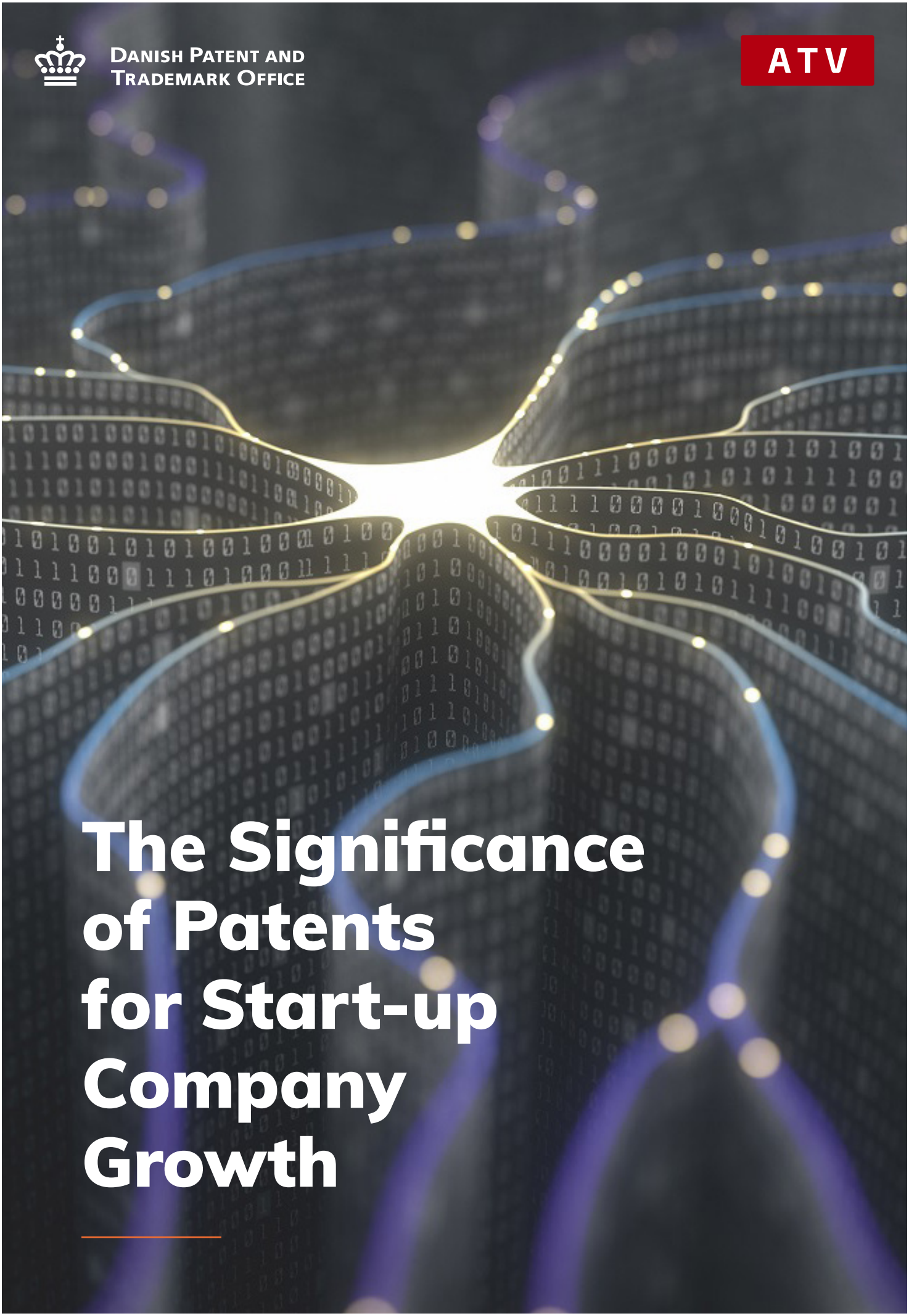
Danish Patent and Trademark Office
ATV
The Significance of Patents for Start-up Company Growth

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Chapter 1 - **Foreword**

Innovation is important, and a crucial factor in overcoming many of the challenges we face today. If Denmark is to continue living off its knowledge and innovation in the future, Danish start-ups and other SMEs will need to continue to strengthen their innovation and competitiveness.

In the analysis, *Danmarks nye vækstlag [Denmark's New Growth Layer]*, the Danish Academy of Technical Sciences showed that Science & Engineering (S&E) start-ups perform better than other types of start-ups measured on a number of economic key figures, including turnover, exports and value added. The analysis also shows a correlation between the knowledge intensity within companies, their growth and their impact on the Danish economy. At the same time, several European studies show that companies with IP rights perform notably better than companies without IP rights when measuring factors such as turnover, growth, and number of employees. This holds true for SMEs in particular. It is therefore important that start-ups actively determine whether and how IP rights might contribute to the growth of their specific company.

Over the past 10 years, international competition in innovative technological fields has intensified massively. This is partially reflected by the fact that the majority of global patent applications currently come from Asia. This was also presented in the conclusion of the Danish Academy of Technical Sciences' analysis of the *World's Leading Tech Regions*, which emphasised the increasing competition to which Danish companies are exposed, even within the technology areas where we hold a strong position.

If Denmark is to continue to rank among the world's richest and most innovative countries in the future, it is crucial to increase the focus on the elements necessary for innovative start-ups to become growth companies, which contribute to the creation of Denmark's future growth and jobs.

The Danish Academy of Technical Sciences and the Danish Patent and Trademark Office have therefore carried out an analysis which helps shed light on some of the traits that characterise start-ups with strong finances, including an examination of the role of patenting.

Happy reading!

Lia Leffland
Director, Danish Academy of Technical Sciences

Sune Stampe Sørensen
Director, Danish Patent and Trademark Office

Chapter 2 - **Introduction**

In May 2019, the Danish Academy of Technical Sciences published the report *Danmarks nye vækstlag [Denmark's New Growth Layer]*[1], which is an analysis of Science & Engineering (S&E) start-ups, their development and their significance for the Danish economy. S&E start-ups are characterised by a large concentration of employees with STEM competencies[2] as well as investments in Research and Development (R&D). The analysis showed that S&E start-ups outperform other types of start-ups on all key parameters. They employ more people, they grow faster, realise a higher turnover, contribute more to GDP, and they export earlier and at a greater value than peer start-ups.

At the same time, several European studies have shown[3] that companies with intellectual property rights (patents, trademarks, and design rights) outperform companies without intellectual property rights.

This holds true for SMEs in particular. Since there is often a correlation between knowledge intensity and investment in R&D and patenting, the Danish Academy of Technical Sciences and the Danish Patent and Trademark Office have had a common interest in analysing the role that patents play in the growth and development of knowledge-intensive start-up companies[4].

The aim has been to compare roughly similar populations in order to try to isolate the effect of patenting. This was done by comparing S&E start-ups, both with and without patents, to Danish start-ups with patent rights. Where possible, start-ups from industry and the Danish business community have been used as benchmarks.

The purpose of the analysis is to gain a better understanding of what drives growth and development within start-ups. Increased understanding of this development could help facilitate a better consultation potential for the future development of more successful Danish start-ups to the benefit of each individual company and to Denmark as a whole.

The analysis starts with an outline of the most important conclusions and observations (Chapter 3).The characteristics of the populations studied are then described in order to identify differences in employee and sector composition, geographical location etc. (Chapter 4). Chapter 5 examines the economic performance of the populations and their impact on the Danish economy. Chapter 6 analyses S&E start-ups with and without patents along with the growth trajectories of all patent-holding companies, i.e., their development within various economic indicators throughout their first 13 years of existence. The analysis ends (Chapter 7) with an examination of the differences among patent-holding companies in relation to the number of patents they hold and whether they have applied for patents internationally or only within Denmark. Finally, Chapter 8 explains the analysis background and method.

S&E companies

Science & Engineering companies, in this analysis, are defined as companies basing their business on a strong foundation of expertise in engineering science and STEM competencies.

Read more here
https://atv.dk/sites/atv.dk/files/media/document/ATV_State%20of%20the%20Nation%202020_web.pdf

[1] *https://atv.dk/sites/atv.dk/files/media/document/ATV%20Danmarks%20nye%20v%C3%A6kstlag%202019%20WEB_0.pdf*
[2] *Science, Technology, Engineering and Mathematics*
[3] *See, among others, https://euipo.europa.eu/ohimportal/documents/11370/80606/Intellectual+property+rights+and+firm+performance+in+Europe og https://euipo.europa.eu/tunnel-web/secure/webdav/guest/document_library/observatory/documents/reports/2019_High-growth_firms_and_intellectual_property_rights/2019_High-growth_firms_and_intellectual_property_rights.pdf*
[4] *Start-ups are defined as companies established from 2000 onwards.*

The populations analysed:

1. Patent companies
Include companies established since the year 2000 which have taken out at least one patent. In some sections of the analysis, this group is further subdivided into companies taking out one vs more patents, and companies taking out Danish-only patents vs companies taking out patents internationally.

2. S&E start-ups
Include companies meeting the definition criteria for Science & Engineering companies established since the year 2000.

3. S&E start-ups with patents
Include S&E start-ups which have taken out at least one patent. Accordingly, this is an intersection of S&E start-ups and the total patent population.

4. Benchmarks
Industry and the wider business community have been added as benchmarks, which cover all industrial companies and all Danish companies established since the year 2000, respectively.

Chapter 3 - **Main observations and conclusions**

Overall conclusions

- Out of 1,162 S&E start-ups, 274 have patents (hereinafter referred to as S&E start-ups with patents), equivalent to 24 pct. In comparison, approximately 0.8 pct. of European SMEs holds a patent. This can be seen as an indication that technology-intensive S&E start-ups have a high level of patent activity. However, it also suggests that many successful S&E start-ups do not need patents.
- In general, start-ups with patents outperform other start-ups within industry and the business community in general. This is borne out in part due to the fact that in 2017, the value added for start-ups with patents was more than twice that of start-ups within industry and more than four times that of the business community in general.
- Regardless of whether S&E start-ups hold patents or not, they generally outperform other companies on most economic parameters used in the analysis.
- When comparing S&E start-ups with and without patents, it is difficult to draw unambiguous conclusions in terms of performance. There are a number of areas in which S&E start-ups with patents perform better than the S&E population as a whole, while the opposite is true in other areas.
- There is a clear correlation between number of patents and value added. The more patents, the higher the value added.

Company characteristics

- SS&E start-ups with and without patents have generally similar company characteristics, both in terms of number of employees per company, sector composition, geographical location, and employee educational background.
- However, S&E start-ups with patents have more employees per company, more highly educated employees and more employees with STEM competencies.
- In addition, there are slightly more industrial companies among S&E start-ups with patents, while there are more information and communication companies in the group of S&E start-ups without patents.
- The total patent population shares more characteristics with the business community as a whole than with the S&E populations.

