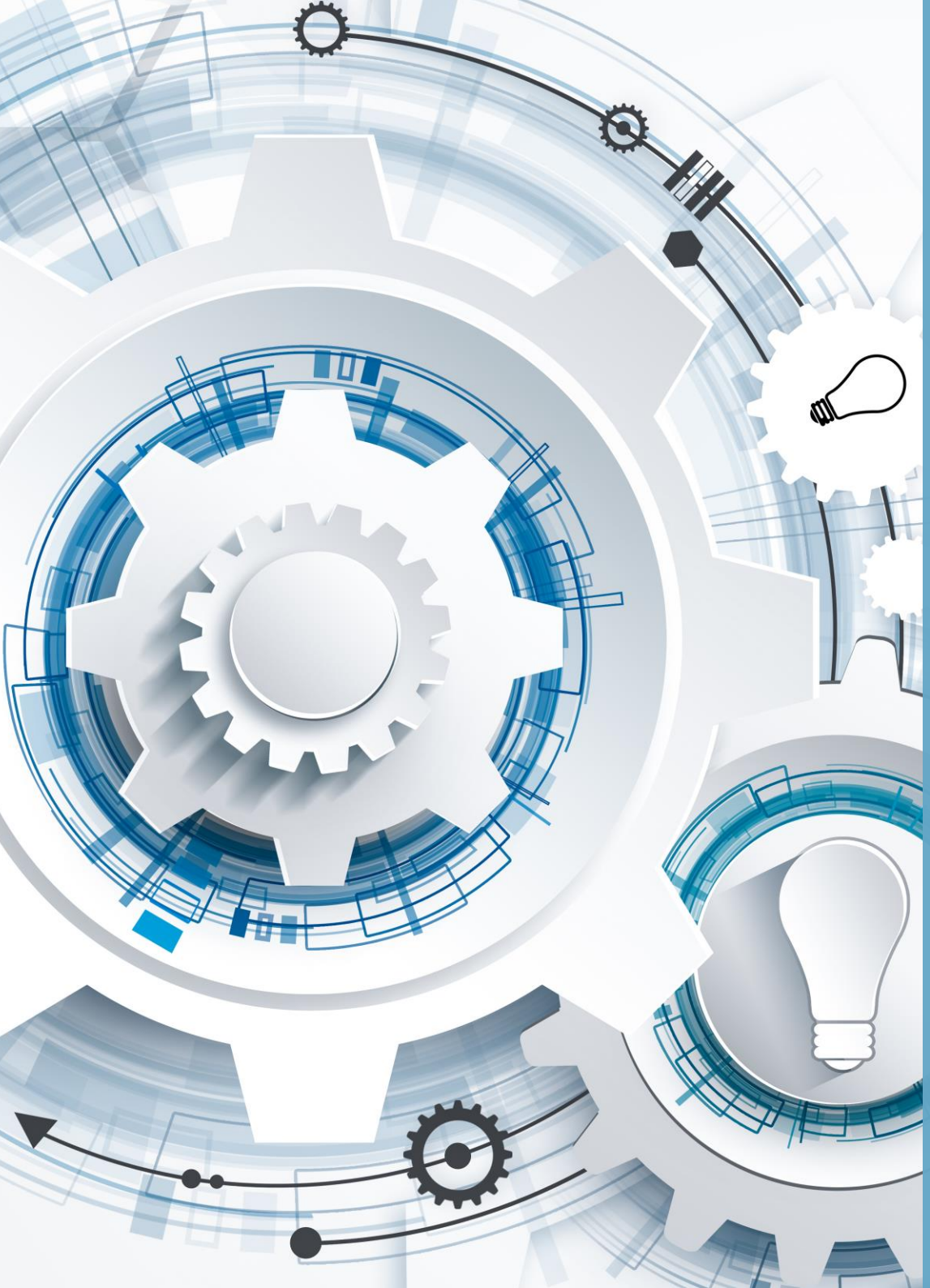

Literature review and assessment of the Danish knowledge-based innovation support system

Prepared for the Danish Ministry of Higher Education and Science

November 2018

IRISgroup

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1. Introduction

1.1. Background

In December 2017, the Danish Government published its research and innovation strategy, *Denmark – Ready to Seize Future Opportunities*, outlining its goals and objectives for future research and innovation policy.

The strategy required the Danish Ministry of Higher Education and Science to set up an international panel of experts. The panel was asked to determine how Denmark's efforts in knowledge-based innovation rank among the global elite. It was also expected to support stakeholders to work effectively and in close cooperation towards common overall objectives.

The panel of experts is tasked with reviewing the Danish knowledge-based innovation support system as a whole, including the value chain from research to innovation in established and new companies. Drawing on this review, the panel will make recommendations on ways in which Denmark can strengthen its public policy efforts in areas including I) Knowledge-based technological service for businesses, II) Collaboration, networking and matchmaking, and III) Knowledge-based entrepreneurship.

The present literature review, conducted by IRIS Group for the Danish Ministry for Higher Education and Science, provides background material for the international expert panel.

The literature review examines current knowledge and assessments of the Danish knowledge-based innovation support system. The aim is to develop a broad picture of findings across existing literature on the Danish knowledge-based innovation support system as a whole.

To make the most of large public and private investments in research and innovation, the knowledge-based innovation support system needs to be efficient and act as an integrated part of the whole innovation ecosystem. It is therefore vital to think of the framework of the Danish knowledge-based innovation support system as one that is closely connected with the educational system and the public business promotion system.

In May 2018, the Danish Government concluded a political agreement to reform the public business promotion system. The reforms will introduce changes to parts of the public framework involved in knowledge-based innovation from January 2019. Among other things, state funds to the innovation incubators will be phased out in 2019, and a new model supporting knowledge-based entrepreneurship is to be developed in Innovation Fund Denmark in cooperation with universities. The number of publicly funded national innovation networks will also be gradually reduced.

1.2. Executive summary

PART I: THE KNOWLEDGE-BASED INNOVATION SUPPORT SYSTEM IN DENMARK

Part I (Sections 2-4) provides an overview of the knowledge-based innovation support system in Denmark covering focal areas, key institutions, and programmes and user profiles of the different programmes, as well as innovation performance indicators.

Section 2 presents a graphical summary of the innovation system and introduces the different parts of the system – the Danish business sector, the research institutions, and key programmes and instruments facilitating knowledge-based innovation, entrepreneurship and collaborative research.

Section 3 focuses on the users of the programmes and instruments available in the innovation system. Many companies, including small and medium-sized enterprises (SMEs), have connected with the system. The Danish Research and Technology Organisations (*the GTS system*) and the *Innovation Networks* have especially many users. The section also reveals that engagement with the system is unevenly distributed across sectors and company sizes, and that participation is markedly higher in some universities than others.

Results from recent *impact analyses* are also summarised. These analyses indicate that use of the main programmes and instruments in the system is associated with higher levels of innovation, growth and increased productivity among the participating companies.

Section 4 looks at indicators of the general performance of the Danish knowledge-based innovation support system. The section shows that levels of private research and development (R&D) spending have increased in Denmark, but also that R&D expenditures have been more concentrated on fewer and larger companies.

The share of innovative companies has been broadly constant during the last few years and is at a modest level relative to other OECD countries. However, Denmark is ranked among the top-performing countries on the EU´s Innovation Scoreboard. Closer scrutiny reveals that Denmark is performing better on indicators measuring conditions for innovation than it is on indicators measuring actual levels of innovation in the private sector.

PART II: STRENGTHS, WEAKNESSES AND LINKS IN THE KNOWLEDGE-BASED INNOVATION SUPPORT SYSTEM

In Part II (Sections 5-8), we present conclusions from recent analyses and publications examining the trends, strengths, weaknesses and links in the knowledge-based innovation support system in Denmark. The aim is to synthesise recent findings on the functioning, effectiveness and user-friendliness of the different parts of the innovation system.

Section 5 focuses on collaborative research and innovation. The section opens with an overview of national innovation policy over recent years. It explains that the two principal goals have been 1) to develop solutions to societal challenges which have been identified as having strong business potential, and 2) to increase the number of companies collaborating with knowledge institutions.

The first of these goals is addressed in the “Grand Solutions” programme. A preliminary evaluation of the programme shows promising results.

The second goal has also, to some extent, been successfully addressed, since the share of companies collaborating with higher education institutions (HEIs) has increased by 25%.

1.2. Executive summary

The universities and their strategies for innovation and business collaboration are a decisive element in the innovation system. The section concludes that the focus on the innovation agenda by senior university managers has increased considerably over the last 5-10 years. Similarly, the number of full-time employees (FTEs) in central functions for innovation and the commercialisation of research has increased. Some universities have also introduced tools designed to incentivise researchers to engage in collaborative research and innovation.

The analyses also conclude that more can be done, however. Formal acknowledgement of researchers and criteria for the promotion and hiring of researchers still focus on research performance alone. None of the universities make use of parallel career tracks. Furthermore, the degree of sector mobility (researchers moving from private research labs to universities and vice versa) is low.

The analyses also conclude that most of the increase in collaborative research and innovation over the last few years concerns long-term projects making a high demands on the research competence of participants. The growth in other types of business-university relation has been modest, except in student projects conducted in businesses. Furthermore, only one university has developed specific goals for collaborating with SMEs.

The Innovation Networks play a crucial role in bridging company needs and the knowledge and expertise in higher education institutions. And they work intensively on matchmaking and the development of collaborative projects.

Participation in the networks has increased considerably and almost doubled between 2011 and 2016. More than a third of the participating companies have established collaborations with higher education institutions as a result of their participation.

The networks do, however, face challenges, especially when it comes to the participation of researchers. All universities are engaged in the networks, but awareness of the networks is limited among scientists other than those already participating. A noticeable skewedness also emerges: there are very high levels of participation in a couple of universities and by senior researchers, as apposed to other universities, junior scientist and students.

Section 6 focuses on efforts to foster knowledge-based entrepreneurship in Denmark. Drawing on a literature review, the section concludes that while the level of spinouts from universities is somewhat disappointing, recent years have also been characterised by growing entrepreneurial activity at the higher education institutions in general. During the last few years, Danish universities have devoted a great deal of time and resource to the development of better ecosystems for start-ups (i.e. courses in entrepreneurship, events, incubators for students and research-based companies, advisory services, etc.). Student entrepreneurship, especially, has received increased attention. This has resulted in an increase in the number of students, candidates and university employees who start new companies.

The challenge within knowledge-based entrepreneurship is to create a greater number of scale-ups and potential “unicorns”. It seems that the ecosystem for entrepreneurship in Denmark still struggles to develop specialised services and framework conditions capable of supporting companies with high growth potential.

1.2. Executive summary

Section 7 summarises conclusions from recent publications on the functioning and prospects of the GTS system (knowledge-based technological services). Annually, the seven Danish GTS institutes help to boost innovation and/or technology implementation in 16,000 Danish companies, of which 65% are small businesses (fewer than 20 employees).

More than 50% of users state that the services enhance their innovation capacity, and the section reveals that GTS institutes play an important role in all parts of the innovation chain – from research to market.

The section also emphasises that development of technological services within the GTS system is based on participation in R&D projects of the kind facilitating the development of new services and approaches to technology diffusion. A key point is that levels of R&D expenditure in the GTS system have decreased over the last few years, largely as the result of increased competition for external funding. Moreover, micro companies are underrepresented in the R&D projects organised by the GTS institutes.

Finally, **Section 8** focuses on access to funding, and how well the funding programmes fit the needs of their target groups.

The section shows that lack of knowledge about programmes is the most common reason for not making use of the knowledge-based innovation support system. On the other hand, there is no evidence of major gaps in the funding system.

The section does, however, point to a problem with administrative "silos" in which there is a tendency for operators to refer to programmes administered by the same authorities as themselves.

1.3. Approach

The report is based on a thorough review of recent publications dealing with the knowledge-based innovation support system in Denmark. Approx. 50 publications were selected in collaboration with the Danish Ministry of Higher Education and Science (MHES) to ensure that all relevant publications were included. A comprehensive list of the publications can be found at the back of the presentation.

Publications were selected and prioritised so that most attention was given to:

- Publications concerning MHES and its affiliated operators and programmes
- New publications describing programmes and schemes as they are today
- Publications focusing on links, overlaps and gaps in the innovation system
- Publications focusing on user profiles and user experience

The publications comprise:

- Innovation Policy strategies and strategies for specific parts of the system
- Broader analyses of the functioning and impacts of the knowledge-based innovation support system
- Evaluations and impact analyses of specific programmes/schemes
- Analyses focusing on specific sectors and clusters, and their needs in relation to innovation policy

The review does not include academic articles. Attempts were made to identify academic articles in the preliminary desk research, but no published articles dealing with the functioning and impacts of the present knowledge-based innovation support system in Denmark were identified.

During the initial reading of the publications, conclusions and key findings relating to the purpose, function, results and impact of the various parts of the Danish innovation system, as well as the system as a whole, were extracted and noted in a predefined template. After the reading, the results and conclusions were thoroughly examined and compared in detail.

The account of the knowledge-based innovation support system in Denmark presented in the first part of the report is based not only on the literature review, but also on the latest available data from databases, web pages, and the like.

PART I

THE KNOWLEDGE-BASED INNOVATION SUPPORT SYSTEM IN DENMARK

2. Outline of the knowledge-based innovation support system in Denmark

2.1. The knowledge-based innovation support system in Denmark

The knowledge-based innovation support system in Denmark has five main components, or focal areas:

1. Collaborative research and innovation
2. Knowledge-based entrepreneurship
3. Knowledge-based technological service
4. Financing
5. Networks and matchmaking

The figure on the next slide presents an overview of the knowledge-based innovation support system in Denmark. With the users of the system in the centre, the inner circle contains four of the focal areas, while the white boxes show the most important operators relating to each function. Innovation Networks, as well as cluster organisations, are important operators in facilitating access to all parts of the system and are therefore shown in the ring around the inner circle.

It is important to emphasise that the operators in the white boxes also participate to some extent in other parts of the system. For instance, the universities are central in facilitating knowledge-based entrepreneurship. The suppliers of financing instruments are also engaged in collaborative projects as investment managers, and in developing ecosystems for entrepreneurship. Thus, the positions of the operators in the figure reflect their primary functions.

It should also be mentioned that, as in most countries, broader public support for businesses in Denmark also includes organisations at both local and regional level. These organisations are not included in the figure, but they play an important role in supplying information to the knowledge-based innovation system and in guiding companies to the right programmes and collaborative partners (see also Section 8).

In the figure, operators financed by the Ministry of Higher Education and Science (MHES) are shown in **bold text**, with the number of operators within each category recorded in brackets.

Subsequent pages present details of the operators and programmes in the Danish knowledge-based innovation system. First, we show key quantitative data on its target group: the Danish business sector. These include data on size, productivity, human capital, automation and R&D expenditures. Then we map the research institutions in Denmark, noting individual research budgets and numbers of students enrolled in each institution. Finally, we profile the operators and present an overview of financing instruments in the innovation support system.

In examining the operators financed by MHES, we apply a systematic approach in which each initiative is described with regard to its purpose, total budget and financing (2018), main target groups and/or criteria for participation, key services and/or supported activities, with a listing of individual operators.

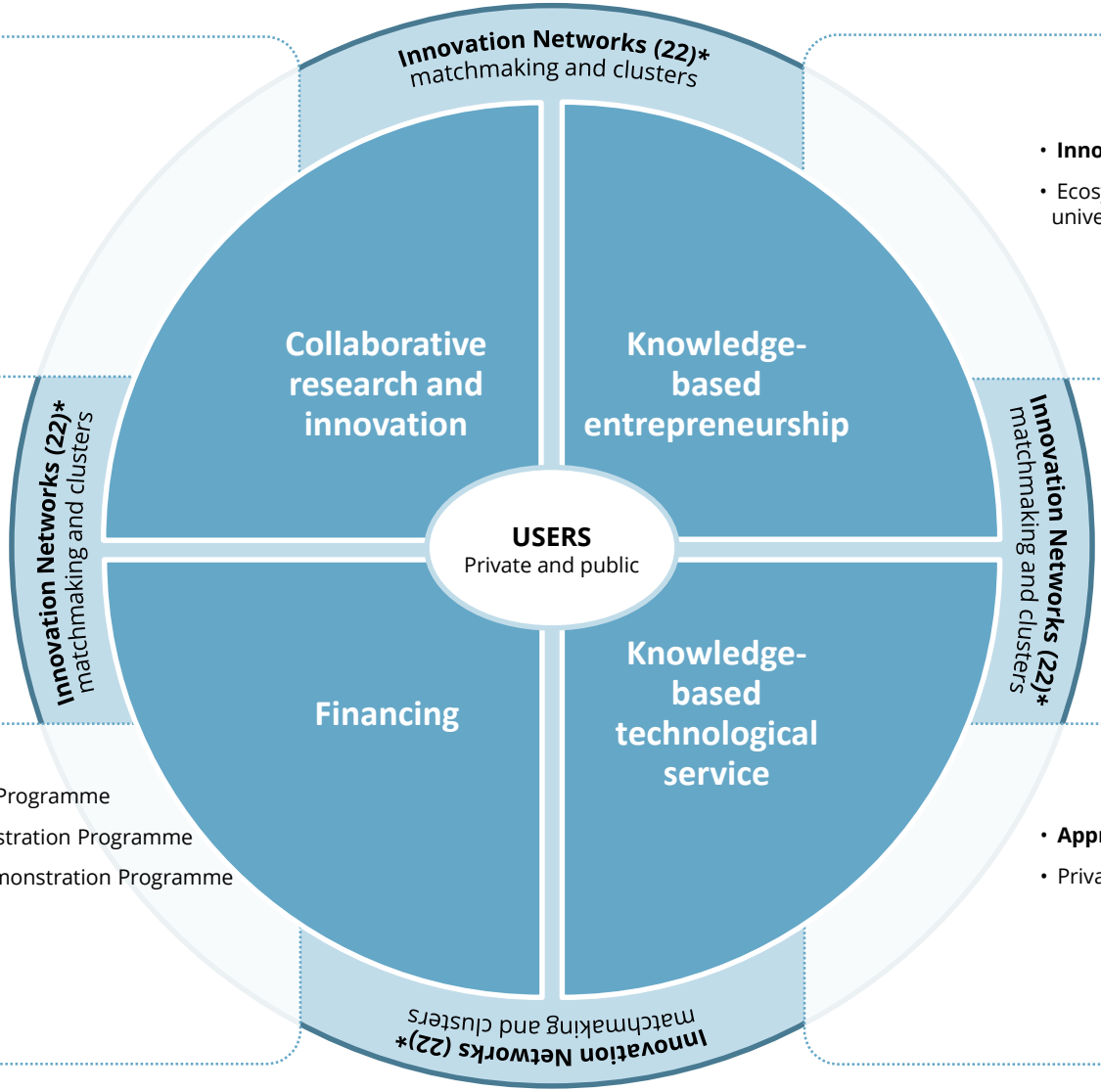
Keep an eye on the tracker

The remainder of the report is structured around the figure presented on the next page.

Each section of the report relates to a specific part of the innovation system. The part in question is marked with a red circle in the tracker located in the upper-right corner of the page.

2.1. The knowledge-based innovation support system in Denmark

- **Universities (8)**
- **University colleges (7)**
- **Business academies (8)**
- **Schools of marine engineering (5)**
- **Academies of art (3)**
- **Approved RTOs (7)**



- **Innovation incubator operators (4)****
- Ecosystems for entrepreneurship at the universities

- **Innovation Fund Denmark/MHES**
- Green Development and Demonstration Programme
- Environmental Development and Demonstration Programme
- Energy Technology Development and Demonstration Programme
- Private funds
- Danish Regions***
- International programmes
- *Tax deduction schemes*

- **Approved RTOs (7)**
- Private technology consultants

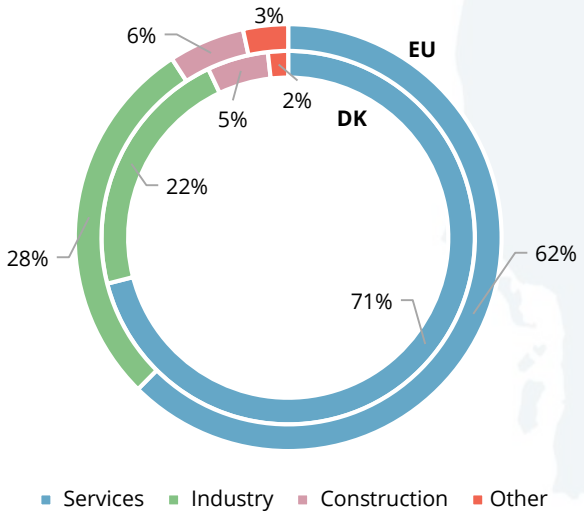
* *The number of Innovation Networks will be reduced from 22 to 17 in 2019.*
** *The Innovation incubator operators will be phased out from 2019. Tasks will be transferred to the Innovation Fund Denmark and the Growth Fund.*
*** *The role of the Danish Regions will be modified as a consequence of the political agreement to reform the public business promotion system (see Section 1.1.).*

2.2. The Danish business sector at a glance

The figures show that:

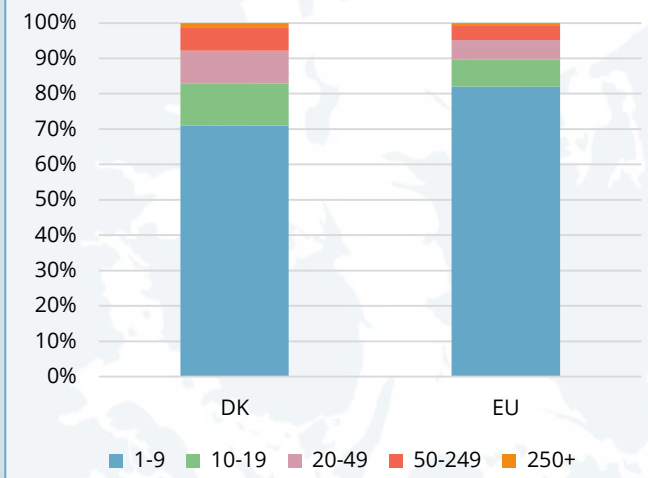
- The service sector in Denmark is larger than the EU average, but the EU has a larger share of employees in industrial jobs.
- Denmark has a larger share of companies with 10-49 employees than the EU average, which in turn has a larger share of micro companies (<10 employees). The share of large companies (+250 employees) in Denmark equals the EU average (1%).
- Denmark is the 5th most productive country in the world. Productivity is considered a central driver of long-term economic growth and living standards.

