
Entrepreneurship at DTU through two decades – initiatives, results and socio-economic impact

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Table of contents

| | |
|---|-----------|
| Foreword | 4 |
| 1. Summary | 5 |
| 1.1 Introduction | 5 |
| 1.2 Developments in the numbers of DTU-based entrepreneurs | 5 |
| 1.3 The DTU entrepreneurs' survival and development | 6 |
| 1.4 Economic impact | 7 |
| 1.5 The profile of the DTU entrepreneurs | 10 |
| 1.6 DTU's ecosystem for entrepreneurship | 11 |
| 2. Entrepreneurship at DTU 1999-2017 | 14 |
| 2.1 Introduction | 14 |
| 2.2 Company characteristics and development | 15 |
| 3. DTU-based start-ups growth and impact | 19 |
| 3.1 Introduction | 19 |
| 3.2 Ambitions of the entrepreneurs | 19 |
| 3.3 Survival, spinouts, sale and mergers | 20 |
| 3.4 Growth and economic impact of DTU entrepreneurs | 21 |
| 3.5 Longitudinal analyses | 24 |
| 3.6 Attracting capital | 27 |
| 4. The profiles of the DTU-entrepreneurs | 30 |
| 4.1 Introduction | 30 |
| 4.2 The profiles of founder teams and their networks | 30 |
| 4.3 Mentors, advisory boards and boards of directors | 34 |
| 5. The importance of DTU for the founding and development of start-ups | 38 |
| 5.1 The ecosystem for entrepreneurship | 38 |
| 5.2 DTU's significance in the establishment of new companies | 44 |
| 5.3 DTU's significance in the growth and development of start-ups | 48 |
| 6. Common features in successful DTU entrepreneurship | 50 |
| 6.1 Introduction | 50 |
| 6.2 Differences between successful and unsuccessful companies | 50 |
| 6.3 Recapitulation | 54 |
| 7. Appendix A: Method | 55 |

Foreword

DTU – the university of innovation

Two decades of investment in entrepreneurship at the Technical University of Denmark (DTU) have created great value in terms of new technologies, benefitting people as well as new businesses. This analysis, conducted by IRIS Group, shows that students at DTU, graduates from DTU and employees at DTU have established more than two new companies every week since 1999 – equivalent on average to 115 companies a year and about 2,200 new companies overall. These companies have generated more than DKK 7 billion in turnover and, no less importantly, 2,700 new jobs.

These results have been created in collaboration with companies, funds and policy makers which have taken part in expanding DTU's ecosystem for entrepreneurship: Courses, case competitions, advisory services and matchmaking activities, creative labs and facilities, DTU Skylab for student entrepreneurs, incubators and much more. Today, the DTU campus accommodates one of the biggest and most well-developed ecosystems for entrepreneurship among technical universities in Europe, and DTU has been elected as the most innovative University in Scandinavia.

We are proud of the results. But we are also eager to add to our knowledge of the characteristics of the entrepreneurial companies and understand which elements of the ecosystem are most important for the entrepreneurs. Therefore, the analysis we present here includes a survey shedding light on how entrepreneurs assess the services and facilities, and how the ecosystem can be improved.

Three out of four companies state that DTU, and its ecosystem for entrepreneurship, was of great importance during the start-up of their company. 60% also believe that the ecosystem has been of real importance in the company's later phases. It is especially DTU's science and knowledge base, the access to facilities, and the opportunity to place the company on campus in the start-up period, which are considered essential by the companies.

The analysis clearly shows that growing innovation and entrepreneurship benefit not only DTU and our business partners, but also Denmark and the entire world as well.

Enjoy the read!

Anders Bjarklev

President, DTU

1. Summary

1.1 Introduction

Entrepreneurship is important for industrial development and for economic growth in society. Entrepreneurs contribute with new ideas and innovation. They create many jobs. And they develop new products and business concepts that compel established companies to renew themselves and become more productive.

High tech (or deep tech) entrepreneurs from the universities are a particularly important group. They help to translate knowledge and research from the technical sciences into new technologies and products. And they may even develop entirely new industries.

DTU's vision is to be an elite technical university which operates at a high international level, as well as a driver for Danish society. An important element in this vision is that both scientists, students and graduates establish new companies.

Continuing that vision, DTU has in recent years invested significant resources in strengthening the 'ecosystem' for entrepreneurship at DTU. This includes investments in incubators, facilities, events, courses, advisory services, funding, etc. – all of which are designed to support the establishment and growth of new companies. Today, DTU's campus accommodates one of the biggest and most well-developed ecosystems for entrepreneurship among technical universities in Europe.

The purpose of this analysis is to map the development of entrepreneurship at DTU over the last two decades and to measure the socio-economic impact of DTU entrepreneurship. An additional aim is to describe and assess the quality of DTU's ecosystem for entrepreneurship, and to investigate how it can be improved even further.

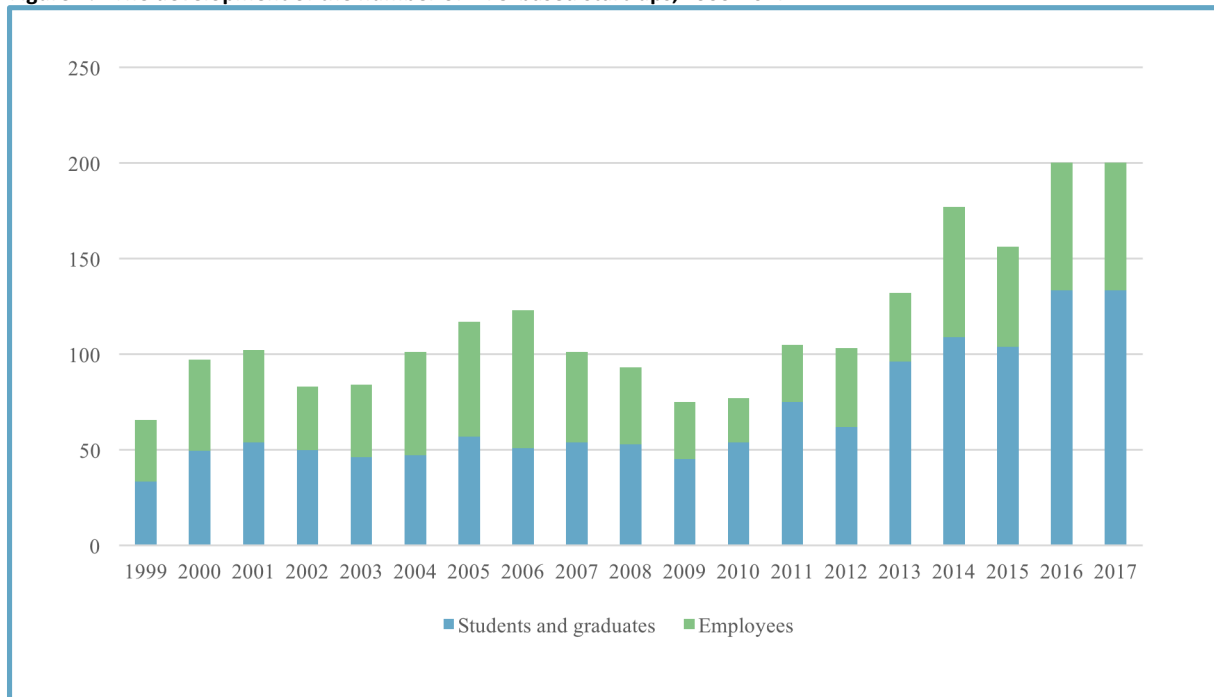
The analysis is based on data from various registers, a survey among DTU entrepreneurs who established companies between 2007-2017, and interviews with a range of DTU-based entrepreneurs.

1.2 Developments in the numbers of DTU-based entrepreneurs

We have mapped the development of the number of entrepreneurs with a DTU background in the last two decades by integrating a number of registers from Statistics Denmark and information from DTU (see Figure 1.1, on the next page). In the analysis, entrepreneurs with a DTU background are defined as:

- Companies established on the basis of DTU-patents (based on scientific results from DTU).
- Employees, graduates and students who established a company while still at DTU – or no more than two years after they have terminated their studies or employment at DTU.

Figure 1.1 The development of the number of DTU-based start-ups, 1999-2017



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: For the period 2016-17, numbers are estimated because a linkage of registers only enables a mapping of DTU-based entrepreneurs up to 2015. Numbers are based on growth in DTU’s registrations between 2014-2017 where a significant growth between 2015 and 2016 has occurred.

The figure shows that between 70 and 200 new, DTU-based entrepreneurial companies were established annually between 1999-2017. In the period 1999-2015, we have calculated the number of DTU-based entrepreneurial companies at 1,792 companies. For the period 2016-17, the numbers of DTU entrepreneurs are estimated. If we add the estimated numbers from 2016-2017, then about 2,200 new companies have been established in the entire period 1999-2017, which corresponds to an annual average of approximately 115 companies.

The figure also shows a significant increase in the number of DTU-based entrepreneurs after a small reduction during the global financial crisis – and that the level of start-ups has been higher in recent years compared with earlier years. This indicates a positive effect of the considerable investments in strengthening DTU’s entrepreneurial culture and the expansion of its ecosystem for entrepreneurship.

1.3 The DTU entrepreneurs’ survival and development

In the analysis, we have mapped how DTU-based entrepreneurial companies established between 1999-2015 have developed. As mentioned above, 1,792 new companies were established in this period. Table 1.1 provides an overview of the development of these companies during the entire period.

Table 1.1 Overview of the development of DTU-based entrepreneurial companies established between 1999-2015

| | Status, 2015 |
|--|--------------|
| Number of companies established in the period 1999-2015 | 1,792 |
| Closed CVR ¹ numbers | 463 |
| Still active in 2015 | 1,329 |
| <i>Hereof companies with a significant turnover</i> | 731 |
| The share of surviving companies | 74% |
| The total number of spinoff companies (new businesses) | 92 |
| The number of spinoff companies still active in 2015 | 71 |
| Converted companies (merger or acquisitions) | 11 |
| The total number of companies, in 2015, based on ideas, knowledge and technologies from DTU | 1,411 |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.
 Note: By 'a significant turnover', we mean companies that have a turnover corresponding to at least half a full-time equivalent in the relevant industry.

The table shows that 1,329 of the original companies were still active in 2015. That corresponds to a survival rate on 74%. Of these companies, 731 had a significant turnover.

In comparison, the national survival rate after three years for all entrepreneurial companies in Denmark has been 52-54% in recent years. The survival rate after three years for DTU-based entrepreneurs is 68%. The DTU-based entrepreneurs are thus faring better than Danish entrepreneurs in general, when it comes to survival.

The rather high number of companies without any significant turnover needs to be interpreted in the light of the fact that it takes time for technology-based entrepreneurs to develop new products and enter them into the market. The increase in the number of DTU-based entrepreneurs in later years adds to this fact, as there are currently many young companies which have not yet entered a phase where their products or technologies are ready to be marketed.

Moreover, some of the original entrepreneurial companies have created *new* companies – so-called 'spinoffs'. Typically, this happens because the technologies can be used in other areas of business or for new types of products. 71 spinoffs still existed in 2015. Finally, we have calculated that at least 11 of the original companies have either been bought up by larger companies or merged with other firms.

All in all, in 2015 1,411 companies still existed which were wholly or partly based on technologies that were the foundation for the 1,792 entrepreneurs. That high number mirrors the fact that a very high number of companies today are working with transforming knowledge and technologies from DTU and applying them to society and the markets.

1.4 Economic impact

We have also mapped total economic activity among the 731 companies with a significant turnover in 2015. Besides that, we have prepared a forecast of economic activity in 2017 and 2020 for all companies that were established after 1998. The economic activity in 2015 and the forecast is shown in Table 1.2.

¹ CVR = det Centrale VirksomhedsRegister/The Central Company Registry. It is mandatory for all active Danish companies to have a CVR number

Table 1.2 Economic activity in DTU-based entrepreneurial companies in 2015, 2017 and 2020 (for all companies established after 1998)

| | 2015 | Forecast 2017 | Forecast 2020 |
|---|-------|---------------|---------------|
| Number of companies | 1,357 | 1,595 | 1,863 |
| <i>Hereof companies with a significant turnover</i> | 731 | 829 | 932 |
| Total number of full-time equivalents | 2,520 | 2,748 | 3,493 |
| Total turnover (billion DKK) | 5.1 | 7.0 | 9.2 |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: By 'a significant turnover', we mean companies that have a turnover corresponding to at least half a full-time equivalent in the relevant industry. As shown in Table 1.1, there were 1,400 DTU-based companies in 2015 (including spinoffs and excluding mergers and acquisitions). Of these, 43 companies from 1999 and 2000 were excluded from the analysis, since we did not have access to adequate information about their development and survival in Statistics Denmark. The assessment of the entire economic activity in DTU-based entrepreneurial companies in 2015 is therefore based on the 1,357 DTU entrepreneurs.

The table shows that the 731 companies in 2015 had a total turnover of DKK 5.1 billion. Moreover, they employed 2,520 full-time equivalents.

The forecast shows that the economic impact of DTU entrepreneurs increased significantly over the years. The turnover of the DTU-based entrepreneurs increases by approximately 85% to DKK 9.2 billion (in 2020), while the rate of employment increases almost 40% to about 3,500 full-time equivalents. These high rates of growth indicate that more companies are reaching the sales phase, exports are increasing, and the total number of DTU-based companies is increasing (see Section 1.2).

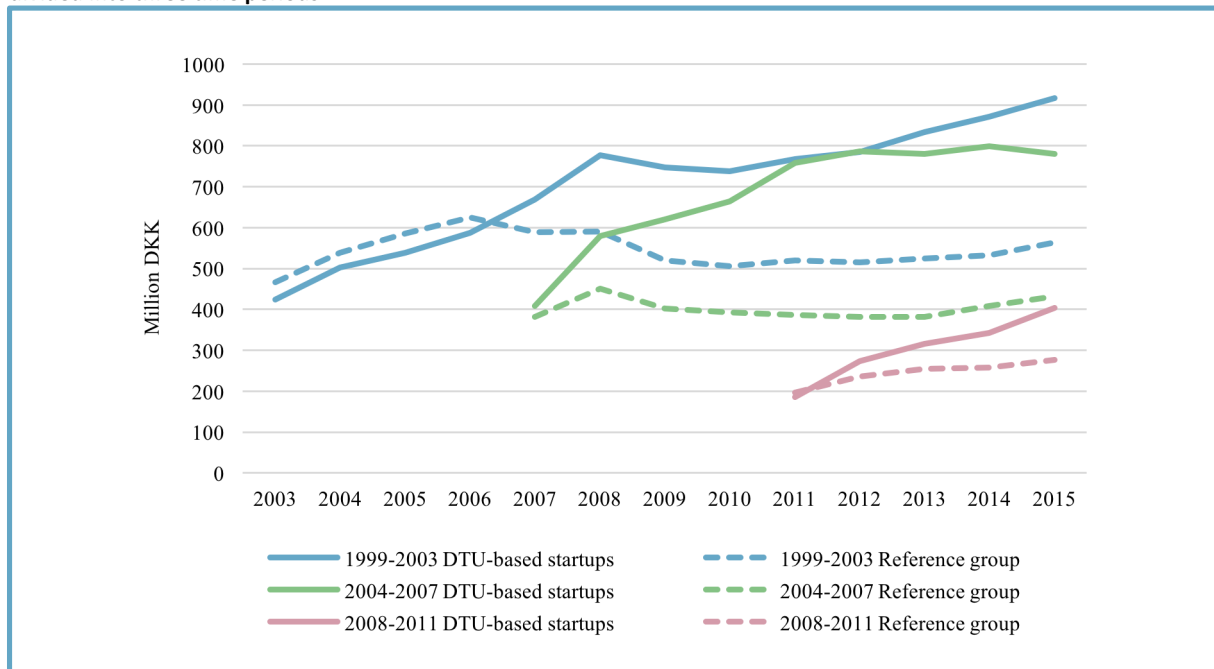
We have also measured developments among the DTU-based entrepreneurial companies against reference groups of comparable entrepreneurs. The reference groups are composed in such a way that they match the DTU entrepreneurs with regard to numbers of companies in each group, age and industry. The purpose was to study if university- and technology-based entrepreneurs are faring better than comparable entrepreneurs.

In the analysis, the DTU-based entrepreneurs were divided in three groups:

- Companies established in the period 1999-2003
- Companies established in the period 2004-2007
- Companies established in the period 2008-2011

The figure below shows developments in total staff employment for the three groups from the end year of each of the three periods (2003, 2007, 2011) until 2015. The solid lines show developments for the DTU entrepreneurial companies, while the dotted lines show developments in the reference groups.

Figure 1.2 Developments in the total number of full-time equivalents for DTU-based entrepreneurs and reference groups, divided into three time periods



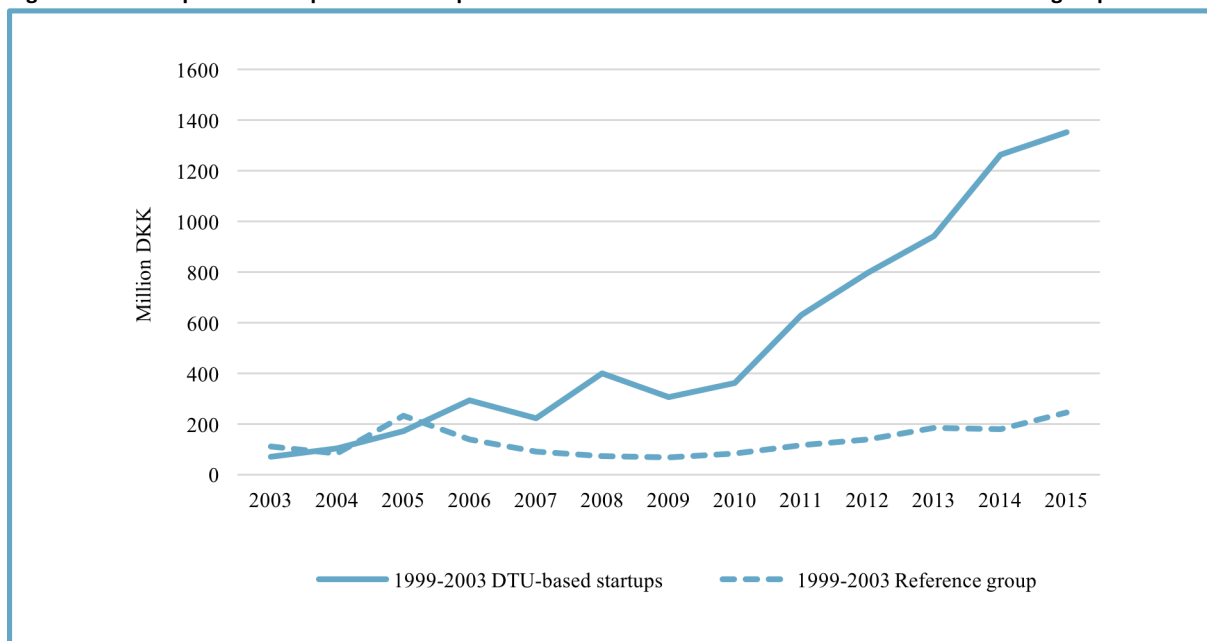
Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: The 2008-2011 group has a lower point of departure because fewer companies were established during the financial crisis. Moreover, the period only includes four years, whereas the 1999-2003 group includes five years.

The figure shows that all three groups of DTU-based entrepreneurial companies have enjoyed higher growth in their staff employment than their reference groups have. Regardless of whether the companies were established when the economy was booming or struggling, they have created more jobs than entrepreneurs positioned in the same industries.

The DTU entrepreneurs also exhibit stronger growth rates in turnover and exports than the reference groups. Figure 1.3 shows developments in exports for DTU entrepreneurs established in the period 1999-2003 compared to the reference group.

Figure 1.3 Developments in exports for entrepreneurs from DTU established in 1999-2003 and reference group



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Like figure 1.2, this figure shows that DTU entrepreneurs are faring better than the entrepreneurs in the reference groups. However, it also underlines an important point in the analysis – namely, that it often takes high-technology entrepreneurs several years to achieve growth and success. It is not until 2010 that the DTU-based entrepreneurs (established 1999-2003) really surpass their reference group, but in 2010-15, after the modest initial growth, their exports increased fourfold.

The analysis also reveals that there are differences in economic impact across the different types of entrepreneur. The best performing group is the DTU-IP-based companies (i.e. companies developing inventions emerging from scientific work, where DTU has protected its intellectual property by taking out a patent). In this group, companies with products on the market (significant turnover) had an average turnover on DKK 13.5 million in 2015. Compared with that number, companies established by DTU employees (not based on a DTU-patent) had an average turnover on DKK 9.9 million, while companies established by students and school leavers had an average turnover of DKK 4.5 million in 2015.

On the other hand, companies based on DTU-patents are the smallest group, as they account for only 4% of the DTU-based start-ups.

1.5 The profile of the DTU entrepreneurs

It is a common feature of the DTU-based entrepreneurial companies that they are technology-based and exploit ideas, knowledge and technology developed at DTU. But there are also considerable differences in the way the companies get started and how they develop in the first few years after being established. We have completed a survey among a number of DTU-based entrepreneurs. Judging by the responses from companies that answered the survey, the main results were as follows²:

- There is great variation in the number of founders. Most companies have 2-3 founders, but 15% have 5 founders or more.
- At least one of the founders or key employees has entrepreneurial experience in about a third of the companies. Similarly, one or more of the founders or key employees has great commercial insight and business understanding.
- There is a considerable variation in founder teams' networks with investors, potential customers and other companies in the relevant industries. In these areas, a substantial share of the DTU-based entrepreneurial companies

² There is an overrepresentation of companies based on IP, removed by DTU.