Impact on the economy

- The average company holding one or more patents (see Chapter 5) leaves a significantly larger impact on the economy across all four parameters (value added, turnover, exports, productivity) than the average company within industry and the wider business community.
- When looking at the S&E population's economic impact measured as the average per company, S&E start-ups with patents perform better than S&E start-ups without patents in terms of value added and productivity. However, the opposite is true for exports and turnover, where the collective group of S&E start-ups performs better than S&E start-ups with patents.
- Looking instead at the "typical S&E start-up" (i.e. based on the median value, see method section), the picture is different. The "typical" S&E start-up with patents has more exports, but lower value added than S&E start-ups without patents. The difference between the average impact of the populations and the impact of the "typical" company is that some companies are included in the S&E population, which performs very strongly in terms of exports and value added. This raises the average for the population.

Company growth trajectories

- During the first 13 years, every "typical" S&E start-up undergoes a similar development in annual work units, turnover and value added, regardless of whether the start-up has patents or not. However, the "typical" S&E start-up with patents has a significantly larger export activity than the "typical" S&E start-up without patents.
- S&E start-ups with patents have a higher annual percentage growth rate than S&E start-ups without patents regarding the number of employees, turnover and value added. However, S&E start-ups with patents start from a lower baseline, which is why, despite a greater annual growth, they end up at nearly the same level as S&E start-ups without patents, measured by annual percentage growth in the number of employees.

Development of patent-holding companies

- Both S&E start-ups with patents and the general patent population see an increase in all economic indicators during the 10 years following the first patent application.
- A tendency towards a small decrease in the economic indicators in the years leading up to the first patent application can be seen for the entire patent population, followed by an increase over the subsequent 10 years.
- There is a clear correlation between number of patents and value added in the patent population. The more patents, the higher the value added. Thus, the 10 pct. of the companies with the most patents has a significantly higher value added per company than the 25 pct. with the fewest patents.

Chapter 4 - **Characteristics of the populations**

The analysis focuses on the economic output of Danish start-up companies, defined as companies established from the year 2000 onwards, with a special focus on three populations; the group of S&E start-ups as a whole, the group of S&E start-ups with patents, and the collective group of start-ups holding at least one patent. This chapter takes a closer look at the characteristics of the three populations.

Number of companies

All the companies in the patent population as well as in the S&E group were established from 2000 onwards. Thus, the populations also include companies, which were both established and closed during this period. Of the 2,380 companies included in the patent population, which have existed at some point during this period, there were only 1,406 left in 2017.

This corresponds to a 40 pct. reduction. For the sake of comparison, 259 of the 274 S&E start-ups with patents are still in existence, amounting to a 5.5 pct. reduction. Within the group of S&E start-ups as a whole, there is a 7.7 pct. reduction during this period, i.e. a slightly higher number than for S&E start-ups with patents.

Table 1 – **Number of active companies in the period 2000 - 2017**

	Total population	Number of active companies in 2017
Patent companies total	2,380	1,406
Science & Engineering total	1,162	1,072
Science & Engineering with patent	274	259

Observations:

- Of the 1,162 S&E start-ups, 274 have taken out one or more patents, equal to 24 pct. In comparison, less than 1 pct. of European SMEs took out patents. This underlines that patents are important to many S&E start-ups. However, it also suggests that patenting is not relevant to all companies, or that the companies have not seen any value of patenting. This may be due to sector differences or the company's stage of development, just as there may be barriers preventing S&E start-ups from patenting.
- Far fewer companies in the population of S&E start-ups with patents ceased operations during the period (5.5 pct.) compared with the total patent population (40 pct.), and slightly fewer compared with the total S&E population (7.7 pct.). However, the analysis does not provide the reasons for cessation, i.e. company closure or acquisition, etc.

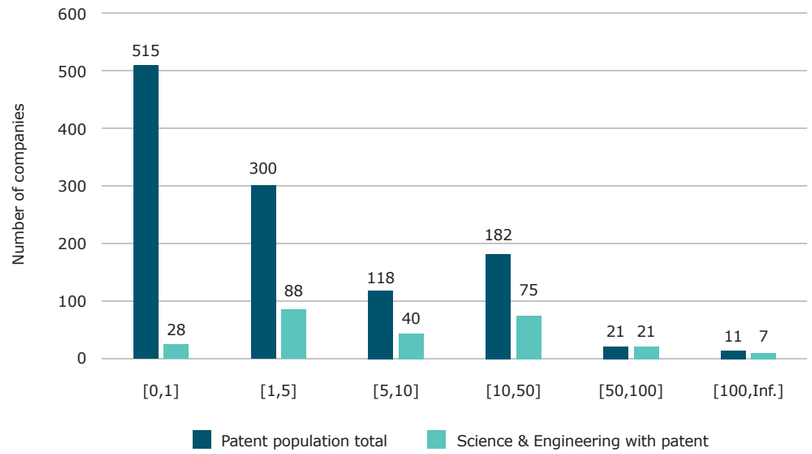
Company sizes

The three populations encompass a total of 44,553 employees, the majority of whom arewithin the total population of S&E start-ups. Table 2 shows that S&E start-ups with patents have an above average number of employees per company. This is confirmed by Figure 1, which shows the company size as measured in annual work unit intervals for the total patent population (dark blue) and S&E start-ups with patents, respectively. In the patent population as a whole, the distribution is clearly skewed to the left, where the smaller companies make up the largest share. It is also clear that the large companies are predominantly S&E start-ups with patents.

Table 2 – **Number of employees** [5]

	Total employees	Average number of employees per company
Patent companies total	20,083	14
Science & Engineering total	24,470	23
Science & Engineering with patent	6,964	27

Figure 1 - **Company size determined via annual work unit intervals** [6]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations:

- The total patent population comprises many sole proprietors, while the S&E start-ups with patents are more evenly distributed in terms of companies of various sizes.
- Among companies with more than 50 full-time equivalents there is an almost 1-to-1 overlap. In other words, almost all of the large companies in the total patent population are S&E start-ups.

Company age

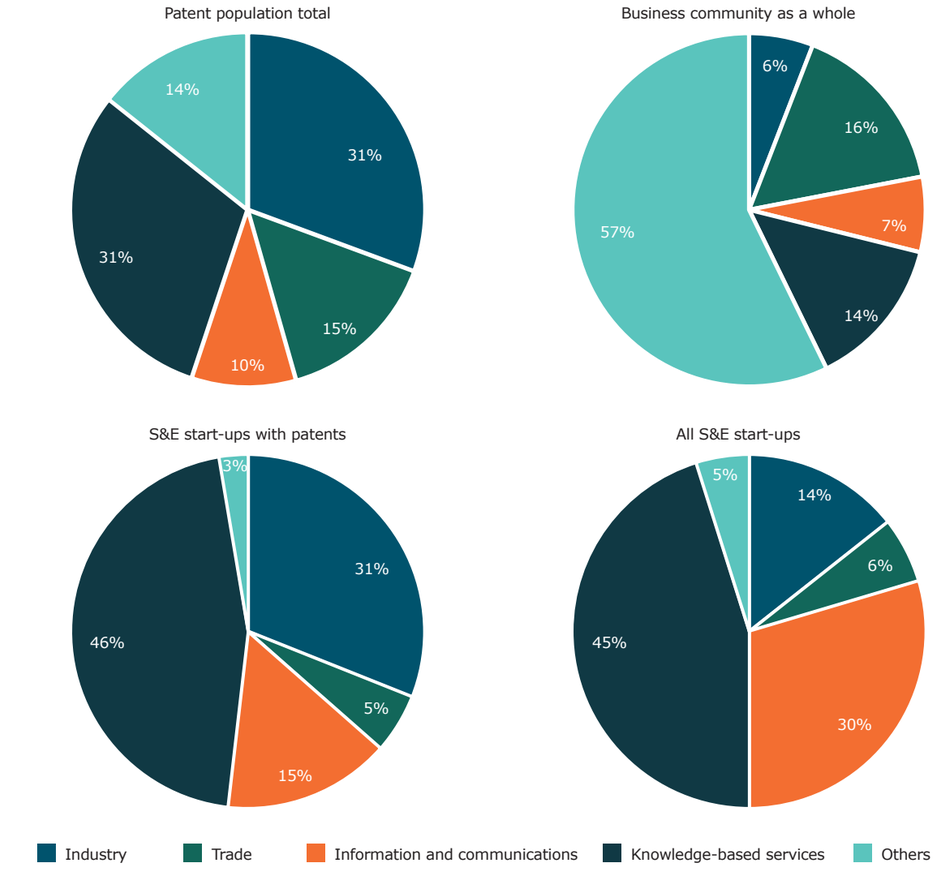
The age distribution is based on companies existing in 2017, i.e. companies both established and shut down within the 2000 - 2017 period are not included in the final distribution.

[5] *Employees per company is based on the number of active companies and employees in 2017.*
[6] *The distribution is based on active companies in 2017.*

Sector distribution

The figure below illustrates a rather large variance in sector distribution across the different populations.

Figure 2 - **Sector distribution among populations**[7]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations:

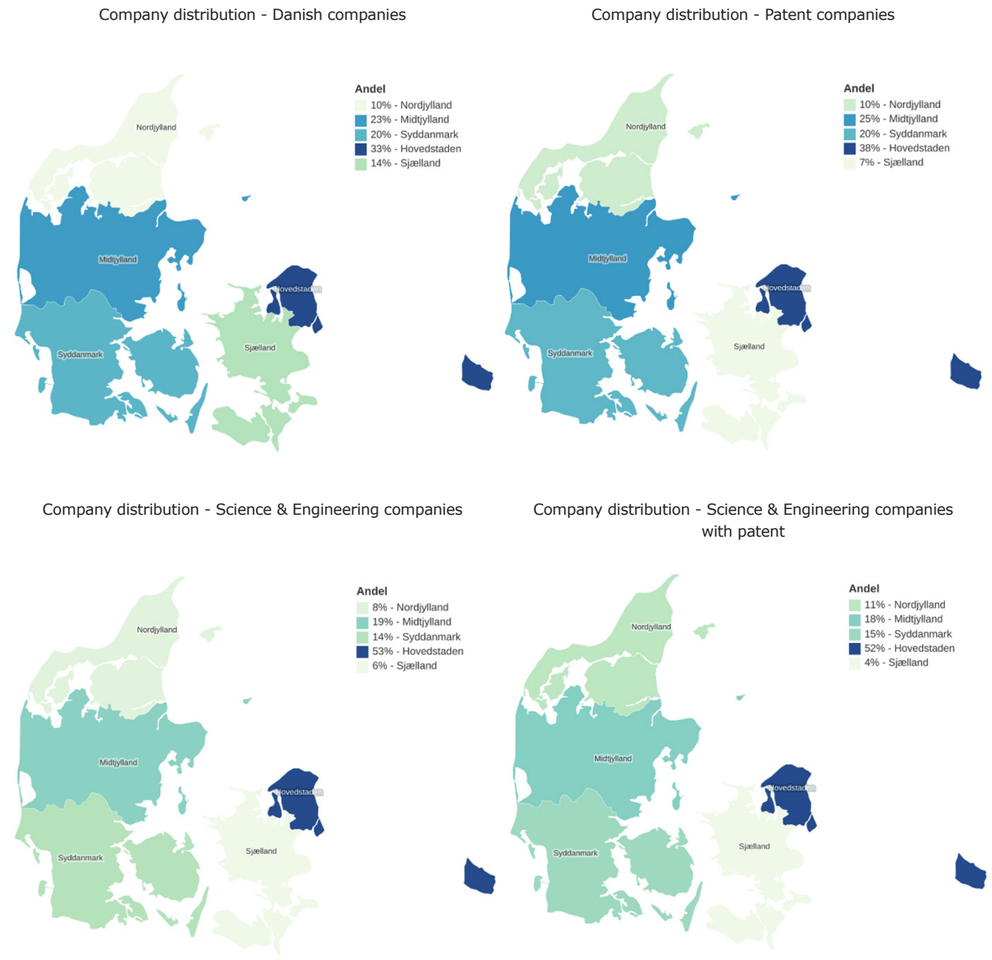
- The sector distribution is similar for S&E start-ups with and without patents. It can be seen that both populations have a high intensity of companies in the "Knowledge-based services" sector. The "Research and Development" sector is included as a subcategory within this sector..
- A high proportion of the total patenting companies are within the industry, where the largest subsector is the "Electronics industry".
- The category "Information and communication" companies is largest among S&E start-ups, both in relation to S&E start-ups with patents, the patent population as a whole and the business community in general.

