of size but also in scope. Thus, critical attention should be paid to the analysis of these firms. This paper takes a first step in that direction by shedding light on the characteristics of entrepreneurial academic biotechnology spin-offs.

1.2 Prior literature on academic biotechnology and other knowledge intensive spin-offs

This study positions itself amongst a fairly lean but steadily growing literature on the Finnish biotechnology sector. The first comprehensive depiction of the Finnish biotech sector was sketched by Halme (1994). He identifies and describes qualitatively

[3] For a comparison of the Finnish biotechnology and ICT sectors refer to Palmberg and Luukkonen (2004).

every Finnish biotech SME that was active in 1994 firm by firm, mostly providing information on the nature of business these firms were engaged in. He also provides a generic introduction to biotechnology and the evolution of the industry in Finland. Furthermore, Halme (1994) traces the patterns of knowledge spillovers between firms among themselves, on one hand, and between universities and firms 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 firms 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 expanding the picture to incorporate a depiction of basic biotechnological research conducted in Finland, the entities applying this research (firms mainly), the innovations based on it and the biotechnology centers established in Finland. Halme (1996) also covers foreign biotechnology sectors and sheds light on the markets for biotechnology touching shortly on the role of small businesses in the commercialization process of biotechnology. He concludes with a discourse on the operational environment of new Finnish biotech companies. 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. Halme 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. He also argues that the USA and the UK have reached leading positions in biotechnology due to favorable economic and industrial structures.

Ahola and Kuisma (1998) is another descriptive study that examines the state of the sector in 1997 and pictures its development. The paper identifies firms 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. Ahola and Kuisma summarize their findings in a SWOT-analysis. According to this analysis, the Finnish biotechnology sector is strong (a) in maintaining a good platform for growth through high quality education, (b) in building networks of interaction between educational and research institutions, firms and public entities and (c) in establishing a global orientation through a strong research background. Further strengths include a well-functioning support system for the commercialization of research results and for high-technology entrepreneurship as well as the sophisticated maturity of home markets. The sector is weak in the sense that it lacks commercial skills, is faced with rather small domestic markets and particularly lacks skilled people necessary to apply biotechnology in process industries. As major opportunities for the sector, Ahola and Kuisma (1998) identify global and growing markets, new emerging fields of application, international joint research and the skills provided by it, and the combining of technologies as a source of innovation. Threats comprise lack of skilled personnel having combined knowledge on the substance of biotechnology and commercial aspects, tight legislative regimes hindering the introduction of products to markets, lack of acceptance of biotechnological application (e.g. genetically modified food) in society, and the diminutive patience of investors.

Tulkki, Järvensivu and Lyytinen (2001) provide a comprehensive disquisition of the Finnish biotech sector in general. Using case studies, special attention is paid 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 centers 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, Järvensivu and Lyytinen (2001) express their concern about the smallness of companies. They argue that in order to be able to increase their absorptive capacity - required for applying biotechnological knowledge that in turn becomes increasingly necessary for product innovation and improvements in operating efficiency - firms 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.

In the light of expressed concern of influential political instances about the allegedly poor output performance of the biotech sector in Finland, Saarinen, Rantanen and Ebersberger (2003) study the actual performance of biotech firms as measured by the number of patents filed over the period 1993 to 2002. They find that especially new and small firms are actually performing rather well increasing their share of total patenting in Finland year after year. Taken altogether, the sector has displayed increasing patenting in the observed period.

Hermans and Luukkonen (2002) present quantitative results on the evolution of the sector in terms of the number of established firms, 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).

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.

The literature referred to so far concerns empirical works that are country specific and serve the purpose of indicating that there is relatively little existing literature concerning Finnish biotechnology, not to speak of literature that focuses explicitly on entrepreneurial academic biotechnology spin-offs in Finland. More relevant to the study at hand is a sub-branch of the generic entrepreneurship discussion focusing on *academic entrepreneurship*.

Literature on academic entrepreneurship is rather broad covering issues that approach the matter from very different perspectives and often use biotechnology companies as a target of observation due to the fact that biotechnology has its roots in academic and scientific research, as do the majority of high technologies. One of the most intensively studied aspects concerns cooperation patterns, networking and cluster formation of firms. Shan, Walker and Kogut (1994), for example, examine the association between inter-firm cooperation and the innovation output of start-ups in the biotechnology industry. Their key finding suggests that commercial ties to other companies, in this particular case to larger companies, is a pre-condition to higher innovation output measured by the number of patents.

Nilsson (2001) analyzes the role of interaction between researchers, managers, and venture capitalists in the process of recognizing and pursuing emerging opportunities in biotechnology. Whether an actor takes an entrepreneurial role or not in capturing emerging commercial opportunities depends on particular characteristics, like the ability to recognize opportunities in the first place and the relative position "in networks through which financial and human capital can be gathered" (Nilsson 2001, p 64). Particular emphasis within the above process is laid on interaction, which according to Nilsson is a prerequisite of acquiring and preserving social capital. Social capital, in turn, is needed to locate complementary human and financial capital that facilitates the pursuit of opportunities in biotechnology. Thus, interaction, defined by Nilsson as reciprocal action between two or more persons, is regarded to be central to successful commercialization in biotechnology.

Similarly Powell (1998) sees relationships as a critical pre-condition for knowledge diffusion, learning, and technology development that in turn are vital for keeping up with the competition in the "learning race". Shan (1990) investigates the determinants of entrepreneurial biotechnology firms to establish cooperative agreements. He shows that a late entrant or a follower is more likely to pursue such arrangements than an industry leader. Shan additionally finds that firm size is negatively correlated to the propensity to cooperate. New high-tech firms that try to commercialize a product on foreign markets also seek after cooperation.

Another heavily covered aspect of academic entrepreneurship relates to locational, cultural, and policy issues of different regions and countries. The most prevalent benchmark in studies is the USA due to its widely recognized leading position in biotechnology. According to Zucker, Darby and Brewer (1998), for example, the geographic location and the point of time where and when firms initially start to utilize biotechnology is positively correlated to where and when star bioscientists are actively producing publications and contributing to the basic science underlying the commercialized technology. The collaboration of firms with such stars functions also as a predictor of companies' success. The relationship is explained by the localized spillovers concept. Audretsch and Stephan (1996) elaborate further on this subject and conclude that the importance of geographic proximity in the firm-scientist relationship is strongly affected by the role taken by the scientist. The finding that proximity is especially positively affected when the scientist is a founder of the company is of interest regarding the present study. Unfortunately, explicit data on the identity of firm founders was not available for this study. Another key finding is that formal relationships between the firm and the scientist tend to be non-local whereas informal links are usually local.