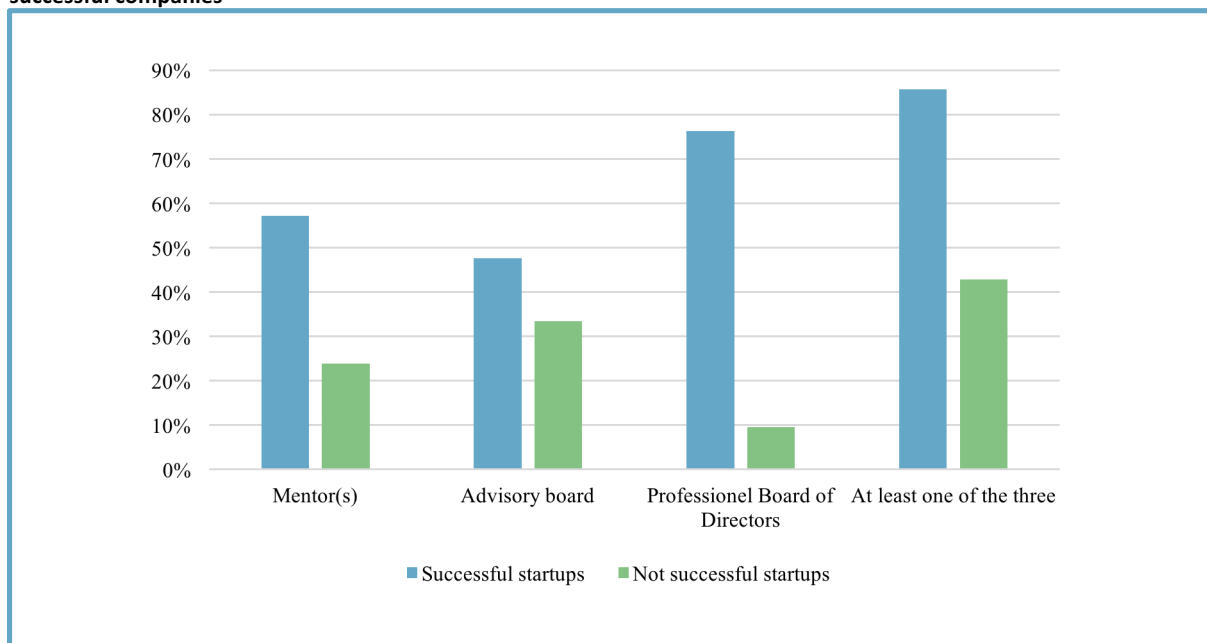
have a strong network, but a substantial share has no network at all. The network is typically weaker in companies established by students and school leavers.

- 54% of the entrepreneurs have had a mentor or a team of mentors. 33% have a board of directors.
- The boards of directors, as well as advisory boards, contribute with many types of experiences and competencies, especially commercial experience.

The analysis indicates that key differences across companies in the above-mentioned areas explain to a high degree why some companies are growing faster than others. Not least, the early use of mentors, advisory boards and/or boards of directors seems to affect growth potential. Dividing the entrepreneurial companies into ‘successful’ and ‘not successful’ companies (measured in terms of development in turnover, staff employment and capital attracted), our analysis shows that successful companies are much more inclined to use these opportunities (see Figure 1.4).

The figure below shows, among other things, that almost six out of ten successful companies have used mentors. The equivalent share of not successful companies is 25%.

Figure 1.4 Shares of companies making use of mentors, advisory board and boards of directors among successful and not successful companies

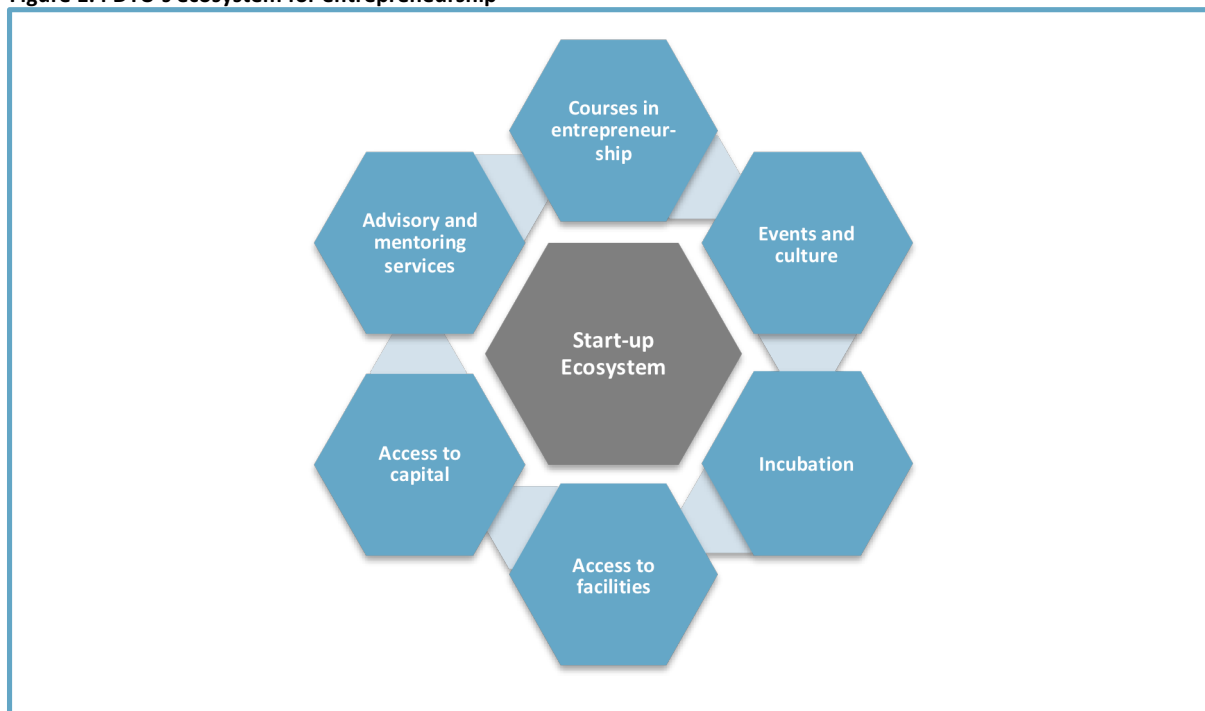


Source: Survey among DTU-based entrepreneurs, N =42.

1.6 DTU's ecosystem for entrepreneurship

Over the last few years, DTU has initiated a whole range of activities aiming at supporting entrepreneurship – both among students and employees. At the same time, a range of private actors which provide counselling and capital for entrepreneurs have established operations in the DTU Science Park. Hence, a comprehensive ecosystem of actors and activities supporting entrepreneurs in different phases is now available on the DTU campus. This ecosystem, which consists of more than 40-50 actors, events and facilities, can be split into six categories (see Figure 1.5).

Figure 1.4 DTU's ecosystem for entrepreneurship



Source: IRIS Group

Initiatives for entrepreneurship were first seen at DTU in 2000 when new legislation permitting universities to take over ownership of scientific results obtained by scientists was introduced. Today, about 20 people are employed at the central office for commercialisation of research at DTU, which cooperates with DTU departments in scouting, patenting and the commercialisation of research. DTU Skylab – an innovation hub for students – opened in 2012. The focus of the hub is to teach entrepreneurship to students and to support students in creating new companies. DTU Science park, which was established as early as 1962, is also one of the biggest science parks in Europe.

Most of the entrepreneurs we interviewed acknowledged that DTU today has a comprehensive and well-functioning ecosystem for start-ups – an ecosystem that is effective in:

- Stimulating entrepreneurship and developing a culture of entrepreneurship at DTU
- Educating and training potential entrepreneurs
- Co-funding the early stages of the technology maturation
- Matching entrepreneurs with investors, companies, scientists, etc.
- Offering sparring³, advisory services, counselling and mentorships
- Offering flexible incubation opportunities on campus and at the DTU Science Park which correspond to different phases in the development of new companies
- Providing access to facilities for product development, testing, and the development of prototypes, etc., which significantly lowers the expense of bringing products to the market

Three out of four companies indicated that DTU, and its ecosystem, had been *very important* in the start-up phase, and 60% believed that the ecosystem had been *very important* in later phases.

³ The term 'Sparring' is used in Danish and means discussions that can, for instance, help to strengthen the strategy, the financial management, the business model, the market focus and the ability to raise funding. They can also contribute to the development of the company's network and open up new possibilities for investors, markets and perhaps specific customers. See Chapter 4.

The interviews also point to areas where the ecosystem can be further developed. *First of all*, DTU should focus on expanding the entrepreneurship culture, and on creating effective frameworks for entrepreneurship within more departments. Today, a handful of the total 22 DTU departments account for most of the entrepreneurial activities.

Secondly, the focus of the prevailing ecosystem is more on start-ups than on scale-ups (i.e. entrepreneurial companies with significant growth rates). The analysis shows that relatively few DTU start-ups have developed into bigger companies with many employees and a high turnover, and the ecosystem could be more effective in trying to remedy this situation. The message from several of the companies interviewed is that DTU could focus on creating frameworks, competencies and courses which target entrepreneurs with high growth potential. The interviews we conducted pointed especially to the following areas of improvement:

- Increased focus on targeting the services and competencies of the ecosystem on different groups – for instance, in relation to the different needs that characterise hardware, software and life-science companies (the three most important business areas among the DTU entrepreneurs).
- Different levels of accelerator programmes targeting both start-ups and scale-ups, as well as programmes focusing on entrepreneurs with a high growth potential. One approach would be to attract serial entrepreneurs to advisory boards and boards of directors for entrepreneurial ventures with a very high growth potential.

More emphasis on assisting start-ups to attract and realise their first large investment – for instance, from early-stage investors, business angels or similar.

2. Entrepreneurship at DTU 1999-2017

2.1 Introduction

We have divided the entrepreneurs from DTU into the following three groups:

- Companies established on the basis of patents taken out at DTU (i.e. companies based on IP from DTU).
- Companies established by employees from DTU, but where the company is not based on a patent taken out at DTU.
- Companies established by students or graduates from DTU.

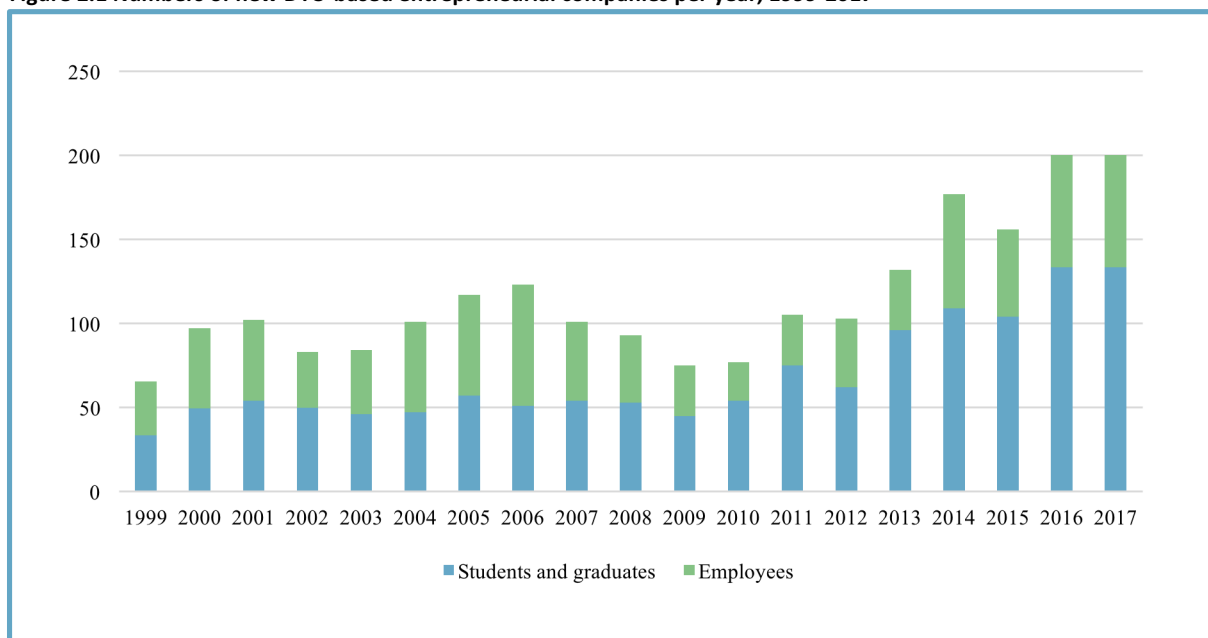
To help to ensure that companies in the last two groups base their entrepreneurial activity on knowledge from DTU, the following two conditions were proposed:

- 1) For DTU students, the company must be established within two years of graduation. For former DTU employees, the company must be established no more than two years after termination of their employment.
- 2) Employees must have been employed for at least two years at DTU in order to be counted in.

The entrepreneurs are subsequently identified by correlating registers of employment and company establishment as well as information from DTU on civil registration numbers for students and on all companies established on the basis of IP from DTU.

Figure 2.1 shows the development in the number of DTU-based entrepreneurs from 1999-2017. As the correlated registers only allow for an assessment of the number of entrepreneurs up to 2015, the numbers for 2016 and 2017 are estimates based on DTU's own registrations.

Figure 2.1 Numbers of new DTU-based entrepreneurial companies per year, 1999-2017



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

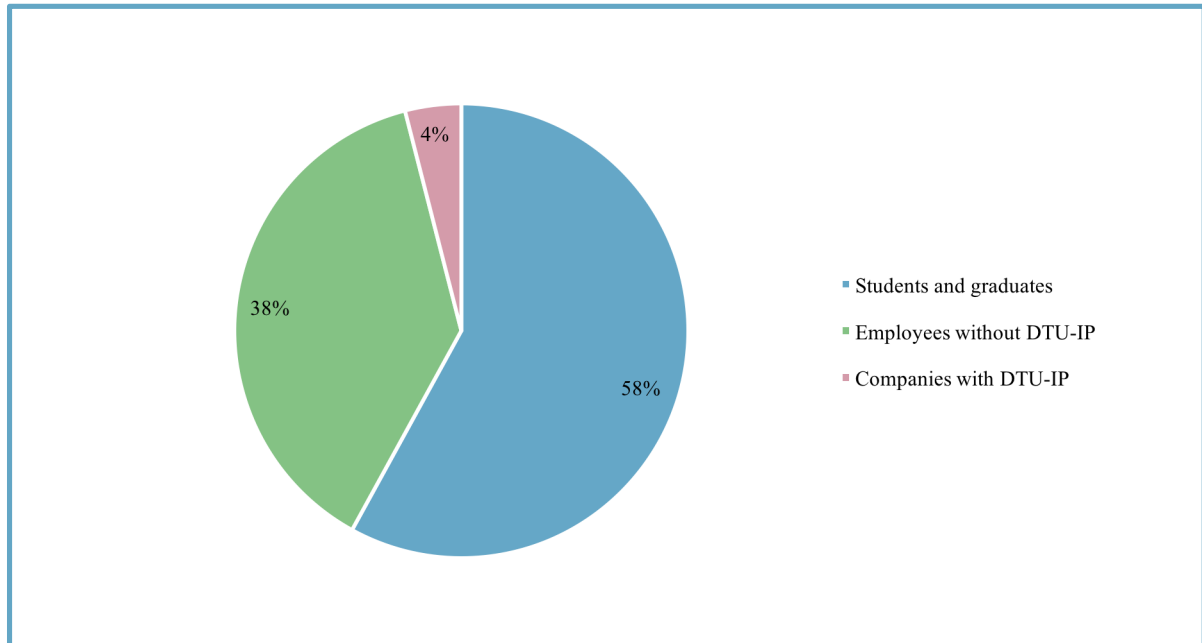
Note: The figures for 2016 and 2017 are estimated.

As the figure shows, between 70 and 200 new DTU-based companies were established per year between 1999 and 2017. This included a total of 1,792 DTU-based start-ups in the period 1999-2015. Including the estimated numbers for 2016-2017, the total number of companies based on knowledge and technology from DTU increases to approximately 2,200 companies over the period 1999-2017, equivalent to an average of 115 companies per year.

The figure also shows that – after a decrease during the financial crisis – there have been substantial annual increases in the number of DTU-based entrepreneurs, and that the numbers have been somewhat higher throughout the past few years compared to previous periods.

Out of the 1,792 companies established before 2016, 1,040 (or 58%) were established by students or graduates. Figure 2.2 shows the distribution of the three main groups in percentages.

Figure 2.2 Distribution of three main groups of DTU-based companies



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

The figure also shows that companies with DTU-IP make up the smallest group (4%), and that 38% of the companies are established by employees without patented technology from DTU. Thus, a rather small proportion of the companies are occupied with patenting and commercialising research discoveries.

2.2 Company characteristics and development

2.2.1 Areas of industry and technology

In the survey, we asked companies whether their business activities lie primarily within the life sciences, hardware, software, consulting or other areas. The responses appear in Table 2.1 below.

Table 2.1 Distribution of DTU-based start-ups within business areas

| | All companies | Reference group |
|-----------------------|---------------|-----------------|
| Life Science products | 24 | 23% |
| Hardware | 44 | 43% |
| Software | 19 | 18% |
| Consultancy | 16 | 16% |
| Total | 103 | 100% |

Source: Survey among DTU-based entrepreneurs, N=103.

The table shows that 44% develop hardware, e.g. new materials, robots, sensors, electronics, production equipment, etc. Almost a quarter deal with life science products, e.g. medical technology, biotech, advanced food products (including ingredients, bioactive feeding material, etc.). Only 16% of the companies are exclusively occupied with consultancy. The vast majority of the DTU-based entrepreneurs are bringing new technologies and products to market⁴.

2.2.2 Regional distribution of DTU-based start-ups (localisation of active companies in 2015)

Not surprisingly, the vast majority of the entrepreneurs from DTU are located in the Capital Region of Denmark. However, 22% of the companies are currently located outside the Capital Region, as shown in Table 2.2.

Table 2.2 Regional distribution of DTU-based start-ups (localisation of active companies in 2015)

| | All companies |
|----------------------------|---------------|
| Capital Region of Denmark | 78% |
| Region Zealand | 10% |
| Region of Southern Denmark | 5% |
| Central Denmark Region | 5% |
| North Denmark Region | 3% |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

The table shows that after the Capital Region, Region Zealand has most DTU-based start-ups, with 10% of the entrepreneurs located there.

2.2.3 Nationality of the founders

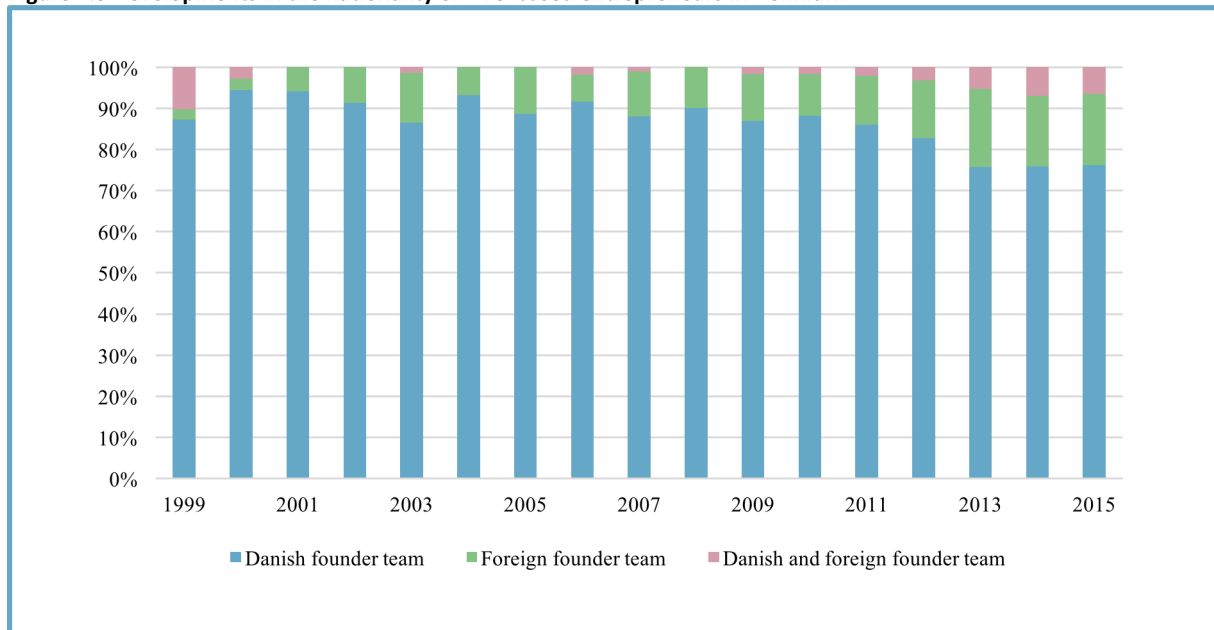
DTU is an international university with researchers and students from all over the world. Today, non-Danish nationals account for 23% of researchers, 52% of PhD students and 10% of students. Therefore, how many companies were established by foreign nationals is of interest. This may have several positive effects. For example, non-Danish nationals may:

- Contribute to the internationalisation of Danish business life.
- Increase labour supply by retaining foreign researchers and students in Denmark (companies established by foreigners are probably more likely to recruit labour from abroad).

Figure 2.3 shows developments in the share of DTU entrepreneurs who are non-Danish nationals, measured by the nationalities of founders/members of the founding team.

⁴ It is important to emphasise that the survey only covers entrepreneurs who are registered by DTU and established after 2006. This means that the respondent group does not reflect the distribution of the total population when it comes to age and type of entrepreneur (cf. the main groups of DTU-based companies). Thus, the IP-based companies are overrepresented compared to the share of this group among all DTU-based entrepreneurial companies (see appendix 1). For instance, this may imply that software and consultancy are in fact underestimated in table 2.1, as knowledge in these areas are not as patentable as life science and hardware.