[7] *Distribution based on companies established after 2000.*

Geographical distribution

Companies from all three populations are found throughout the country, although the concentration of S&E start-ups - and in particular S&E start-ups with patents - is largest in the capital area, while these companies are very scarce in the region of Zealand.

Figure 3 - **Geographical distribution among populations** [8]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations:

- In general, a picture emerges of S&E start-ups being very similar in terms of location, whether they hold patents or not, while the patent population as a whole share more similarities with the general business community.

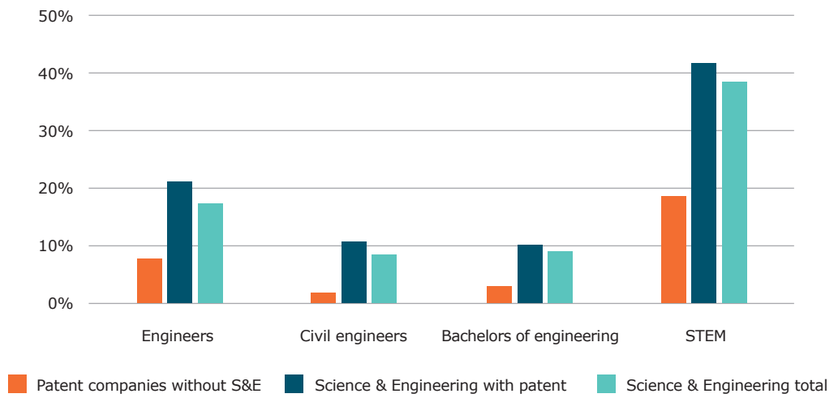
[8] *Distribution based on active companies in 2017.*

Employee composition

The figures below take a closer look at employee composition within each population. S&E start-ups are characterised by a high density of employees with STEM competencies. This is particularly true for S&E start-ups with patents.

Within the patent population as a whole, the proportion of employees with STEM competencies is significantly lower.

Figure 4 - **STEM graduates**



Source: Damvad Analytics, based on figures from Statistics Denmark
Note: Diploma and Civil sums for Engineers, a subset of the total STEM figure, which also includes scientists, laboratory technicians, etc. Determined on the basis of active companies in 2017.

When looking at the employee composition in relation to duration of education (Table 3 and Figure 5), a picture emerges in which the concentration of employees with a PhD education is greatest among

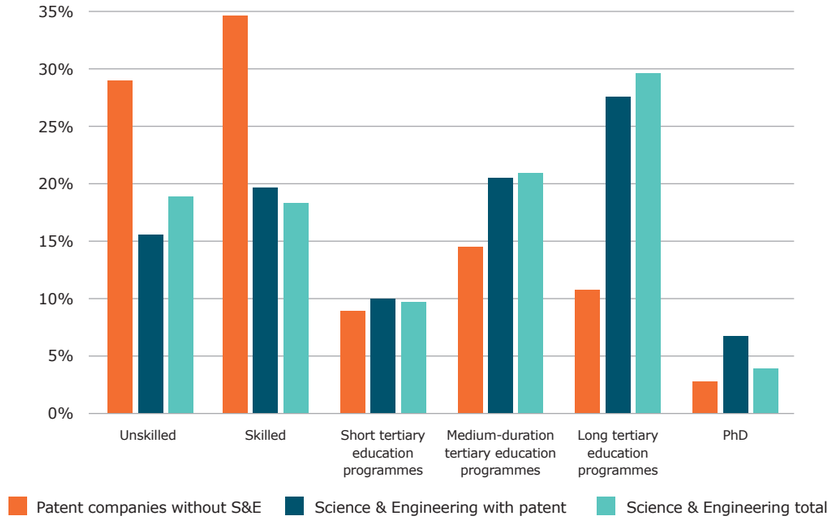
S&E start-ups with patents, and lowest in the wider patent population. For unskilled workers, however, the picture is the opposite, i.e. the patent population employs a much larger proportion than the other two populations.

Table 3 – **Duration of education (number)**

	Quantity of unskilled	Quantity skilled	Quantity Short tertiary education programmes	Quantity Medium-duration tertiary education programmes	Quantity Long tertiary education programmes	Quantity PhD	Number employees
Patent companies without S&E	3,737	4,542	1,094	1,853	1,563	330	13,119
Science & Engineering total	4,458	4,426	2,294	5,242	7,254	796	24,470
Science & Engineering with patent	1,107	1,345	665	1,447	1,896	504	6,964

Source: Damvad Analytics, based on figures from Statistics Denmark.
Note: Based on active companies

Figure 5 - **Duration of education (pct.)**



Source: Damvad Analytics, based on figures from Statistics Denmark.
Note: Based on active companies

Observations:

- The concentration of employees with a STEM education is very high among S&E Start-ups and in particular among S&E start-ups with patents.
- The concentration of employees with longer educations is particularly high in the S&E population (regardless of whether they hold patents or not), while the patent population has a higher percentage of unskilled and skilled workers.
- The concentration of employees holding a PhD is greatest among S&E start-ups with patents.

Number of patents

Table 4 below shows the average number of patents for the S&E population with patents, the total patent population, and the patent population excluding the patent-holding S&E start-ups. The average number of patents divided into percentiles is also shown.

The percentiles are calculated to show the average number of patents among, for example, the 10 pct. of companies with the fewest patents (10^{th} percentile) or the number of patents among the 10 pct. with the most patents (90^{th} percentile).

Table 4 – **Patent distribution**

	Average	10-percentile	25-percentile	50-percentile	75-percentile	90-percentile	Number of companies
Science & Engineering with patent	15.89	1	3	7	15	35	274
Patent companies total	7.02	1	1	3	6	14	2,380
Patent companies without S&E	5.87	1	1	2	5	12	2,106

Source: Damvad Analytics, based on figures from Statistics Denmark

Observations:

- On average, S&E start-ups with patents hold more than twice as many patents as companies in the patent population as a whole. This massive difference is largely due to a marked difference in the 90^{th} percentile between the two groups. This points to the fact that a lot of patents are held by just a few companies in the S&E population with patents, which significantly raises the overall average.

Chapter 5 - **Impact on the Danish economy**

This chapter examines the impact of the populations on the Danish economy. The impact on the economy is analysed on the basis of annual work units, value added, exports, turnover, and productivity.

The populations are held up against a benchmark consisting of companies launched after 2000, both within industry and the Danish business community.

The statements are calculated as mean (chapter 5.1) and median (chapter 5.2), respectively.

The following economic variables are used:

Value added
Value added is a measure of how much the individual company (by using labour and capital goods) contributes to the increase in value of goods and services. Value added is calculated as the difference between the production value and the expenses for raw materials, consumables and services purchased from other companies or abroad.

Productivity
Productivity is a measure of how effective a company is at creating value. Productivity can be calculated in various ways. In this report, we use labour productivity, i.e. value added per annual work unit.

Exports
Exports are a measure of sales of products and services abroad.

Turnover
Turnover consists of the company's total revenue in a given period. This will usually be income from invoiced services/goods, cash sales, and other income.

Annual work unit
The total working time or the total work of one person working full-time for one year. The number of employees in a company can thus exceed the number of annual work units.

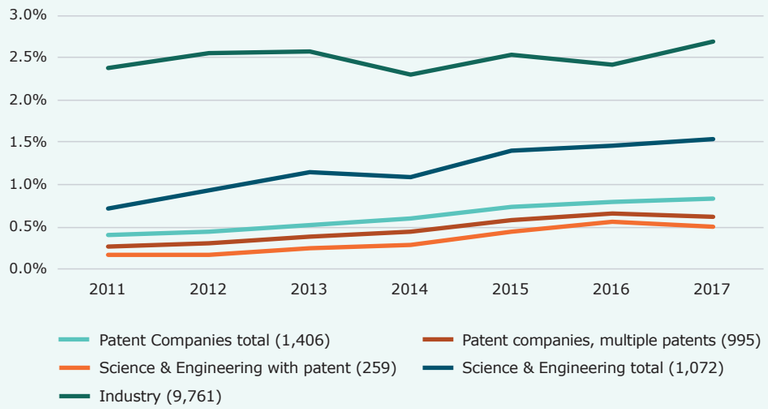
Chapter 5.1 **The economic impact of the populations**

In Chapter 5.1, the figures are either based on the populations' shares of the total impact on the Danish economy (Figures 6 and 9) or on the basis of the mean value (simple mean), as seen in Figures 7-8 and 10-13.

In addition to the total patent population, this chapter also includes a subgroup of patenting companies, that have taken out more than one patent.

Value added
Figure 6 shows the share of Denmark's total gross value added (GVA) represented by the surveyed populations. The share of Denmark's total BVT clearly reflects the size of the populations, which varies greatly between populations (the number of companies in each population in 2017 in parentheses).

Figure 6 - **Share of Denmark's total gross value added** [9]



Source: Damvad Analytics, based on figures from Statistics Denmark.
Own calculations based on figures from statistikbanken.dk (Table NAHD21).

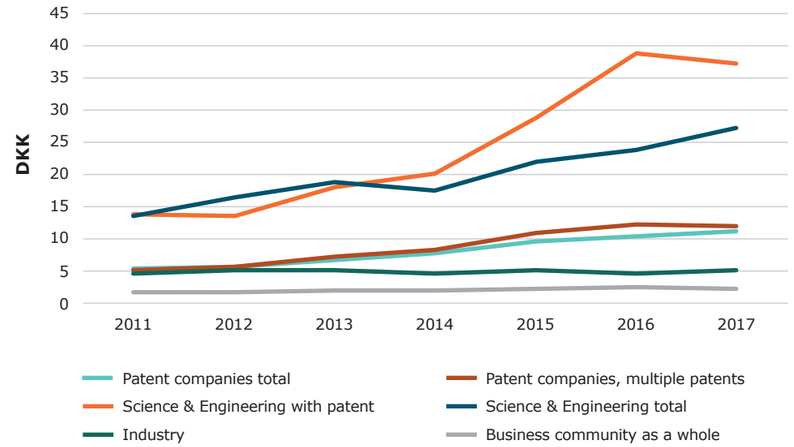
Observations:

- Industry is the biggest contributor to Denmark's total GVA but is also the largest population.
- S&E start-ups comprise the population making the second greatest contribution to the total gross value added, despite the fact that this group contains fewer companies than the patent population as a whole.
- The S&E population with patents represents, as a whole, the smallest share of Denmark's GVA. However, this is largely due to the limited size of the population, cf. Figure 8.
- Looking at the development across several years, the share of Denmark's total GVA represented by patenting S&E start-ups triples from 0.18 pct. to 0.51 pct. Over the same period, the share of total GVA represented by the total population of S&E start-ups doubles from 0.72 pct. to 1.54 pct.t.
- The share represented by patent companies has doubled over the period from 0.41 pct. to 0.84 pct. Similarly, the proportion of patent companies with more than one patent increases from 0.27 pct. to 0.63 pct.