Studying country specific differences in the emergence of academic entrepreneurship and small-firm formation, Etzkowitz, Asplund and Nordman (2001) compare the USA with Sweden, while Walsh, Niosi and Mustar (1995) observe differences between France, Britain and Canada. Where entrepreneurial culture and a strong private finance industry are identified as the major driving forces in the US, public policy is found to compensate for these in the three countries Walsh, Niosi and Mustar (1995) observe.

Smith and Fleck (1988) draw a picture about the development phases of business models that biotech firms apply in different stages of their life cycle, especially in order to cope with binding financial constraints in the early phases. They find that firms start with a business logic that requires relatively little capital, e.g., contract research and production as well as different services. These modes generate incoming cash flows much earlier than heavily R&D–intensive modes. As a next step, biotech firms move towards diagnostic products that require substantially more R&D efforts, but reward firms with higher returns on success. The ultimate goal, according to Smith and Fleck (1988), is the development, production and sale of pharmaceuticals, which requires large amounts of capital. Another paper concerning strategies of commercialization in biotechnology is presented by Pisano (1991). He examines the strategies of (a) forward integration by new biotech firms into production and marketing, (b) backward integration by incumbent firms into biotechnology, and (c) different forms of cooperation between entrants and incumbents in terms of R&D, technology transfer, and distribution. Option (c) is found to be rather common in biotechnology, since new SMEs are cash constraint and limited in their ability to forward integrate fast enough, while incumbent firms find it cumbersome to accumulate biotech specific knowledge in-house. Transaction costs inherent in every type of cooperation, on the other hand, might be a driving force towards an integration strategy. Arguably transaction costs in biotechnology are rather high due to extensive embedded tacit knowledge.

Deeds (2001) analyzes whether entrepreneurial wealth - as measured by MVA (Market Value Added) - can be related to the R&D-intensity, technological capabilities and the absorptive capacity of 80 biotechnology start-ups active in the pharmaceutical business. Technological capabilities were proxied by the number of patents and their applications, products in different stages of development and products already in the market. A new measure based on co-citation analysis served as the indicator for capacity to absorb technologies from outside for further enhancing own R&D. Deeds found that all three aspects are positively related to entrepreneurial wealth created. This means that markets appreciate firms with high R&D-intensities, in late product/service development stages and firms that are involved and embedded in scientific communities.

Another study that is quite interesting with respect to the underlying paper is provided by Lindholm-Dahlstrand (1997). She compares employment growth and patenting activities of university spin-offs from Chalmers University of Technology with those of other new technology-based firms. Lindholm-Dahlstrand concludes that university spin-offs grow slower than corporate spin-offs but are more successful in patenting activities. University spin-offs are argued to be particularly beneficial to regional development in the proximity of the institution, if they function as a technology supplier to other local companies.

Louis *et al.* (1989) focus more on the academic entrepreneur as an individual. They categorize academic entrepreneurship of individuals related to life sciences in five distinguished types: First, people aiming at externally funded, large-scale science. Second, people desiring to earn supplemental income. Third, people, who strive to gain industry support for university research. Fourth, people trying to obtain patents or create trade secrets, and fifth, people attempting to commercialize their own research by forming or holding equity in a private company. Louis *et al.* (1989) argue that entrepreneurship related to large-scale science and supplemental income can be predicted by individual characteristics and attitudes inherent in the entrepreneur herself. Entrepreneurship related to commercialization of academic research, the focus of this study, on the other hand depends on local group norms, which are defined as the way in which most of the members of the local research organization behave. Structures and policies of universities are found not to have an influence on entrepreneurship.

Fontes (2001) explores the role of academic entrepreneurs in the process of commercializing biotechnological academic research in Portugal. She identified a specific group of entrepreneurs at the center of the process. Young, highly qualified people, who had the ability to match knowledge available in public research organizations and to needs identified in the market. Equipped with high technological competencies and relational assets in the form of opportunistic relations to public research organization, they could take advantage of emerging opportunities. These entrepreneurs were able to avoid typical weaknesses like low motivation or lack of market orientation while experiencing difficulties accessing capital, manufacturing competencies, and distribution channels, all of which have been said to apply to Finnish biotechnology companies, too.

Wells, Coady and Inge (2003) deal with issues that concern bioentrepreneurship in Australia. They identify reasons for Australia's relatively poor performance in commercializing biotechnology. Major impediments are an inadequate level of commercialization skills, on one hand, and insufficient financial support by the government and the private industry on the other. As an example foe the former serves the premature licensing of research results, which leads into a loss of significant potential value downstream. Due to insufficient financing, firms have to generate cash flow by licensing away results as soon as possible in order to avoid shut down of operations. The traditional “ivory tower” conception of the role that public research institutions take in society is also pointed out by Wells, Coady and Inge (2003) as a factor that slows the diffusion of technology towards the industry.

As already stated, there is a vast amount of additional related literature that will not be touched upon further in this study. For interested parties the following papers include comprehensive reviews of studies dealing with different aspects of entrepreneurship. Blanchflower (2004) summarizes works on entrepreneurship that deal with the entrepreneur as a person, mainly from the point of view of labor economics. Davidsson, Low and Wright (2001) picture the development of entrepreneurship research within the past decade including works that study entrepreneurship from diverse angles.

The paper proceeds as follows. Section 2 provides a description of the research data as well as the analysis of firm characteristics that are specific to academic spin-offs as compared to other types of biotech SMEs in the Finnish biotechnology industry. Section 3 discusses the findings and section 4 closes the paper with conclusions.

2 Firm characteristics of academic spin-offs in biotechnology

2.1 Data

The empirical evidence in this paper is based on data originating primarily from the ETLA survey of biotechnology firms, and the National Board of Patents and Registration of Finland (PRH). The survey data serves as a primary basis for the analysis. Only in cases of controversial, inaccurate, missing or misleading data is the data from PRH used. No data from PRH is used that originates from periods prior to the year 2000. The survey covers the majority of companies operating in the Finnish biotechnology sector. Out of an estimated 120 active biotech companies at the end of 2001, the sample includes 84 companies of which 68 are small or medium-sized [4].