Figure 2.3 Developments in the nationality of DTU-based entrepreneurs in Denmark



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

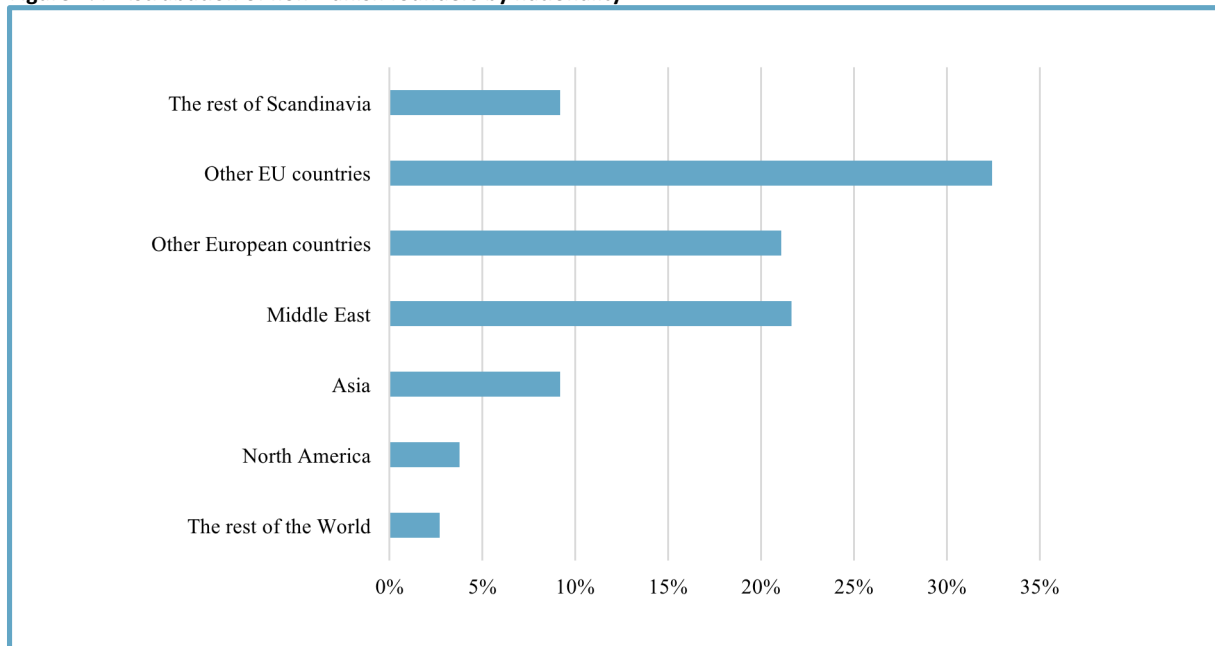
Note: The nationality of the founding team is based on 1.540 company observations out of a total of 1.792 company observations.

The figure shows a substantial increase in the number of companies established by foreign nationals – particularly after 2010. Between 2013-2015, more than 20% of the companies (approximately 30 companies per year) were established by non-Danes or by a team consisting of both Danish and foreign founders. Throughout the entire period, 11% of the companies were established by people with foreign citizenship, while 3% had both a Danish and a foreign member from DTU in the founding team.

Naturally, it is also possible that foreign students from DTU have started businesses in their home countries after graduation.

Figure 2.4 examines the distribution of non-Danish founders more closely. It shows that around two thirds of the foreign founders were Europeans, and that 10% of these came from the other Scandinavian countries. An interesting further finding is that just over 20% of the founders were from Middle Eastern countries.

Figure 2.4 Distribution of non-Danish founders by nationality



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: The distribution of non-Danish founders is based on 179 start-ups from DTU.

It is clear from the figure that the foreign DTU entrepreneurs come from all over the world. In other words, DTU helps highly educated people from all over the world to set up a business in Denmark.

3. DTU-based start-ups growth and impact

3.1 Introduction

This chapter takes a closer look at the growth and development of start-ups from DTU, and their general socio-economic significance.

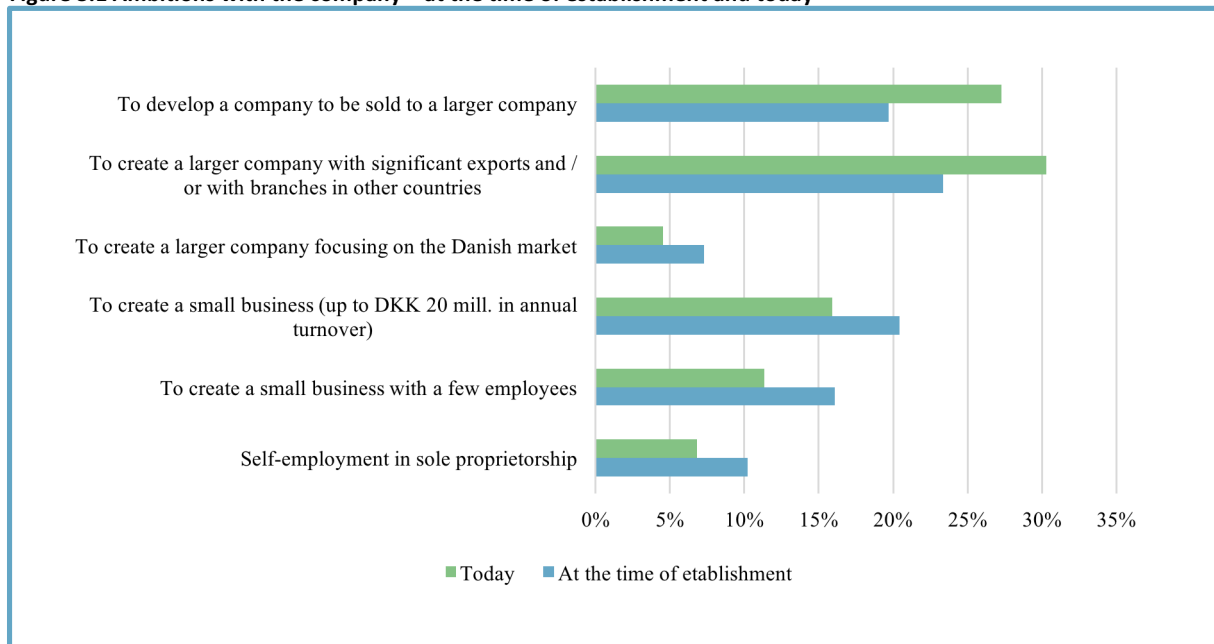
Section 3.2 focuses on the growth ambitions of entrepreneurs from DTU. Section 3.3 investigates outcomes for start-ups from DTU in terms of survival, mergers, new spinoffs, etc.

Section 3.4 analyses total value creation and employment among entrepreneurs from DTU and estimates developments up to 2020, while Section 3.5 analyses growth compared to relevant reference groups. Finally, Section 3.6 focuses on the attraction of capital.

3.2 Ambitions of the entrepreneurs

In considering business growth, we begin by asking whether DTU entrepreneurs have growth ambitions. To some entrepreneurs, starting a new company is all about self-employment and being a free agent, while for others the ambition is to create a large, possibly global, company. Hence, in the survey we asked respondents to specify their ambitions (see Figure 3.1).

Figure 3.1 Ambitions with the company – at the time of establishment and today



Source: Survey among DTU-based entrepreneurs. N=79.

Note: The reply 'Don't know' is not included in the basis of calculations.

The figure shows that approximately 10% of entrepreneurs start their company with self-employment as the only ambition, and that less than 20% of the companies currently have the limited ambition either of securing self-employment or having a few employees. In other words, having more than a few employees and creating growth is a very common goal.

Around one in three companies have the ambition of creating a large company with a large turnover of more than DKK 20 million. The majority of these companies also wish to export. A relatively large proportion of the entrepreneurs aim to develop their company and technology to a stage where it can be sold to a larger company (27%). Approximately 65% want either to develop a large company or to develop the company in preparation for future sale. Hence the typical DTU entrepreneur has significant business ambitions.

The figure also shows that DTU entrepreneurs have become more ambitious over time. It is noticeable that the total level of ambition is higher today than it was at the time of the companies' establishment.

3.3 Survival, spinouts, sale and mergers

Chapter two explained that between 1999 and 2015 around 1,800 new companies were established by students, graduates, researchers and employees at DTU. It is of interest to ask, how many of these companies still existed by the end of this period, what happened to those that no longer existed, and whether new companies emerged from the existing companies. Table 3.1 provides an overview of the total number of companies established throughout the period and their eventual destinies.

Table 3.1 Overview of developments in DTU-based start-ups established between 1999-2015

| | Status, end of 2015 |
|---|---------------------|
| Number of companies established in the period 1999-2015 | 1,792 |
| Closed CVR-numbers | 463 |
| Companies with active CVR-numbers in 2015 | 1,329 |
| <i>Hereof companies with a significant turnover</i> | <i>731</i> |
| The share of surviving companies | 74% |
| The total number of spinoff companies (new businesses) | 92 |
| The number of spinoff companies still active in 2015 | 71 |
| Converted companies (mergers or acquisitions) | 11 |
| The total number of companies, in 2015, based on ideas, knowledge or technology from DTU | 1,411 |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: Significant turnover means companies that have a turnover equivalent to half a full-time equivalent in the given industry.

The table shows that 1,329 out of a total of 1,792 start-ups were still operating in 2015, equivalent to a survival rate of 74%.

By 2015 some of the original start-ups had established new companies – so-called spinoffs. This typically happens because technologies are applicable within other business areas or in new types of product. It may, for example, be an advantage to establish a new company focusing on the development of a single product or business area. It may be easier to attract venture capital on the back of such a development.

Our analysis shows that the original 1,792 companies established 92 spinouts, and that of these 71 still existed in 2015. Thus, a significant number of still-operative companies originated from DTU-based start-ups.

Finally, we have calculated that at least 11 of the original companies were either acquired by or merged with larger/other companies.

In total, 1,411 companies fully or partly based on technologies brought to market by entrepreneurs from DTU were still operating in 2015. This is equivalent 79% of the original DTU start-ups.

We also assessed survival rates in the 'traditional way' by determining the proportion of start-ups that are still operative one and three years after their establishment. The results are shown in the Table 3.2. We divided the entrepreneurs into four groups, including spinouts.

Table 3.2 Companies established between 1999-2012 surviving one and three years later

| | Number of companies established in the period 1999-2012 | Share of surviving companies | |
|--------------------------|---|------------------------------|------------|
| | | +1 year | +3 year |
| Students and graduates | 720 | 88% | 66% |
| Employees without DTU-IP | 529 | 89% | 70% |
| Companies with DTU-IP | 32 | 94% | 91% |
| Spinoff companies | 73 | 92% | 67% |
| All companies | 1,354 | 88% | 68% |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

The table shows that 68% of all DTU-based start-ups are still operative three years after establishment. The survival rate is significantly higher among companies with DTU-IP (91% after three years). In comparison, companies established by students and graduates have the lowest survival rate (66% after three years).

According to several interviewees (e.g. the manager of DTU Skylab), student entrepreneurs can be divided into two categories. Those who start their own business primarily in order to acquire new knowledge and experience, and those who do so with the aim of building a solid company. The lower survival rate and average turnover in the student and graduate group must be seen in light of these trends.

In comparison, the three-year survival rate for all entrepreneurs in Denmark has been somewhere between 52-54% throughout the past few years. At this point, then, all groups of entrepreneurs from DTU are more successful than Danish entrepreneurs in general.

In total, the analysis shows that many DTU-based companies are being established and have a high survival rate. Furthermore, around 5% of the companies are rather young and originate from other companies established at DTU. More than 1,400 companies continue to work with products and technologies which entrepreneurs from DTU have tried to bring to market between 1999 and 2015.

3.4 Growth and economic impact of DTU entrepreneurs

The most recent available data for economic growth in start-ups is from 2015. Hence, we have calculated the total activity among entrepreneurs from DTU in 2015 and compared it with the activity in a reference group of entrepreneurs outside DTU.

Table 3.3 shows total activity in the DTU start-ups in 2015 (including the surviving 71 spinouts) and the corresponding activity in the reference group.

The table focuses on companies with a turnover higher than the triviality limit of Statistics Denmark. This means that – as a minimum – they have a turnover equivalent to half a full-time equivalent in the industry in question. In all, 731 out of the 1,329 operative companies had a turnover above this level. The remaining 598 companies had not (yet) launched products on the market or had low levels of activity.

The 731 operative DTU start-up companies are compared with a reference group of 731 other start-ups with the same composition in terms of age and industry (see Appendix 1). The latter also have a turnover higher than the triviality limit (see Table 3.3).

Table 3.3 Key figures for economic activity and productivity among DTU-based start-ups and reference group

| | All companies | Reference group |
|--|---------------|-----------------|
| Number of companies with turnover | 731 | 731 |
| Total number of full-time equivalents | 2,508 | 1,693 |
| Total turnover (bill. DKK) | 5.01 | 3.96 |
| Share of companies with exports | 27% | 17% |
| Total direct exports (bill. DKK) | 2.20 | 1,23 |
| Productivity (value added in million DKK per full-time equivalent) | 0.87 | 0.73 |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: The numbers are based on operative start-ups from DTU, meaning companies with a turnover above the triviality limit of Statistics Denmark (at least half a full-time equivalent and/or a turnover of a certain size depending on the industry affiliation of the company).

The figure shows that the 731 DTU-based start-ups employed around 2,500 staff (measured in terms of full-time equivalents) and had a total turnover of approximately DKK 5 billion. On average, the companies created value of DKK 0.9 million per employee (productivity).

The table also shows that the DTU-based entrepreneurs are managing better on all parameters than companies in the reference group⁵. The DTU-based companies employed around 800 more full-time equivalents than the reference group and had approximately DKK 1 billion higher turnover (equivalent to 25%).

Additionally, the reference group has on average substantially lower productivity. Thus, the average value creation per employee in the DTU-based companies is 20% higher than it is in the reference group. This clearly indicates that university-based entrepreneurs are positively contributing to our prosperity and welfare, since high productivity is the foundation of better remuneration for employees and greater wealth in society.

Another important result is that entrepreneurs from DTU are more internationally oriented than the reference group.

In order to represent the present and future, projections to 2017 and 2020 were calculated. Here, we assumed that between 2018 and 2020, 200 new DTU-based companies will be established per year (see Chapter Two). We also assumed that the companies' average growth and survival rates (at different ages) in the years to come will be the same as that observed in the period 1999-2015 (the methodology is elaborated in Appendix 1).

Table 3.4 shows our forecast for the activity among DTU-based start-ups (established after 1998) in 2017 and 2020.

Table 3.4 Economic activity in DTU-based start-ups (established after 1998) in 2015, 2017 and 2020

| | 2015 | Forecast 2017 | Forecast 2020 |
|--|-------|---------------|---------------|
| Number of companies | 1,357 | 1,595 | 1,863 |
| Hereof companies with a significant turnover | 731 | 829 | 932 |
| Total number of full-time equivalents | 2,520 | 2,748 | 3,493 |
| Total turnover (billion DKK) | 5.1 | 7.0 | 9.2 |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

The projections suggest there will be a total of 1,595 surviving DTU entrepreneurs in 2017. This number is expected to increase to 1,863 companies by 2020.

The total number of full-time equivalents is expected to be around 2,750 in 2017 and to increase further towards 2020. Correspondingly, total turnover in DTU-based start-ups is expected to increase from about DKK 5 billion to DKK 9.2 billion in 2020, an increase of approximately 85%.

⁵It must be emphasised, however, that the comparison does not give a complete image of the performance of the entrepreneurs from DTU compared to the performance of other entrepreneurs. The comparison does not take into account the higher survival rate of DTU entrepreneurs. And it does not take into account that many entrepreneurs from DTU have not launched products at the market and may have a lower activity than the other entrepreneurs.

Thus, the projections show that the combination of increasing numbers of entrepreneurs after 2013 (see Chapter Two) and the fact that the established companies, growing older, will launch more products in different markets means that economic impacts will increase substantially.

3.4.1 Differences in economic activity across types of entrepreneur

We have also analysed how overall economic activity is distributed across the three types of entrepreneur. Table 3.5 shows the economic activity of companies with a substantial turnover divided between companies started by students/graduates, employees without DTU-IP and companies based on DTU-IP.

Table 3.5 Key figures for economic activity in DTU-based start-ups, distributed by type of entrepreneur

| | Students/graduates | Employees without DTU-IP | Companies based on DTU-IP |
|---|--------------------|--------------------------|---------------------------|
| Number of companies with significant turnover | 426 | 265 | 40 |
| Total number of full-time equivalents | 1,026 | 1,069 | 413 |
| Full-time equivalent per company | 2.4 | 4.0 | 10.3 |
| Total turnover (bill. DKK) | 1.96 | 2.51 | 0.54 |
| Turnover (million DKK) per company | 4.6 | 9.5 | 13.5 |
| Share of exporting companies | 20% | 35% | 48% |

Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

The table shows that, out of the 731 companies that were above the triviality limit in 2015, 426 were established by students or graduates. This is equivalent to 58% of the active companies in 2015. Of the remaining companies, 40 were DTU-IP companies and 265 were established by employees without DTU-IP.

In 2015, the IP-based companies had on average both a considerably higher turnover and more employees than companies in the remaining two groups. This indicates that the scalability of the technologies in DTU-IP based companies is generally higher than it is in the other companies.

The numbers also show that DTU-IP based companies are more likely to export (48%). Companies established by students and graduates are the least likely to have direct exports. It should, however, be noted that the share of exporting companies in all groups exceeds the 10% average share for all Danish companies.

3.4.2 Distribution of economic impact

With more than 600 companies with no substantial turnover, the analysis in the previous sections confirms that it takes time for technology-based entrepreneurs to bring their products to market. We have examined this further by taking a closer look at turnover and employment in 2015 in different age groups (see Table 3.6).

Table 3.6 Key economic figures, distributed by age group (2015)

| Age groups: | Number of companies | Average number of full-time equivalents | Average turnover (million DKK) |
|-------------|---------------------|---|--------------------------------|
| 0-2 years | 467 | 1.0 | 1.6 |
| 3-5 years | 254 | 2.4 | 3.6 |
| 6-9 years | 362 | 3.5 | 4.9 |
| 10-12 years | 106 | 5.5 | 10.9 |
| 13-16 years | 168 | 10.1 | 27.4 |

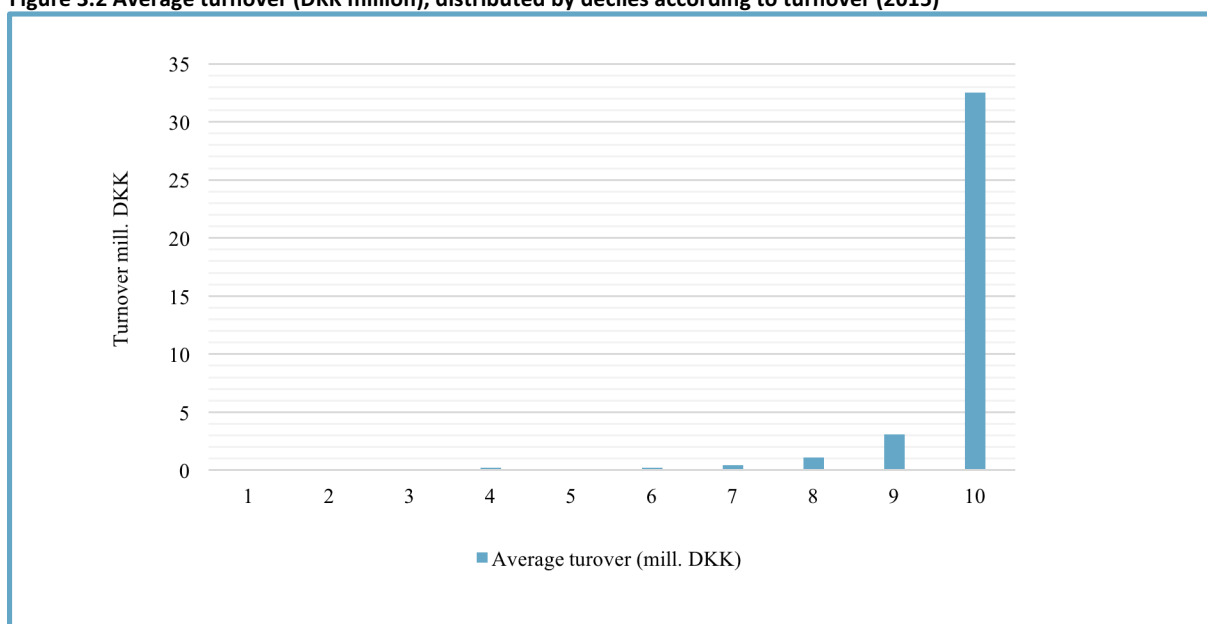
Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

In the table, there are significant differences between the age groups. It is particularly striking that companies between 13-16 years have a high turnover on average.

The results confirm that it takes time to create growth in a company when it is based on knowledge and technology created in universities.

Finally, we have looked at average turnover in the almost 1,400 operating companies, dividing them into 10 groups (of same size: around 140 in each group) based on the size of their turnover. The 140 companies with the highest turnover were placed in group 10, the 140 companies with the next highest turnover in group 9, and so forth (see Figure 3.2).

Figure 3.2 Average turnover (DKK million), distributed by deciles according to turnover (2015)



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

It can be seen that the largest 140 companies account for a very large part of the total turnover. On average, they have a turnover around DKK 33 million. The average in the second-best group, i.e. group 9, is only DKK 3 million. To put it another way, more than 85% of the turnover is concentrated in the largest 10% of companies. When we examine the data more closely, it transpires, moreover, that 20% of the companies in group 10 are responsible for 70% of the total turnover in this group. This corresponds to 28 companies being responsible for 60% of the turnover among the approximately 1400 operative DTU-based start-ups.

As mentioned in previous sections, it takes time to develop successful companies. This probably explains the distribution seen in Figure 3.2 – at least, in part. But the distribution also reflects the fact that it takes several entrepreneurs to create one success. In popular terms, promoting high-tech companies is also a ‘numbers game’. Several start-ups are required in order to create a substantial amount of success.

3.5 Longitudinal analyses

Another way of assessing growth and development among DTU entrepreneurs is through longitudinal analyses in which growth in DTU start-ups is compared with that in a similar group of companies without a DTU background.