[9] *Figures based on active companies in 2017*

When looking at the populations' average value added per company, instead of the total share of Denmark's GVA, the picture looks markedly different.

Figure 7 - **Value added for companies (mean)** [10]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observatios:

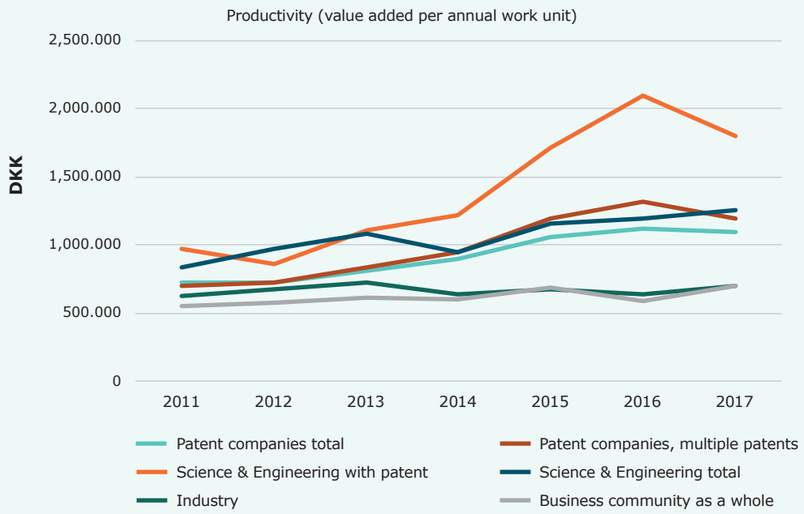
- S&E start-ups with patents is the company category delivering the greatest value added, when broken down per company. With an average growth of approximately DKK 37 million per company in 2017, S&E start-ups with patents have a significantly higher value added per company on average than the S&E population as a whole.
- The patent population has more than twice the value added per company compared to the benchmarks (industry and business community as a whole) in 2017. Despite the value added per company being largely the same across patent companies and industry in 2011.
- The value added within the S&E population with patents grows more than the other populations during the period.
- Whether or not a patenting company has taken out more than one patent appears to make no significant difference.

[10] *Figures based on active companies in 2017*

Productivity

Figure 8 shows the productivity of the populations over the period 2011-2017. Productivity is calculated through value added per annual work unit and thus reflects how much value each employee contributes.

Figure 8 - **Productivity for companies (mean)** [11]



Source: Damvad Analytics, based on figures from Statistics Denmark.

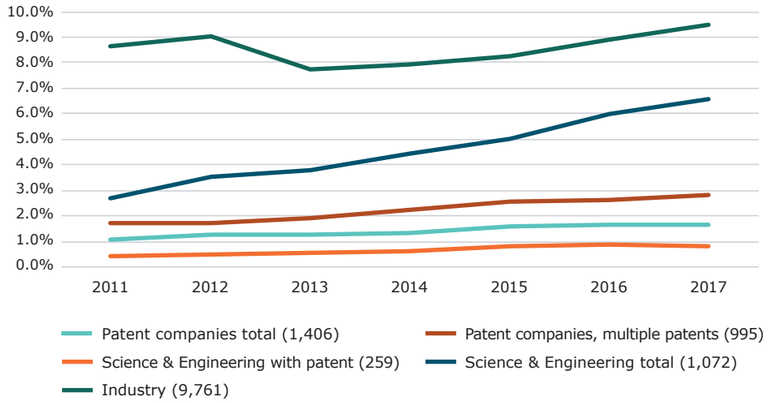
Observations:

- S&E start-ups with patents surpass all populations in productivity. It is S&E start-ups with patents have experienced a steep growth over the period.
- The population of S&E start-ups as a whole the other is on par with the patent population also seen that. All four groups have, however, significantly higher productivity than the two benchmark industries and the business community as a whole.

Export

The figures below show the extent to which the populations contribute to Denmark's total exports (figure 9) and exports per company (figure 10) and per annual work unit (figure 11).

Figure 9 - **Share of Denmark's total exports** [12]

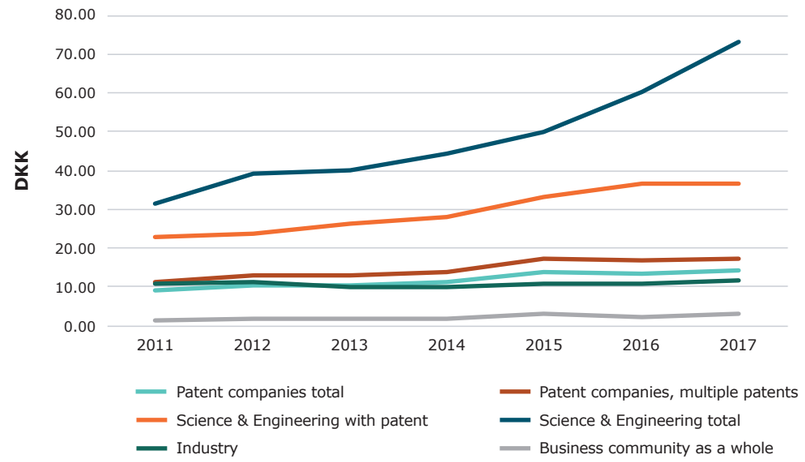


Source: Damvad Analytics, based on figures from Statistics Denmark. Own calculations based on figures from statistikbanken.dk (Table NAN1).

[11] *Figures based on active companies in 2017*

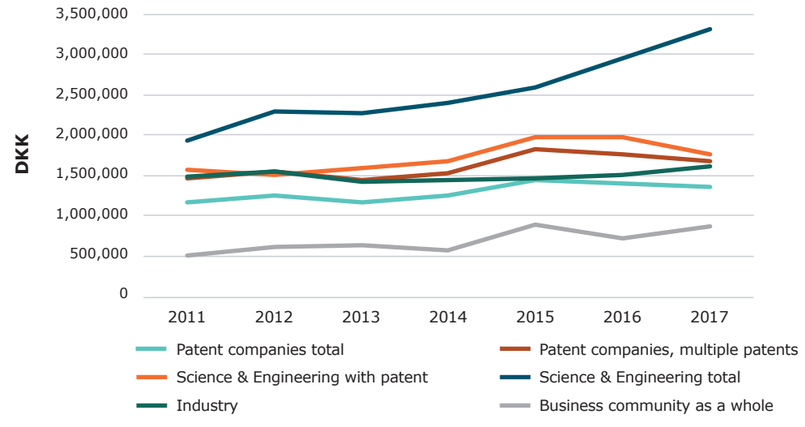
[12] *Figures based on active companies in 2017*

Figure 10 - **Company exports (mean)** [13]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Figure 11 - **Exports per annual work unit (mean)** [14]



Source: Damvad Analytics, based on figures from Statistics Denmark.

[13] *Figures based on active companies in 2017*

[14] *Figures based on active companies in 2017*

Observations across figures with export numbers:

- S&E start-ups export significantly more than the other populations measured in terms of annual work units and per company. When measured as a share of Denmark's total exports, S&E start-ups also leave a significant mark, surpassed only by industry benchmark comprising nine times as many companies.

- S&E start-ups with patents account for the second-highest exports per company and per annual work unit. However, they do not export much more than the general patent population in terms of annual work units.

- It is interesting to see such a large discrepancy between the S&E start-ups as a whole and those with patents, since the two populations are similar in so many other aspects. This is due to the fact that a number of super-performing companies, which are not included in the S&E population with patents, are included in the population of S&E start-ups. These raise the mean value (see also Chapter 8).

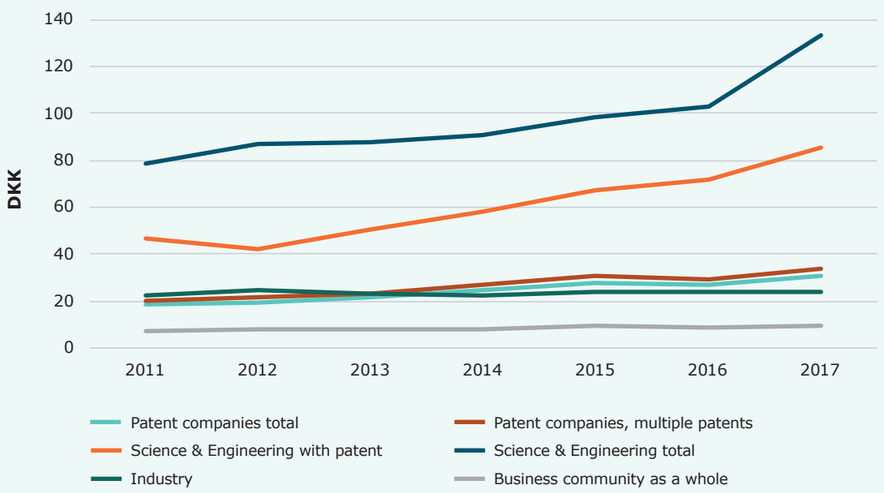
- Measured per company and in terms of annual work units, companies with multiple patents export more than the group of patent companies as a whole.

- Industry exports more per annual work unit than companies in the patent population, while this figure is slightly lower per company.

Turnover

Figures 12 and 13, respectively, show the populations' average turnover per company and per annual work unit.

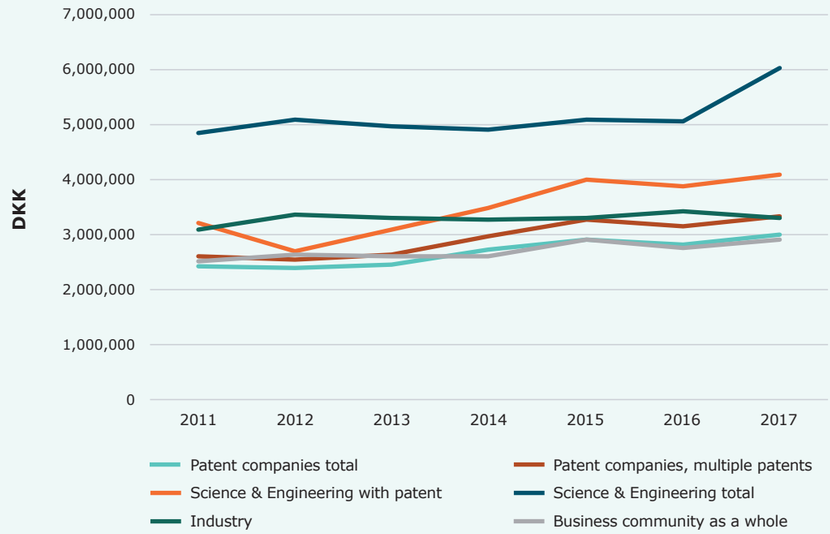
Figure 12 - **Turnover per company (mean)** [15]



Source: Damvad Analytics, based on figures from Statistics Denmark.