Sector distribution of private employees (2017)



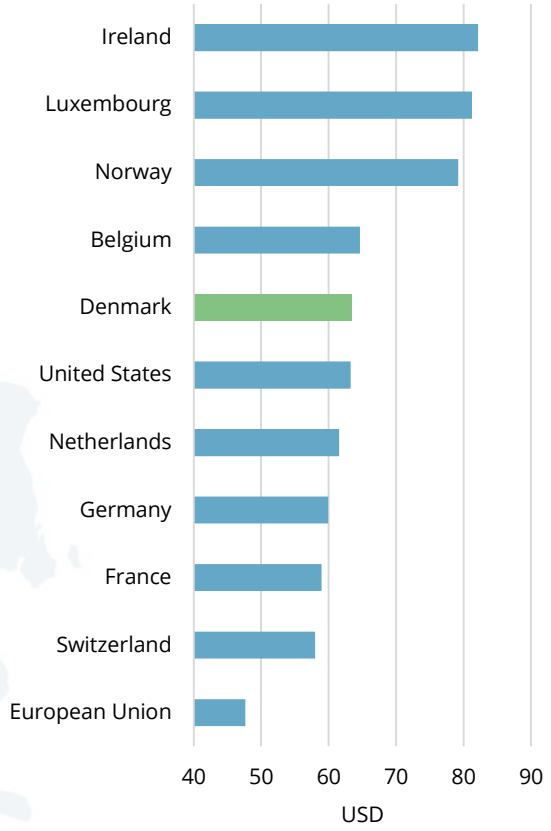
Source: OECD (online database)
Note: The indicator "Employment by activity" is used to calculate the figure.

Private companies by number of employees (2015)



Source: OECD (online database)
Note: The indicator "Enterprises by business size" is used to calculate the figure.

Productivity - GDP per hour worked
Top 10 countries and EU (2016)



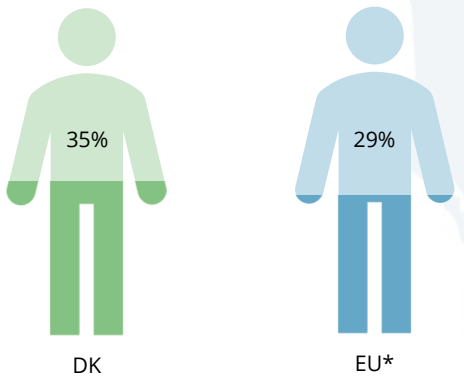
Source: OECD (online database)
Note: The OECD Compendium of Productivity Indicators is used to calculate the figure. Productivity is measured in USD, constant prices, 2010.

Human capital and automation in the Danish business sector

The figures show that:

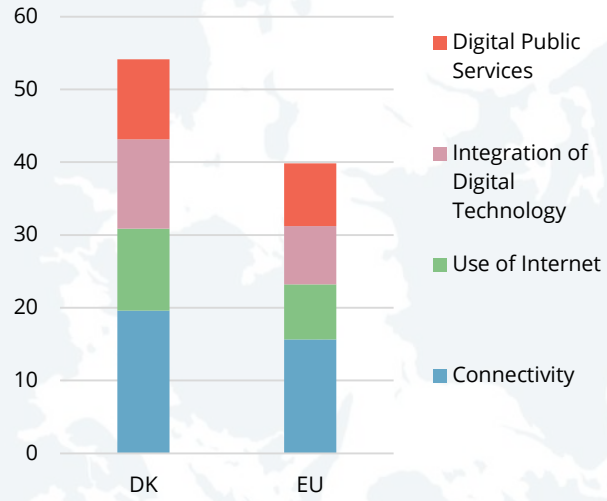
- The percentage of the working age population with a higher education is slightly higher in Denmark than the EU average.
- Denmark is more digitalised than the EU on average, and is, in fact, the most digital economy and society in the world according to the European Commission Digital Scoreboard.
- Denmark is among the top 10 most automated countries in the world with 211 installed industrial robots per 10,000 employees in the manufacturing industry (world average is 74).

Share of working age population with a higher education (2017)



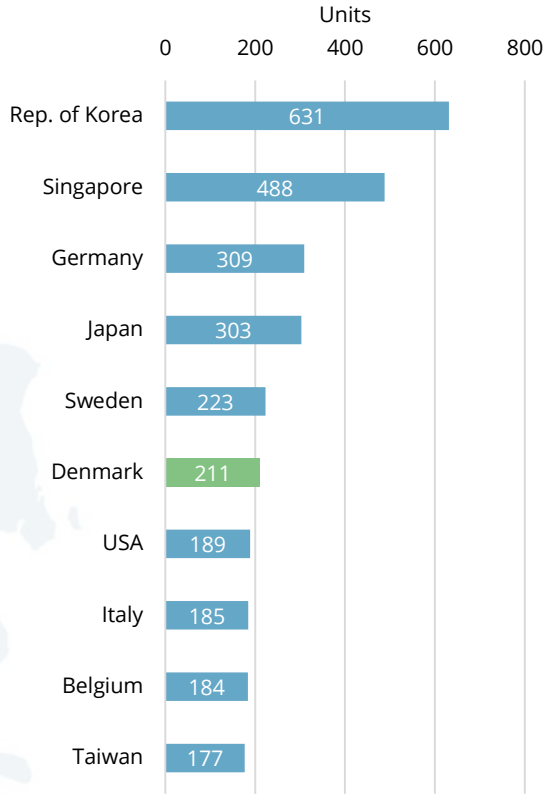
Source: OECD, 2018
*Note: Working age population defined as 25-64 year-olds. Higher education comprises a bachelor's degree or equivalent education level, a master's degree or equivalent education level, or doctoral degree or equivalent education level. *EU member countries except Bulgaria, Croatia, Cyprus, Lithuania, Malta, Romania.*

Level of digitalisation (2018)



Source: European Commission (online database)
Note: The European Commission Digital Scoreboard is used to calculate the figure. The four dimensions that comprise the index are calculated as the weighted average of a number of sub-dimensions (see the European Commission Digital Scoreboard for details).

Number of installed industrial robots per 10,000 employees in the manufacturing industry (2016)

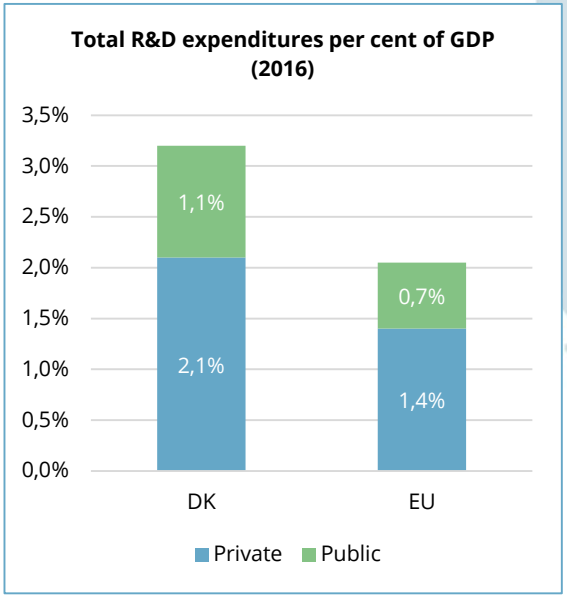


Source: International Federation of Robotics, 2017
Note: The figure shows the top 10 most automated countries in the world. The survey covered 44 countries.

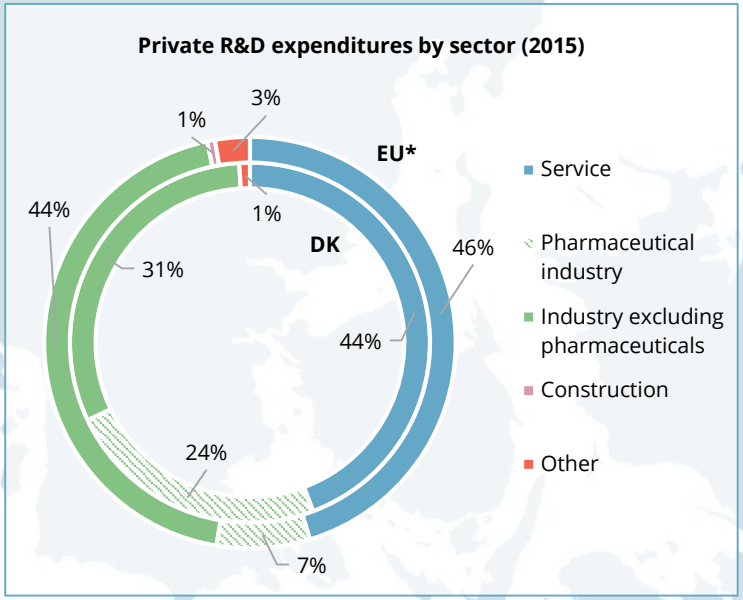
R&D in the Danish business sector

The figures show that:

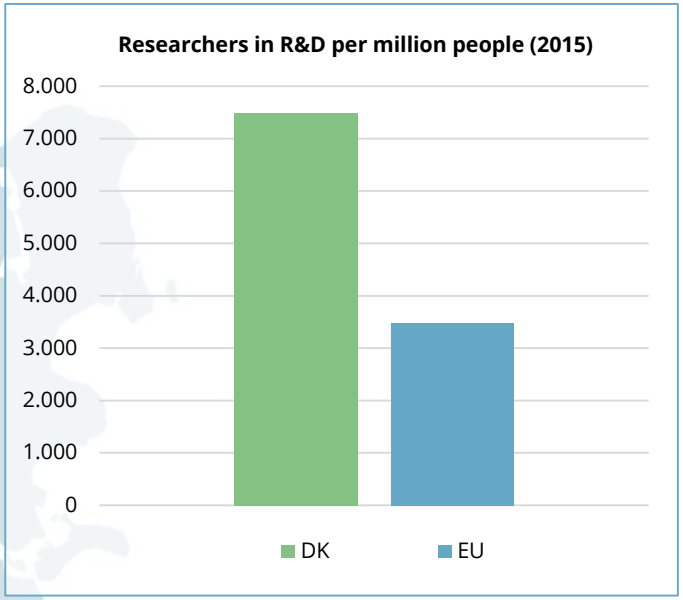
- In 2016, Denmark spent 3.2% of its GDP on research and development (R&D), while the EU average was 2.1% of GDP. In 2016, the total R&D expenditures reached DKK 66 billion, of which DKK 42.9 billion where private expenditures and DKK 23.1 billion where public expenditures (DST, 2018).
- The share of R&D expenditure spent by the pharmaceutical industry is more than three times as big in Denmark than the EU average.
- Denmark has more than double the number of researchers in R&D per million people than the EU average.



Source: Eurostat (online database); DST, 2018.
Note: EU data is provisional. Eurostat online data code: rd_e_gerdtot.

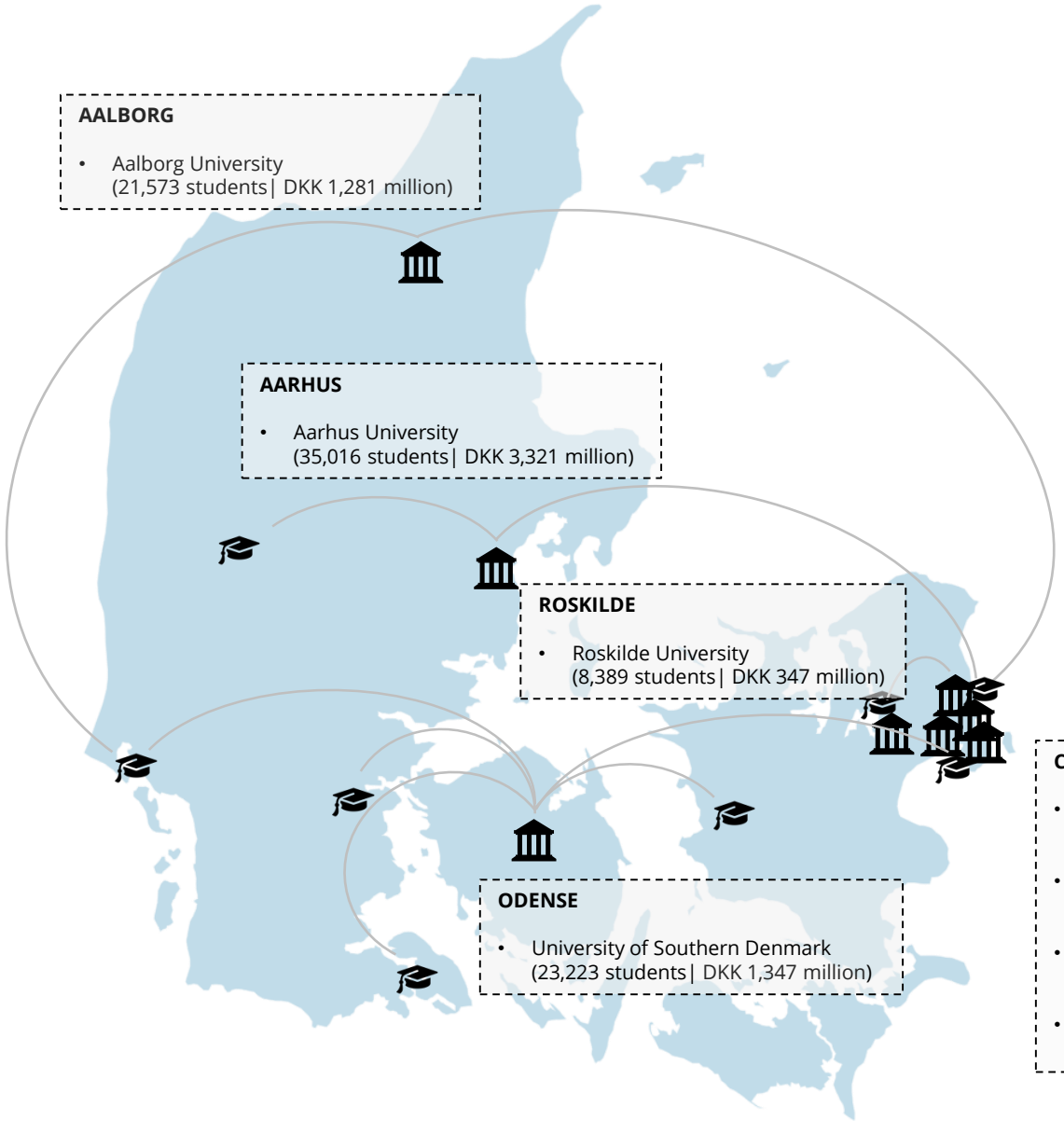


Source: OECD (online database)
*Note: The indicator "Business enterprise R&D expenditure by industry" is used to calculate the figure. *EU member countries except, Bulgaria, Croatia, Cyprus, Hungary, Latvia, Lithuania, Luxembourg, Malta and the Netherlands. France data from 2013, and other data 2015.*



Source: The World Bank (online database)
Note: The indicator "Researchers in R&D (per million people)" is used to calculate the figure. The number of researchers engaged in R&D is expressed as number per million Researchers are professionals who conduct research and improve or develop concepts, theories, models, techniques, instrumentation, software used in operational methods. R&D covers basic research, applied research, and experimental development.

2.3. Universities in Denmark



The map shows the location of Denmark's eight universities and their affiliated campuses.

In brackets, the number of students enrolled and the size of the research budget (2017) is shown for each institution.

Students are located on all campuses, while most research takes place on the eight main campuses.

Main campus

Major satellite campus

COPENHAGEN

- University of Copenhagen
(42,104 students| DKK 4,906 million)
- Technical University of Denmark
(12,537 students| DKK 3,306 million)
- Copenhagen Business School
(14,971 students| DKK 465 million)
- IT-University of Copenhagen
(1,854 students| DKK 107 million)

Source: MHES

2.3. Other higher education institutions in Denmark

FREDERIKSHAVN
- MARTEC
(622 students| DKK 1 million)

AALBORG
- University College of Northern Denmark
(9,282 students| DKK 39.9 million)

RANDERS
- Dania Academy
(2,204 students| DKK 4 million)

HERNING
- Business Academy of Higher Education MidtWest
(764 students| DKK 1.6 million)

FREDERICIA
- Fredericia School of Marine Engineering
(574 students| DKK 1 million)

ESBJERG
- University College South Denmark
(6,506 students| DKK 37.7 million)
- EA Business Academy SouthWest
(1,377 students| DKK 1.6 million)

KOLDING
- IBA International Business Academy
(1,450 students| DKK 3.3 million)
- Design School Kolding
(362 students| DKK 18.1 million)

AARHUS
- Danish School of Media and Journalism
(2,004 students| DKK 2.8 million)
- VIA University College
(20,232 students| DKK 114.1 million)
- Business Academy Aarhus
(4,825 students| DKK 7.8 million)
- Aarhus School of Architecture
(761 students| DKK 23.3 million)
- Aarhus School of Marine and Technical Engineering
(914 students| DKK 2 million)

ODENSE
- University College Lillebaelt
(11,508 students| DKK 53.1 million)

SVENDBORG
- SIMAC
(780 students| DKK 2 million)

SORØ
- University College Absalon
(8,233 students| DKK 35.3 million)

KØGE
- Zealand Institute of Business and Technology
(3,568 students| DKK 4.1 million)

COPENHAGEN
- University College Copenhagen
(20,595 students| DKK 108.9 million)
- Copenhagen Business Academy
(5,919 students| DKK 13 million)
- The Copenhagen School of Design and Technology
(5,350 students| DKK 11.7 million)
- The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation
(1,593 students| DKK 47.9 million)
- Copenhagen School of Marine Engineering and Technology Management
(827 students| DKK 1.6 million)

The map shows the location of Danish university colleges, business academies, schools of marine engineering and academies of art. Only institutions with a research budget are included. University colleges and academies of professional higher education have regional educational obligations, and thus additional campuses strategically located in the region of the institutions (not shown).

In brackets, the number of students enrolled and the size of the research budget (2017) is shown for each institution.

Most research in Denmark takes place at the eight universities (see previous page). The institutions presented on this page account for less than 5% of the total research budget. These institutions focus mainly on education.

Source: MHES

2.4. Knowledge-based entrepreneurship

Innovation incubator operators

Introduction

On behalf of the Danish government, four Innovation incubator operators ("Innovationsmiljøer") provide professional counselling, pre-seed and seed funding for entrepreneurs and new, knowledge-based companies. In legal terms, the Innovation incubator operators are private limited companies approved by MHES.

Purpose

To invest risk capital on behalf of the Danish government in order to provide capital (up to DKK 6 million) to knowledge-based start-ups at the earliest stage of the investment chain where private investors are reluctant to engage.

Total budget and financing

The four operators are financed by a national budget grant of approx. DKK 200 million annually (SIU, 2017c).

Main target group

Entrepreneurs and researchers planning to establish a company based on knowledge-intensive business ideas. Every year, the four Innovation incubator operators invest in approx. 60 new companies of which 40% originate from a research institution.

Key activities

Innovation incubator operators can engage financially in three successive stages:

1. A preliminary analysis and evaluation of the technological perspectives and commercial potential of the project (due diligence). On average, an amount of DKK 80,000 can be allocated at this stage.
2. Pre-seed funding for the initial capital injection and early-stage development activities in the start-up. On behalf of the government incubators can, at this stage, invest a maximum of DKK 3.5 million in loans or equity, provided that a supplementary private investment is raised equalling 18% or more of the total primary investment.
3. Seed funding for further development activities. On behalf of the government the incubator can, at this stage, invest a maximum of DKK 2.5 million in loans or equity, provided that a supplementary private investment is raised equalling 60% or more of the total secondary investment.