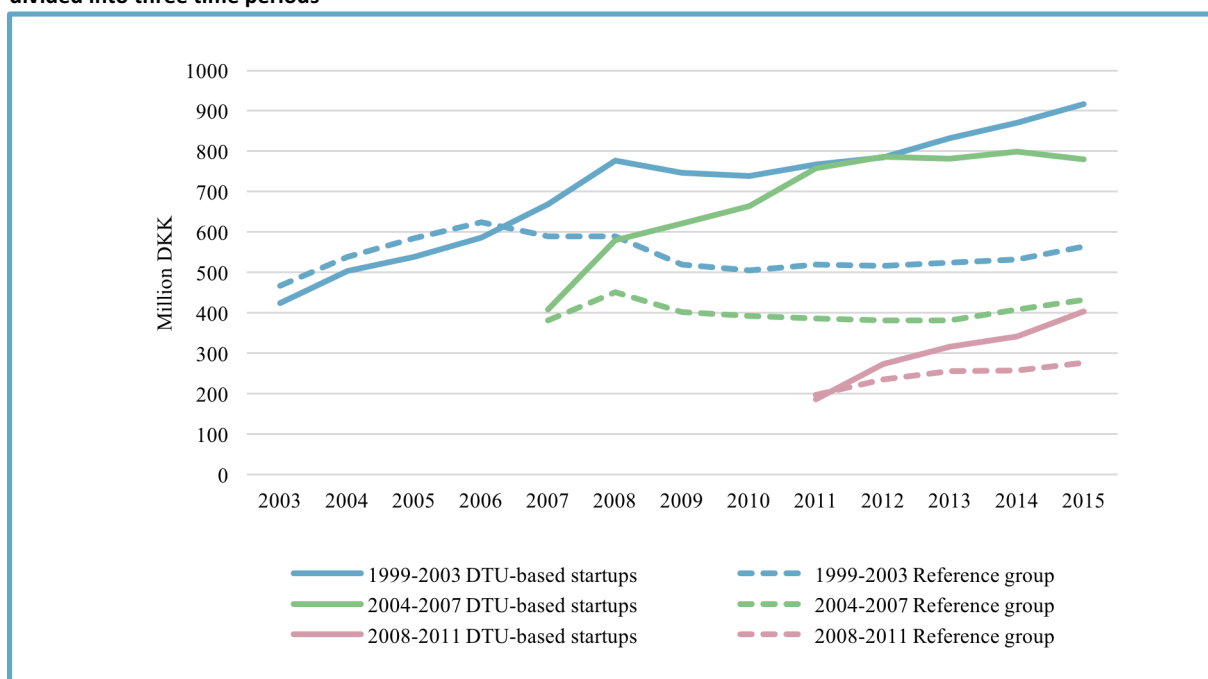
Thus, we constructed reference groups containing the same numbers of entrepreneurs as the groups of entrepreneurs from DTU, which also have the same distribution in respect of age and industry affiliation (see Appendix 1). Differences in growth between the two groups tell us how well entrepreneurs from DTU are managing in comparison with entrepreneurs in a similar situation.

In the analysis, the DTU-based entrepreneurs were divided into three groups according to year of establishment:

- Companies established in the period 1999-2003
- Companies established in the period 2004-2007
- Companies established in the period 2008-2011

Figure 3.3 below shows each group’s development in terms of total employment for each period of time (2003, 2007 and 2011) up until 2015. The solid lines show developments among entrepreneurs from DTU and the broken lines show developments in the reference groups⁶.

Figure 3.3 Developments in the total number of full-time equivalents for DTU-based entrepreneurs and reference groups, divided into three time periods



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Note: The numbers are based on operative start-ups from DTU, meaning companies with a turnover above the triviality limit of Statistics Denmark (at least half a full-time equivalent and/or a turnover of a certain size depending on the industry affiliation of the company). The group of companies from 2008-2011 has a lower point of departure due to the fact that fewer companies were established during the financial crisis. Furthermore, only four years are included in this period, as opposed to the five years in the period 1999-2003.

The figure shows that all three groups of entrepreneurs from DTU had a higher levels of employment growth than their respective reference groups.

However, DTU entrepreneurs established between 1999 and 2003 do not outpace the total employment in the reference group until 2007-2008, after which the distance between the groups increases gradually until 2015. The same goes for companies established between 2004 and 2007, where the additional growth gathers speed around 2007-2008, which is significantly earlier considering the age of the company. Thus, the overall picture given by the two groups is that the DTU-based entrepreneurs are managing better than their reference groups in the years up to and during the global financial crisis.

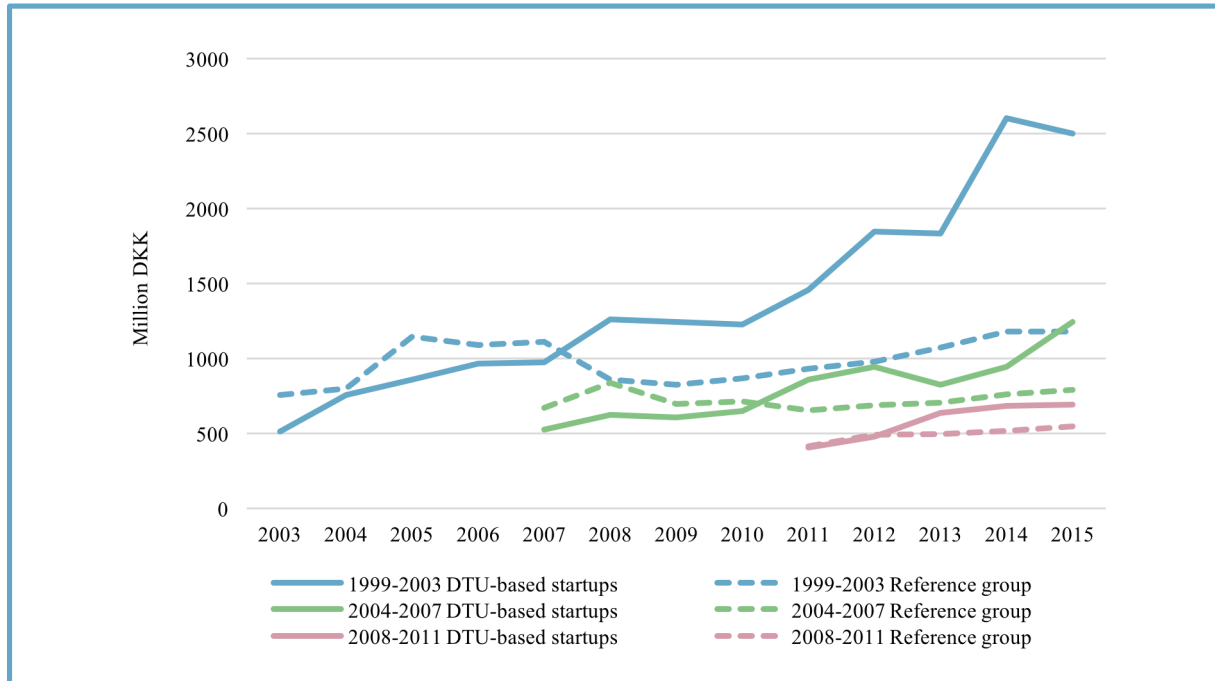
Additionally, the figure shows that DTU-based companies established between 2008 and 2011 generally managed better than their reference group. The difference between these two groups increases steadily over time.

The figure shows that the entrepreneurs from DTU in general are characterised by moderate, but relatively constant, growth. Even when the development is overall positive, it takes a long time to create growth in technology-based start-ups.

⁶ For the reference groups, the total development in full-time equivalents and revenues from the end of the year and ahead has been calculated as the average of 10 random samples from the population of new Danish companies above the triviality limit. The random samples were carried out in a way that ensured that the reference groups matched the entrepreneurs from DTU with regard to number of established companies of same age and industry distribution.

A corresponding development in turnover is illustrated in Figure 3.4, where the growth among entrepreneurs from DTU again is compared to the same reference groups.

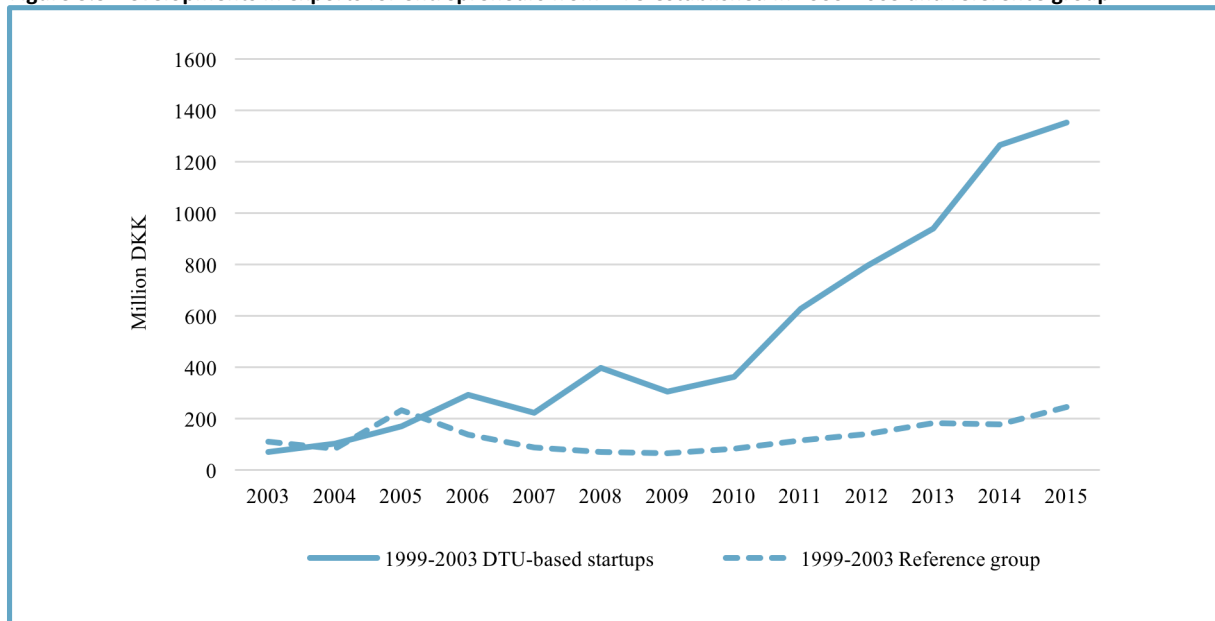
Figure 3.4 Development in turnover for entrepreneurs from DTU and reference groups, distributed by three periods of time



Source: Own calculations based on registrations from DTU on IP-based companies from the university as well as data from Statistics Denmark.
 Note: The numbers are based on operative start-ups from DTU, meaning companies with a turnover above the triviality limit of Statistics Denmark (at least half a full-time equivalent and/or a turnover of a certain size depending on the industry affiliation of the company).

The general picture is the same as that in Figure 3.3 – DTU-based start-ups have had higher growth than the reference groups. When comparing the three groups of entrepreneurs from DTU, it is also interesting to note that the 1999-2003 group has conspicuously outgrown the reference group, with the acceleration in growth most pronounced from 2010 and onwards. This is also a sign that it takes time for technology-based entrepreneurs to create growth and successfully enter the market.

Figure 3.5 Developments in exports for entrepreneurs from DTU established in 1999-2003 and reference group



Source: Own calculations based on DTU registrations of companies with DTU-IP and register data from Statistics Denmark.

Figure 3.5 shows the development in the exports of the group of older DTU-based entrepreneurs (established in the period 1999-2003) and the reference group. Again, the figure shows that it takes time for high-tech entrepreneurs to achieve additional economic growth. On the other hand, the difference after 2010 between entrepreneurs from DTU and the reference group is even greater than the corresponding difference in observed turnover.

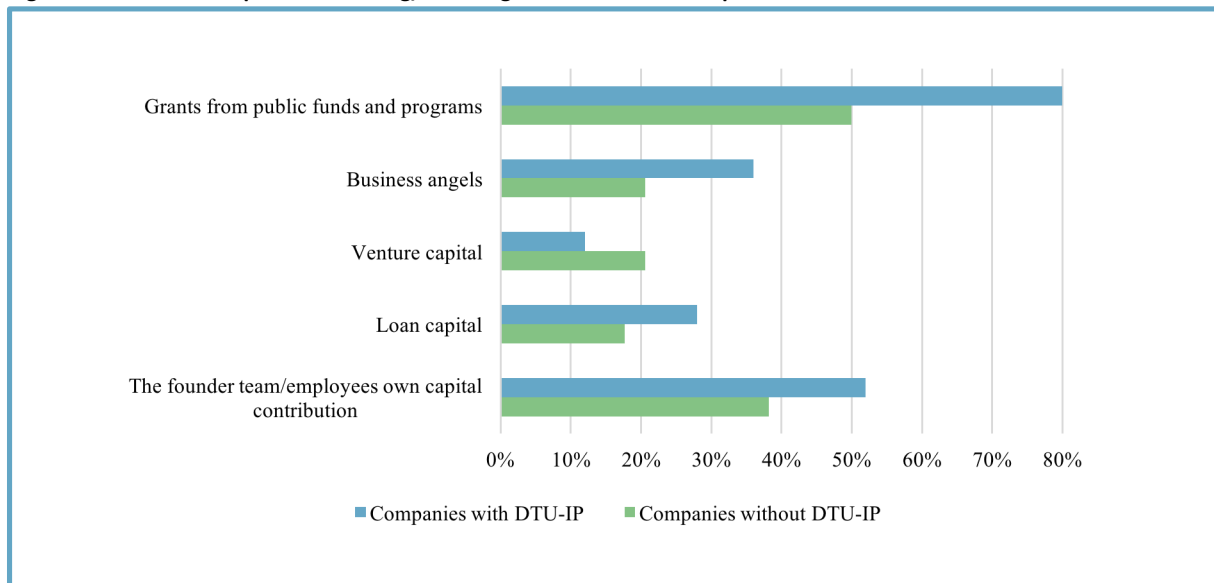
3.6 Attracting capital

The ability to attract capital to finance development is an important criterion for success and a precondition of growth in technology-based companies.

No data are available on how much capital DTU-based entrepreneurs attract totally. However, we asked the participants in the survey about incoming capital (which, as previously stated, included companies established in the period 2007-2017⁷). Figure 3.6 shows the shares of companies attracting different forms of capital, according to the survey data.

⁷ Only entrepreneurs registered by DTU participated in the survey.

Figure 3.6 Share of companies attracting/receiving different forms of capital



Source: Survey among DTU-based entrepreneurs, N=65.

Note: Companies ‘only’ stating own self-employment as their ambition are not included in the calculations; nor are companies which did not wish to answer the question or answered ‘Don’t know’.

The figure suggests that many entrepreneurs from DTU base their development on grants from public funds and programmes (e.g. Innovation Fund Denmark). No less than 80% of the IP-based companies have received such grants. The corresponding figure for companies without DTU-IP is 50%. Business angels, venture capital, loan capital and the founder team’s own contributions are also important sources of funding in several companies. And it appears that in general a larger proportion of DTU-IP based companies than those without IP attracted capital in various forms (venture capital being an exception here).

In Table 3.7 we set out how much capital the companies have attracted from various sources. In total, 65 companies answered this question in the questionnaire. Of these 52 had attracted capital. It can be seen from the table that these 52 companies have attracted approximately DKK 500 million in capital in total, or around DKK 10 million per company.

Table 3.7 Capital attracted and its sources among 65 entrepreneurs from DTU

| | Number of companies that have attached capital | Total amount (million DKK) | Amount per company |
|--|--|----------------------------|--------------------|
| Grants from public funds and programmes | 38 | 212.7 | 6.0 |
| Business angels | 16 | 67.3 | 4.2 |
| Venture capital | 12 | 114.8 | 9.6 |
| Investment companies | 5 | 63.1 | 12.6 |
| Loan capital | 13 | 23.0 | 1.8 |
| The founder team/employees' own capital contribution | 27 | 20.8 | 0.8 |
| Total | 52 | 501.7 | 9.6 |

Source: Survey among DTU-based entrepreneurs, N=65.

Furthermore, it must be mentioned that several of the respondents have established their company between 2014-2017. Therefore, the numbers in figure 3.6 and table 3.7 reflect how young technology-based companies are financing their development. For instance, it is likely that venture capital would play a bigger part if the same companies instead were asked in three to five years. The underlying numbers also show that a very large share of the total amount of venture capital investments companies is placed in companies that were established before 2014.

Finally, it must be emphasized that survey respondents only cover a very small part of all DTU-based entrepreneurs. Thus, the table gives a picture of the average capital attraction among DTU-based companies, but it does not reveal the total capital attraction among entrepreneurs from DTU.

The fact that companies which attract capital on average have attracted DKK 10 million throughout a relatively short period of time shows that many of these companies have a significant potential, which both funds and investors believe in.

4. The profiles of the DTU-entrepreneurs

4.1 Introduction

The entrepreneurs from DTU have in common that their companies are based on knowledge, new technologies and ideas developed at DTU. But there are significant differences in how the companies were started, the competencies of the start-up teams, and the ways in which the companies developed in the first years after their formation.

In this chapter we will therefore examine the profiles of the DTU start-ups and ask how they differ in their competencies, their networks, their use of mentors, and so on. Section 4.2 focuses on the founding teams and their networks, while Section 4.3 focuses on the use of mentors, advisory boards and professional boards of directors.

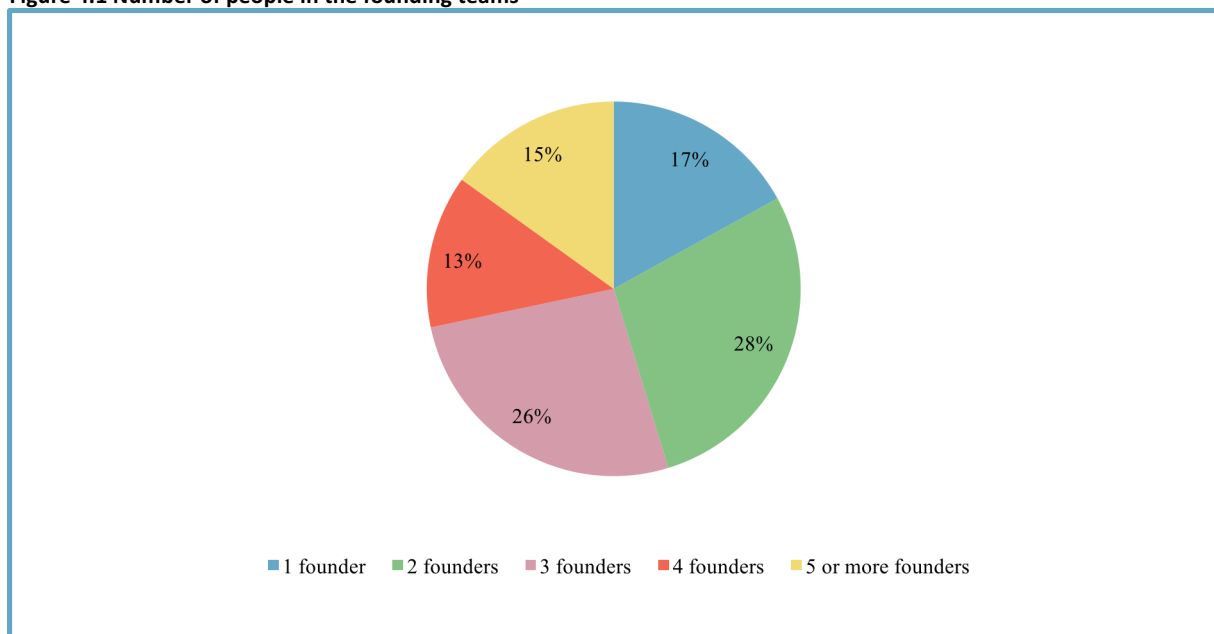
The chapter builds on results from a survey of DTU-based start-ups. As described in the method (see Appendix A), this survey targeted entrepreneurial companies registered in DTU's own records of DTU-based start-ups after 2006. Among other things, this means that there is a significant overrepresentation of companies based on IP taken out at DTU – and probably also, more generally, of entrepreneurs who have used DTU's start-up ecosystem.

This means that the typical profiles of all actual DTU-based companies may differ significantly from those presented in this chapter. The same point applies to Chapter 6.

4.2 The profiles of founder teams and their networks

Figure 4.1 shows the relative frequencies of different-sized founding teams in DTU-based start-ups.

Figure 4.1 Number of people in the founding teams



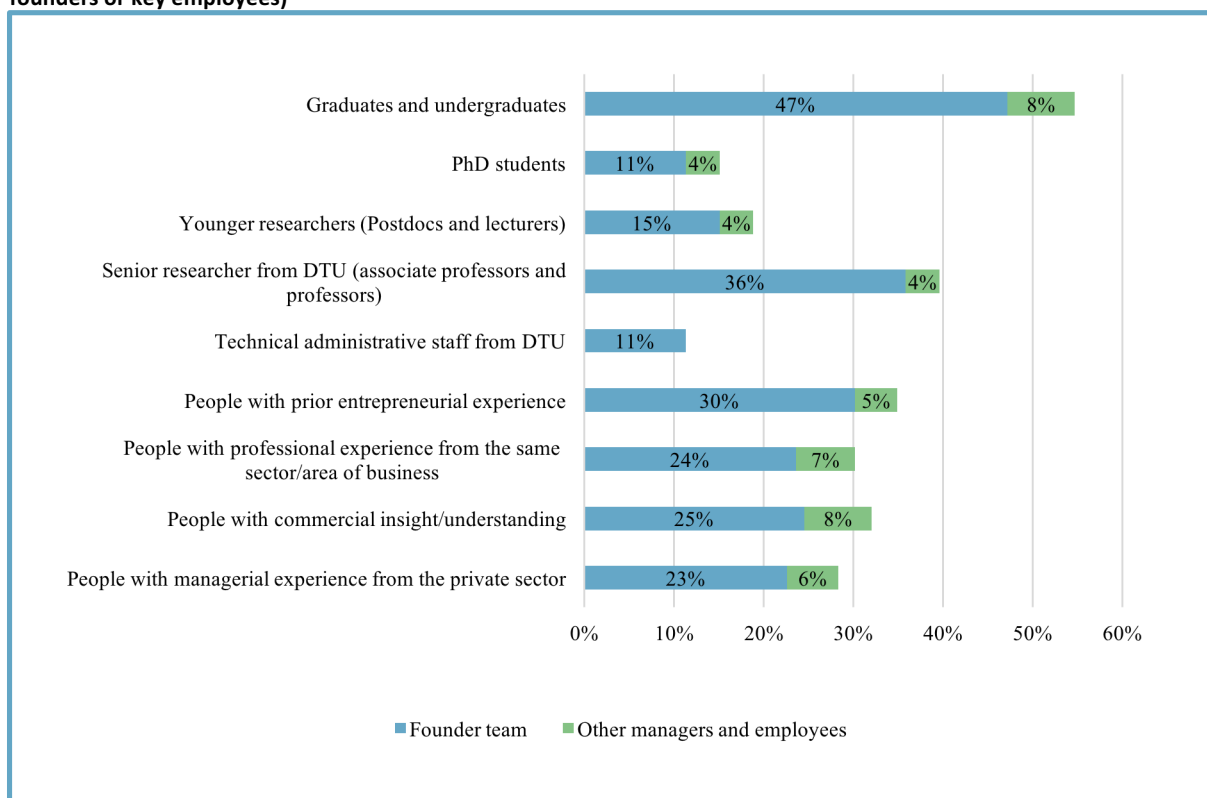
Source: Survey among DTU-based entrepreneurs, N=106.