[15] *Figures based on active companies in 2017*

Figure 13 - **Turnover in terms of annual work units** [16]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations across figures including turnover figures:

- The S&E population as a whole has the largest turnover, measured both per company and per annual work unit.

- Whether a patent company has been granted more than one patent or not, does not seem to make much of a difference. While patent companies with more than one patent have a turnover of approximately DKK 34 million in 2017, this figure is DKK 30 million for patent companies with a single patent.

- Both the patent population as a whole and the patent companies with multiple patents perform better than the benchmarks when measured per company. Similarly, both patent populations have had a more positive development over the time period than the two benchmarks.

Sub-conclusions across figures calculated by mean

- Across all the figures (7-8 and 10-13), it seems like S&E start-ups (with and without patents) perform the best and make the biggest impact on the economy.

- No clear differences can be demonstrated in terms of performance between S&E start-ups with and without patents, as S&E start-ups with patents perform better measured in terms of value added and productivity, while the S&E population as a whole per forms better in terms of turnover and exports.

- Companies in the patent population as a whole, generally perform worse than S&E start-ups, but significantly better than industry and business community in general.

[16] *Figures based on active companies in 2017*

Chapter 5.2 **The economic impact of the “typical” company**

This section examines economic performance based on the median. This method serves to remove outliers (companies with completely atypical performance), making it possible to say something about the economic performance of the “typical” company.

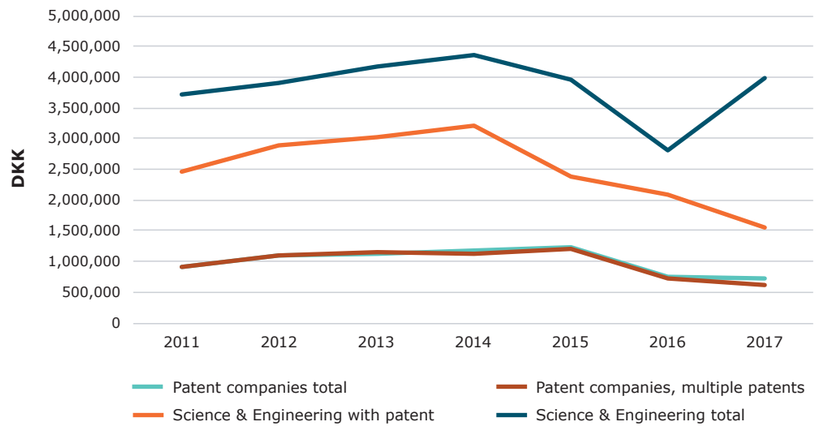
When using the mean value for a population (used in the previous section), there will be a risk, especially for smaller populations, that any outliers will have too significant an effect on the overall number. In the study of mean values, over-performing companies will thus tend to create a skewed picture of what characterises the typical company in a given population.

To counteract this, a new average calculation in the form of a median is introduced in the following section (Figures 14-16). The median is the middle-most value in a sorted data set, i.e. the middle economic key figure (see Chapter 8 for further explanation).

Value added

The figure below shows the value added for the typical company in the S&E population as a whole, the population of S&E start-ups with patents, the population of all patent companies, as well as the population of companies with more than one patent.

Figure 14 - **Value added for the typical company**



Source: Damvad Analytics, based on figures from Statistics Denmark.

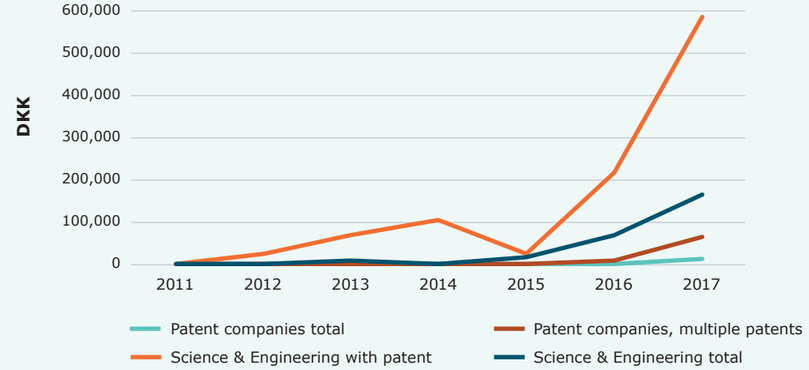
Observations:

- The typical company in the overall S&E population has the highest value added, while the typical S&E start-up with patents has a somewhat lower value added over the entire period.
- It is interesting that the typical company in the overall S&E population outperforms the typical company in the S&E population with patents. This is the opposite result compared to the average of the individual populations (Figure 7). This indicates that within the S&E population with patents, there are a few companies that have a very high value added, thus pulling up the average.
- No significant difference is seen in value added in relation to whether patent companies have more than one patent.
- The large difference between the “typical” and the “mean” company (mean and median) measured in DKK millions indicates that in all four populations there is a marked difference between the top performing companies and the bottom ones. For example, S&E start-ups with patents in 2017 have on average a value added of DKK 37 million, while the “typical” S&E start-up with patents has a value added of DKK 1.5 million in 2017.

Exports

The figure shows the export level of the typical company. It is clear that exports in the initial years are quite low, while growing later in the period. This is to be expected, as the companies’ export level must be expected to increase in line with age and maturity..

Figure 15 - **Exports for the typical company**



Source: Damvad Analytics, based on figures from Statistics Denmark.

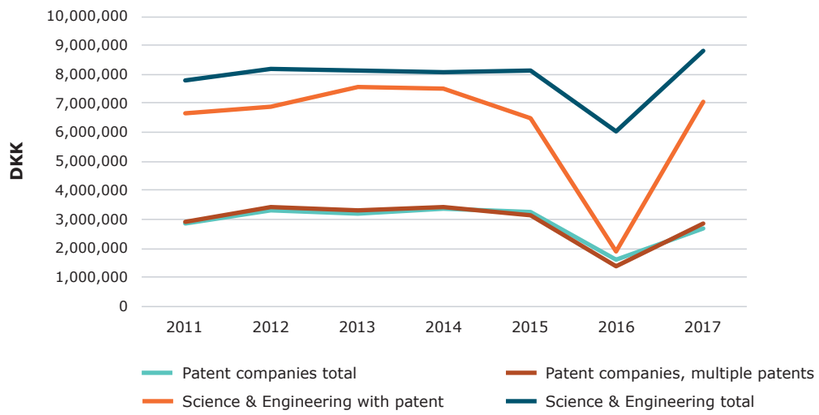
Observations:

- The figure shows that all four populations begin with low exports in 2011. After this point, S&E start-ups with patents develop significantly compared to the other three populations in 2017.
- There is a major difference between this figure and the corresponding export figure, which looked at the average of the companies (figure 10). On average, the total population of S&E start-ups has a significant level of export, but it is not especially strong when looking at the “typical” company. An image emerges of a small number of S&E start-ups accounting for a significant share of the population’s total exports.
- The typical patenting S&E start-up has a high level of export activity, which may be an indication of the importance of patents in the context of exports.
- Patent companies with more than one patent export more than those with a single patent.

Turnover

The figure below shows the turnover for the typical company in the S&E population as a whole and the population of S&E start-ups, with patents, the population of all patent companies as well as the population of companies with more than one patent.

Figure 16 - **Turnover for the typical company**



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations:

- The typical S&E start-up has the highest turnover, while the typical S&E start-up with patents has a slightly lower turnover.
- If we look at the "typical" company instead of the "average" company, the total population of S&E start-ups and S&E start-ups with patents switch ranks when looking at the value added, while their rankings remain the same as far as turnover is concerned. This illustrates a number of outliers with high costs among S&E companies without patents.

Chapter 5.3 **Economic impact on the basis of sector division**

In order to gain a deeper understanding of the performance across the different populations, the economic variables are examined by sector in greater detail below.

However, it is important to be bear in mind that there is a dilution of the populations, whereby individual, larger companies within the various sectors have a significant effect on the overall sector figure. This is particularly the case in the S&E population with patents, where, for example, the population of trading companies is based on figures from only 14 companies.

For this reason, the analysis is based on the median, - that is, the "typical" company.

Table 5 – **Sector distribution (median)**

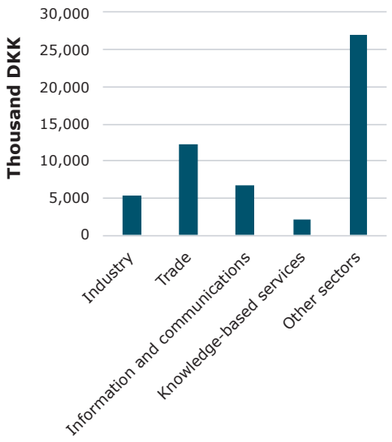
	Science & Engineering with patent	Science & Engineering total	Patent companies total	Patent companies multiple patents
Industry	80	156	457	348
Trade	14	64	210	134
Information and communications	40	318	125	77
Knowledge-based services	118	484	402	313
Other sectors	7	50	212	123

Source: Damvad Analytics based on figures from Statistics Denmark[17]

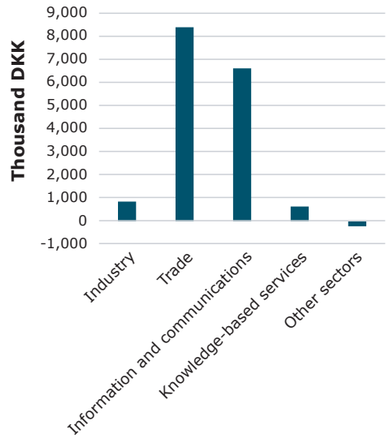
[17] *Figures based on active companies in 2017*

Figure 17 - **Value added for the typical company broken down by sector** [18]

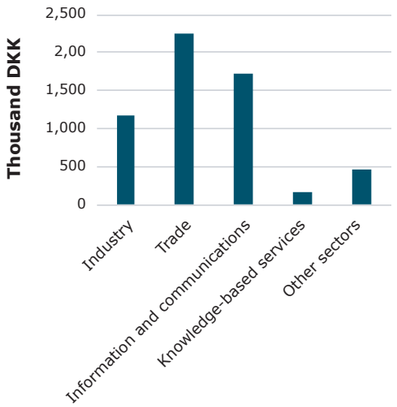
Value added for the typical **S&E start-up** in 2017



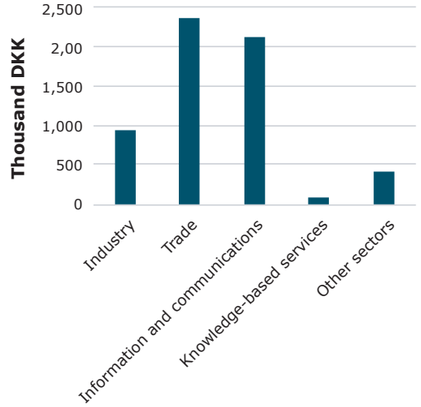
Value added for the typical **S&E start-up with patents** in 2017



Value added for the typical company in **patent population** in 2017



Value added for the typical company **with more than one patent** in 2017



Source: Damvad Analytics, based on figures from Statistics Denmark.