Individual operators

- PreSeed Ventures A/S
- Syddansk Innovation A/S
- CAPNOVA A/S
- Borean Innovation A/S

Innovation incubator operators will be phased out from 2019

As part of the political agreement to reform the public business promotion system in Denmark, it has been decided that the Innovation incubator scheme will be phased out from 2019. Initiatives to support early stage knowledge-based start-ups will be embedded in Innovation Fund Denmark (IFD) and the Growth Fund (read about the reform in Section 1.1).

2.4. Knowledge-based entrepreneurship

Ecosystems for entrepreneurship at the universities

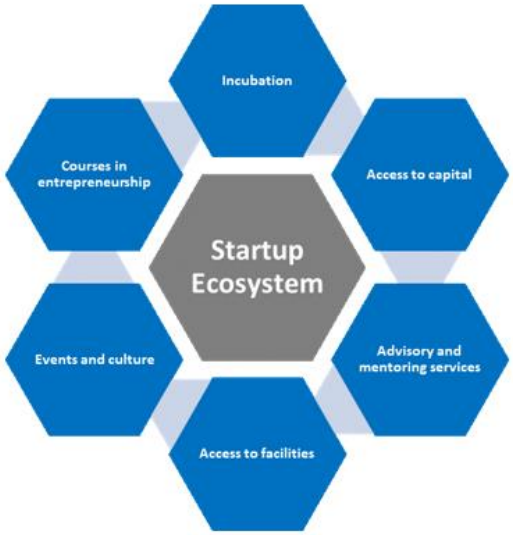
The Danish universities and partners located at the university campuses (or in proximity) supply a number of services to entrepreneurs and potential entrepreneurs, such as incubators, advisory services, facilities, training, funding opportunities, matchmaking services, etc.

As in most other countries, these "ecosystem for entrepreneurship" varies from region to region and from university to university (see also Section 6), and thus it makes no sense to give a general presentation of the ecosystem for entrepreneurship in Denmark. But the following summarises important aspects of the ecosystems:

- All Danish universities have established technology transfer offices (TTOs) tasked with 1) scouting, patenting and commercialisation activities, 2) providing counselling to researchers wishing to commercialise research with promising prospects.
- Most universities have established student incubators and research parks at, or close to, the campus containing flexible office spaces, labs, meeting facilities, etc.
- At some universities, the research park also welcomes private service providers with expertise in patenting, business development, etc., as well as providers of risk capital (including innovation incubator operators).
- Most of the universities have developed local competitions and events promoting student entrepreneurship. Moreover, a number of both curricular and non-curricular courses in entrepreneurship are delivered at the universities.
- Some universities (in cooperation with private companies) run Accelerace programmes for student entrepreneurs and/or researchers containing advisory services, mentoring and in some instances small grants.

The ecosystems for entrepreneurship are results of individual university strategies for entrepreneurship and campus development, and reflects also regional development strategies and differing levels of local private sector engagement.

Overt the last 10 years, the Danish regions have co-financed a number of initiatives that aim to foster knowledge-based entrepreneurship. Moreover, as we explain in Section 6, private funds such as the Danish Industrial Foundation, the Novo Nordisk Foundation and the Obel Family Fund have also provided substantial finance for incubators, events, competitions and projects supporting knowledge-based entrepreneurship.



2.5. Knowledge-based technological service

GTS – Approved RTOs

Introduction

The most important operators within knowledge-based technological services are seven independent, Danish, not-for-profit research and technology organisations (RTOs). They are called the GTS institutes and together they form the "GTS network".

The GTS institutes also play an important role in the part of the innovation support system that concerns *collaborative research and innovation.* The GTS institutes are involved in a large number of R&D-projects with different groups of companies. They also participate as specialists and project managers in a number of projects with participation of both private businesses, universities and GTS institutes.

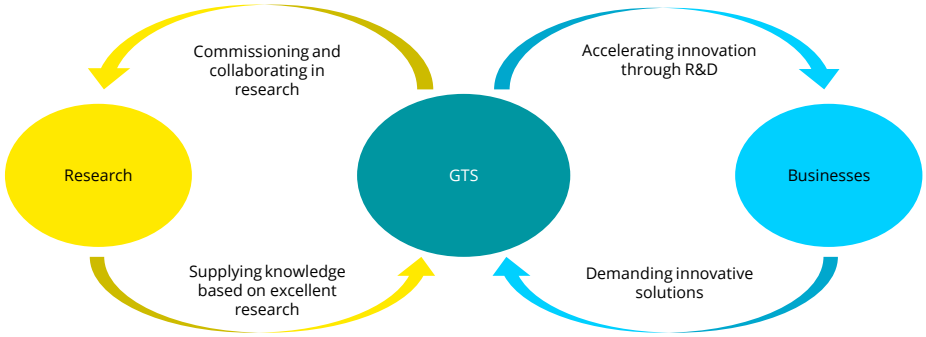
The GTS network was initiated partly in response to general underinvestment in research, innovation and development, and partly to create synergies and knowledge exchange between private companies and universities. GTS institutes are approved by the Minister of Higher Education and Science for a period of three years. Approvals are given on the basis of technological/professional performance, financial performance and organisational soundness. When approved, the institutes are eligible for performance contracts with MHES, which co-funds applied research, development and dissemination activities.

Purpose

To spread technical know-how, new methods and knowledge to industry and society in order to create and increase development. Specifically, to:

- Develop and advance technological innovation and development.
- Develop and maintain an infrastructure for technological services in Denmark.
- Communicate technological knowledge and skills to companies across all sectors.

All services are marketed on a commercial and competitive basis to private companies, organisations and public institutions. In addition, the GTS institutes seek competitive public funds through performance contracts with MHES, as well as funds from other public actors and organisations. The purpose of public co-financing through public performance contracts is to enable the GTS institutes to build new technological competencies and services that are "ahead of market needs" through research, development and innovation.



Total budget and financing

Revenue 2018: DKK 3.6 billion

R&D expenditures 2017: DKK 912 million (of which DKK 346 million from MHES performance contracts, DKK 320 million from other competitive funds and DKK 246 million are self-financed.

2.5. Knowledge-based technological service

GTS – Approved RTOs

Main target group

The main target group is small and medium-sized enterprises (SMEs), but the GTS network also offers many larger companies better and more flexible access to a variety of highly specialised technical services.

Key services

- Technological infrastructure (laboratories, apparatus and professional competencies).
- Long-term R&D co-operation with companies to develop, test and adapt technologies to a company's needs.
- Consultancy services (R&D in new processes/products, optimisation of existing processes/products, certifications, etc.).
- Participation in applied research activities with public co-financing together with companies and universities.
- Facilitation of knowledge diffusion and collaborations between Danish and international companies.
- Sales of complete physical and digital products, components, or equipment.
- Training programmes ranging from short courses to long-term education.
- Innovation check-ups by an "Innovation Agent". A number of technology specialists from the GTS institutes seek to proactively support Danish SMEs which lack knowledge of the possibilities offered by the innovation system. These businesses are offered an innovation check-up at no charge.*

** The "Innovation Agent" scheme has been in operation for the past ten years. The scheme is financed by a performance contract with the HHES. It expires at the end of 2018.*

Individual operators (R&D expenditures, 2017)

- Alexandra Institute: IT-based products and services (DKK 38 million)
- Bioneer: Biomedicine and biotechnology (DKK 39 million)
- DBI: Fire and security technology (DKK 36 million)
- DFM: Metrology and accreditation (DKK 31 million)
- DHI: Water and environment (DKK 121 million)
- Force Technology: Energy, oil and gas, maritime, infrastructure, and
- manufacturing (DKK 185 million)
- The Danish Technological Institute: Polytechnic research and technology (DKK 453 million)

See Section 3.1. for data on the use of services in the innovation system.

2.6. Financing

Several operators manage instruments for financing innovation in Denmark. In the figure below, the instruments available are shown according to 1) whether the instrument targets mainly established or new companies, and 2) location on a value chain, from research to market for established companies, and from early phase to later stage for new companies. Some instruments target both established and new companies and are consequently shown twice in the figure.

The Innovation Fund Denmark (IFD) offers four main programmes (dark blue boxes in the figure). IFD is supervised by MHES but has its own board of directors and executive management (read more about IFD in Appendix A).

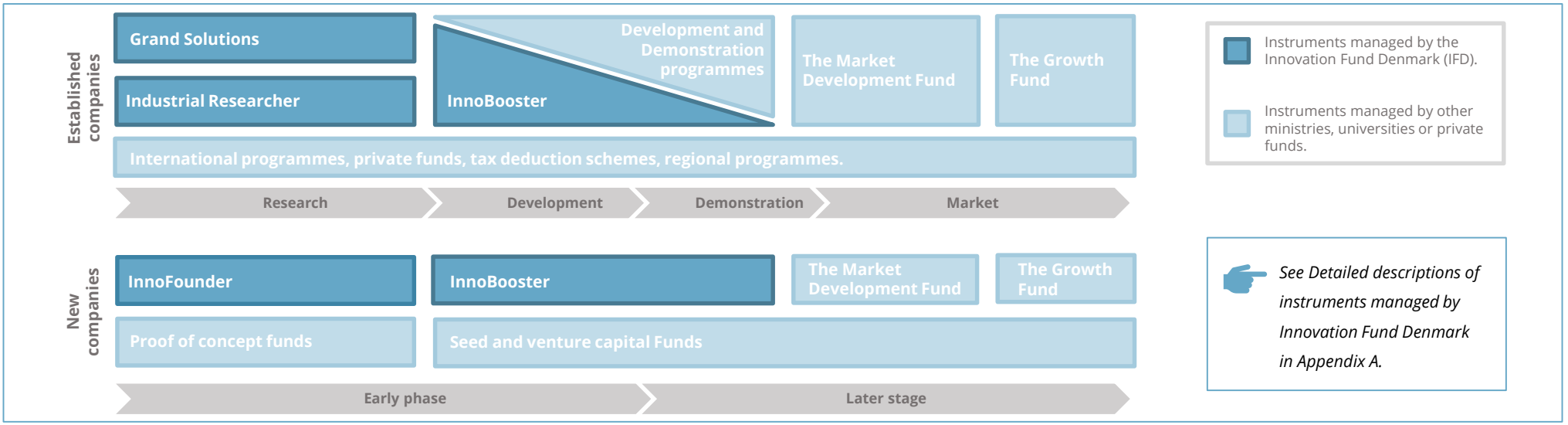
Three development and demonstration programmes are offered by the Ministry of Energy, Utilities and Climate and the Ministry of Environment and Food. The link to InnoBooster is not clear cut, as both programmes support development activities. An ongoing analysis is investigating this link (IRIS Group, in progress).

The Ministry of Industry, Business and Financial Affairs administers the Growth Fund and the Market Development Fund, the latter of which will be embedded in IFD from 2019 (see Section 1.1). The Ministry of Taxation administers tax deduction schemes for R&D spending.

The Danish Regions offer a number of small support programmes and projects targeting companies with growth potential. These initiatives are financed partly by EU structural funds. Following planned reforms (see Section 1.1), the Danish Regions will no longer engage in the innovation system from 2019 .

Private funds (e.g. the Novo Nordisk Foundation and The Danish Industrial Fund) also play an important role in financing research and innovation projects, especially within the life sciences and industry. Finally, private funds and business angels invest seed and venture capital in new companies. Proof-of-concept funding is currently financed by the universities, but it will be offered by IFD from 2019 (see Section 1.1).

Instruments for financing innovation



2.7. Networks and matchmaking

Danish Innovation Networks

Introduction

A total of 22 Danish Innovation Networks* facilitate sector-focused collaboration environments where a group of companies can access relevant research and education institutions and public organisations. The Innovation Networks enable companies to deal with issues within specific focus areas, but they also facilitate collaboration across sectors. The 22 Innovation Networks focus on Danish strongholds such as energy, food and ICT as well as emerging industries. They are approved and funded by MHES for normally four years at a time. The Innovation Networks are operated either by universities, GTS institutes or cluster organisations.

Purpose

Bridging knowledge institutions and businesses in order to improve knowledge sharing, innovation and the utilisation of research. The focus is on stimulating collaborations between SMEs and knowledge institutions.

Total budget and financing

In 2016, the total budget for all 22 Innovation Networks was DKK 235 million MHES funding made up DKK 87 million (or 37%) of this.

Main target group

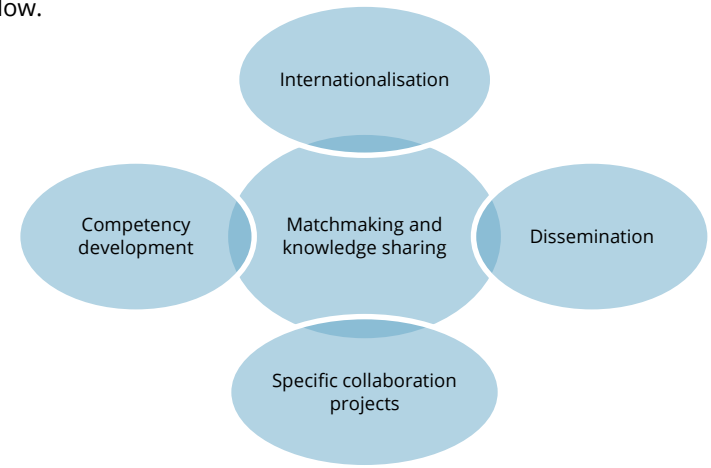
Private companies, public organisations and researchers depending on the sector focus. Some innovation networks focus on a particular sector or technology. Others include a broad group of businesses and research fields (see individual operators on the next page).

Key services

Five key services are offered by the Danish Innovation Networks:

1. Matchmaking and knowledge sharing (e.g. workshops and professional networks)
2. Specific collaboration projects (e.g. innovation projects involving companies and knowledge institutions)
3. Competency development for employees (e.g. courses)
4. Dissemination of new knowledge and technologies (e.g. conferences, PR, newsletters)
5. Internationalisation (e.g. collaboration with foreign clusters and knowledge institutions)

Most of the services above correlate with each other in the manner illustrated in the figure below.



*The number of Innovation Networks will be reduced to 17 by the end of 2018.

2.7. Networks and matchmaking

Danish Innovation Networks

Individual operators

The 22 Innovation Networks can be grouped into nine areas:

- **Energy** Three networks specialising in different aspects of energy production; offshore-energy; energy from biofuels and "smart" energy.
- **Construction** A single network seeking to stimulate innovation in the area of sustainable construction.
- **Environment** Two networks: One focusing broadly on the development of cleantech and the other focusing on the development of technologies for climate adaptions, especially in big cities.
- **Foods** One network with a focus on innovation in food-related SMEs.
- **ICT** Two networks: One focused on the challenges of implementing new ICT across many industries, and the other focusing on the development of audio technologies.
- **Service** Four networks focusing on: technology innovation for the entire service industry; the leisure economy; digitisation of finance; and the adoption of innovations in the marketing area.
- **Production:** Five networks covering various branches of Danish production, from the design of textiles and interiors to materials, lighting and robots.
- **Health** Three networks: Two focusing on innovation in medico-technologies and welfare technologies, and one concentrating on life science for the health care sector.
- **Transport** One network focusing on the development of innovative infrastructure-and-logistics solutions.

Clusters

While grants for national Innovation Networks are allocated by MHES, the Danish Regions have been active in setting up a number of cluster organisations. Clusters typically provide a wide range of services to enhance innovation and interaction among their members, including support for business development and the promotion of exports and inward investments.

Some cluster organisations have received grants to run innovation networks focussed on academia-industry interaction, in addition to other types of funding from sources such as EU research and structural funds, as well as private contributions, from which they finance their portfolio of activities.

Thus, the combination of about 45 significant Innovations Networks and cluster initiatives cover essential areas of Danish business, with a variety of sectors, geographical locations and technological fields being targeted. Together, they link knowledge institutions and businesses in order to improve knowledge sharing, innovation and the utilisation of research.

See Section 3.1. for data on the use of services in the innovation system.

2.7. Networks and matchmaking

Innovation Centre Denmark

Introduction

Denmark has established Innovation Centres overseas in seven global innovation/research hotspots in order to improve access for Danish businesses and research institutions to foreign knowledge, networks, technology, capital and markets.

The centres are located in Shanghai, Silicon Valley, Munich, São Paulo, New Delhi, Seoul, and Tel Aviv. Across the centres, the services, focus and strategy vary, as each centre adapts to needs and context in the region in which it is located.

The Innovation Centres are established and run by a partnership between MHES and the Ministry of Foreign Affairs of Denmark.

Purpose

To support Danish businesses, researchers and knowledge institutions in accessing new knowledge, creating business connections and developing business cases with an international perspective.

Total budget and financing

Annual budget 2017-2021 is DKK 30.6 million.

Main target group

Danish businesses, researchers and knowledge institutions.

Key services

- Business development
- Technology scouting
- Surveying innovation trends
- Customised camps for companies and knowledge institutions
- Customised programmes for delegation visits
- Guidance on funding options
- Support in signing collaboration agreements between research and knowledge institutions
- Matchmaking
- Provision of office space
- Analyses of opportunities for research and development

Individual operators

- Innovation Centre Denmark Munich
- Innovation Centre Denmark New Delhi
- Innovation Centre Denmark São Paulo
- Innovation Centre Denmark Seoul
- Innovation Centre Denmark Shanghai
- Innovation Centre Denmark Silicon Valley
- Innovation Centre Denmark Tel Aviv
- Innovation Centre Denmark Boston (opening in 2019)

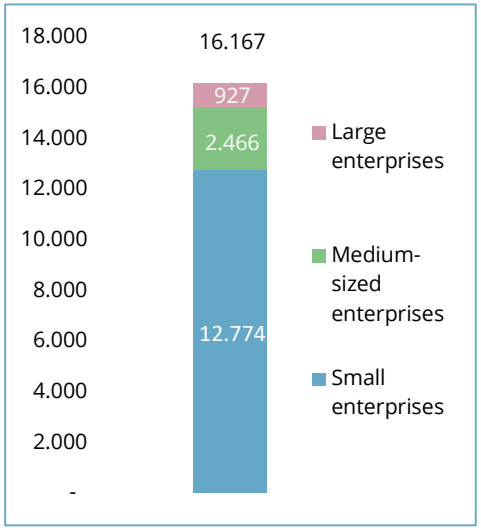
3. Use of services and programmes in the innovation system

3.1. Companies' use of GTS - Approved RTOs

The figures to the right show the number of customers who have bought a service from one or more of the seven GTS institutes, and the number of R&D collaborations involving the participation of a GTS Institute, in 2017.

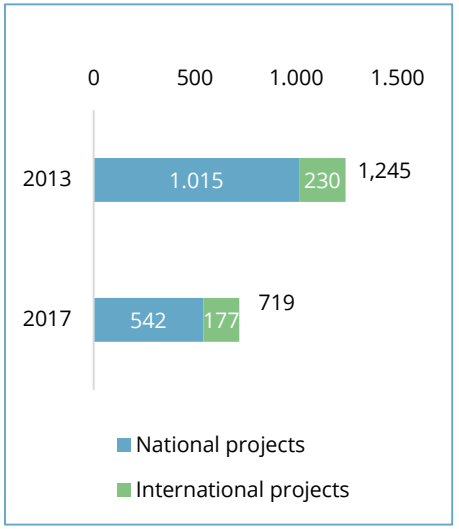
- In 2017, the total number of customers in the GTS network was 16,167. The number of customers had decreased by 5% since 2013 (GTS-nettet, 2018). However, compared with other actors in the Danish innovation system, the GTS institutes engage with a very large number of unique, private companies in Denmark.
- The largest private business group is small companies with fewer than 50 employees, and the smallest business group is large companies with more than 250 employees. However, 55% of the turnover was generated by large companies in 2017 (GTS-nettet, 2018).
- R&D collaborations are project partnerships with public co-funding. These projects are often more R&D heavy. In many cases, the other GTS services purchased in market conditions are standardized tests, certifications, or involve the purchase of complete physical and digital products, components, materials or equipment.
- The commerce and transportation sector, and industry, are the largest customer groups in the GTS network. In terms of turnover industry accounts for 42% of the Danish commercial turnover.

Customers by company size (2017)



Source: GTS-nettet, 2018
Note: Only unique, private companies are included.

Number of R&D collaborations (2017)



Source: GTS-nettet, 2018

Customers by sector (2017)

	Total	Per cent
Industry	3,291	19%
Business service	2,414	14%
Financing & insurance	335	2%
Commerce & transportation	4,264	25%
Construction	1,747	10%
Information & communication	583	3%
Public administration, education & health	1,792	10%
Other sectors	2,897	17%
	17,323	100%

Source: GTS-nettet, 2018

3.2. Companies' use of Innovation Networks

The table below presents data describing companies' participation in activities offered by the 22 national Innovation Networks.

- In 2016, a total of 11,110 companies made use of one or more of the 22 Danish Innovation Networks.
- Matchmaking activities (including workshops and professional networks) are at the core of the Innovation Networks and also the types of activity that most users engage with.
- Most of the collaboration projects initiated by the Innovation Networks involve a company with fewer than 50 employees.