The companies in the sample are independent businesses, partnerships or subsidiaries of bigger corporations. In the latter two cases the businesses had to be independently responsible business units in order to be included in the sample. If the criteria were not fulfilled, the data were collected from the parent company. No companies being 25 years of age or older met the criteria for inclusion. It has to be pointed out that the majority of firms excluded already for their large size belonged also to this age category and the remaining SMEs over 25 years of age could not be included due to the lack of coherent data. Therefore the final sample consists of SMEs that are younger than 25 years of age.

2.2 Model

For the purposes of estimating characteristics of entrepreneurial academic spin-offs in the sample, I use a standard probit regression analysis, the results of which are presented in table 3 in section 2.3. Results of a benchmark logit run are displayed in table 5 in the appendix. The formal expression of the model takes the following form:

$$D_i = c + \alpha I_i + \beta C_i + \varepsilon_i$$

D represents the dependent variable, which is the dummy indicating whether a firm is an entrepreneurial academic spin-off as defined in more detail in the next sub-section (2.2.1). The constant is represented by the lowercase *c* in the formula. The independent variables that explain the dependent variable are incorporated into the model by the vector *I*. The content of the vector is examined more closely in section

[4] The sample is smaller than the population for the following reasons. The existence of a number of companies was unknown prior to the execution of the survey so that 116 companies were initially contacted. The contacts were based on the member list of the Finnish Bioindustries Association that tracks the development of and serves as a central organization for the Finnish biotech sector. One of the companies was tracked from the Internet. Out of these 116 companies, one was untraceable, 13 refused to respond, 12 were operating in an irrelevant sector, three were not in operation, two had merged with another company and five could not be included due to other reasons. Altogether 9 companies were further excluded since they were too large to fit the definition of SMEs. Three companies were excluded because no sensible data was available on them. They were subsidiaries of bigger corporations and could not be properly separated from these in terms of equity and debt issues. 68 is the number of firms that form the sample used for the analysis in this paper. The number of firms that made it into the sample in the final empirical analysis is still less. This is due to incoherent data.

2.2.2, where the independent variables are described in more detail. *α* is the coefficient of the vector *I*. *C* is the control vector representing control dummies and other control variables. *β* is the coefficient of the vector *C*. *ε* is the error term and the subscript index *i* serves as the firm index.

2.2.1 Dependent variable

The dependent variable of this analysis is a dummy that splits the sample into entrepreneurial academic spin-offs and other biotechnology SMEs. Thus, statistically significant coefficients of independent variables indicate that entrepreneurial academic biotechnology spin-offs differ from other types of biotech SMEs in the sample in respect to the particular independent variable. In the results table further, below the dummy is denoted “academic spin-off”. The dummy obtains the value “1” only if both of the following criteria are fulfilled: **(a)** the firm’s establishment is based on the results of academic research carried out in universities or other comparable academic research institutions, and **(b)** the original scientist being the originator of the particular pre-foundation academic research is also the founder or one of the founders of the company. While criterion (a) is the common definition of an academic spin-off, I wanted to narrow down the research target further to encompass only those companies that are based on academic entrepreneurial spirit expressed by the will of an individual scientist to cross the border between the worlds of academia and the industry. This narrow definition excludes firms that, for example, have started operations by acquiring academic research related IPRs from a scientist or organizations like Licentia - a Finnish company specialized in technology transfer between companies, research institutes and universities. It also excludes cases in which the original scientist did not want to abandon her academic career and preferred to pass on the idea of commercializing research results to somebody more willing and eager. By definition, corporate spin-offs and firms that are not spin-offs in the first place are not regarded academic spin-offs.

Seventy-five per cent of observations within the sample met criterion (a). After the application of both criteria 67,6 percent of the sample could be identified as entrepreneurial academic spin-offs.

2.2.2 Independent variables

Table 1 displays the descriptive statistics of all variables included in the final model. The statistical significance of deviation of means is checked with a two-sample t-test with unequal variances. See table 4 in the appendix for a correlation matrix of all included variables.

Table 1 Descriptive statistics for included variables [a]

Variable	Academic spin-off	Obs	Mean	Min/Max	Std. Err.	t	P>|t|
Size (ln)	0	22	2.5887	.693/4.905	.2366	1.6155	.1125
	1	43	2.0857	0/4.407	.2024		
Age (ln)	0	22	1.8313	0/3.135	.1697	.3155	.7540
	1	43	1.7670	0/2.833	.1127		
Life Sciences	0	22	.4545	0/1	.1087	-.6034	.5495
	1	43	.5349	0/1	.0770		
Process Industry	0	22	.0455	0/1	.0455	-1.8668	.0666
	1	43	.1860	0/1	.0600		
Services	0	22	.2727	0/1	.0972	.9759	.3357
	1	43	.1628	0/1	.0570		
Profitability	0	22	-.0713	-.600/.019	.0311	-1.6374	.1147
	1	43	-.0186	-.192/.050	.0080		
R&D-intensity	0	22	.0811	0/1.4	.0341	.2707	.7876
	1	43	.0684	0/.65	.0324		
Patents/employee	0	22	.6591	0/5.5	.2633	-1.0210	.3114
	1	43	1.2209	0/20	.4832		
Is a subsidiary	0	22	.3182	0/1	.1016	2.5459	.0173
	1	43	.0465	0/1	.0325		
Collab. own corp.	0	22	.4091	0/1	.1073	2.7183	.0110
	1	43	.0930	0/1	.0448		
Lead-time protect.	0	22	.7273	0/1	.0972	-.5482	.5867
	1	43	.7907	0/1	.0628		
Human capital	0	22	.2282	0/1	.0598	-1.3251	.1919
	1	43	.3271	0/1	.0448		
Founder is PO	0	22	.0909	0/1	.0627	-3.1028	.0029
	1	43	.3953	0/1	.0754		
Foreign owners	0	22	.3182	0/1	.1016	-.4276	.6710
	1	43	.3721	0/1	.0746		
Has licenses	0	22	.2727	0/1	.0972	1.4347	.1610
	1	43	.1163	0/1	.0495		
Export ratio	0	22	39.9546	0/100	9.3796	.2857	.7766
	1	43	36.7209	0/100	6.3367		
Dif. labour	0	22	.1818	0/1	.0842	-1.2956	.2011
	1	43	.3256	0/1	.0723		
Dif. financing	0	22	.2273	0/1	.0914	-.2513	.8027
	1	43	.2558	0/1	.0673		
Dif. w. bus. idea	0	22	.0909	0/1	.0627	-1.0956	.2781
	1	43	.1860	0/1	.0600		
Dif. experience	0	22	.0909	0/1	.0627	-1.0956	.2781
	1	43	.1860	0/1	.0600		
CEO is Ph.D.	0	22	.5000	0/1	.1091	.0870	.9311
	1	43	.4884	0/1	.0771		

[a] Two-sample t-test with unequal variances

Size is expressed via a natural logarithm of the number of personnel employed in the firm. An additional and common approach to capture size effects by using turnover figures has to be neglected since many of the firms do not display positive cash flows yet. Certainly, there are many that do earn positive returns already and have a product, and even more often, a service on the market, but these turnovers do not express the size of operations as much as the phase in the life cycle of R&D-intensive firms. Even large firms may display zero level turnover figures if their product and service development is still lingering in early phases far from the market place. To allow for a nonlinear effect of size the square of size was inserted additionally into the model with statistically insignificant results.