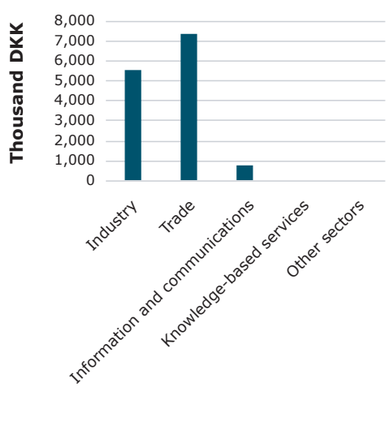
Observations:

- As shown in Figure 14, the average S&E start-up has the highest value added. S&E start-ups with patents have the second-highest value added, while both the total patent population and the group of companies with more than one patent are lower.
- The value added among S&E start-ups is particularly driven by a very high value added among "Other sectors", while this sector does not perform significantly better within the three patenting populations. This shows that there are companies within "Other sectors" which do not patent, but still perform quite well in terms of value added.
- In addition to "Other sectors" among S&E start-ups, the sectors "Trade" and "Information and Communication" across all populations have the greatest value added.

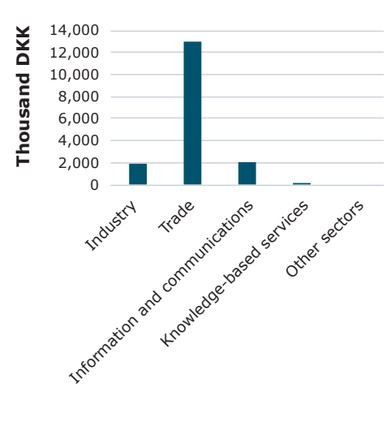
[18] *Figures based on active companies in 2017*

Figure 18 - **Exports for the typical company broken down by sector** [19]

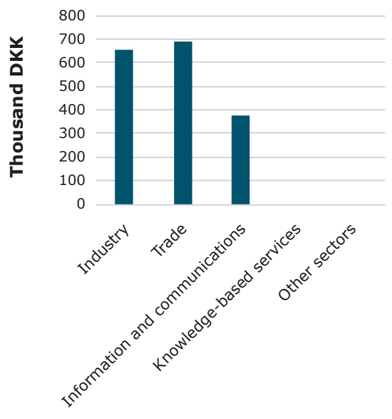
Exports for the typical **S&E start-up** in 2017



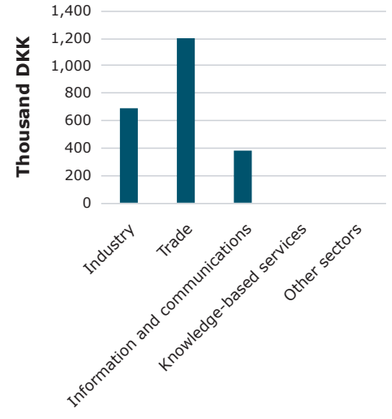
Exports for the typical **S&E start-up with patents** in 2017



Exports for the typical **patent company** in 2017



Export for the typical company **with more than one patent** in 2017



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations:

- "Trade" is the most actively exporting sector across all populations, while "Industry" is the second most active sector exporting across the populations.
- Strong exports in the population are especially driven by the trading companies in the S&E population with patents, as shown in Figure 16.
- It is worth noting that "Other sectors" is the sector within the S&E population with the greatest value added for the average company, while the typical company in this sector hardly has any exports.

[19] *Figures based on active companies in 2017*

Chapter 6 - **Development illustrated by growth trajectories**

The following chapter compares the course of development (here referred to as growth trajectories) for the populations. This chapter utilises more populations than in the previous chapter, as it also includes S&E start-ups without patents and the patent population without patenting S&E start-ups. The aim is to create a more nuanced picture of the populations.

Growth trajectories are anchored in the company's start-up year and show growth for the typical company (median). It is noted that the curves for the S&E population with patents in particular are slightly irregular. This is due to it being a small population, which is becoming 'slim' in recent years.

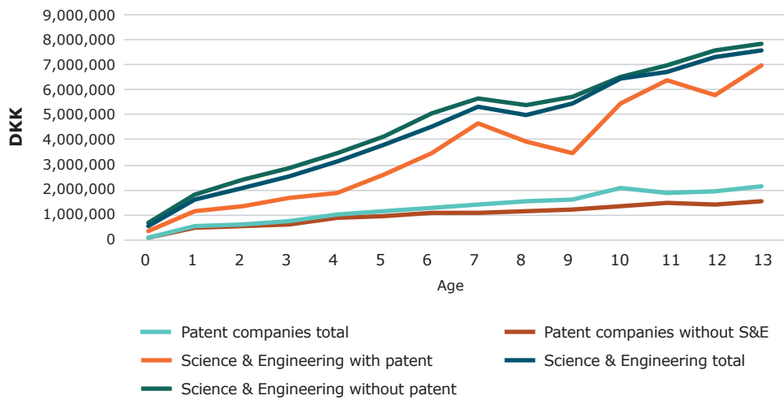
As a supplement to the growth trajectories, the annual growth of the typical company is listed in tables throughout the chapter. Average growth is calculated from year zero. It is not meaningful to calculate annual growth in relation to exports, as the respective populations start exporting at different times.

In general, the tables must be seen in connection with the figures and used with a certain degree of caution, as the populations have a rather different starting point with respect to number and size of companies. A low baseline can therefore result in high growth figures. Nevertheless, the tables showing annual growth figures for the various populations make it easier to understand the development of the companies and indicate their long-term potential.

Chapter 6.1 **Development after start-up year**

This section takes a closer look at the development of the populations after their start-up (year zero). This is done with a focus on value added, number of annual work units, exports, and turnover.

Figure 19 - **Development in value added after company start-up**



Source: Damvad Analytics, based on figures from Statistics Denmark.

Table 6 – **Annual growth in value added after start-up**

	Value added
Patent companies total	23.60% p.a.
Patent companies without S&E	21.46% p.a.
Science & Engineering total	22.49% p.a.
Science & Engineering with patent	25.98% p.a.
Science & Engineering without patent	20.56% p.a.

Observations:

- S&E start-ups with and without patents have reasonably parallel courses. However, S&E start-ups with patents appear to have a somewhat higher annual growth (cf. Table 6).
- Companies within the various populations have different baselines. S&E start-ups with patents and the patent population as a whole start from a lower starting point than S&E start-ups without patents and then see a greater annual development.

Figure 20 - **Development in exports after company start-up**

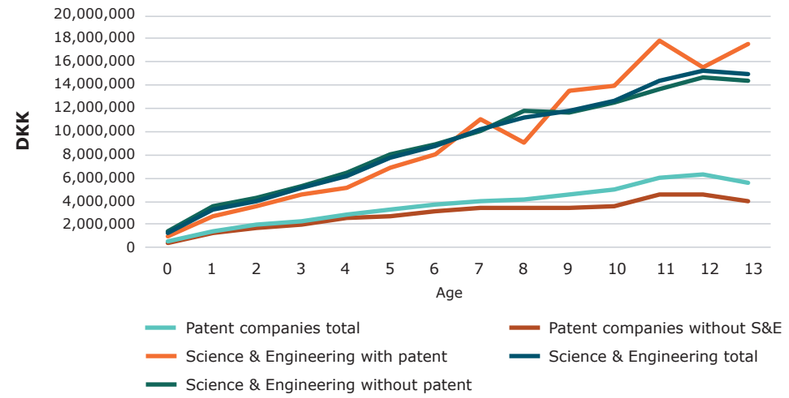
Source: Damvad Analytics, based on figures from Statistics Denmark.

Observation:

- S&E start-ups with patents export earlier and to a significantly greater extent than the other populations. The development of the population differs from S&E start-ups without patents and from the previous figures. However, this coincides with the observation in Figure 15 showing exports over the period 2011-17, based on median calculations. The population of S&E start-ups as a whole has significant export activity judging by the average for all companies (Figure 10), but this does not hold true when looking at the typical company.

This indicates that the S&E population contains a few companies with very high exports, which is uncharacteristic of the "typical" S&E start-up. Conversely, the above shows that the "typical" S&E start-up with patents is very export oriented.

Figure 21 - **Development in turnover after company start-up**



Source: Damvad Analytics, based on figures from Statistics Denmark.

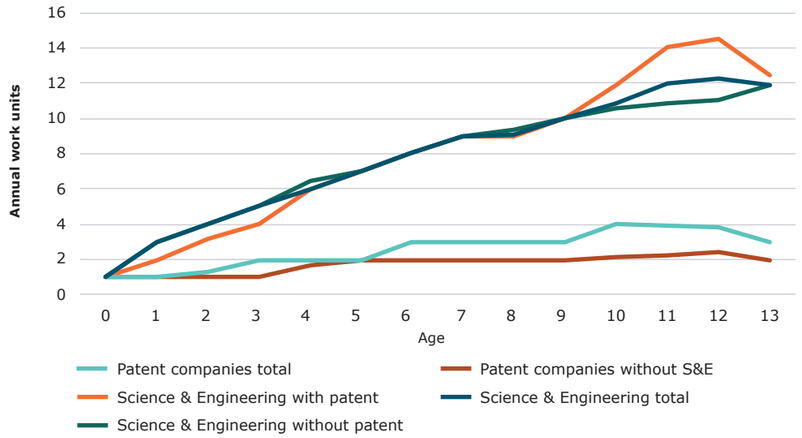
Table 7 – **Annual growth in turnover after start-up**

	Turnover
Patent companies total	19.83% p.a.
Patent companies without S&E	17.67% p.a.
Science & Engineering total	21.14% p.a.
Science & Engineering with patent	24.75% p.a.
Science & Engineering without patent	19.47% p.a.

Observations:

- After 13 years, S&E start-ups with patents have the highest turnover, just as they have a somewhat higher annual growth than S&E start-ups without patents.
- The patent companies excluding the S&E population have a somewhat lower turnover than the S&E population with and without patents throughout the period. Table 9 shows, however, that the annual growth of the patent population is only slightly lower than that of the other populations.
- The populations have very different baselines at year zero. A low baseline will place a lower demand on turnover at the end of the period in order to achieve a high average growth figure. The high growth figures for the patent population as a whole are an example of this when compared directly to the other populations. However, the number illustrates a clear growth despite the impact measured in monetary terms being significantly lower than for S&E companies.

Figure 22 - **Development in annual work units after company start-up**



Source: Damvad Analytics, based on figures from Statistics Denmark.

Table 8 – **Annual growth in annual work units**

	Annual
Patent companies total	8.82% p.a.
Patent companies without S&E	5.48% p.a.
Science & Engineering total	21.00% p.a.
Science & Engineering with patent	21.42% p.a.
Science & Engineering without patent	20.96% p.a.