Participation in Innovation Network activities (2016)

	All companies			Companies with fewer than 50 employees		
	Total	Mean per network	Per cent	Total	Mean per network	Per cent
Total number of participating companies	11,110	505	-	7,384	336	66%
Number of companies participating in:						
Matchmaking activities	6,049	275	54%	-	-	-
Specific collaboration projects	1,182	54	11%	876	40	8%
Collaborative project with knowledge institution for the first time	270	12	2%	237	11	2%
International activities	2,976	135	27%	-	-	-

Source: SUI, 2017b.
Note: Numbers are unique users.

3.3. Universities' use of Innovation Networks

The figure and table show participation in the Innovation Networks by universities and other knowledge institutions.

- All Innovation Networks include at least one university, and all Danish universities participate in a minimum of three networks (Oxford Research, 2017).
- 94 university departments are part of one or more of the 22 Innovation Networks (Oxford Research, 2017).
- Relatively large numbers of researchers from Aalborg University (AAU) and the Technical University of Denmark (DTU) participate in the Networks (see figure below). In the figure, each institution's share of the total national research budget is also shown. The share of researchers in Innovation Networks from DTU equals DTU's share of the total research budget. AAU, on the other hand, is considerably more active in the Innovation Networks than their share of the research budget would indicate.
- Senior researchers are overrepresented in Innovation Networks relative to junior researchers.

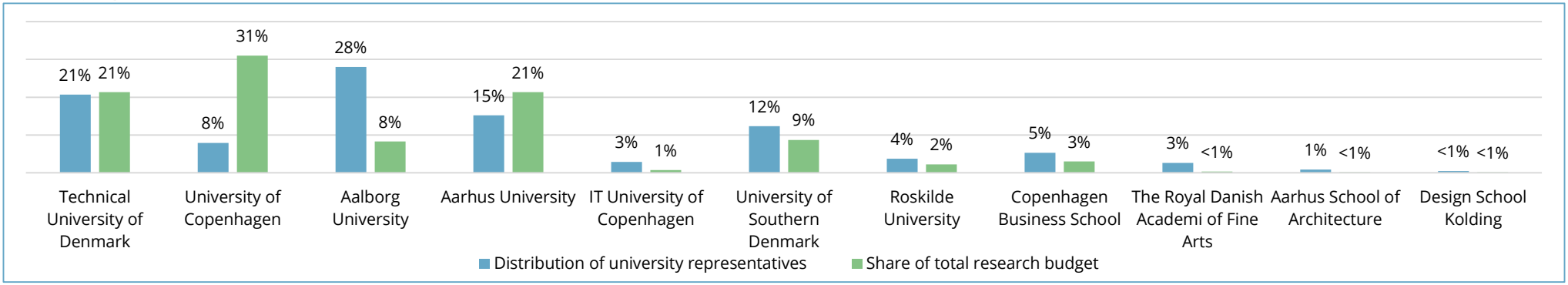
The GTS institutes are actively involved in all but one of the 22 innovation networks, and frequently several GTS institutes take part in a specific innovation network. The GTS institutes contribute with specialist and technological competencies and participate in the networks at every level, sometimes as partner, sometimes managing the network.

University representatives in Innovation Networks by job title

	Per cent
Professors and associate professors	65%
Postdocs	9%
PhDs	3%
Rector/Dean/Institute leaders/other management representatives	15%
Academic administrative personnel	9%
Total	100%

Source: Oxford Research, 2017

University representatives in Innovation Networks by institution



Source: Oxford Research, 2017
Note: Share of total national research budget has been added to the original figure.

3.4. Participation of companies in Innovation Fund Denmark programmes

The tables below and on the next page show users of three of the four main programmes in Innovation Fund Denmark (IFD) distributed by company size and sector. Users of the fourth programme, InnoFounder, are young entrepreneurs who have often not yet established a company (read about IFD programmes in Appendix A).

Distributions of users are compared with those in a corresponding target population of potential research, development or innovation-active (R/D/I-active) companies (see box to the right).

- The shares of companies using the Grand Solutions and Industrial Researcher (PhD and Postdoc) programmes with 50 or more employees are significantly higher than the corresponding share of potential R/D/I active companies in Denmark. Companies of any size can apply to participate in these two programmes, but the economic resources and facilities required by successful applicants are more likely to be found in larger companies.
- InnoBooster's main target group is SMEs with fewer than 250 employees. According to the figure below, 90% of the companies receiving an InnoBooster grant have fewer than 50 employees.

Potential R/D/I active companies in Denmark

The population of potential research, development or innovation-active (R/D/I active) companies in Denmark is estimated by Statistics Denmark in the course of its annual research, development and innovation survey. Companies are selected into the population if:

- They are large (more than 250 employees)
- Their revenue exceeds DKK 1 billion
- They reported R/D/I expenditures in a former survey
- They are in an especially R&D-heavy sector

The population of potential R/D/I active companies is approx. 18,000.

Source: DST, 2011

Users of Innovation Fund Denmark programmes by sector (2016)

	Grand Solutions	Industrial Researcher		InnoBooster	Potential R/D/I active companies
		Industrial PhD	Industrial Postdoc		
Number of participating companies	**309**	**127**	**25**	**305**	**Approx. 18,000**
Less than 50 employees	30%	30%	39%	90%	82%
50 or more employees	70%	70%	61%	10%	18%

Source: IRIS Group based on the InnovationDenmark database
Note: The table is based on an edition of the InnovationDenmark database that has not yet been fully validated. Approximately 20% of the users are not categorised with regard to number of employees. Hence, they are excluded from the table.

3.4. Participation of companies in Innovation Fund Denmark programmes

The table shows the distribution of users of four Innovation Fund Denmark (IFD) programmes by the company's main sector of affiliation.

Distributions of users are compared with those in a target population of potential research, development or innovation-active (R/D/I-active) companies (see box on previous page).

- The industry and business service sectors are by far and away the heaviest users of IFD programmes. They are also overrepresented in all four of the IFD programmes relative to the population of potential R/D/I-active companies in Denmark.
- Transport and trade companies make up 26% of the population of potential R/D/I-active companies in Denmark, but only a few per cent of IFD users.
- Almost half of users of the more research-heavy programmes (Grand Solutions and Industrial Researcher) are in the industry sector. More than half of Innobooster's users operate in the business service sector.

Users of Innovation Fund Denmark programmes by sector (2016)

	Grand Solutions	Industrial Researcher		InnoBooster	Potential R/D/I active companies
		Industrial PhD	Industrial Postdoc		
Number of participating companies	**309**	**127**	**25**	**305**	**Approx. 18,000**
Industry	46%	47%	36%	22%	23%
Business services	31%	34%	37%	57%	28%
Financing and insurance	0%	0%	3%	0%	3%
Transport and trade, etc.	5%	0%	8%	9%	26%
Construction	1%	2%	3%	0%	1%
Information and communication	8%	13%	4%	4%	16%
Other sectors	8%	13%	5%	4%	3%

Source: IRIS Group based on the InnovationDenmark database
Note: The table is based on an edition of the InnovationDenmark database that has not yet been fully validated. Approximately 20% of the users are not categorised into any sector. Hence, they are excluded from the table.

3.5. Participation of research institutions in Innovation Fund Denmark programmes

The figure and table show the participation of universities and other higher education institutions in IFD programmes. Only the Grand Solutions and Industrial Researcher programmes collect systematic data on the participation of research institutions.

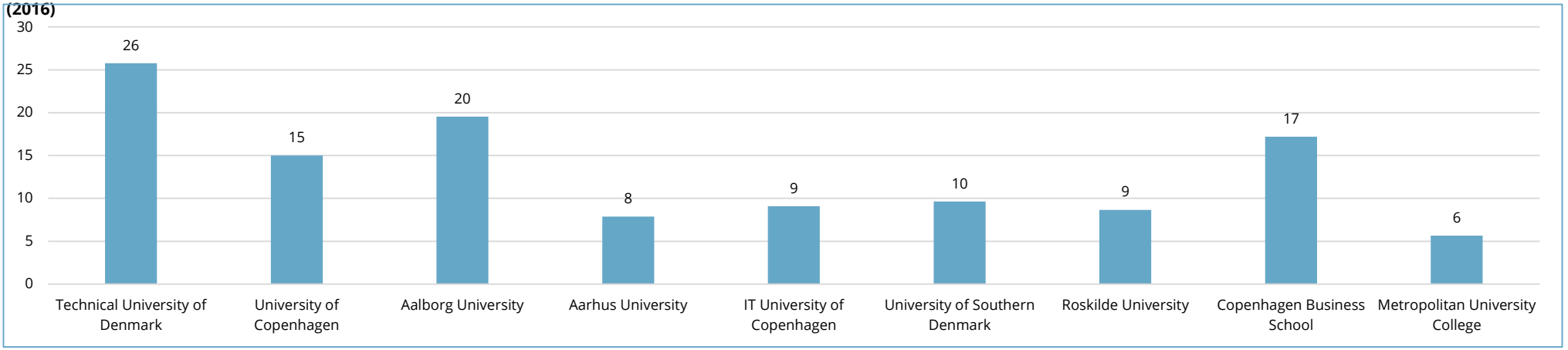
- Every industrial research project funded by IFD must have a university supervisor affiliated to the project. This explains why approximately 60% of all IFD projects with the participation of a university are industrial research projects. The remaining projects (approximately 40%) are Grand Solutions projects in which any type of institution can participate (see table, right).
- In the figure below, institutional numbers of participations in IFD programmes are divided by the research budget of each university. Relative to the size of their research budgets, the Technical University of Denmark and Aalborg University are the heaviest users of IFD programmes.

Participation of universities and other higher education institutions in IFD programmes (2016)

	Total	Per cent
Grand Solutions	83	35%
Industrial PhD	131	56%
Industrial Postdoc	22	9%
All programmes	236	100%

Source: IRIS Group based on the InnovationDenmark database
Note: Data cover only the Grand Solutions and Industrial Researcher programmes.

Participations of universities and other higher education institutions in IFD programmes per DKK 1 billion of research budget (2016)



Source: IRIS Group based on the InnovationDenmark database
Note: Data cover only the Grand Solutions and Industrial Researcher programmes.

3.6. Value creation and impact of services and programmes

Since 2007, the Danish Ministry for Higher Education and Science has placed a strong emphasis on developing and applying appropriate methods for impact assessment of key programmes in the knowledge-based innovation support system.*

Over the last decade, all major programmes have been examined in quantitative impact assessment studies based on state-of-the-art methods.

The table to the right summarises the key results. The overall conclusions are:

- A significant, positive impact on participating companies for all institutions and most programmes.
- Participating companies realise an increase in total factor productivity (TFP) of between 3% and 7% within 2-3 years after participation.
- The Industrial Researcher programme has a significant impact on employee incomes.

The results are based on a literature review incorporating both qualitative evaluations and quantitative impact assessment studies. A more detailed presentation of the results can be found in Appendix B.

Service/programme	Key findings
GTS - Approved RTOs	Companies collaborating with GTS in research and innovation projects realise a positive and significant effect on labour productivity. The average productivity gain is 9% in each of the first four years after the company's first interaction with a GTS Institute.
Innovation Networks	Participating companies realise a significant 3.6 percentage point increase in TFP within 2-3 years of participation.
Innovation Consortia programme*	Participating companies realise a significant 6 percentage point increase in TFP within 2-3 years of participation.
Innovation voucher programme*	Participating companies realise a significant 5-7 percentage point increase in TPF within 2-3 years of participation.
Industrial Researcher programme	Individuals with a Industrial PhD obtain 7-10% higher wage income compared with other PhDs. No significant impact on companies with industrial PhD projects is identifiable (possibly due to a limited number of observations).

Source: See Appendix B for a detailed account of the impact studies, including sources.
** The current programmes, InnoBooster and Grand Solutions, were launched in 2014, and it is too early to complete a comprehensive impact assessment for them in their current form. To a large extent, however, these programmes are redesigns and refinements of previous programmes which have been subject to more comprehensive impact assessments. Hence, The Grand Solutions programme is the successor of the former Innovation Consortia programme, and InnoBooster is the successor of the former Innovation voucher programme.*

**From 2007 to 2014 the Danish Agency for Science, Technology and Innovation (DASTI) conducted a number of econometric impact studies of Danish innovation schemes. The studies was carried out in cooperation with Danish researchers and ministries and are a key element of evidence-based policy making. To secure the same standard across the different research and innovation programmes, DASTI formulated a Central Innovation Manual (CIM) which sets out a set of best practices on the conduct of excellent econometric impact assessments of public research and innovation programmes and policies. The first version of CIM was published in 2012. It was republished with revisions in 2014.*

4. Innovation performance indicators

4.1. Private sector R&D

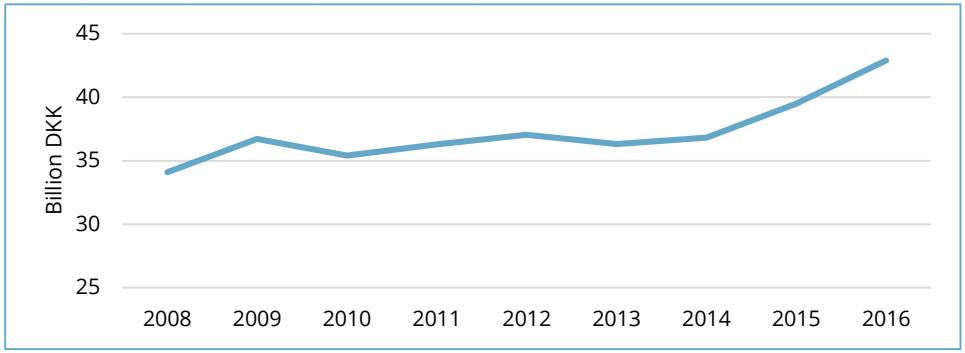
In Section 2, total R&D spending in Denmark was benchmarked against the EU. In Denmark, annual private sector investments in R&D were stable at around DKK 36 billion over the period 2008-2014, after which R&D they increased to almost DKK 43 billion in 2016 (see figure, right). As a consequence, the share of private R&D investments as a percentage of GDP increased to 2.1% in 2016.

In an international context, Denmark has a high level of private sector R&D expenditure as a percentage of GDP. In 2016, only Sweden and Finland were on a higher level, while countries such as the Netherlands and Norway had a lower share of R&D investments as a percentage of GDP (SFU, 2018).

The recent increase in R&D expenditure in Denmark, however, conceals significant changes in the composition of private companies with R&D activities. In general, investments in R&D were concentrated on fewer and larger companies in 2016 as compared with earlier years.

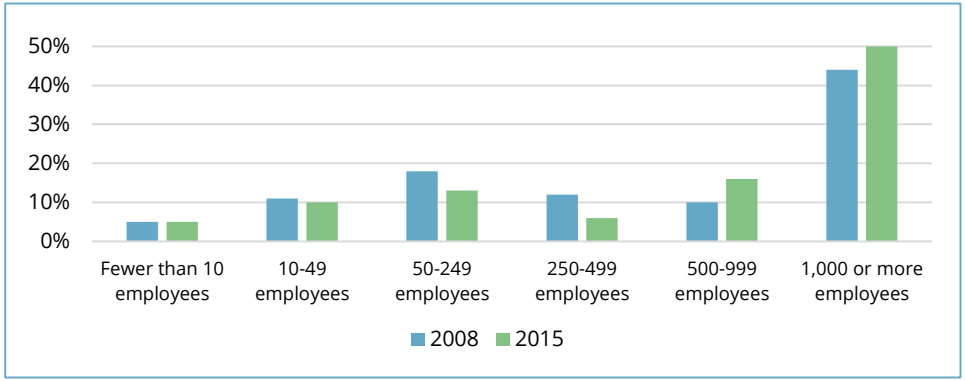
- It is estimated that the number of companies investing in their own R&D activities fell by 35% between 2009 and 2016, while the average R&D expenditure per R&D-active company increased by 57% from 2009 to 2016 (see table, right).
- In the period 2008-2015, the share of private R&D expenditure increased in companies with more than 499 full-time employees, but fell among companies with 10-249 full-time employees (SFU, 2018).

Development in private companies' R&D expenditures in Denmark (billion DKK)



Source: Statistics Denmark based on an annual survey collecting data on innovation and R&D activities. The survey question regarding R&D expenditures covers only one year.

Shares of private R&D expenditure by company size



Source: SFU (2017)

Development in number of private companies with R&D expenditure, and R&D expenditure per R&D-active company (million DKK)

	2009	2010	2011	2012	2013	2014	2015	2016
Companies with R&D	3,309	3,115	2,675	2,649	2,389	2,342	2,464	2,459
R&D expenditure per company	11.1	11.4	13.6	14.0	15.2	15.7	16.0	17.4

Source: SFU (2018)

4.2. The EU's Innovation Scoreboard

The annual European Innovation Scoreboard (EIS) provides a comparative assessment of the research and innovation performance of EU member states and selected third countries, and of the relative strengths and weaknesses of their research and innovation systems. The EIS framework distinguishes between ten innovation dimensions (shown in the table, right) covering both business innovation outcomes and the country's innovation environment and capacity.

Overall, Denmark is one of the highest ranked countries in Europe. According to EIS, Denmark is one of the *Innovation Leaders* – ranked second, after Sweden – with innovation performance well above the European average. The other *Innovation Leaders* include Luxemburg, the Netherlands and Finland.

- Looking at the different indicators which together make up the Innovation Index, Denmark scores highly in terms of human resources (covers *new doctorate graduates, population with tertiary education* and *lifelong learning*) and attractive research systems (*intellectual scientific co-publications, most cited publications* and *foreign doctorate students*).
- In comparison, Denmark is doing less well than other European countries when it comes SME innovators and sales impacts (*exports of medium/high tech products, exports of knowledge intensive services* and *sales of new-to-market and new-to-firm innovations*). Here Denmark is below the European indicator.

	Relative to EU in 2017	
	DK rank (score)	Top three countries
Summary Innovation Index	**2 (132.4)**	**SE, DK, LU**
Human resources	1 (184.2)	DK, SE, FI
Attractive research systems	3 (181.7)	LU, NL, DK
Innovation-friendly environment	1 (197.8)	DK, SE, FI
Finance and support	7 (102.6)	FR, NL, LU
Firm investments	7 (109.1)	SE, DE, AT
Linkages	6 (131.3)	BE, NL, AT
Intellectual assets	2 (165.8)	MT, DK, SE
SME Innovators	12 (111.9)	IE, BE, DE
Employment impacts	11 (100.5)	IE, UK, MT
*Sales impacts**	15 (75.1)	DE, UK, IE

Source: European Commission, 2018.
*Note: *Denmark is below the European average. The different indicators are based on data from different sources and years (2014-2017) depending on where the most recent data is available.*

4.3. Innovative companies

Recent statistics indicate that almost half of all Danish companies (44%) reported some form of innovation activity in 2016. The share of innovative companies has remained relatively stable since 2007 (top figure, right).

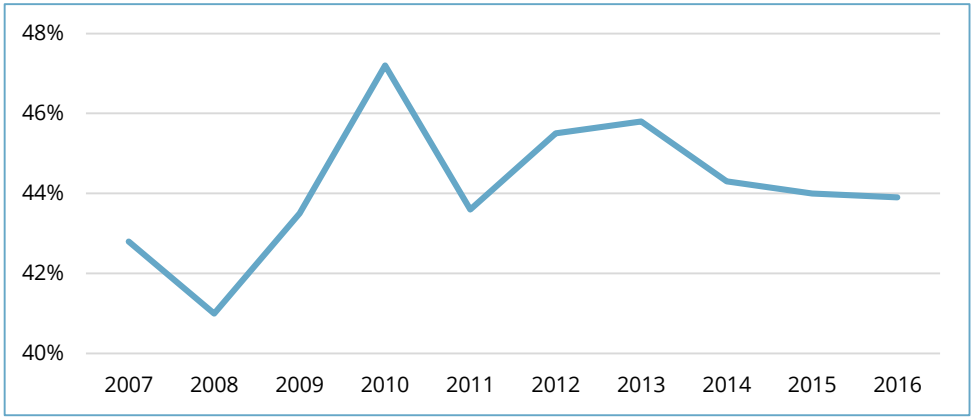
- With the different types of innovation activity differentiated, it emerges that most companies undertake organisational and marketing innovation. In 2016, close to 30% of Danish companies were involved in these types of innovation activity. Fewer companies were developing new products or services.
- The share of companies developing new processes and/or products has been stable, at around 21%, throughout the period 2008-2016. In comparison, a slight increase can be observed in the share of companies engaging in marketing innovation (bottom figure, right).

Turning to Denmark's innovation intensity in the European context, it can be seen from the Innovation Index presented on the previous page that Denmark is ranked relatively poorly on this specific indicator:*

- Denmark is ranked number 12, just above the European average, with respect to the share of SMEs with innovation activities in the business sector (product/process innovation, market/organisational innovation and in-house innovation).
- Denmark also performs worse than the Republic of Ireland, Belgium, Germany, Greece, Portugal, Italy and Cyprus. Danish performance on this part of the index is particularly low owing to its low share of SMEs with in-house innovation.