It can be seen from the figure that there is a high degree of variation. Only 17% of the companies were established by a single person. Most had two or three founders, and 15% of the founding teams consisted of five people or more. In other words, there are approximately the same number of companies with one founder as there are companies with at least five times as many founders.

IP-based start-ups from DTU have the largest founding teams, with an average of 3.5 persons. By contrast, companies founded by employees (without IP) have an average of 2.6 founders, while student start-ups have founding teams averaging 2.9 persons.

Figure 4.2 presents an overview of the backgrounds of the founders and other key employees hired in the first year after the founding of the company. The five upper categories in the figure show the team’s background as either students, graduates or scientists, while the four bottom categories show the fraction of companies where the founders and/or key employees had business or entrepreneurial experience.

Figure 4.2. Frequencies of different profiles and competencies in the first year after the founding of the company (either founders or key employees)



Source: Survey among DTU-based entrepreneurs, N=106.

The figure indicates that many of the entrepreneurial companies have students and/or senior scientists within the founding team, and that relatively few companies are founded by junior scientists and PhD students.

The low number of junior scientists involved in start-ups can be interpreted as the result of young researchers’ focus on building a scientific career rather than trying to grapple with entrepreneurship. Senior scientists, on the other hand, may have more ‘room’ in their career for entrepreneurship.

Among the companies examined, there were also several examples of companies established by permanently employed senior scientists who had been working on the development of technologies in academia over many years and who have developed a desire to apply their technologies commercially well into their careers. Some of these scientists choose to become an active member of the company’s management team, while others choose to continue as scientists and, for instance, participate in the advisory board or as a member of the board of directors (see the examples in Box 4.1).

Box 4.1 Experienced scientists participated in the establishment of Glycom and HPNow

Glycom was established in 2005 as a collaboration between five carbohydrate chemists, among them DTU Professor Inge Lundt. Glycom produces milk oligosaccharides identical to those in human milk which are added to some of the Nestlé formula products. They expect to launch other dietary supplements in 2018.

Glycom is an example of how a group of well-established scientists try to launch themselves as entrepreneurs – in this example, successfully. All of the scientists are now retired, but for many years they were active in both the management team and on the board of directors – the last of them recently retired from the board due to old age.

HPNow, established in 2015, has developed a method of producing hydrogen peroxide for water treatment in very small quantities which can be adjusted to different forms of use. The company's primary area of business is the cleansing of drip irrigating devices for farming, but potentially the technology has a wider range of uses.

HPNow was founded by two junior scientists, Rasmus Frudendal and Arnau Casadevall. Both were physics PhD students at DTU, and together they discovered how to produce hydrogen peroxide in small quantities. The two juniors quickly chose to ally themselves with a pair of senior scientists, Ib Chorkendorff and Debasish Chakraborty, with considerable technical and entrepreneurial experience. Chorkendorff and Chakraborty are still part-owners of HPNow. Their counsel and network have several times proved decisive in the development of the company. E.g. it was Chorkendorff who sent the group to a start-up competition in Australia where they developed their market focus, and it was Chakraborty who introduced the group to the business developer – and now CEO of the company – Ziv Gottesfeld.

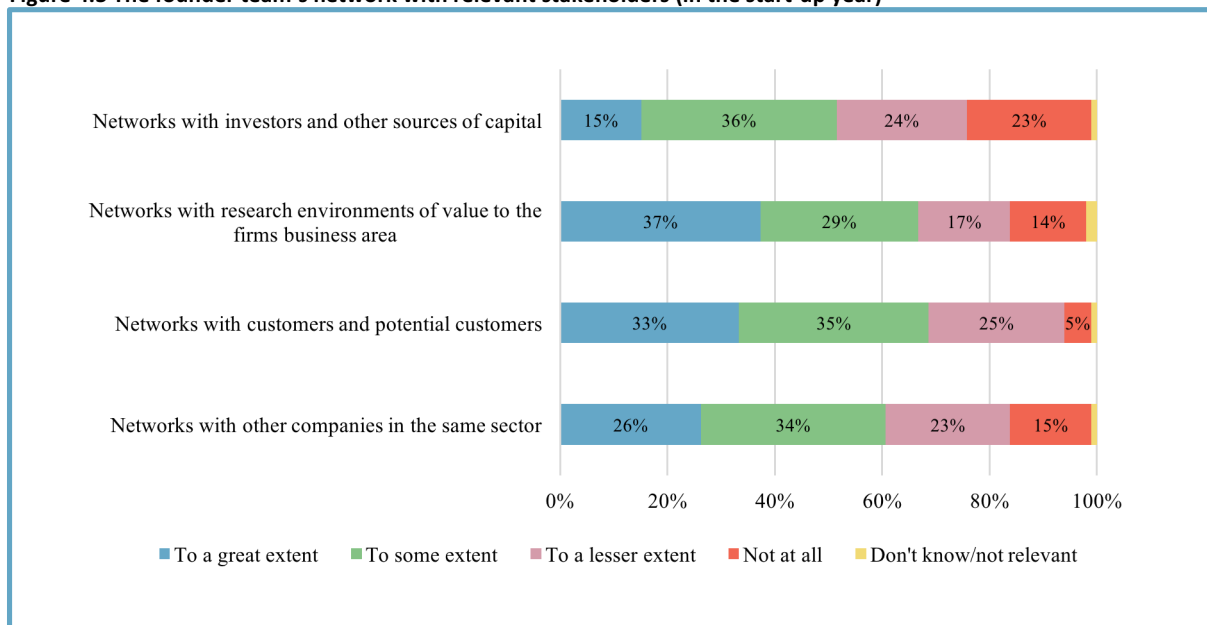
It is also interesting to see that a third of the companies confirm that their team includes people with prior start-up experience. This reflects the fact that some of the companies prioritize the establishment of a relatively broad team with technical competencies from DTU, commercial insight and experience with setting up start-ups.

For many start-ups, it is also important to have a strong network with investors, potential clients and other companies – and perhaps also with scientific environments that may contribute to the development of the technology through collaborative projects. Several analyses have concluded that a strong network often has a significant impact on a company's growth potential – including the amount of time it takes to move from the establishment phase to the growth phase⁸. Figure 4.3 presents a picture of the DTU entrepreneurs' own perception of their professional network in the start-up year.

The figure shows a high degree of variation across the companies. In each of the categories, the majority confirm that they are in networks connecting with the different kinds of actor to some extent or to a great extent, but there are also many companies which have networks to a lesser extent or not at all. In other words, the start-ups have very different points of departure from which to begin the process of attracting customers, create partnerships, and generally establish their business.

⁸ E.g. IRIS Group (2015); 'Det midtjyske vækstlag – Profilanalyse af midtjyske vækstvirksomheder og deres udbytte af erhvervsfremme'.

Figure 4.3 The founder team’s network with relevant stakeholders (in the start-up year)



Source: Survey among DTU-based entrepreneurs, N=99.

Most entrepreneurs stated that they had strong networks with scientific environments that are relevant to the company’s business. This is not surprising, considering their background at DTU. Thus, many of the companies we interviewed indicated that they continue to work with the research environment in which they were previously employed or where the technology was developed (see Box 4.2 for an example).

Box 4.2 Intomics’ network of scientists create value

Intomics is a consultancy firm established in 2008 in the area of bioinformatics. It specialises in analysing big, complex sets of biodata which can be used to tailor treatments for patients and develop new medicines. Intomics now works together with roughly one in three of the pharmaceutical companies that are active in Europe.

Intomics originated in DTU Bioinformatics and has two scientists, Thomas Jensen (current CEO) and Søren Brunak, among its founders. Jensen and Brunak continue to collaborate – both formally and informally – with DTU Bioinformatics. There are ongoing, informal discussions between the company’s employees and the scientists at Bioinformatics, and Intomics is collaborating in several research projects with DTU and the University of Copenhagen. Among other things, Intomics has received funding from Innovation Fund Denmark for an analysis of genetic information about cancer cells and a Horizon 2020 project mapping the failing cells in the pancreas in type-2 diabetes patients.

We investigated whether there are differences in the strengths of the networks across the different types of start-ups. Our analysis shows that companies based on DTU-IP and companies established by DTU employees have a well-established network with potential customers and investors more often than companies established by students and graduates. But still, only 16% of the companies based on DTU-IP stated that they had networks with investors *to a great extent* when they established their company, and only 32% stated that they had networks with customers and potential customers to a great extent.

For many of the entrepreneurs it may, in other words, prove difficult to attract capital and establish contact with potential customers. The process of attracting mentors and establishing boards of directors and advisory boards at an early stage (see next section) should be considered in that light, especially as the companies who succeed in that process bring more experienced business people with these network relations onboard.

4.3 Mentors, advisory boards and boards of directors

In many cases, a start-ups’ ability to create a viable and successful business may depend on its access to qualified professional advice and what we refer to in Denmark as ‘sparring’. The access to sparring may, for instance, help to strengthen the strategy, the financial management, the business model, the market focus and the ability to raise funding. The sparring can also contribute to the development of the company’s network and open up new possibilities for investors, markets and perhaps specific customers.

Not least, access to qualified professional sparring and counsel is important in areas where the management of the company lack the necessary competencies and networks themselves (see Section 4.2).

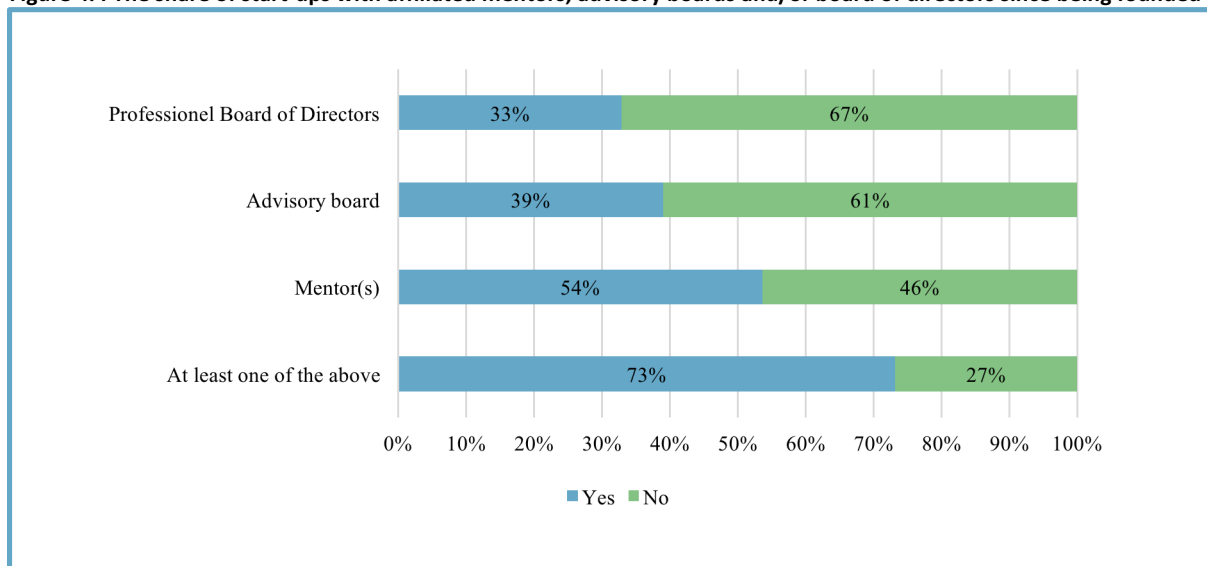
Entrepreneurs can build connections with those offering professional guidance and experience in a number of ways. One step would be to attach a mentor, or mentor team, to the company. Mentors are typically experienced business people with strong networks and/or people with great insight in the company’s field of technology.

The next step (or an alternative) is to appoint an advisory board, i.e. a committee akin to a board of directors, but without the formal power or legal and economic responsibility boards of directors have.

Finally, the company and its owners may choose to establish a conventional board of directors. This will often happen when the company manages to attract investor capital and the investor demands active ownership and the kind of influence which comes with board membership. The establishment of a board is also a means of bringing in additional competencies from people who take an active responsibility for the development of the company.

Figure 4.4 shows the share of entrepreneurial companies which have had mentors, advisory boards and/or board of directors affiliated since being founded.

Figure 4.4 The share of start-ups with affiliated mentors, advisory boards and/or board of directors since being founded



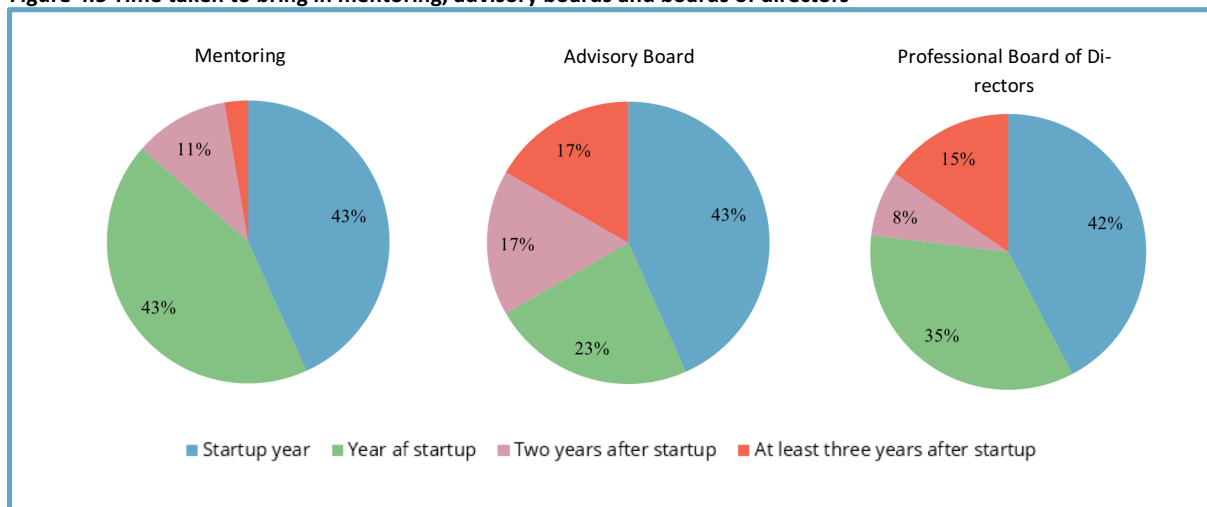
Source: Survey among DTU-based entrepreneurs, N=82.

Note: Entrepreneurs who today only have the ambition of self-employment are excluded from the calculations.

The figure shows that a little more than half of the companies had affiliated mentors at some point in their development. Additionally, about 40% had used an advisory board and 33% had established a professional board of directors. Just under three-quarters of the companies (73%) had used at least one of the three sources for professional sparring and counsel. Thus, a clear majority of the companies supplemented the competencies already present in the management team with competencies attracted in from outside the company.

Figure 4.5 illustrates how far the companies had proceeded in their development before they brought in external competencies to take part in professional discussion, counsel and decision-making.

Figure 4.5 Time taken to bring in mentoring, advisory boards and boards of directors



Source: Survey among DTU-based entrepreneurs, N=60.

The figure shows that in 40% of cases the companies had brought in mentors, and/or set up advisory boards and professional boards of directors in the first year after the company’s establishment. The overall picture is thus that ‘professionalization’ happens at a rather early stage of the company’s development. More often than not, mentors, advisory boards and professional boards of directors are tools that the entrepreneurs turned to early on in the company’s development.

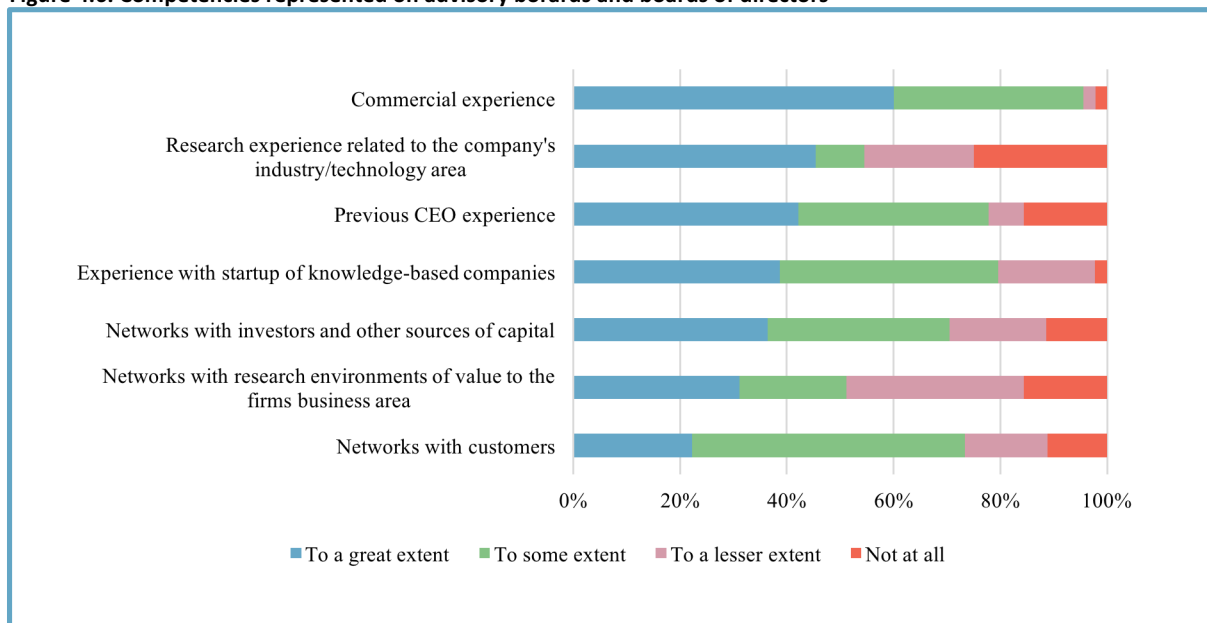
Box 4.3. Norlase received help from a strong advisory board

Norlase, established in 2014, produces high-intensity lasers. Their new laser ‘AuroraOne’ sets new standards for quality, precision and effectiveness in laser technology. Norlase produces lasers of a specific ‘medium’ niche size which can be used in the healthcare system. Elsewhere the size of their lasers varies from very big ones for industry to very small ones for ordinary consumers.

Norlase is an example of a company which, from its outset, appointed an advisory board. The board’s members mainly had technical knowledge within the field of photonics. But one of them, the current CEO, Peter Skovgaard, possessed both a deep technical knowledge of laser technology and experience from private business – specifically from the laser technology company, Crystal Fiber. Norlase has been through a long technical maturation phase, and the competencies on the advisory board have been indispensable in the process. Moreover, the engagement of Peter Skovgaard in both technical aspects and business development has made him a key figure in the business.

We also asked the entrepreneurs we interviewed about the kinds of competency that their advisory boards and professional boards of directors bring to the company. Figure 4.6 shows the answers we obtained from companies with an advisory board or a professional board of directors.

Figure 4.6. Competencies represented on advisory boards and boards of directors



Source: Survey among DTU-based entrepreneurs, N=46.

Note: In the figure, we have shown the results for all of the companies with an advisory board and/or a professional board of advisors. Where the company had both, we have included the competencies of the board of directors.

Not surprisingly, the figure shows that boards of directors and advisory boards are especially strong in contributing commercial competencies. 96% of those questioned stated that the company benefited from competencies in the commercial field to *some extent* or a *great extent*. The figure also shows that many advisory boards and boards of directors had members with top-management experience from other companies – which, of course, is one of the factors explaining why the companies gain competencies in the commercial field from the boards.

Many advisory boards and boards of directors had members with some, or considerable, experience with establishing knowledge-based companies. This experience can be an important competency for technology-based start-ups, where the road to the market is long.

Moreover, the majority of the boards of directors and advisory boards had members who were involved in networks with investors, customers or clients. As mentioned, this may compensate for a lack of competencies in that direction in the company’s management team.

There were fewer companies where the board of directors had members with research experience and networks with scientific environments. But this varies significantly from one start-up to another, as the DTU-based IP-start-ups has often affiliated one or more of the scientists who initially contributed to the development of the technology the company is based on. By contrast, and not surprisingly, few of the student start-ups have research competencies in their boards.

The companies we interviewed with established advisory boards and boards of directors have typically set up a constellation with one scientist with strong technical domain knowledge and other people with commercial and start-up experience. Some of the companies, for instance, have boards of directors with one investor, one serial entrepreneur, and a person with top management experience from a big company. Moreover, there are several examples of companies with international experience represented on the board of directors – for instance, by top researchers or business people with knowledge of foreign markets.

An example is Bifrost Communications, which has an advisory board including a professor of innovation from DTU, a photonics researcher from Eindhoven University of Technology who is also former CFO from Nilfisk, and the laser expert David Hardwick.

In general, the companies we interviewed acknowledged that external boards of directors and advisory boards have played a significant role in their development. In some instances, the board of directors had been established early on, or when the company was founded. This is especially likely to be the case with IP-based spin-offs. In other cases, the board of directors have not been appointed until the technology have reached a certain level of maturity. In those instances, the members of

the board of directors are especially likely to have had a role as sparring partners with commercial experience – for instance, in relation to business planning, strategy, marketing, and the like.

Recapitulation

This chapter has highlighted the many differences between the entrepreneurial companies in terms of competencies and network in the start-up period.

Most companies were established by founder teams of 2-3 people. A few hired additional key employees in the first year following the company's founding, but this was the exception, not the rule. Many companies had a senior scientist and/or a student on the founding team. It also emerged that junior scientists and PhD students do not create as many start-ups as those in other groups.

The chapter also shows that a large proportion of the companies, but far from all of them, had affiliated mentors, advisory boards or professional boards of advisors at an early stage. These guides and sparring partners often contribute with commercial insight. In some instances, they also deliver entrepreneurial experience and technical competencies into the company.

The survey was conducted among entrepreneurial companies known by and registered with DTU. Among other things, this meant that the survey focused quite heavily on IP-based companies (40% of the responses to survey items came from IP-based companies, compared with the 4% of responses from all DTU-based entrepreneurs) and companies that have used DTU's ecosystem.

As we shall explain in the next chapter, then, offers of mentoring and help to establish an advisory board are a central service provided by the DTU ecosystem for entrepreneurship. It is, in other words, likely that the actual share of mentor use and early establishment of advisory boards and boards of directors is somewhat lower for the entire population of DTU entrepreneurs.

The chapter's results can therefore be seen as an indication that the most familiar users of the ecosystem often receive help in their efforts to affiliate people who can assist with coaching and by offering counsel, and more generally by offering professional sparring.