Observations:

- Figure 22 and Table 8 show that the S&E start-ups with patents have the largest increase in annual work units in their first thirteenth years of business, and that all the S&E populations have a uniform growth pattern, which deviates from both the total patent population and the patent companies without S&E.

- After 13 years, the typical S&E start-up – regardless of whether they hold any patents – employs 12 full-time equivalents. By comparison, the typical patent company employs three full-time employees.

- Looking at growth in terms of annual work units after start-up, the table shows that S&E start-ups (both with and without patents) have twice the annual growth rate of companies in the total patent population.

- As annual work units are naturally smaller than other key figures, caution must be taken when drawing conclusions, particularly based on individual figures for patent populations.

Secondary conclusions across figures:

- S&E start-ups with patents perform best during their first 13 years of existence on all parameters examined, with the exception of value added where S&E start-ups without patents perform slightly better.

- S&E start-ups with patents have the highest annual growth across all four economic parameters. S&E start-ups without patents have the second-highest annual growth in terms of turnover and annual work units, but lower annual growth measured by value added than the patent population. When observing the high annual growth rates of the typical patent company (and to an extent the typical S&E start-up with patents), it is important to remember that these companies consistently start from a lower baseline than S&E start-ups without patents. It is unclear why the patent-holding populations (S&E start-ups with patents and the patent populations) across several of the figures appear to start from a lower baseline than the S&E population without patents. However, the patent-active companies do appear to have a high annual growth subsequently, which indicates that the patent populations will do well in the long run. As shown in figures 23, 25 and 26, the companies seem to demonstrate a drop in performance in the years leading up to the first patent application. This may account for the lower baseline and may be due to spending extra resources on research, patent applications, etc.

Chapter 7 - **Development of patent-holding companies**

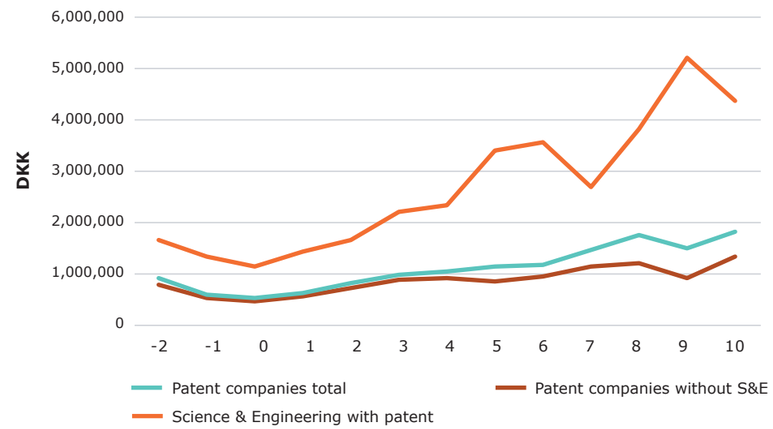
This part of the analysis examines the effect of patents in greater detail. This section will therefore, only include S&E companies with patents and the patent population as a whole. The section examines the growth trajectories after the first patentnapplication, as well as whether companies perform differently depending on whether the patents have been applied for nationally or internationally, and how many patents the company has.

Chapter 7.1 **Development after first patent application**

In this section, the economic performance is examined based on the developments over the years up to and after the first patent application. The growth trajectories serve to map the development of the companies after applying for a patent to see how much the patent application affects the typical company's key financial ratios. The analyses are based on the typical company (i.e. median calculation).

Companies are on average 2.46 years old when applying for their first patent.

Figure 23 - **Development in value added after first patent application**



Source: Damvad Analytics, based on figures from Statistics Denmark.

Table 9 – **Annual growth in value added after first patent application**

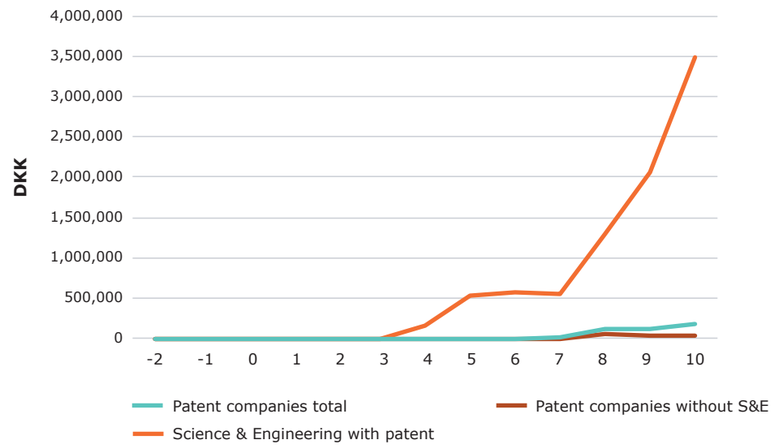
	Value added
Patent companies total	13.05% p.a.
Patent companies without S&E	11.13% p.a.
Science & Engineering with patent	14.42% p.a.

Observations:

- Figure 23 shows that applying for a patent is followed by a positive effect on a company's growth trajectory. While this effect is more pronounced for the S&E population with patents, the value added is also doubled in the total patent population from the year of application to the end of the period.

- The last years of the growth trajectories are subject to uncertainty, especially the S&E population, where there is a reduction in the population.

Figure 24 - **Development in exports after first patent application**



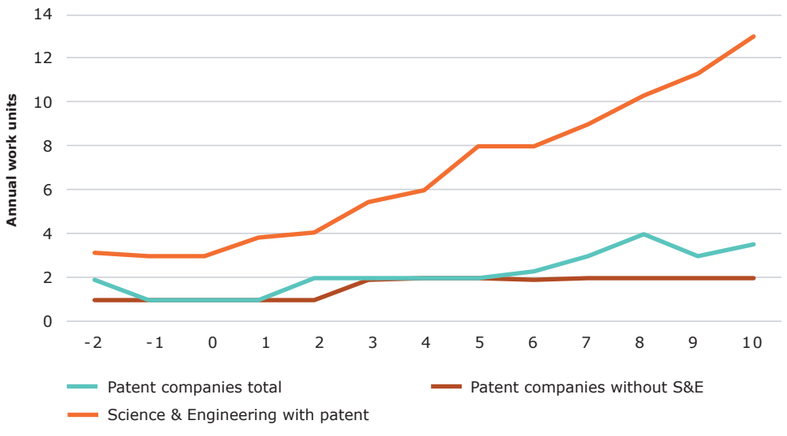
Source: Damvad Analytics, based on figures from Statistics Denmark.

Because of the different starting points for export activity, it does not make sense to calculate annual growth for exports.

Observations:

- Development in exports shows a clear difference in exports between the S&E population with patents and the total population of patent companies. There is only a minimal increase in exports within the patent population as a whole, while significant growth can be seen in the S&E population with patents.
- It is worth noting that all three groups start without exports. S&E start-ups with patents are the first to export and export the most. This can be seen as an indication that patenting is not the only factor playing a role in relation to exports, it seems that the specific combination of patents and the S&E foundation, found in these particular companies, plays a decisive role in terms of exports.

Figure 25 - **Development in annual work units after first patent application**



Source: Damvad Analytics, based on figures from Statistics Denmark.

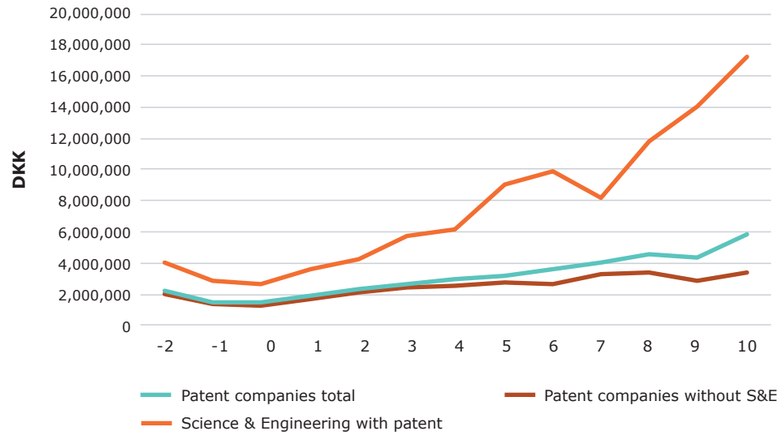
Table 10 – **Annual growth in annual work units after first patent application**

	Annual work units
Patent companies total	13.48% p.a.
Patent companies without S&E	7.18% p.a.
Science & Engineering with patent	15.91% p.a.

Observations:

- S&E start-ups with patents experience a significantly faster growth and become significantly larger than patent companies as a whole.
- S&E start-ups with patents start growing immediately after the patent application.
- The populations experience static development up until the time of the patent application, followed by subsequent growth. This may indicate that the application process is resource intensive for the companies. This pattern is known from previous studies on companies' use of IP rights[20].

Figure 26 - **Development in turnover after first patent application**



Source: Damvad Analytics, based on figures from Statistics Denmark.

Table 11 – **Annual growth in turnover after first patent application**

	Turnover
Patent companies total	15.03% p.a.
Patent companies without S&E	9.84% p.a.
Science & Engineering with patent	20.69% p.a.

Observations:

- The S&E population with patents generates a significantly higher turnover, and growth in turnover begins significantly earlier than for companies in the patent population as a whole.
- A picture emerges of turnover declining up until the first patent application and then increasing sharply (especially for S&E start-ups with patents).
- Although S&E start-ups with patents start at a higher level, these companies have the greatest growth in annual turnover..
- With an annual growth rate of 15.03 pct., the total population of patent companies has three times the turnover at period close compared to the start of the same period.

[20] *See, among others, Intellectual Property Rights Management – Rookies, Dealers, Strategist and Strategic Dealers, Alkærsig, L., Beukel, K. & Reichstein, T.*

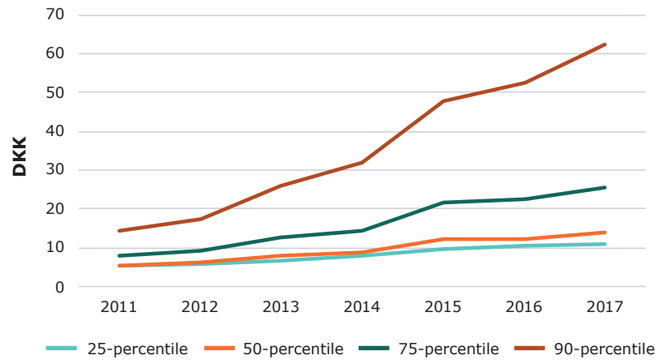
Chapter 7.2 **Effect from individual quartiles**

Previous studies have shown that strategic use of IP rights is crucial to achieving the full value of the rights[21]. This section, therefore, examines whether companies with many patents perform differently from companies with few patents. This is done by looking at percentiles broken down by number of patents. Percentiles are used to reveal how a population is distributed.

The 25th quartile is comprised of the group of companies holding only one patent, while the 90th percentile makes up 10 pct. of the companies with the highest number of patents.

The patent population as a whole was used as a baseline, but it was not possible to separate S&E start-ups.