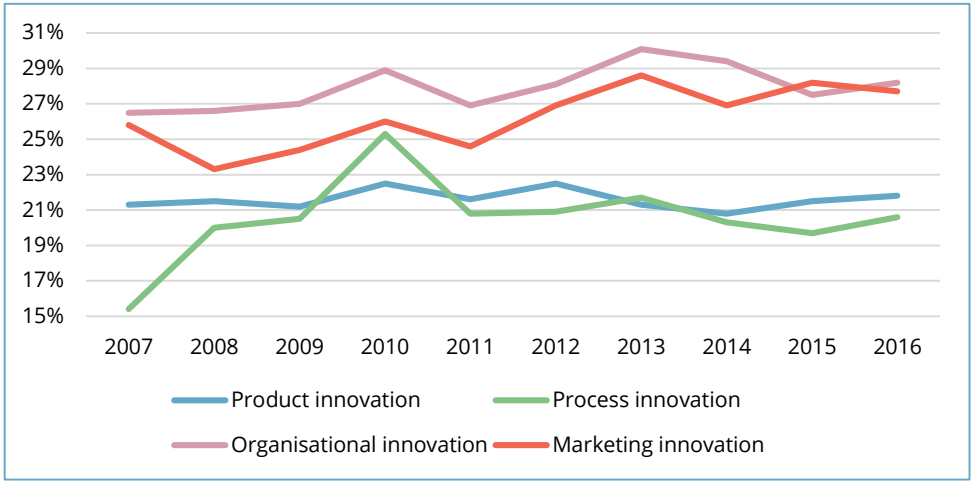
The SME innovation activity in the Innovation Index is based on the most recent Community Innovation Survey, which was collected in 2014.

Innovative companies as a share of all companies (total)



Source: Statistics Denmark based on an annual survey collecting data on innovation and R&D activities.

Share of innovative companies by innovation type



Source: Statistics Denmark based on an annual survey collecting data on companies' innovation and R&D activities. The survey questions regarding innovation activities cover the last three-year period. Hence, innovation activities for the year 2016 cover years 2014-2016 inclusive.

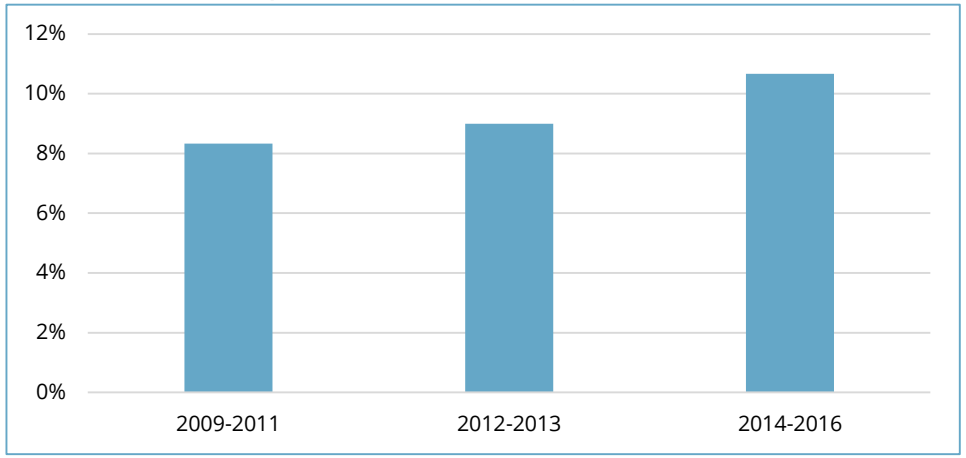
4.4. Innovative companies collaborating with higher education institutions

The share of innovative companies which collaborate with research institutions increased over the period 2009-2016. In 2014-2016, more than 10% of the innovative companies in Denmark were engaged in collaborations with research institutions (see figure, right).

The pan-European innovation survey – the Community Innovation Survey (CIS) – collects comparable country statistics on the share of innovative companies which collaborate with universities and/or other higher education institutions (HEIs).

- The most recent CIS, published in 2014, shows that the share of innovative companies collaborating with HEIs in Denmark is higher than that in countries such as Sweden and Norway.
- Finland is the country where the highest share of innovative companies collaborate with HEIs (23%), followed by Austria and Belgium.
- Since the previous CIS survey, Denmark has gone from being ranked number 10 in the EU to number 6 on this particular indicator (UFM, 2016b).

Share of innovative companies collaborating with higher education institutions



Source: The Danish Business Authority's provincial database (ERSTS409).

4.5. Commercialisation of research at the universities

Transfer of university research to private companies enables established companies and spinouts to access new technologies developed by highly specialised researchers for the greater good of society.

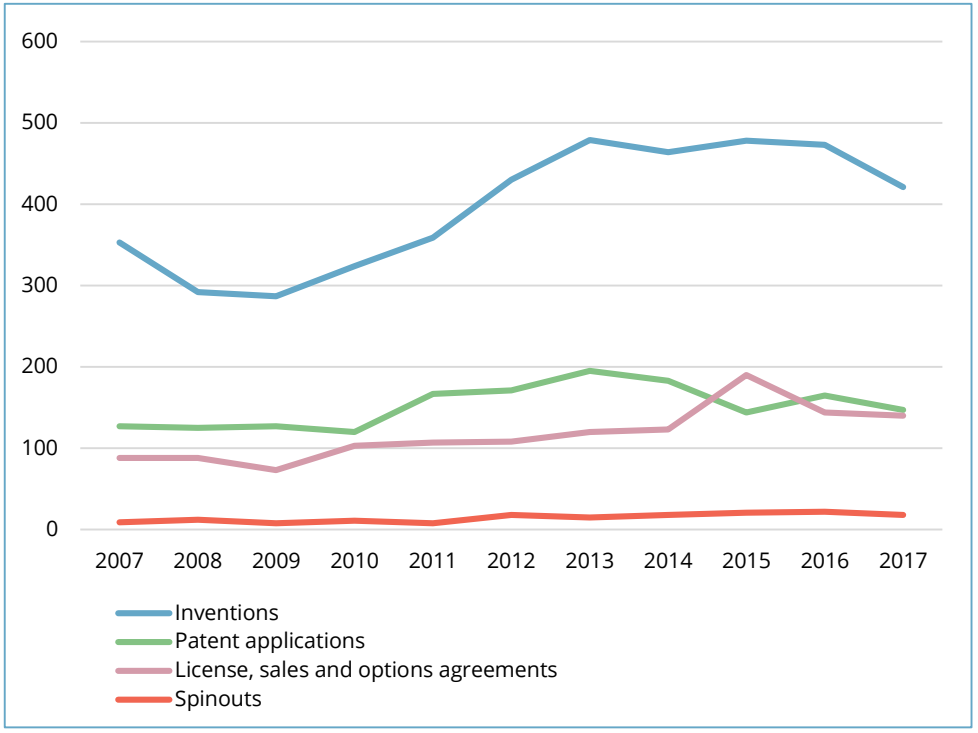
Key indicators of the commercialisation of university research include the number of inventions, patent applications and licence agreements, as well as the number of spinout companies.

- "The Act of Inventions at Public Research Institutions" was introduced by the Danish government in 1999. That was followed by the establishment of Technology Transfer Offices (TTOs) in universities (see Section 5). In the ensuing years, an increase in commercialisation activities was observed.
- Commercialisation activity stagnated in the period 2007-2010.
- After 2010, a slight increase in the number of spinouts, as well as licence/sales/options agreements, was seen (see figure, right).
- 2017 was the first year since 2010 in which the Danish public research institutions delivered a commercialisation surplus (not including wage expenditures). Revenue from commercialisation increased by 58% to a level of DKK 48 million between 2016 and 2017 (UFM, 2018).

Commercialisation statistics permitting comparisons to be made across 8-9 countries were collected some years ago by the Danish Agency for Science, Technology and Innovation. The Annual Time Series statistics most recently published cover the period 2009-2014 and countries including Great Britain, Ireland, Australia, Italy, France, Spain, Switzerland and Canada (UFM, 2015).

In these statistics, Denmark is positioned slightly below the middle rank (at number 6 or 7) across three indicators: licence, sales and options agreements, patent applications and spinout companies. Denmark maintained this position relatively constantly over the period 2009-2014.

Commercialisation of research at Danish universities



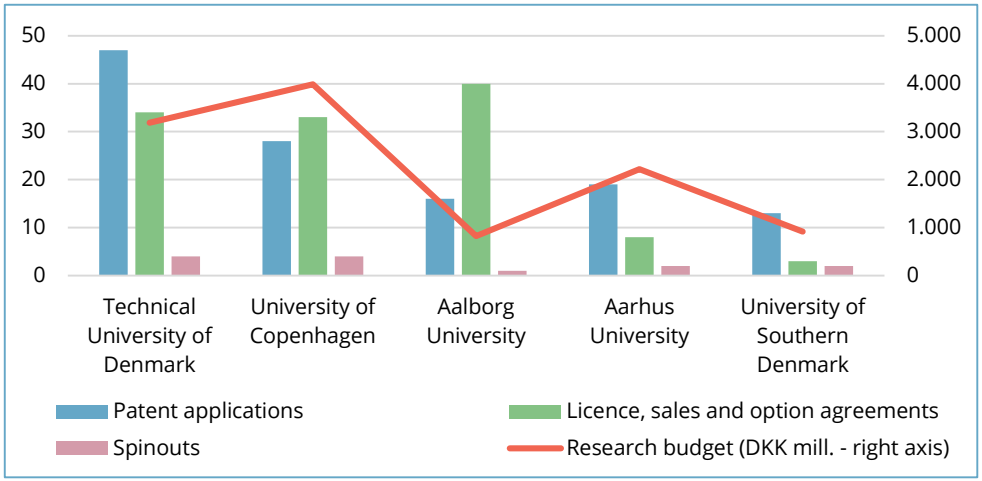
Source: UFM, 2018.
Note: The figures are based on 14 research institutions' own statistics.

4.5. Commercialisation of research at the universities

Levels of commercialisation activities differ across the Danish universities. The Technical University of Denmark (DTU) and Aalborg University (AAU) stand out as the universities with the highest levels of activity when the size of their research budgets is taken into account.

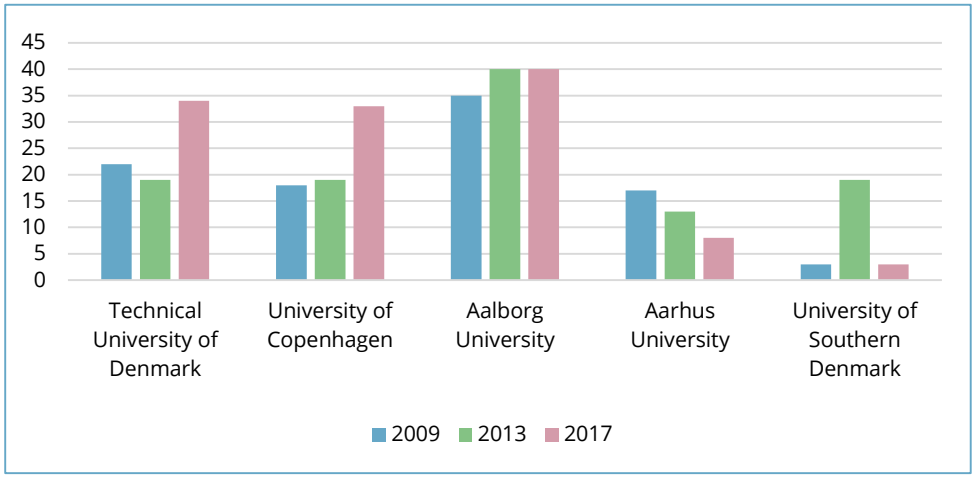
- DTU has the highest total number of commercialisation activities (see figure, below left, covering the five largest universities).
- AAU has the highest level of activity relative to the size of its research budget. AAU performs especially well in respect of number of licence agreements.
- Numbers of spinouts are modest at all universities.
- Research institutions were involved in 140 licence, sales and option agreements in 2017, corresponding to an increase of 30% over the previous five years. Universities accounted for approximately 84% of the agreements in 2017.
- Both DTU and the University of Copenhagen experienced an increase in the number of licence, sales and options agreements in 2017, while the number of agreements at AAU stabilised at a high level (see figure, below right).

Commercialisation within Danish universities (2017)



Source: UFM, 2018.
Note: The figures are based on the universities' own reporting. The IT University Denmark, Copenhagen Business School and Roskilde University are left out of the figure, as they report no or few agreements. Research budget is restricted to technical, natural and health sciences.

The number of licence, sales and options agreements by year



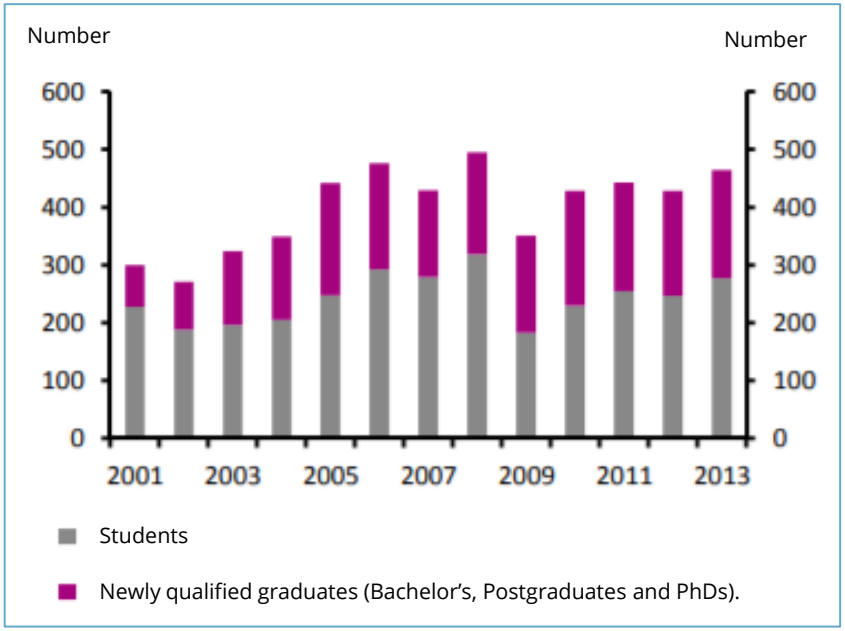
Source: UFM, 2010; UFM, 2014; UFM, 2018.
Note: The figures are based on the universities own reporting. The IT University Denmark, Copenhagen Business School and Roskilde University are left out of the figure as they report no or few agreements.

4.6. University-based start-ups

A recent study investigates whether university students and newly qualified graduates are more likely to start a new company than people in the general labour force (UFM, 2017a). The study is based on data on entrepreneurial activity composed by Statistics Denmark for the period 2001-2013. An entrepreneur is defined in the analysis as a person who has started a company and attained significant economic activity.

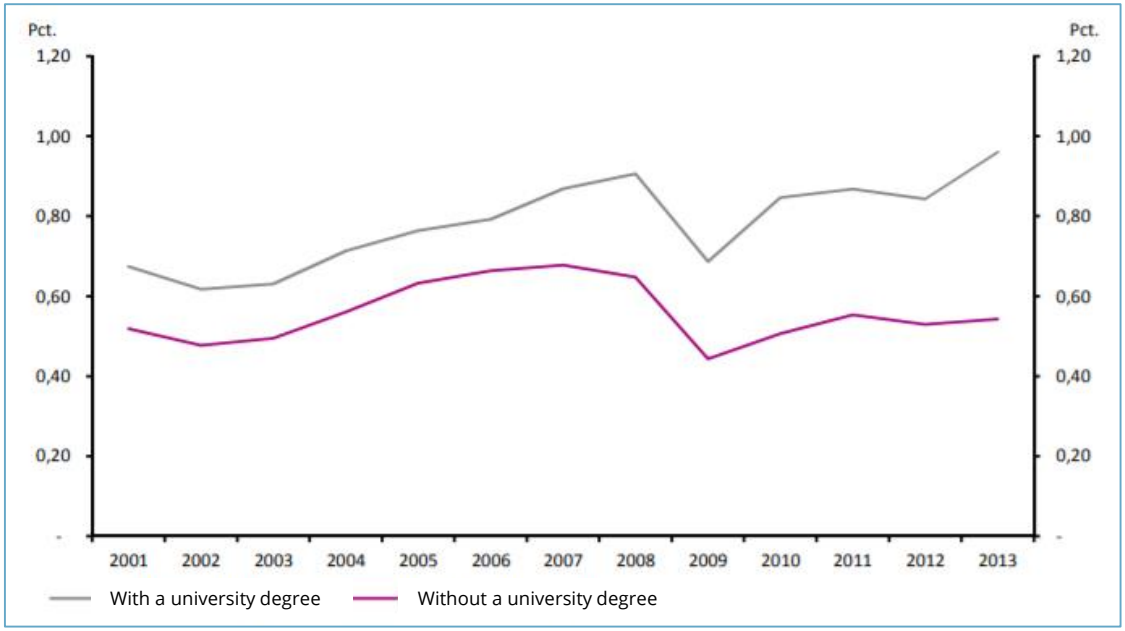
- According to the study, the number of start-up companies among students and graduates increased by 56% from 300 in 2001 to 464 in 2013. The increase over the period was driven by newly qualified graduates (see figure, below left).
- People in the labour force with a university degree are on average more likely to start their own companies. In 2013, 1% of people in the labour force with a university degree started their own company, as compared with 0.5% of other people in the labour force.
- In total, 16,783 new start-up companies were established in 2013. Of these, 3,261 (20%) were established by people with a university degree, although only 10% of the labour force had an academic Bachelor's degree or higher education in the same year.

Entrepreneurs among students and newly qualified graduates

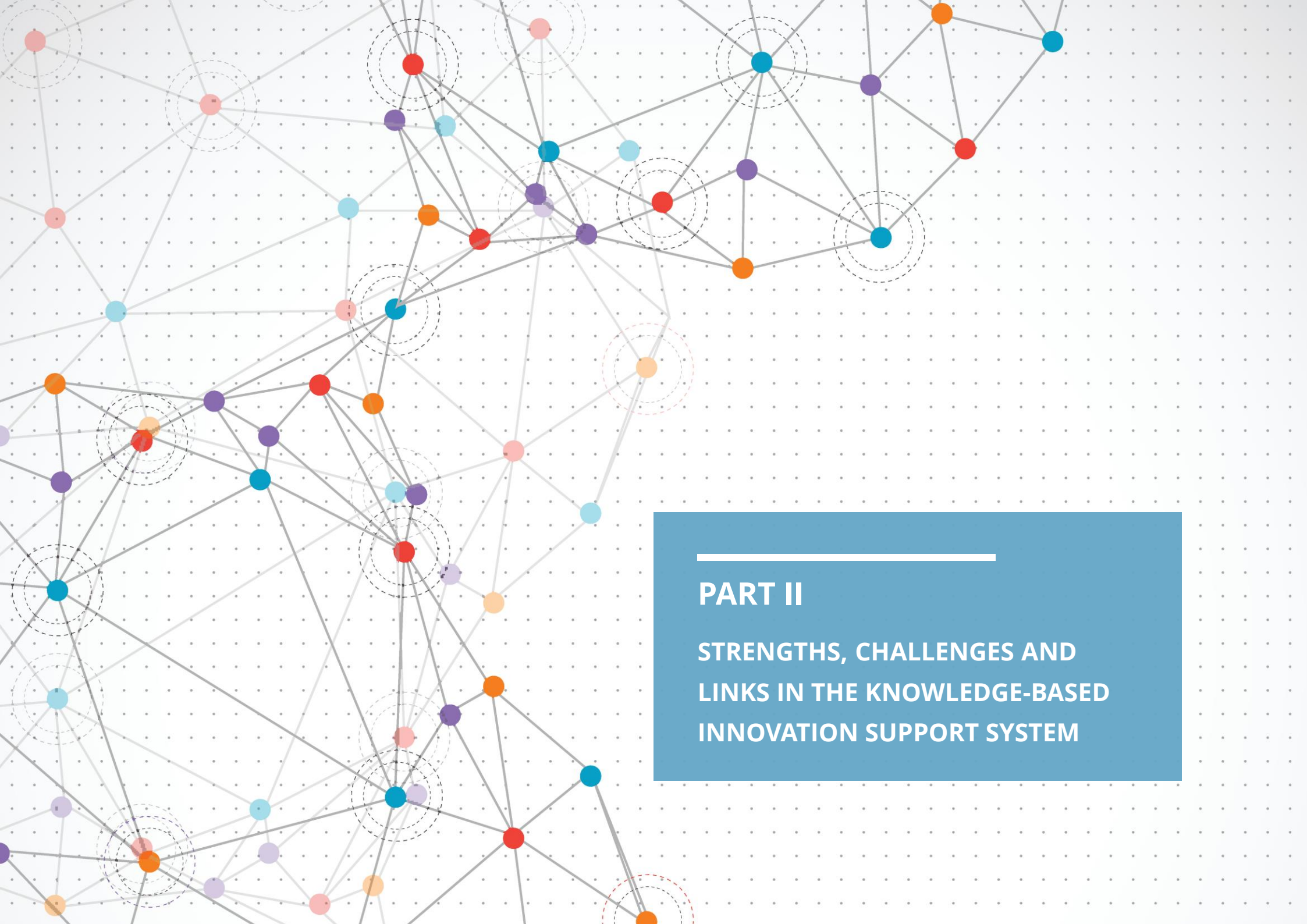


Source: UFM (2017a) based on data on entrepreneurial activity 2001-2013 from Statistics Denmark.