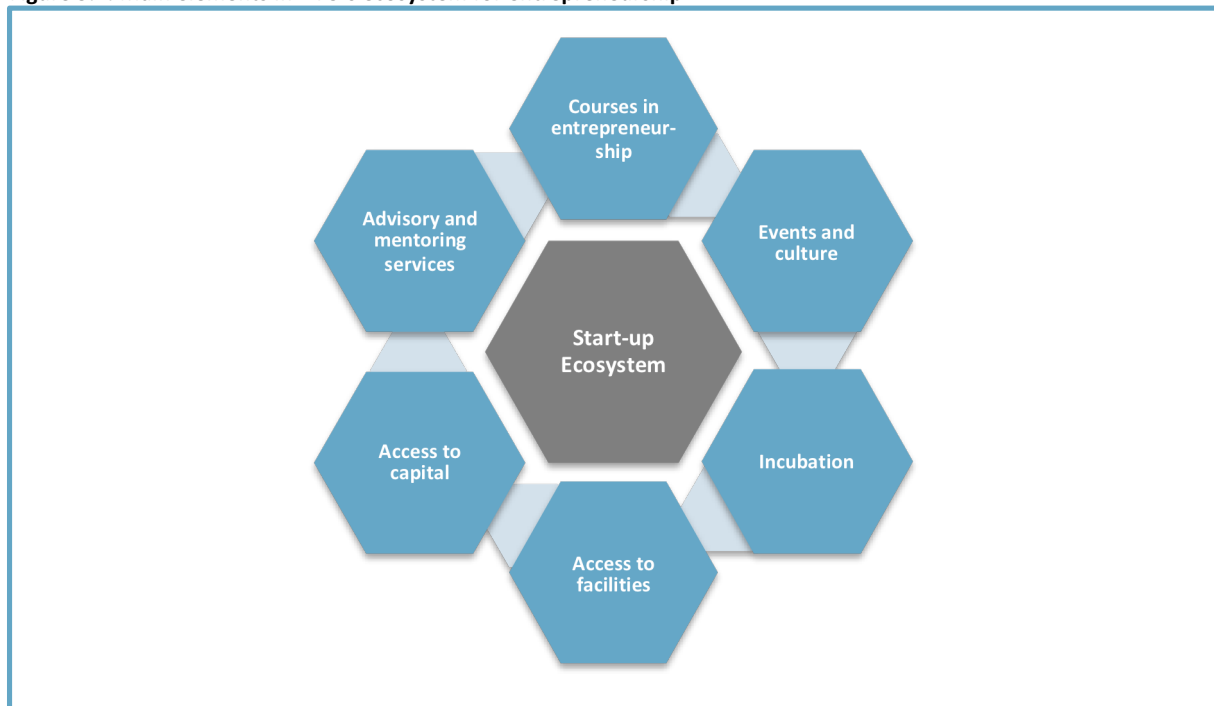
5. The importance of DTU for the founding and development of start-ups

5.1 The ecosystem for entrepreneurship

Over the past few years DTU has launched several initiatives aiming to support entrepreneurship at DTU. Several of these initiatives have been co-financed by private funds or companies that wish to sponsor the development of the start-up ecosystem at DTU. A range of private providers of consultancy and venture capital for technology-based entrepreneurs have also been set up in DTU Science Park.

This means that today the DTU campus hosts a comprehensive ecosystem of organisations, initiatives and activities available for entrepreneurs and aspiring entrepreneurs at different stages in their development. The elements in this ecosystem can be divided into the six headline categories shown in Figure 5.1 below.

Figure 5.1. Main elements in DTU's ecosystem for entrepreneurship



Source: IRIS Group.

Among the interviewed companies, it is widely recognized that DTU has a broad and very effective ecosystem for start-ups that compares well with those in the top technical universities in Europe.

Naturally, the importance of each element differs from company to company. To some entrepreneurs, all six elements had been important at some point in their development, whereas others had perhaps only needed – or benefitted from – a few elements.

Under each of the six headlines, several organisations at DTU's campus cover different demands, focusing on certain target groups. For example, the central business development unit under the Office for Innovation and Sector Services at DTU's administration support IP-based entrepreneurs from DTU, while DTU Skylab supports student entrepreneurs).

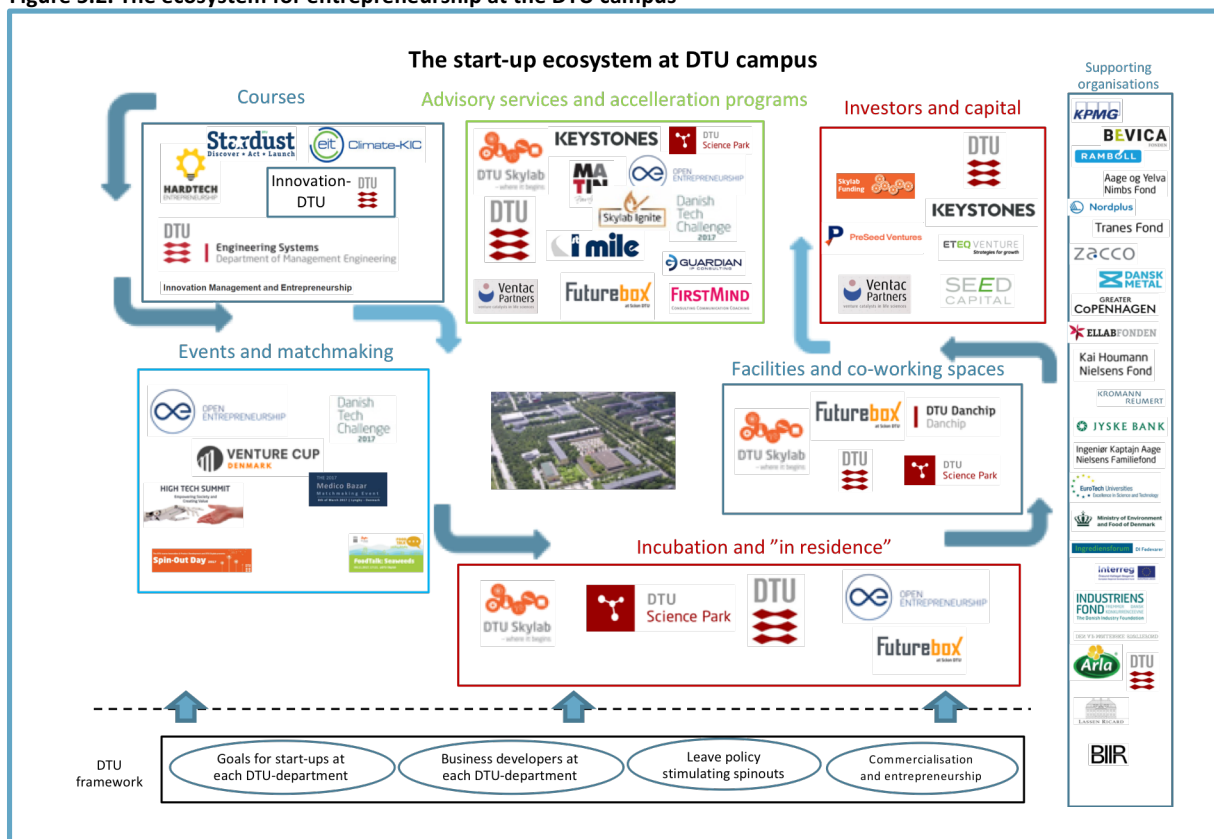
In Figure 5.2 we have attempted to present a comprehensive overview of the DTU ecosystem by illustrating the central players under each headline using their logos. We have also tried to illustrate – with arrow heads - that the ecosystem is often a

process through which entrepreneurs are guided. It must also be emphasized, however, that entrepreneurs do not necessarily make use of the activities in the same order, and that many activities are often undertaken simultaneously.

Besides the six main elements, DTU's general frameworks and policies on the stimulation of entrepreneurship and commercialization of research also form part of the ecosystem (see the lower part of the figure). Among other things, these include goals for entrepreneurship, opportunities to take leave, and the appointment of people in charge of innovation at each institute. To the right, the figure shows the organisations that have contributed financially to the ecosystem in recent years. These include funds, companies and actors within business policy.

Some actors are included under more than one headline. An example is the Danish Tech Challenge, which is both an event and a competition that gives participants the opportunity to participate in sparring and receive guidance over a period of time. The general logo of DTU indicates that either institutes at DTU or DTU's Office for Innovation and Sector Services offer activities targeted at entrepreneurs.

Figure 5.2. The ecosystem for entrepreneurship at the DTU campus



Source: IRIS Group on the basis of desk research and interviews with selected actors from DTU.

We shall not go through all of the organisations and activities in the ecosystem. However, below we present some of the central activities under each of the six headlines in the figure.

Courses and training

DTU offers several courses, some of which are targeted at their own employees and others of which are targeted at students. The purpose is to provide a basic introduction to what it takes to establish a company and develop competencies within entrepreneurship.

At the same time, some of the courses help to develop and mature ideas and bring them closer to market. Here, the 'Hardtech Entrepreneurship' course is worth highlighting, as it also aims to create teams around promising ideas that both include technical and business-related competencies.

Examples of elements in the ecosystem are:

- *Hardtech Entrepreneurship*: a course of 13 weeks where groups of students at Masters level from different backgrounds (including students from Copenhagen Business School) design a business case for an idea or technology, develop a prototype and identify the market for the idea. The ideas can come from students or companies, or be patented inventions from DTU. Throughout the course, the students have access DTU's network of researchers, investors and mentors, and the inventor of the idea is also one of the mentors. On average, four projects from the course qualify for the Venture Cup final.
- *DTU Stardust*: a start-up programme for students, PhD students and employees at DTU designed to help entrepreneurs in the idea phase to develop their competencies within entrepreneurship.
- *Innovation-DTU*: twice a year, DTU's Office for Innovation and Sector Services offer a two-day course in innovation and entrepreneurship for DTU employees.

In addition, DTU Management Engineering offers a large ECTS credits course in innovation and entrepreneurship. Several PhD summer schools teaching entrepreneurship are also run.

Events and matchmaking

Events and matchmaking involve various activities – e.g. competitions and other types of event – that connect good ideas and inventions with companies, entrepreneurs, investors, mentors, etc.

The purpose is partly to present new technologies and ideas to possible business partners and investors, and partly to bring together capital and competencies and the best ideas as a foundation for new companies.

Examples of elements in the ecosystem are:

- *Danish Tech Challenge (DTC)*: an accelerator programme supported by the Danish Industry Foundation running from August to December 2018. The target group is technology-based entrepreneurs working with the development of new physical products. The selected participants move into the DTU Science Park, where they can use the facilities, and are assigned a mentor team. DTC is a competition. A handful of companies qualify for the final and the winner receives an award of DKK 500,000.
- *Spinout Day*: students from the Hardtech Entrepreneurship course present their prototypes and companies to investors and other entrepreneurs in the Danish start-up environment.
- *Bazars and focused matchmaking events* within specific areas of technology, such as medicine and the food sector, where technologies, projects and ideas for products are presented to companies and investors within appropriate specific areas.

In addition, DTU is the project manager of a new project, supported by the Danish Industry Foundation, called *Open Entrepreneurship* which also includes three other Danish universities. The project promotes the commercialization of research through a range of new measures bringing external collaborators closer to the research. A special 'E-corps' of entrepreneurs, intrapreneurs in existing companies and investors are invited into specific research environments at DTU. Here, they are given the opportunity to get closer to relevant research and identify promising technologies at a very early stage.

Incubation

There are several opportunities to start and develop a business on the DTU campus.

The biggest and most significant location is *DTU Science Park*. This facility, covering 180,000m² (including DTU Science Park, Hørsholm), houses 250 companies with 3,500 employees and is one of the biggest science parks in Europe.

DTU Science Park focuses on technology-based companies. Additionally, it accommodates various types of service company that help and support high-tech companies within areas such as IP, financing, business development, and so on. These service companies are important actors in DTU's ecosystem.

DTU Science Park offers four types of service⁹:

- Access to 15,000m² of laboratories, including facilities for developing and testing prototypes. Flexible tenancies enabling rapid up- and downscaling are offered.
- Shared services, such as canteen, reception, meeting rooms, fitness centres.
- Networking in the form of joint arrangements for, and facilitation of, cooperation between companies, and between companies and researchers.
- Counsel and guidance on business development. DTU Science Park offers a structured programme, including the provision of a corps of 3-4 mentors with complementary competencies assembled for a company. A total of 80 mentors are part of the initiative.

In general, the goal of these services is to make it easier, faster and more cost-effective to bring new products to market.

DTU Science Park has also collaborated with DTU and several private sponsors on the establishment of *Futurebox*. This incubator opened in May 2018 and is supposed to work as a special environment for entrepreneurs with significant business potential. Futurebox includes an ambitious accelerator programme with access to a corps of mentors as well as business advisors. In addition, the Futurebox environment is open to bigger and established companies that wish to be close to a start-up environment with technology-based entrepreneurs with significant potential. Several large companies have already been engaged as 'Corporate Sponsors'. Their goal is to be matched with entrepreneurs and to become part of the environment in order to learn how start-ups work with innovation.

The other significant start-up environment is *DTU Skylab*. The DTU Skylab is a 'melting pot of student innovation' and offers support during the start-up phase to student entrepreneurs as well as courses in innovation and entrepreneurship.

DTU Skylab covers 1,600m² and offers the following activities to students¹⁰:

- Workshops for prototype development plus laboratories within e.g. metalwork, welding, 3D-printing, forestry, electronics, chemistry and food sciences.
- Meeting rooms and open spaces for courses and for pitching of ideas to investors and companies.
- The affiliation of 1) start-up coaches, who support company-formation, business model development, network building, and capital attraction, and 2) people with technological insight who can help students to make use of the facilities, including prototype development.
- Skylab Ignite: a three-month accelerator programme offered to ten of the most promising student start-ups every six months. It is a structured programme with two mentors who, among other things, assist in pitching and match-making with big companies and investors.
- Skylab funding: a proof of concept grant of up to DKK 250,000 for student start-ups with great potential.
- Discovery Day, where entrepreneurs present their ideas and the most promising are offered a seed loan from the innovation environment.

⁹ Source: Interview with Steen Donner, CEO at DTU Science Park.

¹⁰ Source: Interview with Mikkel Sørensen, Manager at DTU Skylab.

Between 2018 and 2020, DTU Skylab will be extended and developed further at a cost of DKK 99 million. Among other things, the development will provide access to garages where projects can be housed for a period of time, and there will also be a hall where technologies can be matured as a part of bigger and more ambitious projects focusing on technology development.

Access to facilities

As mentioned before, DTU Science Park and DTU Skylab offer a range of laboratories and facilities for prototype development, and these labs and additional facilities are a substantial part of the technological infrastructure for entrepreneurs at DTU.

However, many entrepreneurs also make use of facilities that are unique to DTU and have great significance to the development of new ideas and thus to entrepreneurs in the start-up phase. An example is *DTU Danchip*, which is a national centre for the fabrication, or manufacture, of micro- and nanotechnology with clean room facilities. According to the interviewees, Danchip provides several high-technology production facilities meeting the highest international standards that are put at both researchers' and companies' disposal (see Box 5.1).

Box 5.1. Copenhagen Nanosystems

Copenhagen Nanosystems was established in 2016 as a spinout company from DTU Nanotech. It has developed a lab-on-a-chip technology that can be applied in the measurement of protein concentrations and control of foods. Using nanotechnology, the company has designed NanoCuvettes of plastic that can be applied to give new types of measurement on existing equipment, and which are comparatively cheap.

In just one year, the company has brought its product to the market at relatively low development cost. A decisive prerequisite was access to Danchip's equipment and clean room facilities. On an hourly rental basis, the company used equipment from Danchip that otherwise costs millions of Danish kroner. This equipment was used to develop a prototype and design the product templates that are applied in the manufacturing of the company's products.

Danchip's facilities can be applied in the development and production of many products within the area of materials technology. An in-house process engineer and several advisors are also hired to support users of the facilities. Essentially, the facilities enable production on a small scale without the manufacturer having to worry about expensive capital investments in equipment and production facilities.

Investors and capital

Several organisations offer entrepreneurs from DTU financing and venture capital at different stages of their development. The following elements of the ecosystem deserve particular mention:

- *DTU Enable Programme*: this includes two types of grants for maturation of technology and inventions with a clear commercial application:
 - *DTU Discovery grants*: grants of DKK 150,000 max offered to employees with technology projects at the early commercial phase. The total fund is DKK 5 million per year.
 - *DTU Proof-of-concept grant*: grants of DKK 500,000 max per project. The total fund is DKK 6.8 million.
- DTU Skylab also offers proof-of-concept funding through *Skylab Funding* (see the description above).
- *PreSeed Ventures*: an innovation support organisation owned by DTU which invests venture capital in new innovative companies on behalf of the state. PreSeed Ventures can invest up to DKK 6 million per company, either as a loan or in capital ownership.
- *Seed Capital*: the biggest Danish early-stage venture fund that invests in young technological companies. Seed Capital invests up to EUR 500,000 in the first phase. In total, the fund can invest up to EUR 10 million in a company.
- In addition, DTU Science Park accommodates several companies which advise and provide other kinds of assistance to high-tech companies intending to raise funds and capital.

Sparring and guidance

Finally, several actors offer sparring and guidance to entrepreneurs at various stages of their development. The actors include units at DTU as well as several private companies located in the DTU Science Park.

DTU's Office for Innovation and Sector Services accommodate a central unit for business development that cooperates with the institutes on commercialisation of patentable inventions. The unit offers a row of different services to researchers considering or aspiring to establish a company:

- Funding of maturation of inventions and technology through DTU's Enable Programme (see above).
- Patent assessment and preparation of action plans with an eye to the development of a product that can be commercially realised.
- Support on clarifying the role of researchers in the commercialisation phase.
- Options to have mentors and advisors affiliated to the project.
- Exposure to industry and investors.
- An 'entrepreneurial package' for commissioning advice from lawyers, auditors and other professional services.

In addition, as we mentioned above, the DTU Science Park and DTU Skylab offer a range of advisory services.

Finally, several private companies offer advice to technology-based entrepreneurs located in DTU Science Park. Some of these are mentioned in Figure 5.2 above, but others are also available.

An example is *Keystones*, which is a private members-only network for commercial actors engaged in building companies. The members are investors, serial entrepreneurs and experienced executives. Keystone introduces their members to new, promising start-ups looking for investors, board members, CEOs, business developers, and other people with relevant expertise. Members are offered training in how to work with start-ups.

General framework conditions for entrepreneurship

As shown at the bottom of Figure 5.2, an important part of the ecosystem is DTU's general framework for entrepreneurship promotion. This help to motivate researchers and students to start their own company and facilitate the students' and researchers' transition into entrepreneurship. Central elements of the framework include:

- From the top management side, there is an important internal articulation of innovation and entrepreneurship. Among other things, this appears on the intranet of the university, at the annual celebration, and in meetings between the president and institute managers every second week.
- Every year, performance contracts with each institute are agreed containing goals for both start-ups and collaborations with the industry.
- DTU has flexible leave policies, enabling both full-time and part-time leave for employees who wish to start their own company.
- DTU (as mentioned above) has a central unit for business development with responsibility for technology transfer and research commercialisation. The unit advises researchers and institutes on matters of entrepreneurship, including action plans, IP, competency development, business plans, starting a company and matchmaking with investors.
- At each institute a person has been nominated to be in charge of innovation and has a special responsibility for the promotion of innovation at the institute.

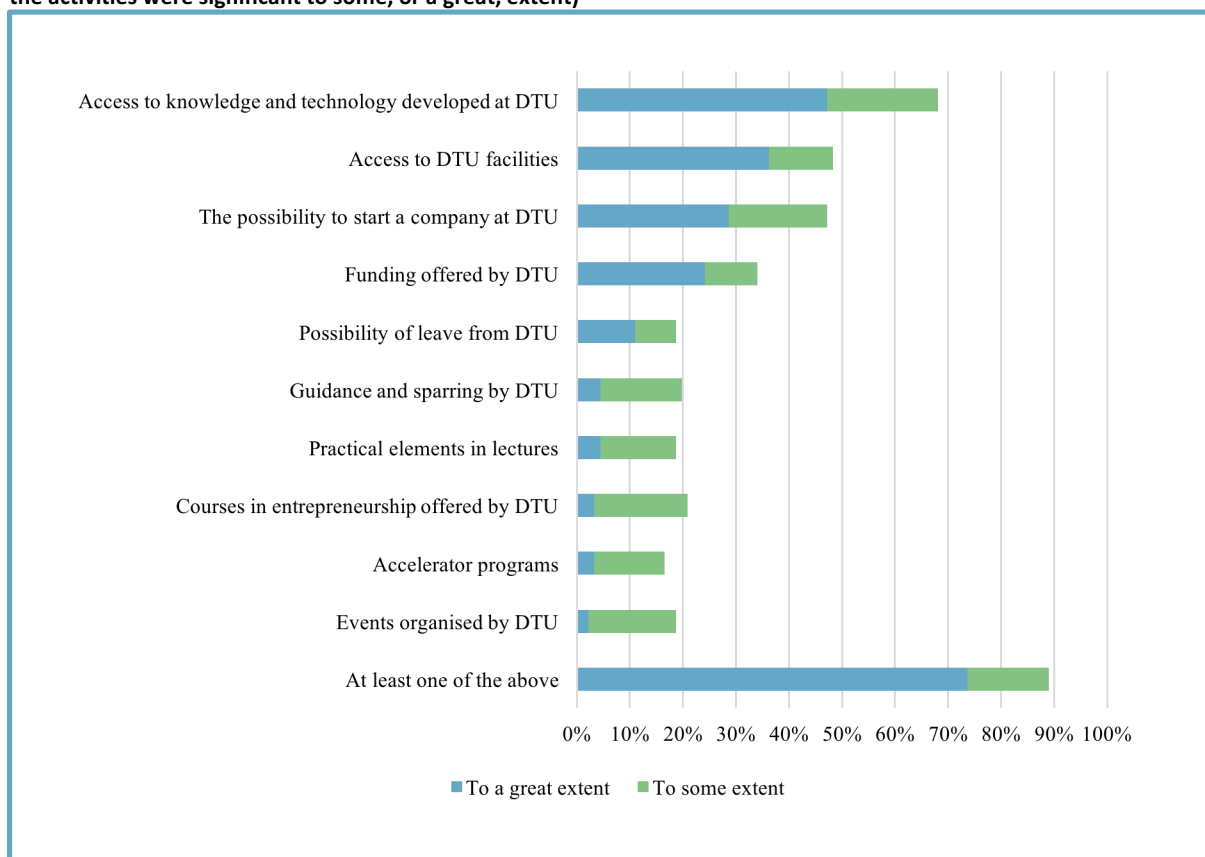
5.2 DTU's significance in the establishment of new companies

In the survey, the companies were asked to indicate the significance of DTU and the different elements of the ecosystem in the formation of their company and the company's development to date.