Figure 27 - **Development in value added per company for quartiles in patent population** [22]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Observations:

- There is a clear correlation between the number of patents and the value added. In other words, the companies with the most patents have the greatest value added.
- To a large extent, the 10 pct. of the companies located in the 90th percentile drive the development of value added in the patent population. This shows a strong correlation between value added and ownership of numerous patents.

Effect of international patent and multiple patents, respectively

The following section looks at whether there is a different effect when dividing the patent population according to whether their patent has been filed internationally or only in Denmark. This division is made based on the assumption that the filing of international patents is a sign that the underlying innovation has a particularly high value. However, only a few companies in the analysis have taken out a patent exclusively in Denmark.

The patent population is further broken down according to whether more than one patent has been taken out. The mean value is used as a basis for calculation in this section.

[21] *Alkærsig, L., Beukel, K. and Reichstein, T. (2015), Intellectual Property Rights Management – Rookies, Dealers, Strategists and Strategic Dealers*
[22] *Figures based on active companies in 2017*

Table 12 – **Number of companies which have applied for an international patent** [23]

	Patent companies (applied internationally)	Patent companies (applied only in Denmark)
Number of companies	1,218	188

Source: Damvad Analytics, based on figures from Statistics Denmark.

Table 13 – **Number of companies with one or more patents** [24]

	Patent companies, single patent	Patent companies, multiple
Number of companies	411	995

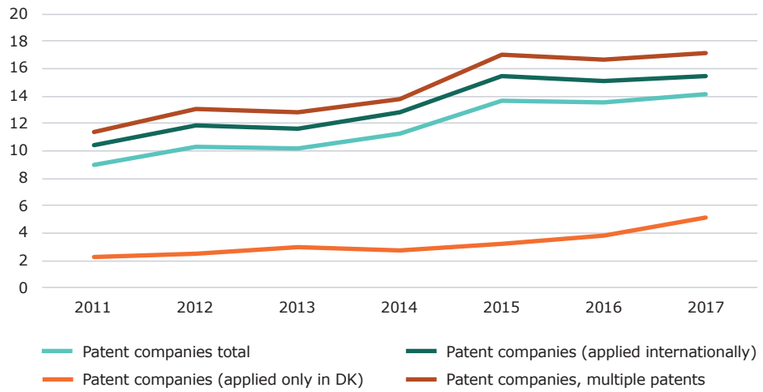
Source: Damvad Analytics, based on figures from Statistics Denmark.

Figure 28 - **Turnover per company with national and international patents**

Source: Damvad Analytics, based on figures from Statistics Denmark.

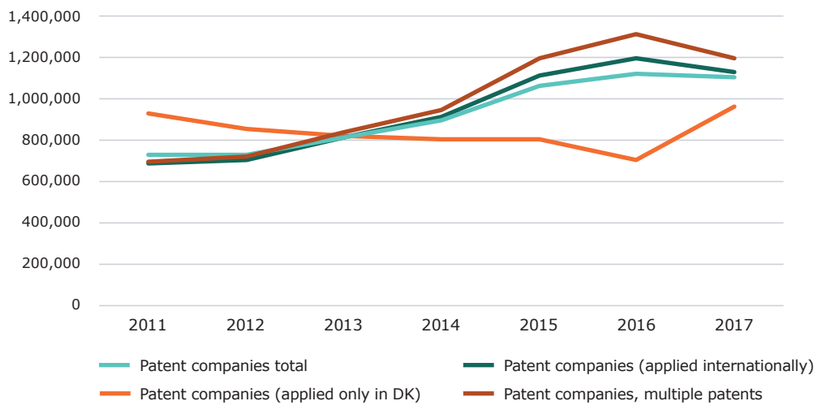
[23] *Figures based on active companies in 2017*
[24] *Figures based on active companies in 2017*

Figure 29 - **Exports per company with international patent** [25]



Source: Damvad Analytics, based on figures from Statistics Denmark.

Figure 30 - **Productivity of companies with international patents** [26]



Source: Damvad Analytics, based on figures from Statistics Denmark.

General observations:

- Across all figures, a picture emerges of companies only taking out a patent in Denmark (orange) clearly performing the worst. However, it is interesting that this particular group ranks at the top at the start of the period regarding productivity, but also takes a dive here, ending up at the lowest rank by the end of the period.
- Companies with multiple patents (dark red) make the biggest impact.
- In the figures for exports per company, it is clear that companies without a foreign patent export significantly less than the other groups. This makes perfect sense, as companies without exports will have limited incentive to obtain rights internationally.

[25] *Figures based on active companies in 2017*
[26] *Figures based on active companies in 2017*

Chapter 8 - **Background and method**

In May 2019, the Danish Academy of Technical Sciences published the report *Denmark's New Growth Layer*, which is an analysis of the development and significance of younger[27] S&E start-ups for the Danish economy. The analysis shows the great impact of S&E start-ups (companies established after 2000) on the Danish economy and compares their pattern of development with other companies of the same age. The growth layer analysis concludes that S&E start-ups perform better than other types of start-ups on all key parameters. They employ more people, they grow faster, realise greater turnover, contribute more to GDP, and they export earlier and at a greater level than peer start-ups. In addition, the analysis shows a correlation between knowledge intensity in the form of concentration of STEM competencies and employees with a PhD education and the companies' growth and impact on the economy.

At the same time, several European studies show that companies with IP rights perform significantly better than companies without IP rights with regard to factors such as turnover, growth, and number of employees. For example, two reports from EUIPO (2015 and 2019) have shown that companies with intellectual property rights have a 29 pct. higher turnover per employee than companies without IP rights, just as SMEs with IP rights have a 21 and 10 pct. greater chance, respectively, of becoming growth or high-growth companies compared to SMEs without IP rights 28.

As such, the Danish Academy of Technical Sciences and the Danish Patent and Trademark Office have had a common interest in analysing which role patenting plays in the growth and development of knowledge-intensive start-up companies. This was done by comparing companies in the S&E start-up population with and without patents and by comparing all Danish start-ups with patent rights against start-ups in industry and business community in general.

Focus of the analysis:

- **Determination of what percentage of S&E start-ups have patents.** The patent companies are correlated with the population of S&E start-ups, whereby the degree of overlap between the populations is identified.
- **Characteristics** of the companies (age, size, geography, industries, employee composition).
- **Economic effect.** The companies' impact on the economy (productivity, exports, turnover, value added).
- **Development.** Company growth trajectories after start-up year and year of obtaining first patent, respectively.

The data work was carried out by consulting firm Damvad Analytics on the basis of anonymised data from Statistics Denmark and the Danish Patent and Trademark Office. The Danish Academy of Technical Sciences and the Danish Patent and Trademark Office then jointly analysed the results and drew up the report.

[27] *Younger companies has been limited to companies established from 2000 onwards.*
[28] *https://euipo.europa.eu/ohimportal/documents/11370/80606/Intellectual+property+rights+and+firm+performance+in+Europe and https://euipo.europa.eu/tunnel-web/secure/webdav/guest/document_library/observatory/documents/reports/2019_High-growth_firms_and_intellectual_property_rights/2019_High-growth_firms_and_intellectual_property_rights.pdf*

The following populations are included in the analysis.

- **Patent companies.** Includes companies established since the year 2000 which have taken out at least one patent. In some sections of the analysis, this group is subdivided further by whether the companies have taken out one or more patents, and whether the companies have only taken out Danish patents or also internationally ones.
- **S&E start-ups.** Includes companies meeting the criteria of being considered Science & Engineering companies established since the year 2000.
- **S&E start-ups with patents.** Includes companies from the S&E growth layer, which have taken out at least one patent. This is therefore an intersection of S&E start-ups and the patent population as a whole.
- **Industry/business community as a whole.** Patents or patents or populations were added as benchmarks and reflect all industrial companies and the business community as a whole since 2000.

A note on the method - mean and median

Several of the populations in the analysis are relatively small, though fairly diverse at the same time. This presents some challenges in relation to how the economic impact of the populations is best determined. The analysis, therefore, uses both mean (simple mean) and median as a basis for calculation, as this is considered to give the most nuanced picture.

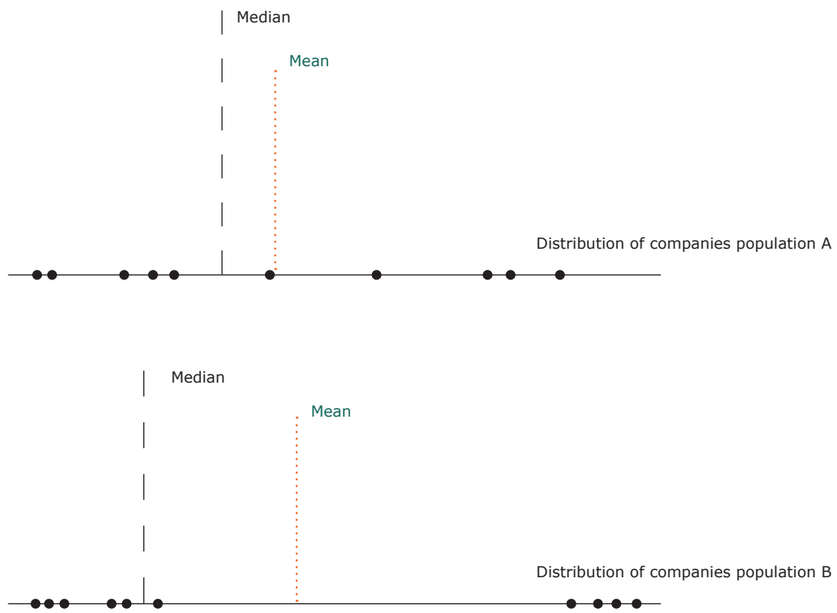
Figure 31 illustrates the difference in basing the analysis on mean vs median calculations when the distribution of the companies included in the population is very different. For S&E start-ups, for example, there are indications of a group of companies with very high levels of export activity raising the mean value. However, the significance of companies with high levels of export activity will become less clear when the median is used as a basis for calculation.

The two bases for calculation each have their own advantages. The mean value is appropriate for deriving information about the overall impact of a company population, while the median is better for understanding the typical company within the population.

In Chapter 5 both mean calculations and median calculations are used, while Chapter 6, which examines the "typical" growth trajectories of the companies, uses median calculations exclusively. With a register analysis like this it is possible to make statements about overall impact, general features, and typical growth patterns. It is not, however, possible to uncover all the nuances concealed behind the various populations and categorisations.

With the data extractions included in this analysis, Damvad has, to the greatest extent possible, ensured that the populations observed are not "contaminated" with old/established companies having registered a new CVR number, thus making them seem like a new company, when they are actually part of an older/larger company. The analysis is therefore considered to be based on a solid and qualified data set.

Figure 31 - **Comments on mean and median**



DANISH PATENT AND TRADEMARK OFFICE

Taastrup
Helgeshøj Allé 81
2630 Taastrup
(Mailing address)

Ikast
Finsensvej 1F
7430 Ikast

Tel. 43 50 80 00
pvs@dkpto.dk
www.dkpto.dk

ATV

Danish Academy of Technical Sciences
Frederiksholm Kanal 30
1220 Copenhagen K

Tel. 45 88 13 11
atvmail@atv.dk
www.atv.dk