Entrepreneurship rate for people in the workforce with and without a university degree



Source: UFM (2017a) based on data on entrepreneurial activity 2001-2013 from Statistics Denmark.



PART II

STRENGTHS, CHALLENGES AND LINKS IN THE KNOWLEDGE-BASED INNOVATION SUPPORT SYSTEM

5. Collaborative research and innovation

5.1. Introduction

As in most other OECD countries (see OECD, 2016), the ability of higher education institutions (HEIs) to translate research into innovation and the creation of new companies has attracted growing attention in Denmark over the past two decades.

Four major government innovation strategies have been launched in Denmark since 2003, and a number of government initiatives have been implemented. IRIS Group (2014) and DEA (2014) emphasise the following interventions as important milestones:

- The "Act of Inventions at Public Research Institutions" ("Forskerpatentloven") was passed in 1999 and provided Danish universities with the right and obligation to pursue the commercialisation of research with promising business perspectives.
- The act was followed by the establishment of technology transfer offices (TTOs) at each university. A scheme was then introduced to provide financial support for patenting and commercialisation activities in the period 2000-2003.
- In 2003, a new University Law was passed. New boards of directors with a majority of external members were introduced, and the law specified that universities had an obligation to engage in collaboration with surrounding society, and to promote economic growth and welfare.
- The "Act on Technology Transfer" was passed in 2004 in order to further stimulate and foster the commercialisation of research. The law made it possible for universities to found and to own limited companies which carry out technology transfer activities. (To date, four universities have established limited companies, but only one of these employs a majority of TTO staff.)
- In 2006, a proof-of-concept (POC) scheme was introduced financially supporting the maturation of inventions and ideas in universities. The scheme expired in 2012.
- From 2003, following the introduction of the University Law, so-called "Development Contracts" were introduced. These contracts created a framework for developing and negotiating individual goals for each university. They were soft agreements between the government and the universities and included goals for research, education and societal engagement. Development Contracts have now been replaced by "Strategic Framework Contracts" between MHES and each university and other HEIs. Strategic Framework Contracts run for four years and include strategic goals for the institutions' main activities.

Following the 2018 political agreement to reform the public business promotion system in Denmark (see Section 1.1), a new programme supporting proof-of-concept activities at the universities will be launched by the Innovation Fund Denmark in 2019. In addition, a range of support programmes co-financing collaborative research and innovation have been developed. Current national programmes are described in detail in Section 2 and Appendix A.

In this section, we present the main conclusions from recent analyses of the strengths, weaknesses and challenges of *collaborative research and innovation* in Denmark. The section is divided into four parts covering:

- Strategic goals at the national level (Section 5.2).
- University strategies for business collaboration and commercialisation of research (Section 5.3).
- Tools and incentives used at the universities to foster business collaboration (Section 5.4).
- Network and matchmaking (Section 5.5).

Section 5.5 addresses *network and matchmaking* activities (the outer light blue ring in the tracker). Network and matchmaking activities do, however, very often include collaborative research and innovation, and are consequently addressed in this section.

Of course, access to programmes financing collaborative research and innovation is also an important matter. This issue is discussed in detail in Section 8.

5.2. Strategic goals at the national level

Collaborative research and innovation, like knowledge transfer in general, has been an important issue in Danish innovation strategies, as the reforms and initiatives mentioned in Section 5.1 indicate.

During the 2000s and early 2010s, special attention was devoted to the aim of increasing the share of companies collaborating with HEIs (Regeringen, 2012; IRIS Group 2018b). Successive Danish governments developed ambitious goals in this area and introduced programmes such as the Innovation Networks (see Section 5.5) in order to make it easier for companies to obtain access to potential partners from the HEIs. As shown in Section 2, these efforts resulted in an approximately 25% increase in the share of innovative companies collaborating with HEIs.

In 2012, the third national innovation strategy of the current century, "Løsningernes land" (Country of Solutions), introduced solutions to a range of significant societal challenges (in energy, health, education, transportation, etc.) as another important focal area for research and innovation policy (Regeringen, 2012). Today, this theme is reflected in:

- National research strategies and approaches to the prioritisation of research. Thus, the government has introduced a procedure to identify promising research areas ("FORSK 2025") based on a co-creation process involving a high number of stakeholders, and focusing on themes with potentially high societal impact (UFM, 2017b).
- The Grand Solutions programme (see Section 2 and Appendix A) through which Innovation Fund Denmark invests (at DKK 5-30 million per project) in high quality research and innovation projects with the potential to create knowledge, growth and employment in Denmark, as well as solutions to large-scale societal challenges.

The first user evaluation of the administration of IFD-programmes (IRIS Group, 2018a) indicates that Grand Solutions projects have been successful in creating interdisciplinary solutions with the potential 1) to solve societal challenges, and 2) to create commercial value, jobs and exports. But the programme is still young, and no impact evaluation has yet been carried out.

The box below shows the goals of the present government's strategy for research and innovation relating to collaborative research and innovation (Regeringen, 2018). Unlike previous strategies, the new strategy does not employ quantitative goals. Instead, it sets a number of guidelines on how the government will invest in research and innovation.

Goals in the government's strategy for research and innovation (Regeringen, 2018)

- *"Research and innovation must foster development and application of new technologies."* Concrete initiatives are expected to include higher levels of investment in technical research and a 'National Centre for Research in Digital Technologies'.
- *"Knowledge and innovation must create more value in the companies."* This strategic goal includes the ambition to foster R&D investments in private companies and to improve the interface and connections between schemes for financing innovation and collaborative research.
- *"Acknowledgement (merit) of researchers must promote both research, education and knowledge diffusion."* A committee is expected to develop recommendations in this area in 2019.

It is important to emphasize that the *GTS-institutes* also are important bricks in the national innovation strategies, and that the GTS network within the focal area "collaborative research and innovation" has key functions such as;

- Developing new technologies in collaboration with companies (financed by the basic funding from the government and other sources).
- Participating as partners in Grand Solutions projects and other projects financed by national or international programmes, which also have participation from universities and companies.

The role of the GTS network, and the strengths and challenges in the network, is described in further details in section 7.

5.3. University strategies

An important part of a knowledge-based innovation support system is constituted by the universities' strategies and approaches to innovation and knowledge diffusion.

Recent analyses (IRIS Group, 2017a; DEA, 2016) conclude that the combination of 1) government strategies and initiatives (see Section 5.1), 2) an increasing openness to society in general within universities (spurred by, among other things, the establishment of boards with an external majority), and 3) increasing dependence of external funding, has had a significant impact on universities' strategies and senior management behaviour.

Moreover, IRIS Group (2014) concludes that the increased focus on the level of engagement with the non-academic sector is also a result of universities' willingness to engage with regional development issues and to co-operate with the five Danish Regions.

Today, most of the university strategies contain (aside from the traditional goals of research and education) quantitative goals for 1) increased collaboration with private business, and 2) increased entrepreneurship in terms of both student entrepreneurship and IPR-based spinouts (IRIS Group, 2017a).

However, only Roskilde University (RUC) has formulated specific goals for increased collaboration with the SME sector. Thus, the strategies and goals of the universities reflect an ambition to deliver value to society, and to attract more external funding, more than the ambition to collaborate with a high number of differently orientated businesses (IRIS Group, 2014).

The strategic framework contracts for other higher education institutions in Denmark are primarily focused on strengthening knowledge and developing education and professions through practice-oriented and applied R&D activities.

The box to the right presents the goals for collaborative research and innovation, as well as entrepreneurship, in the strategic framework contracts. As opposed to the former Development Contracts, the goals are not quantitative.

University goals for collaborative research and innovation (2018-2021)

Each Danish University has signed a four-year strategic framework contract with the Minister for Higher Education and Science. The current framework contracts run from 2018 to 2021.

The purpose of the strategic framework contracts is to outline important strategic goals in core areas of the institutions, thereby supporting the universities' development and contribution to society. The strategic goals are established on the basis of the specific strategies, strengths and challenges of each university. However, to an extent, they all contain goals for increased collaboration with businesses and society in general. Examples of strategic focus areas include:

- Technical University of Denmark aims to further develop its position as a melting pot for innovation and entrepreneurship by expanding the incubator 'Skylab', thereby making more room for students', researchers' and companies' innovation activities.
- University of Southern Denmark plans to support development and growth in the regional robot cluster by, among other things, prioritising easy access to excellent robot research through joint research projects.
- Aalborg University intends to commercialise as many inventions and technologies as possible and increase the number of successful spinouts by establishing a Proof-of-Concept programme, that will fund development and demonstrations of product potential among the most promising technologies.

All framework contracts contain performance indicators (e.g. spinouts, license agreements, research collaborations with external actors, student projects or internships in private companies, etc.), but the specific indicators vary across universities.

As the strategies focus on the ambitions and direction of the universities, the indicators of goal achievement are not specified in target figures for the term of the contract. A baseline for each indicator is specified in the contract, however, and the universities are obliged to submit an annual status report to MHES in which developments in the outlined indicators are documented.

5.4. Tools and incentives fostering innovation and business collaboration

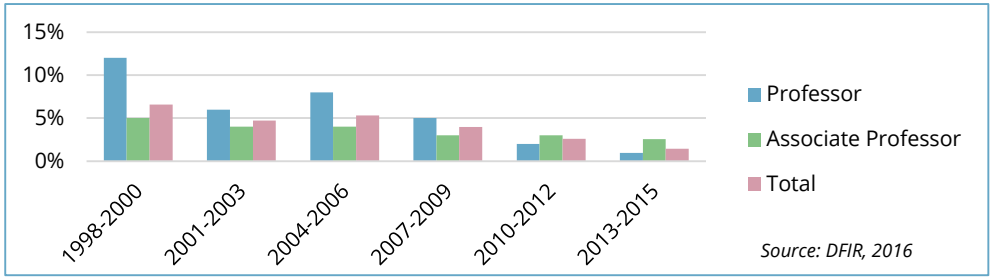
Along with the increased focus on innovation and business collaboration, the universities have also, to varying degrees, invested in support functions and tools which incentivise researchers to engage in collaborative research and innovation. The number of full-time employees (FTEs) working in central administration of innovation and commercialisation has increased considerably (see box, right), and some universities have established specialised roles at local level such as "Business Developers" at DTU and "Vice Deans for Innovation and External Relations" at Copenhagen University (IRIS Group, 2017a).

At most universities, annual performance contracts at the level of faculties and institutes also include goals for engagement with industry (IRIS Group, 2017a).

There is no exact mapping of the application of other types of incentive to increase collaborative research and innovation. But IRIS Group (2017a) concludes that:

- At some universities flexible leave policies have been introduced and communicated to researchers in order to increase engagement in entrepreneurship and spinouts.
- None of the universities make use of parallel career tracks and/or specialised positions at the senior level focusing on primary success criteria other than traditional publication. Positions shared between a university and a company are also rare, but they have been introduced at AAU and a few departments at other universities.

Share of hired senior researchers at Danish universities hired from organisations outside of the university sector



Source: DFIR, 2016

Trends in university-business collaboration

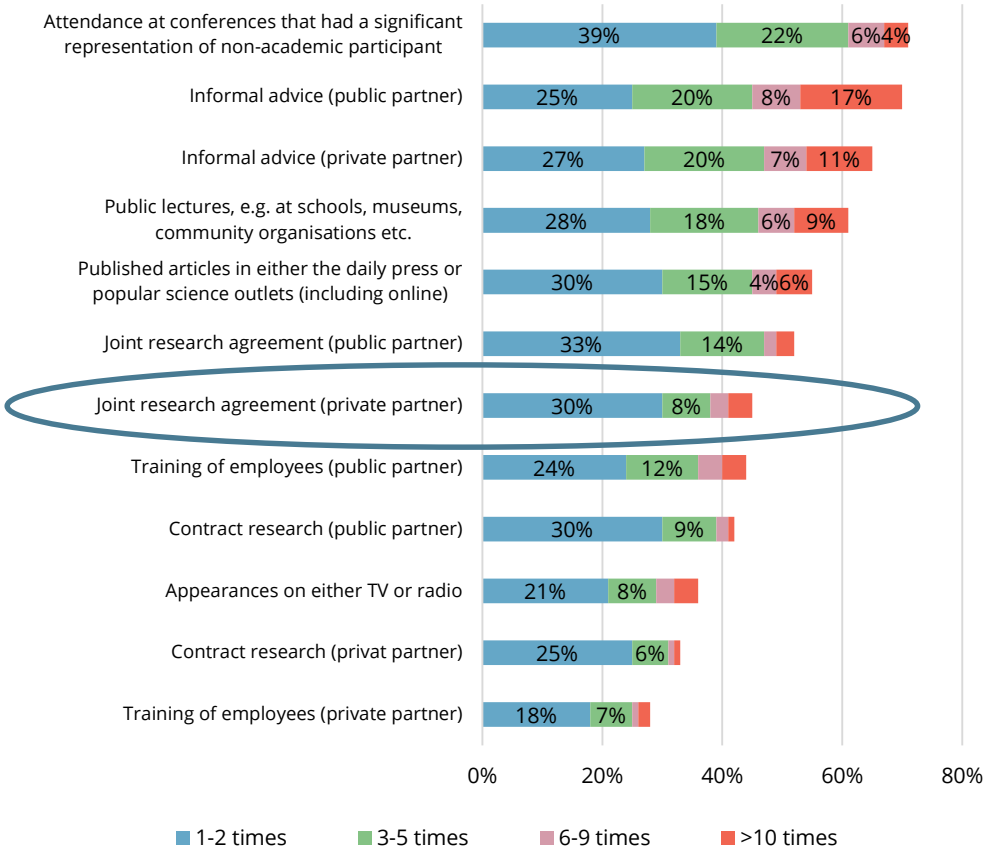
- The number of FTEs in central administration of innovation and commercialisation of research (including TTOs) was 255 in 2014 (IRIS Group, 2014). The number of FTEs in TTOs alone increased from 50 in 2010 to 80 in 2017 (UFM, 2018).
- The level of collaboration between universities and businesses has increased considerably since the mid-2000s measured in terms of the share of companies collaborating with universities (see IRIS Group, 2014 and Section 4).
- The recent years have probably been characterised by an increase in the number of student projects, student internships and use of students to solve problems in private companies. No exact numbers exist in this area, but most universities report increased emphasis on students as a mean of engagement with businesses, and more resources are spent on matching students with businesses (IRIS Group, 2017a).
- In total, 42% of all Danish university researchers have collaborated with private partners in joint research agreements over a two year period (see next page). The share is 29% for social sciences and humanities, and 48% for other sciences (DEA & CBS, 2017).
- As revealed on the next page, the primary motives to engage with non-academic stakeholders are benefits to research and teaching (rather than personal gains or pressure to deliver impact to society).

Attention points

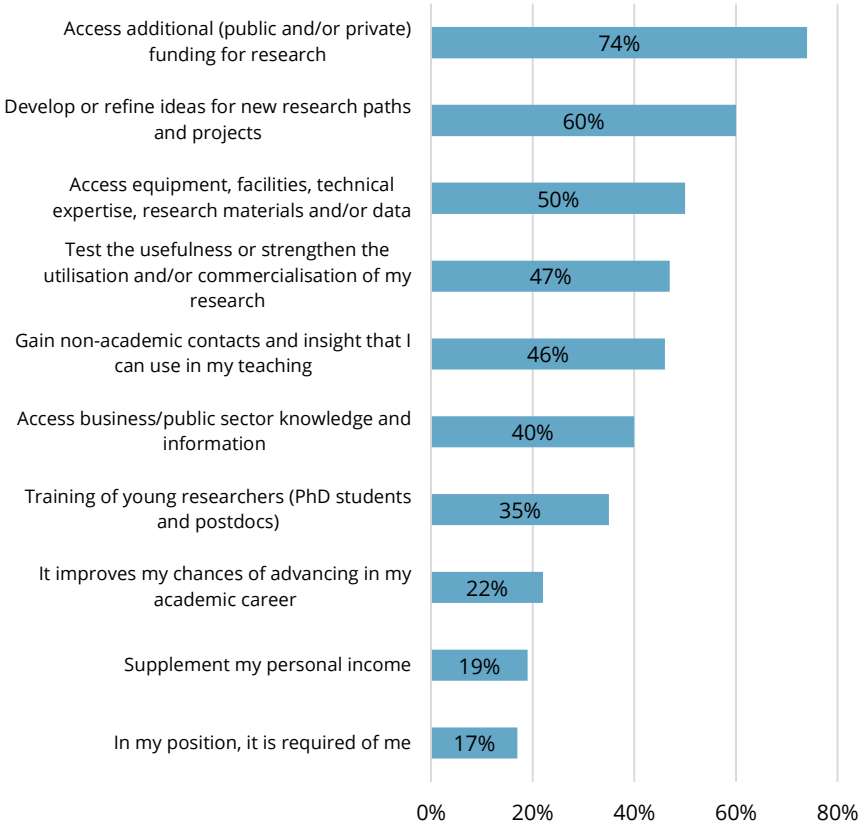
- Most of the increase in the level of collaboration concerns long term research projects, while growth in the commercialisation of research and smaller projects have been modest. This might reflect that additional funding is the primary reason for collaborating with businesses, while national goals on societal impact and a high share of collaborating companies are less important for researchers (IRIS Group 2014; DEA & CBS, 2017).
- The intensity of collaboration varies across researchers. While most researchers only have been engaged in one or a few collaborative project(s), a small group has participated in many projects (see next page) This indicates a need for greater attention on support mechanisms and incentives for collaborative research (DEA & CBS, 2017).
- The level of sectoral mobility among senior researchers (i.e. researchers moving from private companies to universities and vice versa) is low and has fallen during the last years (DFIR, 2016 – see figure to the left).

5.4. Tools and incentives fostering innovation and business collaboration

"In the last two years, how frequently have you been engaged in the following types of activity in your capacity as an academic researcher?" (as a percentage of all respondents who reported some engagement)



"Which reasons do you consider important for interacting with non-academic organisations?"



Source (both figures): DEA & CBS, 2017. Note: The survey was carried out in 2017 and included researchers at all Danish universities. N=3.428/3.315

5.5. Networks and matchmaking

As emphasised in Section 5.2, it has been an important goal of Danish innovation policy to facilitate access to universities and other HEIs in Denmark by, especially, SMEs.

The main *national* instrument used to reach that goal is the "Innovation Networks" (see Sections 2-3) at the national level. At the regional level, the five Danish Regions have also co-financed regional networks and cluster organisations focusing to varying degrees on matchmaking and collaborative innovation projects (SFI, 2016). The focal area of networks, matchmaking and clustering is also addressed in the political agreement to reform the public business promotion system (see Section 1.1). It is expected that the reform will lead to fewer and bigger networks.

Drawing on survey data, Væksthus Sjælland (2017) concludes that up to 50% of all companies in Region Sjælland are interested in collaborating with research institutions. Hence, it would appear that there is still potential for a further increase in the share of innovative companies collaborating with HEIs.

This hypothesis is backed up by other analyses, which conclude that information barriers and lack of knowledge are widespread barriers to participation in the networks by both companies (Damvad, 2014; McKinsey &Co. et. al., 2016) and researchers (Oxford Research, 2017).

Evidence from recent analyses reveals, on the one hand, that the Innovation Networks play an important role and are successful in attracting more companies and creating value. On the other hand, there is also room for improvement in the networks' efforts to bridge researchers and companies. The boxes to the right summarises findings from these analyses.

Finally a recent analysis (REG LAB, 2017) points to a specific challenge regarding how to engage more companies with limited experience of collaborative research and innovation in HEI-business collaboration. It concludes that a more dedicated supply of "facilitation services" is needed in order to ensure a major increase in the share of collaborating companies, as well as higher impact and success rate. (see next page).

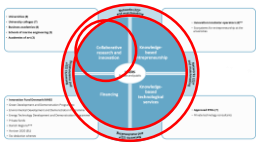
The Innovation Networks' central role as a bridge between HEIs and businesses

- Participation among companies has increased considerably, from 5,900 companies in 2011 to 11,100 companies in 2016 (SIU, 2017b).
- 36% of the companies involved in Innovation Networks and clusters have established collaborations with higher education institutions (SIU, 2017b).
- 65% of the companies which have participated in either Innovation Networks or regional clusters state that technical knowledge within the company has increased as a result of their participation (SIU, 2017b).
- Although services provided by the Innovation Networks (such as conferences and matchmaking) are also provided through other initiatives (other university-based networks, regional cluster organisations and industrial organisations), many companies and researchers find the value proposition to be unique (Oxford Research, 2017). The national scope, the participation of SMEs and the opportunity to share knowledge across universities are particularly highly valued by participants. Moreover, the *mix* of services (see Section 2) is considered unique.