Age is rather self-explanatory and is expressed via a natural logarithm of the age of a firm in years. Age was also tested for an exponential distribution with insignificant results.

The biotechnology sector as such is very heterogeneous. The sector encompasses a variety of sub-sectors ranging from services over food and forestry to pharmaceuticals. The business models applied within those sectors are assumed to vary accordingly, which in turn affects firm characteristics directly. Thus, these effects have to be controlled for. For this purpose I have divided the biotech sector in four sub-sectors. The “Life sciences” sub-sector includes firms developing pharmaceuticals, diagnostics and biomaterials. The “Process industry” sub-sector incorporates companies active in developing applications in the following sub-sectors: food and feeds, enzymes, agriculture and forestry. “Services” comprehends contract R&D and other service activities. A decent number of firms not belonging to any of the three sub-sectors are excluded from the analysis as a control group.

Profitability is typically a measure of economic efficiency and, thus, a performance measure. In this study, profits before interests and taxes (EBIT) serve as the measure of profitability. EBIT is used in order to filter out artificial effects that interests, taxes, and especially extraordinary items may have on profits.

Including a variable measuring R&D costs per employee controls for effects of R&D-intensity. The usage of more conventional measures like R&D costs per turnover or

R&D costs per total costs was not an option due to inconsistencies in the data and because many firms do not display any turnover yet.

Patents serve as a proxy for the innovativeness of companies in the sample and are used for such purposes in a vast amount of literature. The variable is expressed by the number of patents per employee a firm has obtained already or applied for. A patent is not double counted if the same patent is obtained in different countries simultaneously.

A dummy variable indicating whether a firm is a subsidiary of a corporation is included mainly to control for implicit effects that could interfere with the cooperation variable.

An R&D-collaboration variable is further included into the final model to express whether firms in the sample cooperate with other firms in the same corporation. Other cooperation variables indicating R&D-collaboration relationships with universities, customers, suppliers, competitors and other firms were disregarded due to insignificance. The R&D collaboration variable is a dummy.

A dummy variable is included in the analysis that captures whether firms protect their innovations through lead-time, the time that the closest competitor lags behind in the development of a competing product/service. Other types of protection like patenting and secrecy were also tested for, but were discarded due to statistical insignificance.

The amount of human capital residing within a firm is proxied by the share of Ph.D.s in the company's total personnel.

A dummy variable is included to express whether the original founder or group of founders of the company is still the principal owner holding a share of equity that provides him/it with significant power over decisions in the company.

A variable indicating whether the firm has been able to attract foreign investors can be a measure of a multitude of aspects. The interpretation of this variable calls for a set of certain assumptions, the discussion of which is rather out of place at this point. I will defer the discussion towards the discussing part of the paper. The variable is a dummy.

Another dummy is used to indicate whether a sample firm has acquired any licenses or other kinds of immaterial property rights from other companies that permit the firm to produce products or services as specified by the license/IPR. A license might be acquired, for example, to create initial cash flows from sales of a marketable product or service that are then directed towards own R&D investments.

The share of sales that is generated through exports is rather high in the biotech sector. An exports-to-total sales variable is included in the analysis to test whether academic spin-offs are more globally oriented in terms of markets than other types of biotech SMEs. The ratio is calculated as follows: (Exports/Total sales)*100.

Difficulties to obtain skilled labor represent a clear inhibitor to the growth development of a company. Biotechnology being a highly knowledge intensive business, it is dependent on being able to tap on sources of knowledge and expertise in order to win in the innovation race. Whether the firm experiences difficulties in finding adequately skilled personnel is, measured by a dummy in the analysis.

Difficulties at the start-up phase of a company can be argued to constitute stumbling blocks as well. Additionally to the menace of inhibited growth, start-up difficulties might, if known prior to the establishment, deter the entrepreneur from entering in the first place. They are also more critical in the sense that companies usually are more vulnerable to disturbances at the early stage of their life cycles due to limited resources available to respond to such setbacks. In the final model three different types of start-up difficulties are tested, all of which are indicated by a dummy variable: Difficulties obtaining adequate financing, difficulties conceptualizing a clear business idea and difficulties due to lack of business related experience.

The level of education of the CEO in charge represents a measure of the type of leadership applied in the firm. A dummy splitting CEOs into two categories, Ph.D.s and non-Ph.D.s, acts as a proxy. Generalizing strongly, one could argue that Ph.D.s are more science-oriented than M.sc.s, for example, who in turn are closer to the market in their way of thinking.

2.3 Results

In terms of size, entrepreneurial academic spin-offs do not seem to distinguish themselves from the rest of biotechnology SMEs (Table 3). The negative coefficient is statistically insignificant. It should nevertheless be pointed out that the size indicator remained significant in numerous model runs during the process of analysis and seemed to be fairly robust before turning insignificant during the very last runs. A brief account on the process of the analysis is attached in Appendix 1. The average number of personnel an entrepreneurial academic spin-off employs is 8. The same figure for the rest of biotech SMEs is 13.3.