The survey targeted companies established over the past ten years. It needs to be noted that several elements in the ecosystem are relatively new or have been adjusted over the years. Thus, each company was, in effect, responding to different versions of the ecosystem. The study nevertheless gives us an idea of what DTU has meant to entrepreneurs over the past ten years.

Figure 5.3 shows the share of companies stating that DTU and DTU's ecosystem had some or great significance in the phase of establishment (the ecosystem was divided into ten main areas).

Figure 5.3. Significance of different activities at DTU targeting companies in the establishment phase (share stating that the activities were significant to some, or a great, extent)



Source: Survey among DTU-based entrepreneurs, N=91.

Note: Companies were only allowed to state 'to a great extent', 'to some extent', 'to a lesser extent', 'not at all' and 'not relevant'.

As can be seen at the bottom of the figure, almost 90% of the entrepreneurs ascribed some importance to DTU, and around three out of four respondents stated that DTU had great significance in at least one of the mentioned areas.

Knowledge and technology developed at DTU was significant for most entrepreneurs – almost 70%. Additionally, half of the companies stated that access to DTU facilities and the option to start a company at DTU had some significance in their development.

On basis of the respondents' replies, it may be concluded that these elements are the cornerstones of the ecosystem at DTU. It is DTU's knowledge and facilities – and, not least, proximity to these elements – which has been most important to most entrepreneurs. The significance of the remaining elements varies from company to company, however, the funding of technology maturation appears to be the most important area.

It must be emphasised that several reasons may explain why the entrepreneurs did not attach importance to the different elements. Some entrepreneurs had not had access to some of the activities listed in the table – e.g. because they were not on offer at the time of their company's establishment, or because they were irrelevant (e.g. leave is rarely relevant to students). Others made use of the activities, but perhaps considered them rather insignificant in the phase of establishment. There were probably also entrepreneurs who were unaware of the offers.

In the table below, we show the significance of activities at DTU in the phase of establishment, distributed by the three types of entrepreneur.

Table 5.1. Significance of activities at DTU in the phase of establishment, distributed by type of entrepreneur (share stating that the activities were significant to some, or a great, extent)

| | Start-ups based on DTU-IP | Companies established by students and graduates | Companies established by DTU employees (without DTU-IP) |
|---|---------------------------|---|---|
| Access to knowledge and technology developed at DTU | 94% | 46% | 50% |
| Access to DTU facilities | 69% | 46% | 18% |
| The opportunity to start a company at DTU | 58% | 43% | 36% |
| Funding offered by DTU | 67% | 14% | 9% |
| Possibility of leave from DTU | 31% | 7% | 14% |
| Guidance and sparring by DTU | 28% | 18% | 9% |
| Practical elements in lectures | 14% | 32% | 5% |
| Courses in entrepreneurship offered by DTU | 6% | 36% | 14% |
| Accelerator programmes | 19% | 25% | 14% |
| Events organised by DTU | 22% | 25% | 9% |
| At least one of the above | 97% | 79% | 86% |

Source: Survey among DTU-based entrepreneurs, N=86.

The table tells us that, in general, start-ups based on DTU-IP emphasise the significance of the DTU ecosystem most. This is particularly true in the areas of access to knowledge, facilities, funding and the possibility of leave from DTU.

Teaching elements, unsurprisingly, are most important to student entrepreneurs. Again, it must be emphasised that the ecosystem at DTU has been under development and a great deal has happened in the frameworks around students aspiring to start their own company, not the least as a result of the development of DTU Skylab. Thus, several respondents had not had the opportunities students have today.

Entrepreneurs' assessment of the quality of DTU's ecosystem in the start-up phase

Judging by our interviews at DTU, it is clear that the entrepreneurs generally has a very positive view of the quality of the ecosystem at the university. The responses we received also indicates that the quality of the ecosystem has significantly improved over the past 3-5 years.

The conditions most often emphasised by interviewees as positive elements in the ecosystem are the following:

- DTU Science Park and DTU Skylab – both 1) because of their practical significance when it comes to facilities, tenancies and the affiliation of, for example, mentors, and 2) because of their culture-affecting role as lighthouses for entrepreneurship at DTU.
- The DTU Enable Programme (DTU Discovery Grants and DTU Proof-of-Concept Grants) in maturing technology at an early stage – particularly among IP-based companies at DTU.
- DTU's hosting of entrepreneurial competitions and accelerator programmes – especially Danish Tech Challenge and Venture Cup. Especially the access to mentors, the competitive element and the awards were emphasised.
- Interdisciplinary training programmes such as Hardtech Innovation in paving the way for founding teams with both technical and commercial competencies.
- Access to facilities and laboratories at the institutes throughout the start-up phase.
- Access to highly qualified students from DTU for student projects, and the possibility of recruiting among graduates from DTU.
- Cooperation with researchers from DTU in specific research and innovation projects.

Excerpts from the interviews

'DTU is very helpful – and even more today than five years ago.'

'Previously, there would be a lot of paper work at DTU if you started a company. But it has become much better than it was the first time I started a business. It goes much faster today. The management has things under control.'

'DTU does really well – SCION [DTU Science Park] is brilliant and Skylab has really helped to boost student entrepreneurship.'

'I would say that you can compete at an equal level with industry by using the research facilities at DTU while studying. We did that in my company. We used DTU Skylab during our studies and after graduation. That alone has reduced our time for development and product maturing by 1-1½ years compared to a scenario where you did not have such facilities at your disposal.'

'In general, DTU has one of the best support policy systems of all technical universities in Denmark.'

Source: Interviews with entrepreneurs from DTU.

Despite the positive developments, some interviewees emphasised that there is considerable room for improvement. Among other things, it was noted that a large proportion of the start-ups come from a small group of institutes, including the Department of Photonics Engineering, the Department of Micro- and Nanotechnology, the Department of Mechanical Engineering and DTU Compute.

According to the interviewees, a distinctive feature of these entrepreneurial environments is that they are driven by passionate people, including researchers, who have a strong personal interest in entrepreneurship together with experience in the area and strong networks among investors and the business sector in general. This feature of the entrepreneurial spirit influences colleagues among the researchers and students working in the environment. In these environments, several role models have been created in the form of successful companies that hire students from the same institutes – and several companies have close research collaborations with the institutes they originated in.

Excerpts from the interviews

'The culture at DTU is in some areas negative with regard to entrepreneurship. Some institutes are extremely technical or theoretical in their approach. It has been decisive that we had people on board who had competencies within both design and innovation.'

'The big challenge is that there is a great difference between institutes. To some extent, it is the same institutes that create the entrepreneurs and these also happen to be located around the same parking lot. You could examine further what the differences between the institutes originate from and how the entrepreneurial culture at DTU as a whole could be enhanced.'

Source: Interviews with entrepreneurs from DTU.

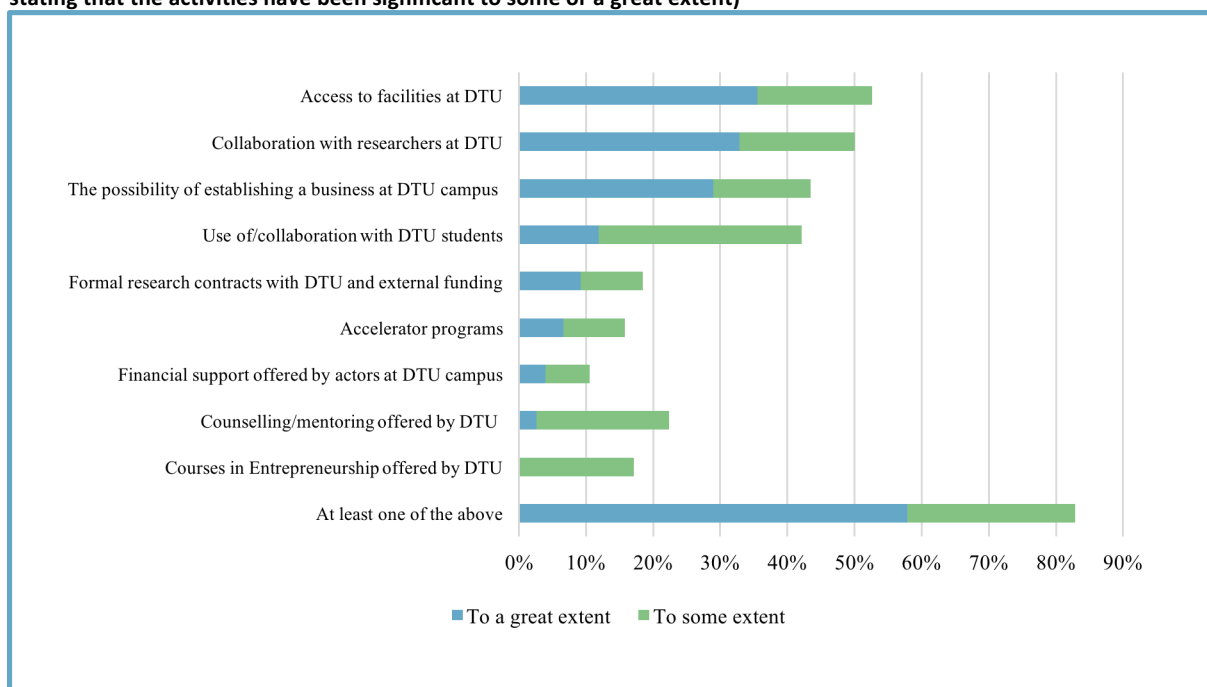
In particular, several interviewees emphasised that DTU's ecosystem for entrepreneurship can be improved in the following areas:

- Clear and visible guidelines on entrepreneurship for employees at DTU. For instance, with regard to the application of laboratories and test facilities, as well as the circumstances under which there may be a risk of conflicting interests between the roles of researcher and entrepreneur.
- Even more flexible and economically favourable options for entrepreneurs to use the laboratories and test facilities after start-up.
- Focus on creating favourable conditions for shared positions and part-time leave that may enable researchers to work in a start-up company in parallel with their research and teaching.
- Making career paths as an entrepreneur more visible at an early stage, and an enhanced focus on entrepreneurship as an integral part of the teaching in all educations at DTU.
- More flexible opportunities for student entrepreneurs to develop their companies as a part of their assignments and student projects.
- An ongoing focus on ensuring effective and fast IP negotiations that bring technology to market as fast as possible. Many interviewees agreed that there had been a positive development in this area. However, the perception continues to be that casework time can be shortened further.

5.3 DTU’s significance in the growth and development of start-ups

The entrepreneurs in the survey were asked to evaluate the impact of DTU and its ecosystem on their companies after the establishment phase. The results are shown in Figure 5.4.

Figure 5.4. Significance of DTU activities for growth and development after the establishment phase and until today (share stating that the activities have been significant to some or a great extent)



Source: Survey among DTU-based entrepreneurs, N=76.

Note: Companies were only allowed to state ‘to a great extent’, ‘to some extent’, ‘to a lesser extent’, ‘not at all’ and ‘not relevant’.

Once again, a very large share of the companies indicated that DTU and its ecosystem had been important after the establishment phase. More than 80% stated that DTU had some or great significance in at least one of the areas considered. Again, access to knowledge and research is the area of greatest importance. Both access to facilities and collaboration with researchers from DTU was to some/great extent important to half of the companies. Many entrepreneurs also indicated that collaboration with students from DTU have been important.

Furthermore, the proximity of, and ready access to, researchers, students and facilities have had greater significance than more formal research collaborations – the latter have been significant for 17% of the companies.

Table 5.2 brings out differences between the three types of entrepreneur. It appears that also in the post establishment phase, it is the DTU-IP based entrepreneurs who attribute great importance to their relationship with DTU. In this group, 70% of respondents stated that their access to facilities and cooperation with researchers from DTU had been substantially significant.

In addition, the table shows that there are only minor differences when it comes to the importance of having access to students from DTU and access to sparring and guidance.

Table 5.2. The significance of activities at DTU to growth and development, distributed by type of entrepreneur (share stating that the activities were significant to some, or a great, extent)

| | Start-ups based on DTU-IP | Companies established by students and graduates | Companies established by DTU employees (without DTU-IP) |
|--|---------------------------|---|---|
| Access to facilities at DTU | 70% | 45% | 32% |
| Collaboration with researchers at DTU | 70% | 18% | 58% |
| The possibility of establishing a business at the DTU campus | 70% | 18% | 32% |
| Use of/collaboration with DTU students | 47% | 41% | 32% |
| Formal research contracts with DTU and external funding | 33% | 5% | 16% |
| Accelerator programmes | 23% | 18% | 5% |
| Financial support offered by actors at DTU campus | 10% | 18% | 5% |
| Counselling/mentoring offered by DTU | 27% | 23% | 11% |
| Courses in Entrepreneurship offered by DTU | 7% | 41% | 11% |
| At least one of the above | 93% | 68% | 84% |

Source: Survey of DTU-based entrepreneurs, N=76.

Entrepreneurs' assessment of the quality of the ecosystem at DTU after the establishment phase

The interviewed companies were also, in general, positive about the quality and use of the ecosystem after the establishment phase. In particular, the flexible tenancies at the DTU Science Park and the opportunities to benefit from DTU equipment and facilities in the science park were emphasised positively.

On the other hand, some entrepreneurs felt that the ecosystem is better and more well-developed in the start-up phase than it is subsequently in the scale-up phase. In some interviews, it was emphasised as a challenge that not many entrepreneurs from DTU had grown to large companies. Some added that the design of the ecosystem ought to reflect this challenge.

The message is that more resources can be invested in creating frameworks, competencies and programmes supporting entrepreneurs with a great potential for growth. Among other things, the following areas of improvement were highlighted:

- Improved international cooperation with other universities and science parks – e.g. with the aim of 1) supporting mutual inspiration and the exchange of experience between scale-up companies (in the same technology areas) across science parks, and 2) creating a larger foundation of interesting companies (across science parks) that are capable of attracting a wider circle of investors and companies wishing to invest in the ecosystem and follow the most promising entrepreneurs.
- Greater emphasis on helping entrepreneurs to obtain their first large investment – e.g. through early stage investors, business angels, and the like.
- Increased focus on attracting the right profiles within entrepreneurship and business to the advisory boards and boards of directors in companies with a genuine potential for growth.
- Better differentiation of the tools offered in the ecosystem so that the different needs and development processes that characterise hardware, software and life science companies are recognised.

6. Common features in successful DTU entrepreneurship

6.1 Introduction

It is important to examine what characterises successful start-ups. From such an examination we can learn what is needed in terms of the future prioritization of initiatives for DTU's entrepreneurs. Do DTU start-ups that experience high growth rates have common features which distinguish them from other start-ups? Can these features be used as a basis for further development of the DTU ecosystem – and as useful knowledge which can be applied to secure even more favourable conditions for growth?

In an attempt to answer these questions, we divided the companies involved in the survey into three groups. In the first group we placed companies which had had success, either in terms of high growth rates or because they had attracted a considerable amount of risk capital for their development projects (or both). In the second group we placed companies which had not succeeded in creating growth or in attracting a significant amount of risk capital. The third group included companies lying between these two poles.

We compared the group of successful entrepreneurs with the group of unsuccessful entrepreneurs on a range of parameters. Altogether, we identified 21 successful DTU-based entrepreneurial companies and 21 unsuccessful DTU-based entrepreneurial companies. Box 6.1 lists the criteria we used to place the companies in the two groups.

Box 6.1. Identification of successful DTU entrepreneurs

Our point of departure was companies established before 2017. We laid down a set of minimum and maximum criteria which need to be fulfilled in order for a company to be characterised as successful or unsuccessful, respectively. In order to be categorised as successful, companies needed to satisfy at least one of the following criteria:

- For companies established before 2016: A turnover of at least DKK 10 million in 2017. For companies established in 2016: A turnover of at least DKK 5 million in 2017 and an expected turnover of at least DKK 10 million in 2021.
- At least 15 full-time equivalent employees.
- Raised capital of at least DKK 10 million.

In order to be characterised as unsuccessful, companies needed to fulfil all of the following criteria:

For companies established before 2016:

- A maximum turnover of DKK 3 million in 2017.
- A maximum of five full-time equivalent employees.
- Maximum raised capital of DKK 3.5 million.

For companies established in 2016:

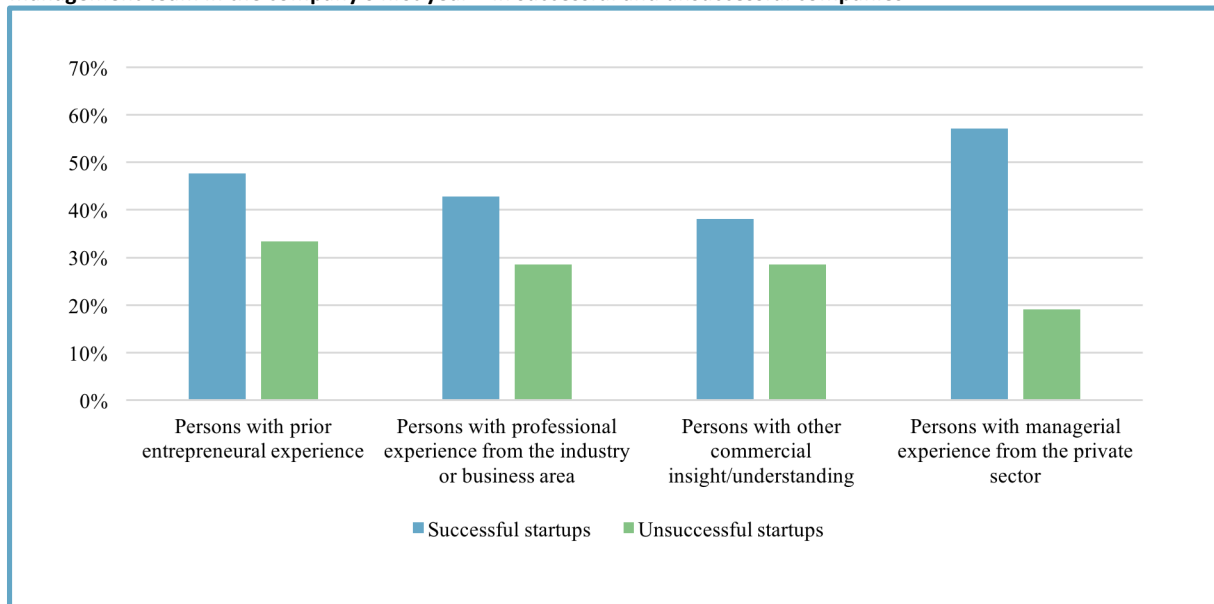
- A maximum turnover of DKK 1 million in 2017.
- A maximum of one full-time equivalent employee.
- Maximum raised capital of DKK 0.4 million.

Besides these criteria, we decided that only companies which, from the beginning, had had an explicit goal of becoming bigger than a one-man business would be included in our sample – this was to prevent the group of unsuccessful companies from including companies without ambitions for growth.

6.2 Differences between successful and unsuccessful companies

Figure 6.1 shows the frequency of a range of competencies and types of business experience in the founding and management teams of successful and unsuccessful companies in the first year after the company formation.

Figure 6.1. The prevalence of different types of competency and business experiences in the founding team and management team in the company's first year – in successful and unsuccessful companies

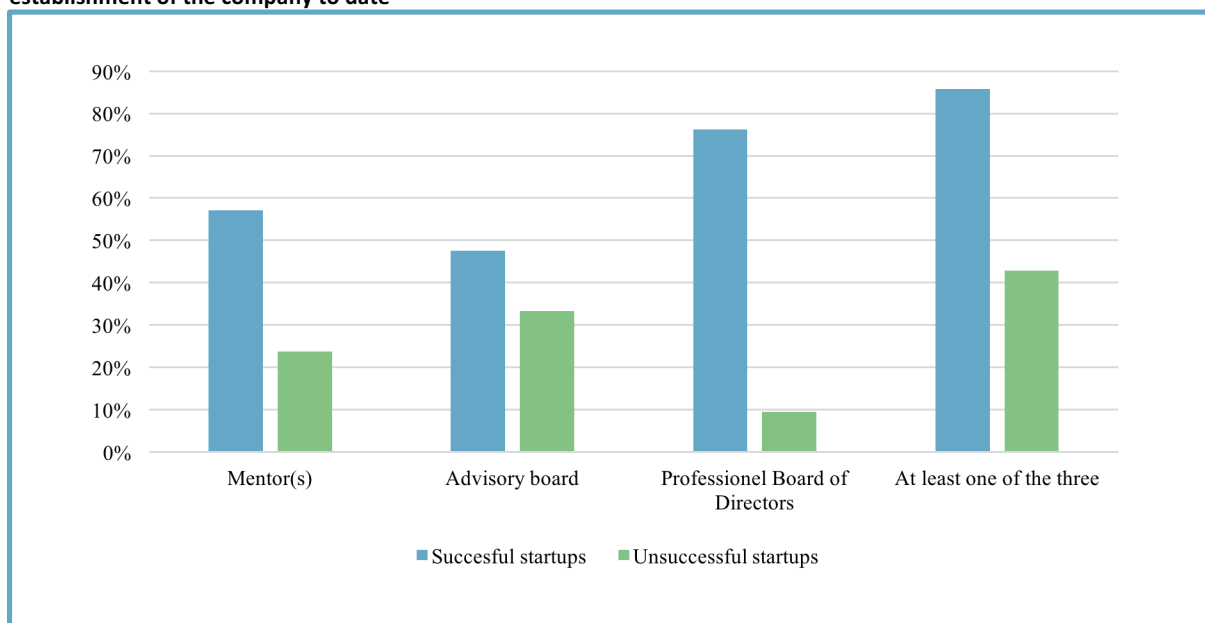


Source: Survey among DTU-based entrepreneurs, N=42.