Attention points

- Knowledge of the Innovation Networks is limited, except among researchers and research groups who are already engaged in them (Oxford Research, 2017).
- There is a skewedness in the user-profile among universities: DTU and AAU are more engaged than other universities (Oxford Research, 2017).
- The participation of junior scientists and students is low (Oxford Research, 2017). This may present an important challenge, since other studies point to the fact that student collaboration often proves a good starting point for companies with no experience with university collaboration (REG LAB, 2017).
- The universities give little attention to Innovation Networks in their strategies for innovation. They consider participation a voluntary matter for the individual researcher, and senior management within the universities give more attention to their own networks and matchmaking events (Oxford Research, 2017).
- Many of the secretariats do not have sufficient manpower to undertake extensive outreach work to industry and the universities (SIU, 2017a).
- Evidence from successful cases suggest that an increased focus on facilitation services might make university-businesses collaboration more attractive and relevant to both companies and researchers.

5.5. Networks and matchmaking

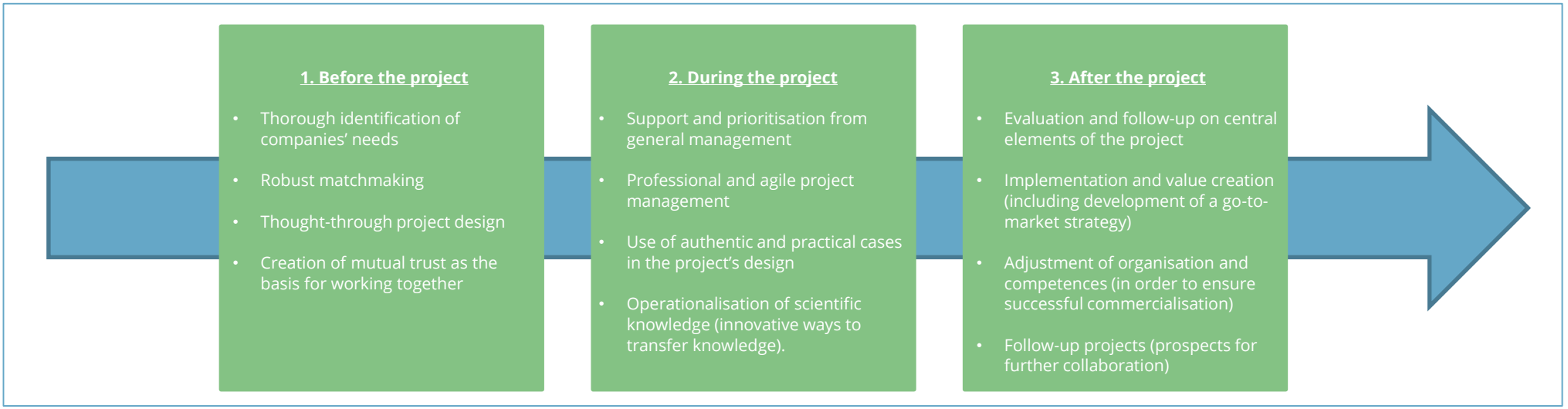


A 2017 Danish analysis attempted to identify common features of successful collaborations between knowledge institutions (at all levels of the HEI sector) and businesses. The study identified 50 successful cases, and through in-dept interviews with businesses and participants from the knowledge institutions a number of common characteristics were identified (REG LAB, 2017).

Needs and prerequisites vary across companies and projects. However, the study provided evidence that it is important to deal with collaborative innovation projects in a "before/during/after" perspective. Efforts to prepare, mature and follow-up on collaborative projects are often just as important for value creation as the project itself – especially for SMEs. The analysis concludes that it is relevant to consider all the elements below when developing (or adjusting) programmes supporting collaborative research and innovation. Moreover, it should be considered whether companies (and projects) have access to facilitation services in all three phases.

The figure below provides an overview of the most important characteristics of successful collaboration between businesses and knowledge institution and constitutes a kind of *check list* for all types of collaborative project. The analysis emphasises that facilitation services are provided to some extent by existing operators such as Innovation Networks. But they are far from offered to all companies and projects, and especially the post-project elements are often neglected Neither the national innovation strategy, nor the national strategy for clusters and Innovation Networks focus on this particular issue (REG LAB, 2017) .

Characteristics of successful knowledge collaborations



Source: REG LAB, 2017

6. Knowledge-based entrepreneurship

6.1. Introduction

Knowledge-based entrepreneurship has been an important part of the Danish innovation strategies during the 2000s and 2010s. The innovation strategies of 2003 and 2006 focused mostly on technology transfer and included the ambition to bring about a marked increase in the number of spinouts from the universities (IRIS Group, 2018b).

The 2006 innovation strategy introduced the development of entrepreneurial skills and student entrepreneurship in HEIs as priority focal areas. A scheme for co-financing student incubators at the universities was introduced, and education in entrepreneurship was implemented in a number of curricula. This theme also became a central part of the next innovation strategy from 2012 (Regeringen, 2012).

In parallel with these government strategies, entrepreneurship gained increased attention in HEIs, and formal goals for both spinouts and student entrepreneurship were formulated in university development contracts and strategies (see Section 5).

There exists no complete mapping of entrepreneurial activities at the HEIs. But recent analyses point to a significant increase in the number of (curricular and extra-curricular) entrepreneurial courses on offer, as well as a greater supply of activities fostering the development of new companies among students, candidates and university employees (DEA, 2014; IRIS Group, 2017a).

Indicators of the increased attention being given to entrepreneurship and university-based start-ups include the following:

- Most of the universities have established incubators for student start-ups, and the capacity in these incubators has increased considerably (IRIS Group, 2017a).
- The same universities are also delivering specialised services for their student entrepreneurs, including advisory services, access to labs, mentoring services, matchmaking events with investors, etc. (IRIS Group, 2017a).
- Total numbers of staff employed in central tech transfer offices at the universities have increased, as mentioned in Section 5, from 50 Full Time Employed (FTEs) in 2010 to 82 FTEs in 2017 (UFM, 2018).
- Some of the universities have established their own proof-of-concept (PoC) funds to finance technical and commercial maturation of ideas and inventions. As an example, DTU has just increased the budget of the university´s PoC-fund to DKK 11 million.
- Most of the universities are supplying local competitions for student entrepreneurs (”Venture cups”) in order to encourage entrepreneurship (IRIS Group, 2017a).

Nationally, the Danish Industry Foundation is financing an accelerator programme called the *Danish Tech Challenge* (DTC) for technology-based entrepreneurs. Participants selected for the programme move in to DTU Science Park and are offered access to labs, facilities and a mentoring team (www.industriens fond.dk).

Additionally, four universities have initiated an ambitious project co-financed by the Danish Industry Foundation called *Open Entrepreneurship* with a budget of DKK 35 million. The aim is to facilitate commercialisation of research via a range of new measures bringing external collaborators closer to research. Serial entrepreneurs, intrapreneurs in existing companies and investors are invited into specific research environments, close to ongoing research activity, where they can identify promising technologies.

A major driver of the improved conditions for entrepreneurship in universities is the private funds (see Section 2). Over recent years these have invested heavily in entrepreneurship at the universities. The Obel Fund, for example, has invested DKK 30 million in a programme stimulating new business creation by students and researchers at Aalborg University (www.aau.dk). The Novo Nordisk Foundation, likewise, has invested DKK 392 million in a new Bioinnovation Institute with the aim of fostering marked growth in the number of university-based biotech start-ups. Moreover, the Danish Industry Foundation is very active in this area, as the above examples indicate.

6.2. Results and challenges

Section 4 has already given a sense of how well the Danish knowledge-based innovation support system performs when it comes to knowledge-based entrepreneurship. The indicators and recent analyses reflect both strengths and weaknesses in the system:

- The number of spinouts is modest compared with that in other OECD countries, and no significant increase has been witnessed during the last 10 years (see Section 4).
- The number of university-based entrepreneurs has increased since the early 2000s, and the gap in the likelihood of starting a new company between persons with and persons without a university background has grown (see Section 4).
- The average turnover in companies started by people with a university background is a little below that of companies started by other entrepreneurs in the first year after the start of the company. The average growth rate is approx. twice as big in the university-based companies, at 18.1% after three years as against 9.2% (UFM, 2017a).

Thus, there is no sign of a markedly higher performance among university-based start-ups than other start-ups – at least in the start-up phase.

There exist no general analyses of the *quality* of the entrepreneurship ecosystems in Denmark. A new analysis carried out for DTU in 2018 has found that the DTU ecosystem is well developed and very successful in stimulating entrepreneurship among both students, candidates and employees (see also next page). It concludes that the combination of incubation facilities, lab access, advisory services, matchmaking events and courses at the DTU campus make it easier and cheaper both to start new companies and to bring deep tech products to market (IRIS Group, 2018b). However, it also concludes that while DTU-based entrepreneurs experience higher growth rates and higher turnover/employment/ exports than other entrepreneurs within the same industries, only a few companies are successful scale-ups (IRIS Group, 2018b).

Other analyses touch on the issue of turning research-based companies into high growth companies in Denmark. They reveal that Denmark has been performing poorly over recent years in stronghold sectors such as energy (Deloitte, 2017) and biotech (IRIS Group, 2017c). Along with the evidence from the DTU analyses, they highlight the need to focus more intensively on ways of developing strong ecosystems and framework conditions for scale-ups (see box below).

As regards biotech, IRIS Group (2017b) concludes 1) that the number of spinouts has grown in the Capital Region during the last years, 2) but also that the level is still lower than in other strong life science clusters. The main explanations for the latter are lower resources spend on tech transfer activities at the universities and a lower supply of seed capital than in competing regions.

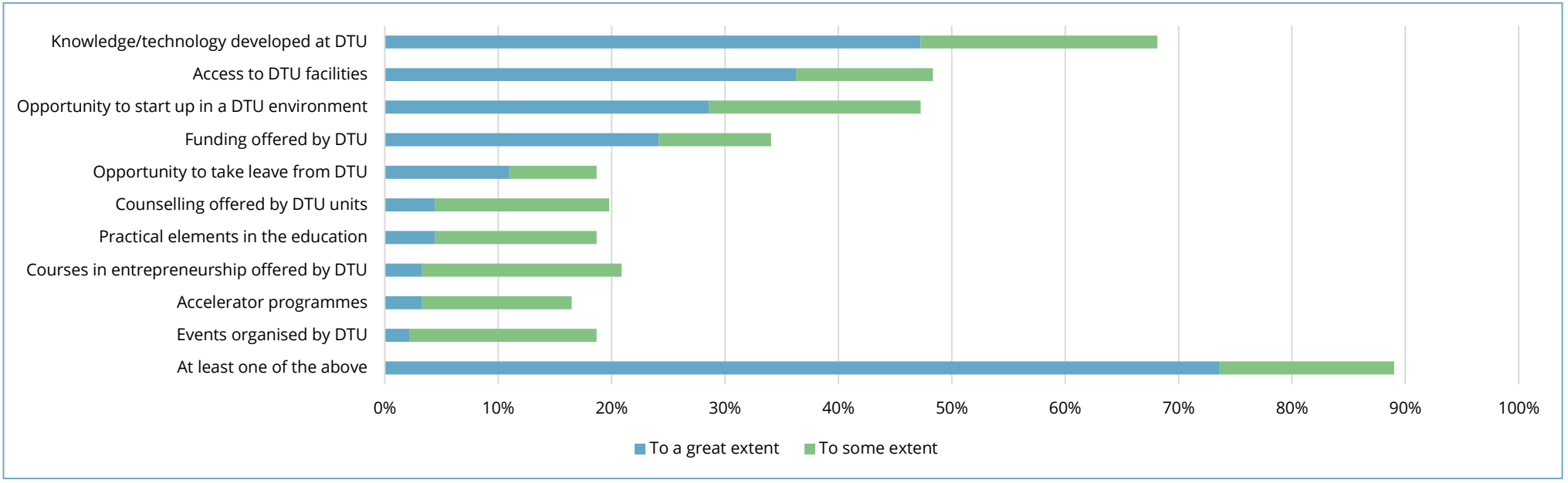
Knowledge-based entrepreneurship – attention points

- There is a need for closer collaboration between Danish universities and the entrepreneurial system. Better connections and networks with serial entrepreneurs, investors, etc. will make it easier to bridge inventions, ideas and research-based technologies with people possessing the skills necessary to evaluate the ideas and bring them successfully to the market (DTU, 2015; IRIS Group, 2018b).
- Many services support start-ups at the Danish universities, but no "Accelerace Plus" programmes are available for university-based entrepreneurs. The universities neither supply nor have access to programmes designed for university start-ups with "unicorn" potential (IRIS Group, 2018b).
- Most Danish TTOs and central innovation offices only support entrepreneurs until a VAT number is received. Part of the success in some European entrepreneurship universities is down to the existence of organisations which support and invests in innovations in the whole value chain from idea to market or from idea to venture funding (IRIS Group, 2018b).
- Current Danish PoC-funds are rather small compared with those offered in comparable universities in other countries (IRIS Group, 2017c), and there is a lack of capital for financing the early maturation of promising research (DEA, 2016; Deloitte, 2017).
- Denmark only ranks as number 10 in Europe, when measuring the ability of Danish firms to attract early stage and venture capital compared to GDP (Vækstfonden, 2018a). The number of new investments by venture funds in Danish companies decreased considerably in the years following the financial crisis, but has been relatively stable since then (Vækstfonden, 2016, 2018c). Particularly within life science and cleantech, investments have decreased (IRIS Group, 2017c , Deloitte, 2017).
- The number of business angels has been increasing and today there are more than 4.000 business angels in Denmark. (Vækstfonden, 2018b). Access to investors and business angels is, however, weaker for university start-ups located at universities outside the Capital Region (Oxford Research, 2018).

6.3. The use of the ecosystem for entrepreneurship at DTU

- A survey (IRIS Group, 2018b) shows that many DTU-based start-ups make use of the DTU ecosystem.
- Almost 80% of DTU-based entrepreneurs state that elements in the ecosystem have played an important role in the start-up phase (see figure below).
- The most important elements are research/knowledge developed at DTU, access to facilities, and the opportunity to start up in "a DTU environment" (i.e. DTU Science Park, a DTU-department or the DTU student entrepreneurship hub "Skylab").
- It should be noted, that the survey covered entrepreneurial enterprises from the period 2007-2017, and that many elements in the lower part of the figure were developed during that period.

Share of DTU-based start-ups stating that different elements of the ecosystem were of value in the start-up phase



Source: IRIS Group (2018b)

7. Knowledge-based technological service

7.1. Introduction

Knowledge-based technological services have been an integrated part of Danish innovation and business policy for decades. The GTS network is by far the most important policy instrument (UFM, 2016a), and it plays a particularly decisive role in making knowledge-based technological service available to Danish SMEs (see also Sections 2-3), as well as fostering collaborative research and innovation projects (see section 5).

Thus, the overall aim is to improve access to new technologies and technical knowledge by companies with limited resources and limited access to the latest technologies (GTS-nettet, 2016).

The business model of the GTS network consists of three parts (GTS-nettet, 2016):

First, GTS institutes carry out a large number of R&D projects with private companies. These activities are financed through performance contracts with MHES, external grants, commercial sales and/or GTS institutes' profits from sales of services. The R&D projects can create new innovative solutions and, of course, boost knowledge and innovation among private project partners.

Second, GTS institutes use new insights and solutions from the R&D projects to improve existing commercial services and develop new commercial services on the frontier of the market. These services help to boost innovation among the more than 16,000 Danish companies that purchase services in the GTS network annually. Of these, approximately 80% are small businesses with less than 50 employees (see Section 3).

Third, the GTS network provides access to an advanced technological infrastructure to Danish companies to be used for product development, test, validation, etc.

Despite the fact that many companies use the GTS network primarily to buy small commercial services (e.g. test or solving of specific technical problems), in a 2016 survey more than half of the companies reported that their use of services from the GTS institutes strengthened their innovation capacity (IRIS Group, 2016).

It is worth noting that resources devoted to R&D projects have been declining in recent years owing to increased competition for external funding. The table below shows key indicators of trends in R&D spending in the GTS network.

The decrease in funding from "other competitive funds" is caused by increased competition for EU funding (Horizon 2020) and a change in policy on public funding of collaborative research and innovation (GTS-nettet, 2018). Before 2015, national R&D programmes placed greater emphasis on technology diffusion, and in some programmes the participation of GTS institutes was required in order to facilitate the building of new competencies that could be used to develop new GTS services.

Trends in the GTS networks R&D from 2013 to 2017

KPI	2013	2017	Trend
R&D: total	DKK 1,095 million	DKK 912 million	↓ -17%
MHES performance contracts	DKK 304 million	DKK 346 million	↑ +14%
Other competitive funds	DKK 463 million	DKK 320 million	↓ -31%
Self-financed	DKK 327 million	DKK 246 million	↓ -25%
Number of R&D FTEs	792	686	↓ -13%
Number of national R&D projects	1,015	542	↓ -47%
Number of International R&D projects	230	177	↓ -23%
Number of published scientific articles	229	173	↓ -24%
Number of conference papers	156	105	↓ -33%

Source: GTS-nettet, 2018.

7.2. Value creation

In the 2016 survey of users of the GTS system, respondents were asked about their collaborative activities in different phases of the innovation value chain, from research to market.

The upper-right figure shows six stages of the innovation value chain. For each phase it gives details of the share of companies that have collaborated with GTS institutes, universities, suppliers and customers, foreign knowledge institutions, private consultants and public institutions.

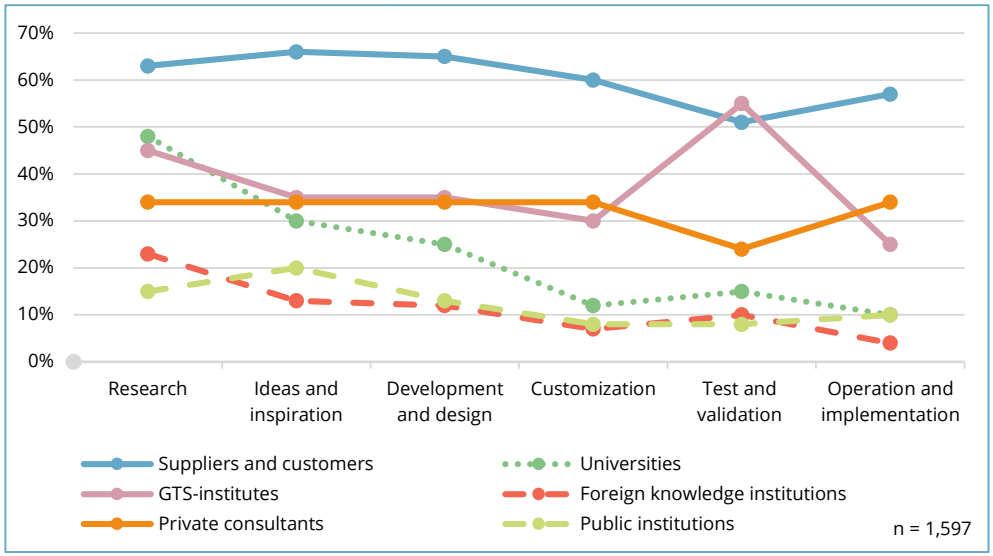
The companies most frequently collaborated with are other companies in terms of users and suppliers.

Universities are used as partners primarily in the early phases of the innovation chain, while GTS institutes play an important role in all phases. GTS institutes are the most common partner in the test and validation phase, where the GTS system has a comprehensive and specialised supply of services (IRIS Group, 2016).

It is noteworthy that GTS institutes also play a role in the research phase for many companies. This reflects the fact that many different companies participate in the R&D projects – see also next page (IRIS Group. 2016).

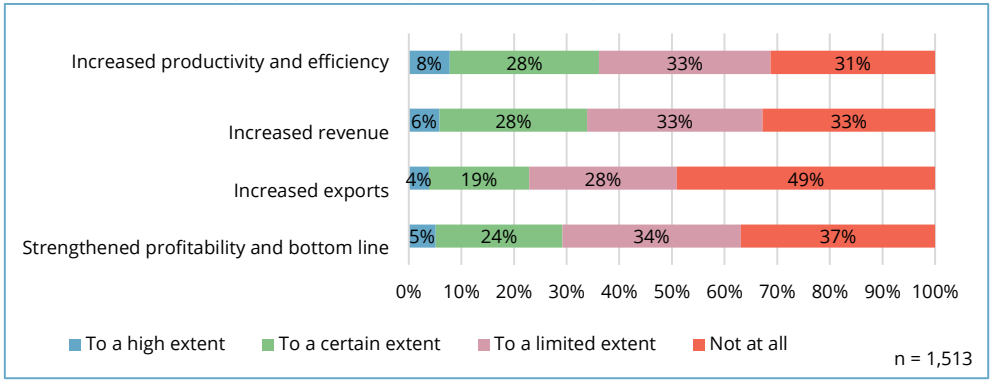
The survey also included questions about the impact of collaboration on the companies' economic performance. The lower-right figure summarises the responses. It can be seen that approximately two out of three users reported that services have had positive impact on productivity, turnover and rentability. In interpreting the figure, it should be borne in mind that 60% of users spend less than DKK 50,000 annually on GTS services (IRIS Group, 2016).