Table 2 Probit regression results with the academic spin-off dummy as dependent variable

Variables	Coef.	Std. Err.	P>|z|
Size	-.920	.670	.169
Age	-1.759*	1.023	.085
Life Science	3.680**	1.566	.019
Process Industry	5.877*	3.174	.064
Services	2.970	2.011	.140
Profitability ratio	40.676**	19.366	.036
R&D-intensity	5.371	13.152	.683
Patents/employee	-.312	.416	.453
Is a subsidiary	-1.371	2.557	.592
Collabor. w. own corporation	-3.989*	2.317	.085
Uses lead-time for protection	3.603**	1.782	.043
Human capital	-1.225	1.535	.425
Founder is PO	1.874	1.246	.133
Has foreign owners	3.624**	1.847	.050
Has acquired licenses	-2.932**	1.435	.041
Export ratio	-.017	.019	.357
Diffic. obtaining skilled labour	5.343**	2.500	.033
Diffic. obtaining financing	4.847**	2.393	.043
Diffic. w. business idea	11.712**	5.706	.040
Diffic. due lack of experience	-2.881	2.499	.249
CEO is Ph.D.	-3.556**	1.577	.024
Constant	1.560	2.487	.531

N = 65
Log likelihood = -13.6746
LR chi2(21) = 55.8500
Prob > chi2 = .0001
Pseudo R2 = .6713

In terms of age, academic spin-offs do differ from other biotechnology SMEs in being slightly younger. The average age of entrepreneurial academic spin-offs is 5.8 years as opposed to an average age of 6.2 years in the case of the rest of biotech SMEs.

Looking at the sector controls, it seems like entrepreneurial academic spin-offs are over represented in life sciences and the process industry as compared to other types of biotech SMEs. In the service sector, on the other hand, they do not distinguish themselves. Fifty-three percent of academic spin-offs are active in life sciences. Close to twenty percent are active in the process industry. Fifteen percent operate in services. The equivalent figures for the comparison group are forty-five for life sciences, five for process industry and twenty-seven for services.

In terms of R&D intensities, the two groups do not differ significantly. Where entrepreneurial academic spin-offs invest 1.4 million euros per employee into R&D activities on average, the equivalent number for the control group is 0.65 million euros. The results are not different concerning R&D efficiency as measured by patents and patent applications per employee. The coefficient is not statistically significant. In average employees of academic spin-offs hold 1.2 patents or applications each, where as employees in the control group hold 0.7.

It appears that academic spin-offs perform better in terms of profitability. They make relatively smaller losses than other types of biotechnology SMEs. Academic spin-offs show losses in the scale of nineteen percent of sales. In the control group losses count for seventy-one percent of sales.

Academic spin-offs cooperate with firms within the same corporation significantly less than firms in the control group. Only nine percent of academic spin-offs have cooperation relationships in R&D within the same corporation, while forty-one percent of firms in the control group cooperate in such a way. This finding is robust even after introducing a dummy indicating whether a firm is a subsidiary, which excludes the explanation that academic spin-offs do cooperate less within the corporation simply because a majority of them are independent businesses and are, thus, no part of a corporation in the first place. Cooperative relationships with academia, customers, suppliers, competitors and other firms were encountered in both groups to an extent that no significant differences can be pointed out by the means of the regression analysis, although looking at plain figures might tell a different story: Seventeen percent of academic spin-offs had R&D cooperation agreements with competitors; fifty-two percent cooperated with customers, thirty-one percent with suppliers, forty-three with other firms and eighty-seven percent with the academia. Equivalent numbers for the control group are forty-five, seventy-seven, fifty, fifty-five and seventy-seven percent respectively. Of course, attention should be paid to the fact that percentages refer to the sample only. Table 3 sums up the figures.

Table 3 R&D cooperation agreements

Cooperation with:	Own corporation	Competition	Customers	Suppliers	Other firms	Academia
Academic spin-offs	11 %	17 %	52 %	31 %	43 %	87 %
Other	41 %	45 %	77 %	50 %	55 %	77 %

Academic spin-offs resort to lead-time as means to protect innovations more often than other types of biotech SMEs. Seventy-nine percent of academic spin-offs answered to use this kind of strategy whereas seventy-three percent of the control group gave the same answer. As already stated above, other instruments of protection like secrecy and patenting could not be identified to be used more by either of the groups in any model run. Eighty-six percent of academic spin-offs use secrecy to protect innovations as opposed to seventy-two percent of the control group. Patenting is used by sixty-three percent of academic spin-offs and by fifty-five percent of the control group.

Neither of the two groups displays higher human capital intensities than the other. The coefficient for the Ph.D.s per personnel –measure is statistically insignificant. In the case of academic spin-offs thirty-three percent of personnel employed have a Ph.D. degree in average. The corresponding figure for the control group is twenty-three percent.

Academic spin-offs are more often owned primarily by the original founder than firms of the control group. Such a principal owner is defined as being the single largest stock owner measured by the total number of votes. In forty percent of all academic spin-offs in the sample, the founder was the principal owner. Just nine percent of the control group were primarily owned by the founder.

Both groups have foreign owners and do not differ significantly from each other in this respect. It has to be highlighted that the variable showed rather robust behavior as it was statistically significant during all other model runs before crossing the 10 per cent level in the very final version of the model.

Buying rights to produce products or services developed by other companies or organizations is less preferred among academic spin-offs than among firms of the control group. Twelve percent of academic spin-offs have acquired such rights whereas among firms in the control group twenty-seven percent have done so. The coefficient is negative and significant at the five percent level.

Neither of the groups distinguishes itself from the other significantly in terms of the export ratio. The coefficient is statistically insignificant. The export ratio for academic spin-offs averages thirty-seven percent. The average export ratio for firms of the control group is forty.

Academic spin-offs are more often plagued by difficulties to obtain skilled labor needed for operations. A third of firms reported to experience such difficulties. In the control group only eighteen percent struggled with the same problem. The coefficient is significant at the five percent level.

Academic spin-offs experience also more often difficulties in the start-up phase of a firm's life cycle than do firms of the control group. Twenty-six percent revealed that there were problems related to inadequate financing. Nineteen percent fought problems related to the lack of a clear business idea. Relevant figures for the control group are twenty-three and nine percent respectively. The coefficient for the dummy expressing difficulties related to a lack of business experience is statistically insignificant, although nineteen percent of academic spin-offs reported such difficulties opposed by nine percent of the control group.

According to the regression results, a CEO having a Ph.D. degree less often directs academic spin-offs than firms in the control group. The coefficient of the dummy is statistically significant at the five percent level. Although finding is counter-intuitive, the dummy serves as a control.

3 Discussion

When looking at the results concerning R&D-intensities and R&D-productivity measures, one cannot tell a difference between entrepreneurial academic spin-offs and other types of biotechnology SMEs. In my opinion the finding is rather intuitive. Firms competing in biotechnology must keep up with each other in terms of R&D efforts as future revenues depend greatly on the outcome of patent races that are highly competitive and are played globally. Loosing a race could render invested capital worthless and mean the end of the company, especially in the case of young enterprises that have only a limited project portfolio over which to spread the risk of failure. This applies to all biotechnology firms regardless of their origin, academic or not. With all biotech SMEs being highly R&D-intensive, the relative differences in R&D activity measures between the two groups might be too small to be observed in a small sample.