It can be seen from the figure that successful and unsuccessful companies differ from one another most strikingly in their inclusion of people with previous managerial experience from the private sector. Almost 60% of the successful companies had such experience in their founding and management team in the company's first year. The corresponding figure for the unsuccessful companies was somewhat less than 20%. The successful and unsuccessful companies also differ in their inclusion of people with industry-specific entrepreneurial experience and knowledge, but the difference between the two groups here is less pronounced.

In Figure 6.2 we compare the two groups of companies again, but this time we examine differences with regards to affiliated mentors and use of advisory boards and professional board of directors in the start-up companies.

Figure 6.2. Successful and unsuccessful start-up companies' use of mentors, advisory board and board of directors from establishment of the company to date



Source: Survey among DTU-based entrepreneurs, N=42.

There are significant differences between the two groups. Approximately 85% of the successful companies had at least one of the three affiliations. The corresponding fraction for unsuccessful companies was 40%.

Turning to professional boards of directors, it is of course difficult to assess whether the board created the conditions for growth or whether instead the formation of the board was a consequence of growth or raised capital. As a company grows, so does the likelihood of it having a professional board of directors. A board of directors is often a precondition for capital injections into a company.

It is interesting that the difference between the two groups is so pronounced when it comes to the affiliation of a mentor (or mentor team). Mentors are often affiliated in a company's early phase, and thus, unlike professional boards of directors, they are not a precondition for attracting capital. The results shown in Figure 6.2 therefore appear to indicate that the affiliation of a mentor in the early phase may be of great importance to the company's growth and development.

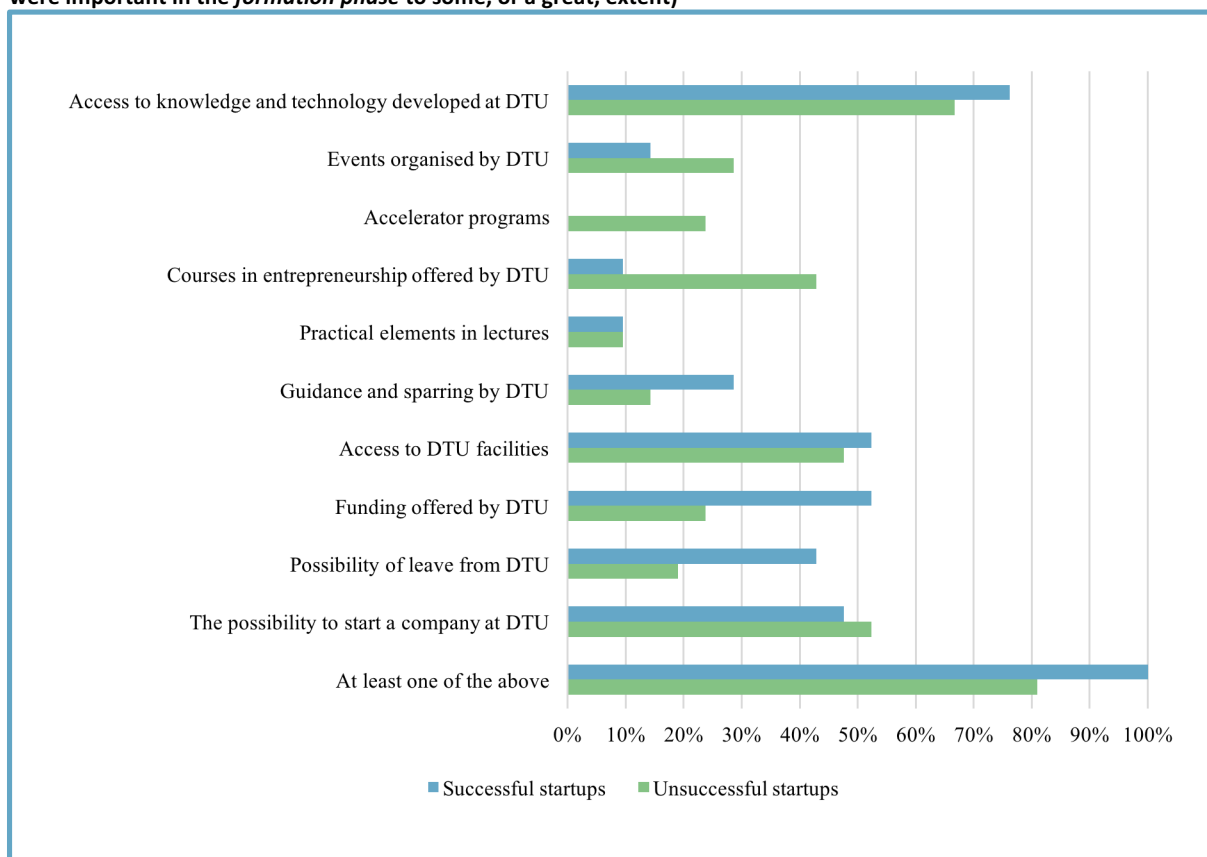
If we compare Figure 6.1 and Figure 6.2, it is interesting to see that the successful DTU based start-ups are distinctive in their inclusion of prior managerial experience from the private sector and an affiliated mentor or a mentor team. This suggests that mentors do not simply fill gaps in the competencies of the management team - rather they contribute with perspectives and networks in their own right, aiding companies which already have a certain amount of commercial experience themselves.

Several of the companies we interviewed underlined the importance of a mentor or mentor team, and stated that affiliations of this kind had accelerated their companies' growth and development.

Use of the DTU ecosystem in the formation phase

We also investigated whether there were any differences between the two groups in their use of DTU's ecosystem for entrepreneurial companies *in the formation phase*. Figure 6.3 shows the extent to which the successful and unsuccessful companies had used various elements of the DTU ecosystem during that phase.

Figure 6.3. Successful and unsuccessful companies' use of elements of the DTU ecosystem (share stating that the elements were important in the *formation phase* to some, or a great, extent)



Source: Survey among DTU-based entrepreneurs, N=42.

The difference between the two groups of companies in their use of the DTU ecosystem does not appear to be very pronounced. A majority of the successful companies had taken up offers of counsel and funding for the maturation of their inventions. On the other hand, a majority of unsuccessful companies had used the accelerator programmes and courses in entrepreneurship. These inconclusive differences are presumably largely an expression of the fact that many of the companies in the successful group were IP-based or established by employees at DTU, while many of the companies in the other group were students, or recent graduates, who had access to training and accelerator programmes as part of their establishment.

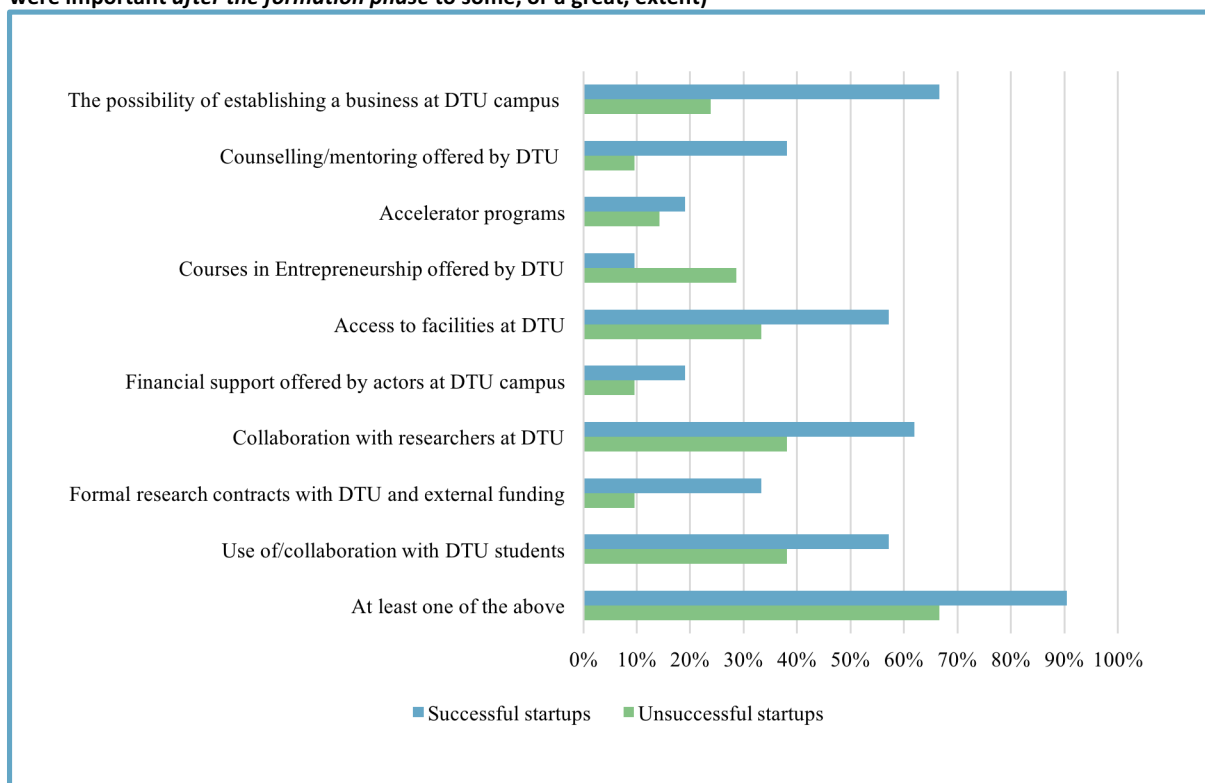
It is noteworthy that none of the successful companies indicated that training or accelerator programmes had influenced their growth and development. In connection with that, several interviewees mentioned that the quality of these programmes has significantly improved in recent years – the courses have become more practically applicable and case-oriented, and the quality of the mentors in the programmes has also improved.

It is likely that a large proportion of the successful companies did not have access to the accelerator programmes. The results shown in the figure need to be interpreted in that light.

Use of the DTU ecosystem after the formation phase

Finally, we investigated whether there were any differences between the two groups in their use of the DTU ecosystem *after the formation phase*. Figure 6.4 shows the extent to which the successful and unsuccessful companies had used various elements of the DTU ecosystem during that phase.

Figure 6.4. Successful and unsuccessful companies' use of elements of the DTU ecosystem (share stating that the elements were important *after the formation phase* to some, or a great, extent)



Source: Survey among DTU-based entrepreneurs, N=42.

It can be seen from the figure that there are significant differences between the two groups. With the exception of the courses in entrepreneurship, which the entrepreneurs typically attend before the company is established, the successful companies have benefitted, in the period after their formation, from their use of the DTU ecosystem to a much greater extent than the unsuccessful ones. The most striking difference concerns the first element of the ecosystem listed – the opportunity to situate the company on the DTU campus. This indicates that the flexible possibilities of office-use at the DTU Science Park, together with easy access to facilities, the access to sparring and research in DTU’s ecosystem, have a significant impact on the potential of a company to grow.

As in Chapter 5, we need to underline at this point that the DTU-based entrepreneurial companies did not all have the same level of access to the courses and programmes (etc.) in the DTU ecosystem.

6.3 Recapitulation

We need to be careful before drawing firm conclusions from the analysis presented in this chapter, as the data presented do not establish causality between actual growth and the various conditions of entrepreneurial development considered. Do the conditions create growth, or are they a consequence of growth? However, there do seem to be some clear trends. The successful entrepreneurs:

- Affiliated people with private sector management experience in their founding and management teams.
- Used mentors as well as advisory boards and professional boards of directors (from an early phase).
- Were located on the DTU campus and benefited from the proximity of DTU advisers and scientists, and DTU facilities, in their development.

The total picture is therefore that the DTU ecosystem is of considerable importance to entrepreneurs who have their company in the environment and exploit their proximity to the range of actors, we looked at in Chapter 5.

7. Appendix A: Method

A. Registry-based analysis

The first step in the registry-based analysis was to identify the population of DTU-based start-ups established in the period 1999-2017.

The entrepreneurial population was identified using six primary data sources:

- A custom-made data extraction from the registry of Company Participants (i.e. *Deltagerregisteret*)
- The Entrepreneurship Database (IVPE and IVPS)
- DTU's own registrations of DTU-based start-ups with and without DTU-IP
- The Business Demography Registry covering *truly* new start-ups (EDRN)
- The Labour force Registry (RAS), which was used to compose a list of all employees at DTU
- The Education Registry (UDDA), which was used to compose a list of students and graduates from DTU

The registry of Company Participants is a newly established registry at Statistics Denmark. It contains information about all founders and owners of companies (up to 2015), allowing one to identify entire founding teams. To separate DTU-based entrepreneurs, a complete list of employees, students and graduates from DTU in the period 1999-2015 was matched with information about founder teams using the Company Participants registry. Using this method 19,927 potential DTU-based start-ups were identified. These potential start-ups were established by 51,689 people, of whom 24,424 had a DTU relation as employees or students/graduates.

To ensure that the identified start-ups were based on knowledge developed at DTU, the following criteria were applied:

- Companies must have been established *either* while the employees, graduates and students were still at DTU *or* no more than two years after they have terminated their studies or employment at DTU.
- Employees must have been employed at DTU for a minimum of two years to increase the probability that the companies established are based on knowledge and skills acquired at DTU.
- Employees must have at least a bachelor's degree and have been employed full-time for at least one year.

Of the DTU-based entrepreneurs identified in the Company Participants registry, almost 4,500 start-ups satisfied these three criteria.

Following this, DTU-based start-ups that had not been identified as genuinely new start-ups were excluded from the population. A new company is a company that is newly registered for VAT, which has not previously been run by another owner, or in another ownership form, or by another company. The sorting here was done by linking the identified DTU-based start-ups with the Business Demography Registry covering only genuinely new start-ups. In total, almost two-thirds of the potential DTU-based start-ups identified were discarded.

Unfortunately, the Business Demography Registry for genuinely new start-ups only runs from 2001 onwards. Therefore, the number of DTU-based start-ups in 1999 and 2000 was calculated based on the average proportion of companies identified as genuinely new in the period 2001-2015 (42%). Of the potential DTU-based entrepreneurship companies identified in the Registry for Company Participants in 1999 and 2000, some 163 were identified as genuinely new start-ups.

As just mentioned, the Register of Company Participants is a new register and still under development. To ensure that all relevant DTU-based start-ups were identified, the list of employees, students and graduates at DTU was cross-checked with the Entrepreneurship Database, which contains information on primary owners. The Entrepreneurship Database covers the period 2001-2013 and is constructed in such a way that it disregards re-registrations of companies, bankruptcies, etc.

Finally, the population of new DTU-based start-ups was linked with DTU's own list of start-ups with DTU-IP – i.e. companies started with a DTU-patent. During the period 1999-2015, DTU obtained 63 patents. Using DTU's own list of DTU-patented companies, 37 additional DTU-based start-ups were identified. Typically, these companies had not been founded by people with an existing relationship with DTU (e.g. employee or student/graduate), and thus they were not identified in the registry-based mapping exercise.

The total population of DTU-based start-ups established from 1999 to 2015 amounted to 1,792 companies.

The second step in the analysis was to identify spinoffs (i.e. new companies created by one of the originally identified DTU entrepreneurs) and mergers and acquisitions.

To identify spinoffs, we investigated whether some of the founders of the original DTU-based start-ups established new CVR numbers in the period 1999-2015. A company was defined as a spinoff if 1) it was established by one of the originally identified DTU entrepreneurs, and 2) the original entrepreneurial company had continued to exist for at least two years after the new CVR number was established. With this definition, a total of 92 spinoffs were identified.

We then investigated whether some of the original entrepreneurs' companies that ceased to exist during the period had in fact been transformed and continued to operate under a different CVR numbers. Essentially, the aim was to pick up cases of merger and acquisition.

This was done by investigating whether a significant proportion of the employees in the original company, which was no longer active, were already employed under a new CVR number in the year the company ceased operating or the following year. The proportion of employees to be retrieved under a new CVR number depended on the number of employees under the original CVR number. The following criteria were imposed. In companies with fewer than 3 employees, all employees must be employed under the new CVR number. In companies with 3-6 employees, a minimum of two-thirds must be found under the new CVR number, while at least half of the employees must be employed under the new CVR number if the original company had more than 6 employees.

With these criteria, a total of 11 company transformations were identified. However, closer examination of the new CVR numbers revealed that the probability of transformations actually being acquisitions or mergers was relatively small. The identified transformations were therefore not included in the impact analysis reported in Chapter 3.

The total population of DTU-based entrepreneurial companies established in the period 1999-2015, including spinoffs and start-ups with DTU-IP, amounted to 1,884 companies (1792 + 92).

The third step in the analysis was to link the identified population of DTU-based start-ups with specific company information, including data on employment, turnover, exports, etc. (i.e. den nye Generelle Firmastatistik).

The registry from which these data were drawn included all companies with a CVR number. This was advantageous, since it meant that the registry covered not just *active* companies but also companies that were active only for part of the year and those with very little activity: we call the latter *non-active* companies. Following EU guidelines, *active* companies included companies with salary hours corresponding to at least half a full-time equivalent, and/or with a calculated turnover of a certain size, with that size to be determined by the company's industry affiliation. For those companies that started operating during the census year, the revenue limit was set to half the level used for companies registered throughout the year. By including companies below this threshold (i.e. non-active companies), we allowed companies to experience their first growth in employment or turnover several years after their establishment.

Finally, the population of DTU entrepreneurs was linked with information about the founder's citizenship. This was done to investigate the entrepreneurial team's nationality and more specifically to analyse developments in the proportion of companies with a foreign or combined Danish and foreign founding team.

Economic impact in 2015

Total value creation and employment in DTU-based entrepreneurial companies in 2015 was compared to a reference group of comparable companies (Chapter 3). The reference group was constructed as a random sample to match the group of DTU-based start-ups with regard to: number of companies, establishment year, and industry affiliation (with the latter based on 10 industry groupings). Differences between the two groups indicate how well the DTU-start-up companies have performed, on average, by comparison with a group of similar entrepreneurs.

In the reference group, total value creation and employment was calculated as the average over 100 samples drawn from the population of genuinely new Danish companies. The samples were drawn with replacement, and the company population was randomly sorted before each sample draw. The calculation of total value creation and employment as an average, based

on 100 random samples, ensured that the results were more robust than they would have been had they been calculated from a single random draw, as the latter may have contained many companies with either very high or very low productivity.

Economic growth

We also traced economic growth – measured in terms of employment, revenues and exports – in different groups of DTU-entrepreneurs, and made comparisons with a reference group.

The DTU-entrepreneurs were divided into three groups based on their year of establishment: 1999-2003, 2004-2007, and 2008-2011. The groups were split in this way in recognition of the fact that the economic situation changed considerably after 1999. Thus growth conditions and survival prospects are likely to have fluctuated in the different groups of DTU-entrepreneurs over this period considerably.

Reference groups for each of the three periods were created. They were constructed to match the groups of DTU-based start-ups with regard to: number of companies in each group, establishment year, and industry affiliation (with the latter again based on 10-industry groupings). Before the companies for the reference groups were drawn, the sample population was limited to genuinely new companies established within the three periods under examination.

In the reference groups, increases in employment, revenues and exports were calculated as averages, based on 10 random samples. The calculations were based on data for the last year in each of the three periods (i.e. 2003, 2007 and 2011). The random samples were drawn from the population of genuinely new and active Danish companies. The limited size of this population meant that it was impossible to draw more than 10 random samples by age and industry affiliation.

Projections

The number of DTU-based start-ups for the period 1999-2015 was projected for 2017 and 2020. Several assumptions were made in order to arrive at qualified, but conservative, projections. Thus it was assumed that 200 new DTU-based start-ups would be established each year between 2016 and 2020. This figure was based on DTU's own registrations of DTU-entrepreneurs starting over the period 2014-2017. The projected increase in the number of DTU-start-ups in the coming years was based on the observed increase in the number of registrations by DTU between 2015 and 2016/17. It was further assumed that the distribution of entrepreneurship types (i.e. DTU-IP-based, employees without DTU-IP and students/graduates) would be the same as that observed in recent years.

In the projections, the fact that some of the companies ceased to exist after 2015 was taken into account.

To determine how many of the originally identified DTU companies were still operating in 2017 and 2020, age-related company survival rates were calculated. The average number of companies ceasing to exist each year was then deducted from the stock of companies, which consists of surviving companies and newly established companies. In the calculation of total employment, revenues and exports, it was assumed that the age-adjusted average turnover and age-related average number of employed full-time equivalents in 2017 and 2020 would correspond to the average values observed in 2015. Based on the age-related distribution of start-ups in 2017 and 2020, total revenues and the total number of employed full-time equivalents were calculated.

It should be noted that the projections here were sensitive to business cycles, and that therefore the actual number of DTU-based companies may have been biased upwards or downwards, depending on the cyclical trend.

B. Questionnaire survey

As part of the analysis, an online questionnaire survey using the program SurveyXact was conducted in January-February 2018.

The target group for the survey was entrepreneurs running DTU-based start-ups since 2007.¹¹ The entrepreneurs were identified through DTU's own register of companies started by students/graduates and employees, including companies with DTU-IP.

¹¹ Since firms established before 2007 are less likely to adequately recall the start-up period, including their use of the facilities and opportunities made available by DTU.

DTU has had a policy of registering all newly established companies with a DTU connection since 2013 (including companies with and without DTU-IP). DTU also registered new DTU-based start-ups during the period 1999-2012, but the registrations in during this earlier period are known to have been less systematic.

The table below gives an overview of the survey showing the number of questionnaires distributed, the number completed, and the response rate.

The questionnaire was distributed to a total of 255 companies. In all, 93 questionnaires were completed and 16 partial responses were received. This corresponds to a completed response rate of 36%, which rises to 42% when the partial responses are also considered. This is a relatively high rate for this type of study.

The increasing focus on registration of DTU-start-ups after 2013 meant that approximately 75% of the questionnaires were completed by companies established in the period 2013-2016.

In addition, 39% of the questionnaires were completed by companies based on IP taken out at DTU, although this group of entrepreneurs only comprise 4% of the total population of DTU-based start-ups. The significant overrepresentation here reflects the fact that all start-ups with DTU-IP are registered by DTU, while only a small proportion of the start-ups established by students and graduates are registered.

| | Key figures |
|--|-------------|
| Distributed questionnaires | 255 |
| Completed questionnaires | 93 |
| - <i>Hereof start-ups based on DTU-IP</i> | 36 |
| Incomplete answers | 16 |
| - <i>Hereof start-ups based on DTU-IP</i> | 2 |
| Answers in total | 109 |
| Response rate (including partially completed questionnaires) | 42 % |
| Response rate (completed questionnaires only) | 36 % |

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