Recalling the above reviewed paper by Deeds (2001), this would imply that academic spin-offs cannot be expected to create higher entrepreneurial value (Market Value Added) than other types of biotech SMEs, since they do not display higher R&D-intensities or technological capabilities.

However, a word of caution should be uttered concerning the findings on R&D-productivity. A problem causing potential distortions is the measure used for R&D-productivity, patents per employee. Patents do not come automatically with innovation and do not necessarily reflect the number of innovations produced within a company. To obtain a patent, the firm or individual has to have knowledge on what criteria the innovation has to meet before it stands a chance of being patented, how to initiate the patent application process, to what extent a patent protects the innovation, and, most importantly, what to apply for and how to formulate the application in order to obtain maximum protection or to succeed in the application in the first place. Additionally and not least significantly, patenting requires considerable amounts of money to be obtained and maintained. These requirements multiply when going global, as is the case in biotechnology. This kind of expert knowledge is often not existent in young and small companies that have a more scientific background and are run by people with an academic origin. On the other hand, such knowledge can be expected to be resident in corporate spin-offs, for example, that come from a commercial background right from the beginning. Also access to expert advice and financing for patenting through readily established networks can be expected to exist more often in this kind of organizations. This being said, it might be that the R&D-productivity of academic spin-offs is not captured properly and it may seem to be lower than it actually is.

The above intuition might also provide an answer to the question why entrepreneurial academic spin-offs revert more often to lead-time as a means of protecting innovation than firms in the control group do. It is cheaper and does not require the hassle of the patent application process. This being said, it would be interesting to find an answer to the implicit question, whether academic spin-offs are in fact more productive in terms of R&D than other types of firms in the Finnish biotech sector. If the above discussion holds true, then it actually is the case, since academic spin-offs in the sample perform just as well as the control group measured by the number of patents per employee even with constraints in access to resources and knowledge on patenting.

The finding that academic spin-offs operate more often in life sciences and the process industry is fairly intuitive. These sub-sectors are far more science-based than services, and current technologies represent usually the forefront of technological research and development. This is in line with the competitive strategy of constant innovation. Nevertheless, thinking of resources necessary for developing avant-garde products or services and taking them to the market (that a large part of academic spin-offs clearly lack) it would be more plausible to see older and larger firms to be over represented in the life science and process industry sub-sectors as compared to academic spin-offs. As Smith and Fleck (1988) state, in the U.S. it is a common entry strategy of young, resourceless biotech firms to provide different kinds of research services in the initial post-foundation phases to create turnover that can then be directed towards own R&D that aims at breakthroughs. It is a natural way of utilizing valuable and expensive human capital existing in the company right from the start to enhance independence from outside financing and avoid complications related to that. So, why do we not find young and small Finnish academic spin-offs to be relatively more active in the service sub-sector instead of life sciences and the process industry as indicated by the results?

The answer, in my opinion, is rather straightforward. The prominent way of thinking in Finnish academic biotechnology SMEs is extremely technology driven, not business driven. Many academic entrepreneurs apparently establish the firm for the love of the technology, business coming second. In their view it is more important to enhance and work on the technology, their “child”, than to think about viable business solutions and ways of establishing a vital revenue stream that would bring a higher degree of independence with it. The firm is seen as a means to apply for further funding (for example Tekes does not fund individuals but companies) that enables the advanced development of the particular technology. According to expert interviews[5], some founder-scientists sometimes even hamper the growth and development of their company as a business and do not want to hand over the lead to more business-skilled individuals, because they prioritize the development of the technology and their personal involvement in it over the well-being of the company. It is a central concern at conferences and seminars dealing with economic aspects of Finnish biotechnology, that there is a huge lack of business-related skills employed in the sector that impedes not only the growth of but makes Finnish biotechnology vulnerable to global competition, where the business logic and the requirements set by that are far better understood than in Finland.

The finding that academic spin-offs suffer from difficulties related to an unclear business plan at the start-up phase underlines the above discussion empirically.

Just realizing the problem is by far not enough. In fact, many firms are aware of the problem and some even want to improve the situation. Venture capitalists even demand the employment of highly business-skilled people that are experts in business administration and have substantial experience in the field before injecting risk capital into a biotech company. So what stands in the way of improvement? The problem is a structural one. A large pool of skilled individuals with relevant background which to recruit from is simply non-existent in Finland. We do not look back at a strong and

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5 Personnel in leading position at a Finnish public organization providing funding to Finnish companies with the biotechnology sector being a major target of investments.

traditional history of industrial evolution in pharmaceuticals or any other relevant field that could spawn experienced leaders like, e.g., Sweden or the UK. In fact, at present venture capitalists have to look abroad for occupying leading positions with the right individuals in their portfolio firms. But even this is extremely difficult not least due to an uncompetitive income tax regime prevalent in Finland.

Problems finding adequately skilled personnel do not concern business expertise only. Entrepreneurial academic spin-offs are hard pressed with finding personnel for research activities as well. This is somewhat surprising, since it is a common consensus that the level and quantity of biotech research relevant know-how as well as the amount of educated people with the appropriate skills in Finland is fairly high. There should be no supply shortage of qualified potential recruits. I believe the dilemma has its roots in the perceivably traditional role of universities and the world of academia as a whole that is prevalent throughout Europe.

The academia's perception of itself still, and unfortunately, resembles that of the famous "ivory tower". Interviews with experts[6] actively involved in the world of academic research revealed that commercialization of research and the business world as such are often perceived by academics as "filthy", "greedy" and "dishonorable". The exposure of scientific research to commerciality is perceived to distort the one and only ultimate purpose of science, namely the quest for truth. Scientists leaving the academia are quickly marked as mavericks and traitors of the cause and are put in negative light. In fear of being branded and not being able to return to academia in case of failure in the business world, talented and potential academic scientists with promising academic careers are reluctant to become entrepreneurs or be recruited to work in a commercial company. Apparent risks are too high. This is a real obstacle that cannot be overcome easily. An improvement would require a major change in attitudes and institutional roles throughout the society as a whole questioning the positions and power of individuals, which most assuredly will cause inertia and friction in the process of change. This line of argumentation is very similar to that of Wells, Coady and Inge (2003).

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6 Medical Doctor actively conducting research in the field of neurology.

Another explanation for problems with the availability of skilled labor is likewise related to the customs of traditional Finnish academia. The entrepreneurial scientist who has freshly started up a firm (a) does probably not understand why they should pay an employee more than this scientist earned at the university or another research institute for the same work he would be conducting at the company and (b) does not necessarily have the capital to that it takes to lure personnel from the academia to work for him and compensate them for all the risks explained above.

There are still more impediments that academic spin-offs have to struggle with. According to the results they had problems with acquiring sufficient funding at the start-up stage of their life cycle. Funding shortages or delays stall the momentum of the commercialization process and add to the business risk. According to expert interviews at a governmental finance institution, the present times and the near future look even worse for academic entrepreneurs dreaming of starting-up their own biotech business.

When the ICT-bubble burst at its peak in 2001, the capital financing for new start-ups became difficult. Before that time biotechnology firms were heading towards public capital markets at very early development stages already accelerated by great expectations as high technology related businesses experienced a boom. Exit channels seemed open from the perspective of investors and investment periods were expected to be between two and four years long. After 2001 a quick exit is not viable anymore. With deteriorated expectations market values of early stage companies became extremely low. Investors invest only in firms that are in a late development stage, close to the markets, and are preferably making profits already. The funds of these investors cannot bear to wait as long as it would take to bring an early stage biotech company close enough to the market to reap high enough returns on invested capital. The timeframe from establishment to exit is three times longer than prior to 2001. The only institution that has a policy to provide capital to early stage companies in Finland nowadays is Sitra. But even Sitra is unable to invest in new start-ups as it cannot free capital bound to the existing portfolio. A glimpse of hope is to be expected from a new instrument announced by Tekes, which is aimed at financing firms at the seed stage already. No exact specifications of that instrument are published yet. Tekes also continues to provide capital loans to companies, which has been a rather successful financing tool from the late nineties onwards.

The lack of outside financing is further underlined by the finding that the original founder of the company still holds the sole principal owner position in entrepreneurial academic spin-offs. In over forty percent of cases it is the founding scientist that owns the majority of voting rights. The equivalent figure for other types of biotech SMEs is nine percent. When the flow of outside equity financing is constraint the implicit consequence on the balance sheet is a high share of equity owned by insiders, here the original founder. It has to be pointed out at this point that the capital and regular loans as well as subsidies provided by Tekes do not constitute an equity item on the balance sheet although capital loans have many traits in common with equity otherwise. A complementary reasoning is the above mentioned reluctance on part of original founders to hand over the control of the company to outsiders as it could jeopardize the founder's right to work on the technology and divert the purpose of the company towards less important priorities from the founder's point of view. Additionally, some founders are just happy with the income they obtain through direct research support schemes and do not even plan to go to financial markets with plans of expansion on their minds.

The relatively small size and struggles with financing are reflected in the profitability ratio of entrepreneurial academic spin-offs; they run a smaller deficit in average than firms in the control group. An average profitability ratio of ca. –20 percent as opposed to ca. –70 percent of other types of firms indicates not only scale effects stemming from a relatively smaller size of operations in terms of staff employed but also cautious and risk-averse behavior under resource constraints and a present threat of running out of funds. I assume that as the firm grows and is able to access better financing sources the degree of risk-averse behavior decreases, as the fear of bankruptcy is not as immediate anymore. In such a case a relatively higher portion of funds is directed towards R&D causing higher losses, assuming that revenues do not increase proportionally to the increase in size simultaneously. This assumption is justified as long as the firm is still in the development phase of an initial product/service and has not entered markets yet.

Small-scale operations and budget constraints also negatively affect the ability to purchase licenses from third parties that would endow the company with rights to market products or services developed by a third party in order to generate initial cash flows. Faint resources are focused on the particular research, which the company has initially been established for. Only eleven percent of academic spin-offs have acquired licenses from a third party as opposed to twenty-seven percent of firms in the control group.

The reason for the lack of collaboration between academic-spin-offs and companies in the same corporation seems apparent on the first sight. The vast majority of academic spin-offs (44 out of 46 firms in the sample) are independent in the sense that they are no subsidiaries to another company as already indicated by a high ownership share of the original founder. Nevertheless, even after controlling for this by inserting a dummy identifying whether firms are subsidiaries, the result remains significant. Not being a subsidiary does not exclude the possibility that academic spin-offs are parent companies themselves and have spun out corporate spin-offs during the course of their existence nor that they have merged with other companies out of strategic reasons. The fact that five of forty-six entrepreneurial academic spin-offs in the sample, three more than there are academic subsidiaries, do collaborate within the same corporation speaks in favor of this theory. Reasons for the relatively inactive cooperation could include the difficulty to transfer relevant tacit knowledge across firm boundaries in an efficient way as well as the lack of business-oriented thinking that emphasizes the importance of cooperation for successful commercialization.

As already pointed out in section 2.4, cooperation patterns with other stakeholders like customers, competitors and suppliers do not differ significantly in the regression analysis. Nevertheless, simple means of cooperation measures (table 2) show that a relatively smaller share of entrepreneurial academic spin-offs do cooperate with other interested parties except the academia. According to Shan, Walter and Kogut (1994), Nilsson (2001) and Powell (1998) this is a threatening finding, since interaction is identified as a prerequisite to commercial success that Finnish biotechnology SMEs obviously seem to lack. A too introvert and technology-focused attitude compromises the ability of firms to identify and capture emerging opportunities, be they technological or commercial, in the absence of a supportive and complementary network.

The insignificance of the difference in export ratios is explained by the fact that the markets for biotechnology are global. Domestic markets are just too small to build a viable business on. Thus, all Finnish biotech companies have the imperative to aim at foreign markets right from the beginning if they want to secure growth and survival in the long run.

4 Conclusions

In conclusion one can say that Finnish entrepreneurial academic spin-offs are at a relative disadvantage as compared to other types of biotechnology SMEs. Hit more often by financial difficulties at start-up, being unable to attract skilled people, and, most unfortunately, lacking the vital strategic sense and skills for transforming research into a thriving business through cooperation and a market oriented approach, academic spin-offs are facing major impediments to successful growth. Probably the most critical challenge is to shift the focus of companies away from a strongly technology-oriented path towards a more extrovert and market-oriented one, where the particular technologies should be evaluated less in terms of technological prowess but more in terms of market potential. Only tapping into the suction of market demand will constitute a viable strategy that brings growth and long-term success with it. This requires a major change in modes of thinking in the minds of today's scientists and an active expansion of support and educational services that aim at bringing that message into the hermetically sealed laboratories. The establishment of biotech centers in Finland has been a welcomed first step, since firms are able to establish cooperative inter-firm links with less effort and utilize spillovers. Now, one should make sure that services at these centers encompass more than just facilities. Education in the processes of commercialization, strategic thinking, project and technology management as well as immaterial property rights is anxiously needed.

The impediments do not rise exclusively from inabilities and lack of skills on part of academic spin-offs. A very traditional and detached perception and definition of the academia's role within society, high income tax regimes, and a still underdeveloped market for equity in Finland contribute unfavorably to the conditions academic spin-offs operate in. These are factors that the companies themselves cannot address properly and should be discussed on the national level. Currently the Finnish biotech sector is under pressure to show hard evidence of success in order to justify past and future public investments to the sector. Instead of being just impatient one should sit down and come up with solutions that address the structural and cultural issues discussed above, first. These are issues that only the public as a whole can have an influence on. Only then will public investments into the sector be productive.

Appendix

Process of analysis

The final version of the model as seen in table 3 is the outcome of the following process. First, variables that ran the risk of having an implicitly determined relationship to the dependent variable were eliminated. Then all possible candidate variables that were left over, interesting from the point of view of the research focus of the paper and could be extracted from the data were inserted into the model. Through iterative runs of the model variables were excluded from the regression one by one based on their statistical significance. In each run the variable with the worst statistical significance was eliminated. With each elimination the adjusted R2 value and the number of statistically significant variables increased.

I ended the iteration process as the number of significant variables started to decrease again as an additional variable was excluded. The result of the iteration was a rather robust model. Nevertheless, during the process I had to exclude variables that were interesting and could have contained important information concerning the characteristics of academic spin-offs. Thus, I checked next none of the excluded variables really had any statistical significance. To this end I iterated the model again by including these variables one by one into the model replacing each of these variables with the next one in each iteration. Some of the excluded variables indeed turned significant when added to the base model. These variables were included into the final version of the model presented in table 3.

At this point one has to point out that, to a certain degree, the final model is sensitive to the inclusion and exclusion of single variables. This is inevitable and typical for samples of small size and data consisting mainly of dummy variables.

Table 4 Correlation matrix for included variables

Variable	Size	Age	Lifsc	Proci	Servi	Profi	R&Din	Paten	Subsi	Colla	Leadt	Human	Found	Forow	Licen	Expor	Labou	Finan	Busin	Exper	CEO
Size	1.000																				
Age	.120	1.000																			
Life science	.033	.059	1.000																		
Process industry	.021	.110	-.407	1.000																	
Services	-.099	-.090	-.508	-.200	1.000																
Profitability	-.194	.263	-.229	.180	.182	1.000															
R&D-intensity	.074	-.128	-.052	-.156	.039	-.254	1.000														
Patents/employee	-.283	.064	.135	-.047	-.044	-.029	.087	1.000													
Is a subsidiary	.249	.095	.038	-.161	.134	-.288	.139	-.010	1.000												
Collab. Own corp.	.350	.106	-.046	.134	.039	-.277	.110	-.020	.690	1.000											
Lead-time protect.	.169	.033	.191	.114	-.365	-.170	.125	.122	.008	.091	1.000										
Human capital	-.387	-.155	.156	-.212	.118	.110	.125	.068	-.199	-.301	-.162	1.000									
Founder is PO	-.426	-.067	-.111	.036	-.068	.228	.084	.162	-.258	-.321	-.130	.450	1.000								
Foreign owners	.427	.158	.150	.076	-.209	-.274	.035	-.080	.076	.113	.253	-.144	-.193	1.000							
Has licenses	.319	.190	.198	.057	-.226	-.087	.019	-.028	.057	.082	.247	-.030	-.110	.181	1.000						
Export ratio	.203	.331	-.002	.223	-.209	-.000	.134	-.133	.115	.046	.172	-.142	.009	.260	.093	1.000					
Dif. labour	.170	-.182	-.010	-.049	.120	-.168	.031	.187	.051	.120	-.069	.033	.056	-.027	-.004	-.135	1.000				
Dif. financing	.102	.032	.134	-.126	-.196	-.188	-.001	-.024	-.022	-.107	.144	.092	.104	.175	.314	-.012	.045	1.000			
Dif. w. bus. idea	.019	-.011	-.092	-.048	.107	-.181	.340	.059	.076	.107	-.070	-.032	.101	-.226	-.193	-.187	.117	.053	1.000		
Dif. experience	.002	-.047	-.007	-.171	.107	.073	.196	-.064	-.048	-.107	-.171	.224	.101	-.226	-.193	-.121	-.073	.251	.646	1.000	
CEO is Ph.D.	.017	-.245	.170	-.217	.123	-.064	-.053	.020	-.128	-.185	-.118	.305	.179	.044	.048	-.210	.147	.152	.177	.092	1.000

Table 5 Logit regression results with academic spin-off dummy as dependent variable

Variables	Coef.	Std. Err.	P>|z|
Size	-1.962	1.388	.157
Age	-3.614*	2.087	.083
Life Science	7.153**	3.202	.025
Process Industry	12.357*	7.319	.091
Services	6.384	4.027	.113
Profitability ratio	81.343*	43.798	.063
R&D-intensity	13.680	25.306	.589
Patents/employee	-.670	.730	.359
Is a subsidiary	-1.906	5.139	.711
Collabor. w. own corporation	-8.641	5.468	.114
Uses lead-time for protection	7.526*	4.027	.062
Human capital	-2.631	2.841	.354
Founder is PO	4.057	2.563	.113
Has foreign owners	7.698*	4.264	.071
Has acquired licenses	-5.919**	2.997	.048
Export ratio	-.035	.038	.361
Diffic. obtaining skilled labour	11.091*	5.860	.058
Diffic. obtaining financing	9.502*	5.257	.071
Diffic. w. business idea	23.657*	12.485	.058
Diffic. due lack of experience	-5.369	4.665	.250
CEO is Ph.D.	-7.393**	3.595	.040
Constant	2.991	4.393	.496

N = 65
Log likelihood = -13.2501
LR chi2(21) = 56.7000
Prob > chi2 = .0000
Pseudo R2 = .6815

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