Share of innovative GTS users (companies) who collaborate with different actors



Source: IRIS Group, 2016

The GTS networks impact on the companies economic performance



Source: IRIS Group, 2016

7.3. Challenges and potentials for further value creation

The table below compares the profile of the total population of GTS users with that of the population of GTS partners involved in R&D projects with public funding.

The table shows that micro-companies are underrepresented in large R&D projects as compared with the total population of users of the GTS network.

Total population of GTS users and GTS partners involved in R&D projects

	Total population of GTS users	The GTS partners involved in R&D projects
Micro (0-19)	59%	40%
Small (20-49)	14%	18%
Medium (50-250)	12%	22%
Large (>250)	6%	11%
Public organisations	10%	9%
Total	100%	100%

Source: IRIS Group, 2016.

Analysis of the 2016 survey confirms that the companies involved in R&D projects gain most value – in terms of increased innovation capacity – from using of the GTS network.

The analysis from 2016 also indicate that the GTS institutes can improve their outcomes by involving SMEs in R&D projects and perhaps design new commercial services which stimulate use of new technology and innovation in SMEs (IRIS Group 2016).

More generally, the 2016 analysis indicates that the role of the GTS institutes in fostering innovation and increased innovation capacity could be even stronger in the future. The analysis concludes the following (IRIS Group, 2016):

- The quality of GTS services is generally considered high in all users segments.
- Technical leaders experience greater value creation from using GTS than technical "followers".
- Technical followers are more likely to use GTS institutes for more traditional tests, calibration services, etc.
- The GTS system possesses the potential to develop new kinds of service which aim to engage more SMEs in innovation activities. That could be achieved through improved access to test facilities and workshops focusing on technology choice, as well as specialised innovation courses where participants work with all phases in the innovation process (from idea, to prototype and market analysis).
- GTS consultants generally possess high-level technical knowledge. But more emphasis could be given to the development of business skills which enable the consultants to 1) adapt services and products to the individual needs of customers, and 2) identify challenges and ideas that could further stimulate innovation capacity among the customers and encourage SMEs to make more use of GTS institutes.
- GTS institutes could intensify their collaboration with universities and foreign knowledge institutions in order to secure access to an even broader supply of technical facilities for their customers. The cost of technical facilities is increasing – a trend which forces RTO organisations to specialise even more, and to identify new ways to help their customers to obtain access to relevant equipment and facilities.

7.4. The GTS strategy 2016-2021

The two boxes below summarise what the key stakeholders in the GTS system in 2016 (but before publication of the analysis referred to on the two previous pages) considered the most important areas of improvement in the Danish GTS network. The findings presented were based on a process in which business organisations, unions, the GTS institutes, universities and other HEIs, Innovation Networks and ministries were invited to contribute with ideas and goals for the GTS system.

The process led to a new GTS strategy, including a number of goals and ambitions for the development of the GTS network (UFM, 2016a):

Development areas for the Danish GTS network 2016-2021

1. Role and position of the GTS network in the Danish innovation system

The network needs to:

- Clarify its specific role in the Danish innovation infrastructure and specify its relations and co-operation with the various other actors in the Danish innovation system.
- Become better at disseminating its knowledge, skills and technical infrastructure to students and teachers at universities, business academies and other educational institutions.
- Continuously strengthen and expand its competencies through co-operation with other public knowledge institutions
- Develop its engagement with the Danish innovation networks
- Improve the effectiveness of the Danish technology infrastructure by working, and co-ordinating more closely, with other public institutions (especially the universities) to avoid overlap in facilities and boost synergy.

Development areas for the Danish GTS network 2016-2021

2. International engagement

The network needs to:

- Strengthen the support it offers to Danish companies who want to participate in international R&D programmes, with a particular focus on Horizon 2020.
- Start providing services to Danish companies which are in strategic partnerships with international research and technology organisations (RTOs), universities or other international actors in order to make better use of specialised facilities and competencies.

3. Governance

The network needs to:

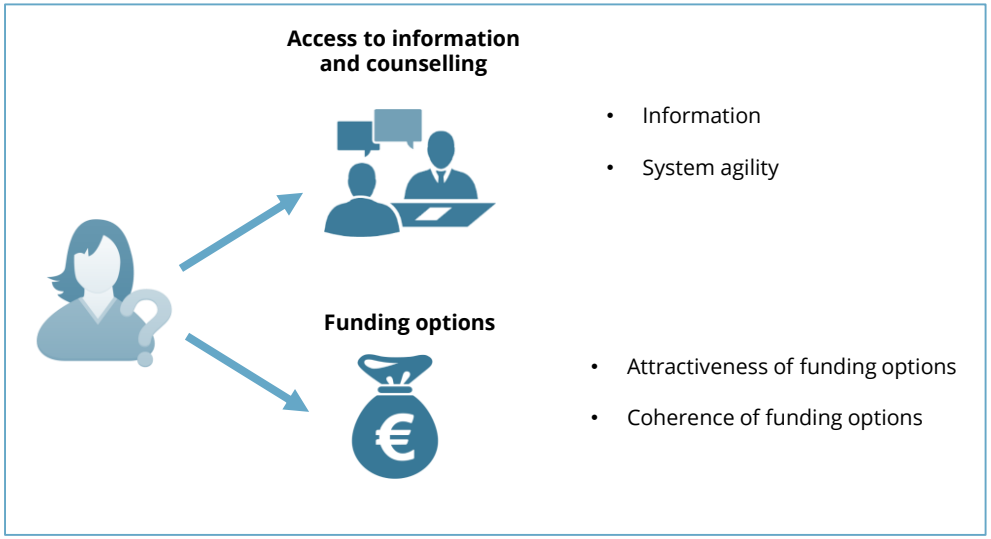
- Improve its management and financing by introducing a new system to measure and evaluate GTS institutes' activities and services. The new system should have an increased focus on the impacts of GTS institutes on innovation and growth in Denmark.

8. Access to financing - a user perspective

8.1. Introduction

In this, the final section of the present literature review and assessment, the access to public funding of innovation activities considered. The section focuses on the access to funding from a user perspective, i.e. to what extent it is easy and possible to finance promising innovation activities (including collaborative research and innovation) that are (usually) to risky to be financed solely by the market.

As illustrated in the figure below, the issue of access to funding revolves around both the relevance and attractiveness of the funding options available in the innovation system, on the one hand, and users' ease of access to information and counselling on those funding options, on the other. Put differently, what are the options, and is it easy to obtain information about them?



It is important to note that the political agreement to reform the public business promotion system (see Section 1.1) is likely to lead to fewer programmes and a more user-friendly business and innovation support system.

Thus, the conclusions and inputs in this section refer to a system that is expected to change in 2019. The reform is expected to:

- Strengthen access to information about business and innovation initiatives through 1) a national, digital hub, and 2) the establishment of new business houses supplying sparring and counselling to all SMEs.
- Facilitate access by entrepreneurs and SMEs to funding at the national level by making *one* "entrance" for grants (Innovation Fund Denmark) and *one* "entrance" for loans and investments (The Growth Fund).
- Lead to mergers of existing Innovation Networks and cluster organisations with the goal of establishing 10-12 national clusters and a couple of upcoming clusters.
- Strengthen access to proof-of-concept funding through a new national scheme.

Moreover, some of the recent analyses focusing on access to funding were carried out in 2014, before Innovation Fund Denmark (IFD) was founded. The number of national funding programmes was reduced in late 2014, with the InnoBooster scheme (supplied by IFD) taking over responsibility for activities and grants formerly supplied via a number of small, individual schemes.

8.2. Access to information and counselling

Information

A number of recent analyses consider user-access to information within the knowledge-based innovation support system and ask whether lack of information is a barrier to participation in the system's schemes and programmes. The studies have found that some users find the system satisfactory and easily accessible (1-2 below), while other companies indicate that lack of information is in fact a barrier to participation (3-4). As mentioned, significant changes in the supply of programmes have taken place since 2014, so it is important to note that the users are not necessarily commenting on the same system in the different analyses.

1. About 33% of users have not experienced "any barriers" for participation in the supplied programmes (Damvad, 2014).

2. Users of InnoBooster give very positive feedback on access and information about the programme (IRIS Group 2018a). They explain that Innobooster is well among business promotion operators at the local and regional level, and there is a high level of awareness of the programme in the start-up environments. This makes it easy to obtain information about the programme. Moreover, the IFD website and access to IFD counselling are considered to be of high value.

3. 28% of users and 69% of non-users of innovation support programmes (within the target-groups) indicate that lack of information about programmes has been a barrier to participation (Damvad, 2014).

4. McKinsey & Co. et al. (2016) conclude that many users are small, older companies with little potential for growth, while SMEs with scale-up potentials are somewhat neglected. This is supported by user interviews with SMEs in which the interviewees point out that the system favours start-ups over scale-ups. This is indicative of difficulties in approaching important target groups (McKinsey & Co. et. al, 2016).

System agility

Three reports (Damvad, 2014; DEA & DI, 2014; IRIS Group 2015b) address the agility of the system from a user perspective. Agility involves 1) access to professional and neutral information/counselling on the different programmes and operators in the system, and 2) the ability of the system to help users to move around, in the system, depending on their needs. The reports conclude that there may be a problem with administrative "silos" which render the system less agile.

- The Innovation Networks play a central role as an entrance point to a range of programmes supporting and financing industry-university collaborations (see Section 2). Damvad (2014) concludes that although many small companies participate in the networks, there is evidence that larger companies (50+ employees) are more likely to use the networks as an entrance to funding schemes, while small companies are mostly supervised through the funding options by the regional Growth Houses (Business Houses from 2019).

- Damvad (2014) and DEA & DI (2014) report that there seems to be a convergence of users in programmes managed by the same parts of the system. In practice, this means that, to some extent, the same groups of users are repeatedly funded either by the Innovation Fund Denmark programmes (formerly supplied by the Council of Innovation and Technology) under MHES, or by the UDP programmes administered by other ministries, or by regional programmes targeting SMEs.

In other words, there are some indications of a need to develop a more neutral system based on the principle of "no wrong door". Another analysis concludes that a number of operators in the business and innovation system are less than fully aware of the services and funding options in other parts of the system (IRIS Group, 2015b). This also indicates a risk for non-neutral advisory services and reference practices.

8.3. Access to funding

Attractiveness of funding options

In general, there is no evidence of major gaps in the supply of programmes financing innovation in Denmark. However, although broader analysis of barriers to use of innovation programmes has not identified lack of funding options as an important barrier (Damvad, 2014; Mc Kinsey et. al, 2016), some narrower analyses have highlighted challenges in financing innovation in *specific* sectors. The problem mainly affects research-intensive industries with long time-to-market perspectives, such as biotech. A benchmark study of this sector points to the fact that funding options in France and the USA (e.g. through the Small Business Research and Innovation Scheme) are more favourable both with regard to the size of the grants and the total budget (IRIS Group, 2017c).

As already mentioned, an important aim of the Innovation Fund Denmark has been to reduce the number of funding programmes in order to create fewer, but more flexible options for funding R&D&I in private companies. Users of IFD programmes value the flexibility of InnoBooster especially (IRIS Group, 2017b):

- No specific type of innovation activity (e.g. collaboration with a university) is required to obtain co-financing from InnoBooster. Thus, the programme offers a variety of funding options depending on the company's needs. This flexibility to design innovation projects according to the needs of the company is appreciated by users.
- Because innovation projects rarely develop as expected, it is possible to adjust IFD projects after approval. The majority of users find InnoBooster flexible as regards the potential to make adjustments (e.g. in budgets and activities).
- Participating companies have to fund 66% of all costs related to the project (IFD funds 33%). The company's financial contribution can be in kind (hours worked on the project). For most companies this allocation of costs is not an issue. Some start-ups do, however, find it difficult to double the IFD contribution.

Coherence of funding options

Data from publications specifically addressing the question of users' experience of transitions between programmes, and the system's ability to finance activities along the whole value chain from strategic research to test, demonstration and product development, are scarce. The following bullets should be read with this in mind.

- Following the findings on administrative "silos" (see previous page), DEA & DI (2014) points out that there is a clear tendency for users to re-apply for programmes in the same parts of the innovation system. They argue that this pattern makes the transition from strategic research projects to innovation projects difficult because the financing in some areas (such as energy and health technologies) are provided by different funds belonging to different authorities.
- This general point is confirmed in an evaluation of one specific programme, namely the Environmental Development and Demonstration Programme – MUDP (Niras et al., 2017). While the role of the programme is to bridge the gap between strategic research and market, only 30% of MUDP projects are a continuation of earlier publicly supported projects. As little as 4% of the projects had previously been supported by Innovation Fund Denmark (i.e. the main fund supporting strategic research).
- The level of proof-of-concept funding is generally seen as a challenge in Denmark (see also Section 5). Several publications conclude that the level in Denmark is lower than it is in comparable countries/regions and partly explains the modest level of commercialisation of research (DEA, 2016; IRIS Group, 2017c).

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Literature

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Abbreviations in references

Abbreviation	Danish	English
CBS	Copenhagen Business School	Copenhagen Business School
CEBR	Centre for Economic and Business Research	Centre for Economic and Business Research
DASTI	Styrelsen for Forskning og Innovation	Danish Agency for Science, Technology and Innovation
DFIR	Danmarks Forsknings- og Innovationspolitiske Råd	The Danish Council for Research and Innovation Policy
DI	Dansk Industri	The Confederation of Danish Industry
DST	Danmarks Statistik	Statistics Denmark
DTU	Danmarks Tekniske Universitet	Technical University of Denmark
FI	Forsknings- og Innovationsstyrelsen	Agency for Research and Innovation
SFI	Styrelsen for Forskning og Innovation	Agency for Science, Technology and Innovation
SFU	Styrelsen for Forskning og Uddannelse	Agency for Science and Higher Education
SIU	Styrelsen for Institutioner og Uddannelsesstøtte	Agency for Institutions and Educational Grants
UFM	Uddannelses- og Forskningsministeriet	Ministry of Higher Education and Science

Appendix A: Detailed descriptions of instruments managed by Innovation Fund Denmark

Innovation Fund Denmark programmes

Innovation Fund Denmark

Innovation Fund Denmark (IFD) was established in April 2014. The main objective was to create a single entrance to innovation funding for Danish companies, universities and talents. Three former national funding bodies were consolidated within the single new entity, and a new board of directors and executive management were appointed. IFD is supervised by MHES.

The existing 14 funding instruments were reduced to three overall programmes:

- **Grand Solutions**: For substantial investments and long-term projects/partnerships where the focus is on research, technology, experimental development and market development.
- **InnoBooster**: For small enterprises and entrepreneurs with sound development plans.
- **Talents**: For undergraduates, recent graduates or postgraduate researchers aiming to become entrepreneurs or to secure a research career in the private sector.

On this and the following pages, we describe the IFD instruments used to facilitate knowledge sharing, co-operation and matchmaking.

Grand Solutions

The most complex IFD programme, with the largest investments in research, innovation and development. Introduced in 2015 and partly modified in 2017.

Purpose
The purpose of Grand Solutions is to invest in high quality research and innovation projects with the potential to create knowledge, growth and employment in Denmark.

Grand Solutions projects are characterised by their high risk profile and focus on ambitious results in terms of new knowledge and/or new or significantly improved processes, systems, products or solutions to societal challenges. Projects must create societal and/or economic value in Danish public and private companies and/or benefit society as a whole.

Total budget and financing
Budget in 2018: DKK 685 million

Grant size: DKK 5-30 million (typical)

Main target group and criteria for participation
Any type of institution, including businesses, research centres, public institutions, etc., can apply for a grant. Partners both in Denmark and abroad can be co-participants and receive IFD funding.

Both thematic and open calls are issued under the programme. Grants are awarded in free competition between applicants, with an emphasis on the following three criteria:

1. Quality of research and innovation
2. Value creation through knowledge, innovation and technology
3. Efficiency and implementation of the project

Projects typically last 3-4 years.

Innovation Fund Denmark programmes

Industrial Researcher

The programme, introduced in 1971, has been administered by IFD since 2014.

Purpose
To raise levels of knowledge and innovation in Danish companies through research projects shared between private companies/public institutions and a public research institution.

This IFD programme invests in Industrial PhD and Industrial Postdoc projects, where the candidate is affiliated with both a university and a company and has a supervisor in both places.

Industrial PhD projects correspond to a PhD degree and last for 3 years. An Industrial Postdoc project is a business-orientated research project lasting 1-3 years, conducted within a company by a researcher with a PhD obtained within the last five years. The Postdoc is employed full-time in the company, and the project is undertaken in collaboration with a research institution.

Total budget and financing
Budget in 2018: DKK 160 million

Grant size: Approx. DKK 1 million

Main target groups and criteria for participation
It is the company that formally submits the application to IFD, and it is possible to apply for an industrial research grant without having a specific candidate in place.

Applicants must demonstrate the project's business potential and explain how it applies state-of-the-art research.

To be considered, the research project must have the potential to create commercial value for the company and build on and exploit high-quality research.

InnoBooster

The programme has existed since 2014 and has been modified three times.

Purpose
To enhance innovation in small and medium-sized enterprises (SMEs).

An InnoBooster project can involve the development of a new product or service that is new to the market, or the improvement of an enterprise process in an innovative way that significantly improves the competitiveness of the company.

Total budget and financing
Budget in 2018: DKK 286 million

Grant size: between DKK 50,000 and DKK 5 million

The company must finance at least 66% of total project costs, either financially or in working hours put into the project by employees in the company (in-kind contributions). The grant can be used to cover:

- Working hours of new or existing employees.
- Expenses for co-operation with public and private knowledge institutions.
- Other expenses related to the innovation project such as materials and equipment.

Main target group and criteria for participation
InnoBooster is targeted at SMEs with clear growth potential as well as new, promising start-up companies and researchers with commercially promising ideas and results.

To receive an InnoBooster grant, a company needs to have an innovative idea that can significantly improve its competitiveness.

Innovation Fund Denmark programmes

InnoFounder

A twelve-month incubator course offered by IFD since 2014.

Purpose
To support new graduates with innovative and scalable business ideas. During the twelve-month course, InnoFounders receive a monthly grant of DKK 15,000 and a one time grant of DKK 35,000 to support the development of their business idea.

The course also provides access to co-working spaces in five major Danish cities, a mentor who will follow the project, and a series of workshops for all InnoFounders across the programme.

Total budget and financing
Budget in 2018: DKK 15 million

Grant size: DKK 215,000

Main target groups and criteria for participation
Graduates who have graduated within the last year, or are about to graduate, from a higher Danish educational institution can apply. It is possible to apply twice a year either individually or as a team of up to three graduates. The application is rather short and focuses on the business idea (innovative dimension, value creation, business potential and implementation).

The course is developed and run by an external operator in collaboration with IFD.

Appendix B: Detailed presentation of impact studies

Evidence of the impact of the GTS network - Approved RTOs

Introduction

The GTS network consists of seven GTS institutes. Their purpose is to develop and gather insight and knowledge of new technological methods and make it applicable for businesses. Key findings from recent impact studies and qualitative evaluations of GTS institutes are summarised below.

The GTS network is described in Section 2.5.

Impact assessment of the GTS network - Approved RTOs	
Estimated effects (statistically significant)	• Companies collaborating with GTS realise a positive and significant effect on 'labour productivity'. • The average productivity gain is 9% in each of the first four years of the company's interaction with a GTS Institute.
Year of publication	2011
Period covered by the evaluation	Companies with collaboration between 1997-2008.
Methodological level of the evaluation	Quantitative impact evaluation (difference-in-difference). 1,400 innovative companies, with collaboration compared to a control group of innovative companies without collaboration.

Source: FI, 2011.

Average annual difference between R&D-active companies *with* interaction and R&D-active companies *without* interaction	
Annual productivity gain per employee	Value added per company
DKK 49,000	DKK 8,800,000
9%	9%

Source: FI, 2011.

Key insights on how the GTS institutes generate impact

- Users are in general satisfied with the quality of the services from the seven GTS institutes (IRIS Group, 2016).
- Companies which participated in a publicly funded research, development and innovation project together with one or more of the GTS institutes are generally satisfied with the GTS institutes' professional contributions, which are often considered important for the results achieved.
- The GTS institutes are in close contact with a broad segment of SMEs, and there is potential for the GTS institutes to further stimulate innovation and technological innovation in SMEs.

Evidence of the impact of the Danish Innovation Networks

Introduction

The Innovation Networks provide a platform within a specific technical or professional area where companies, universities, research institutions and other relevant players can meet and exchange ideas and knowledge and launch shared projects.

The Innovation Networks facilitate collaborative innovation activities between Danish companies and universities and other research institutions.

The Danish Innovation Networks are described in Section 2.7.

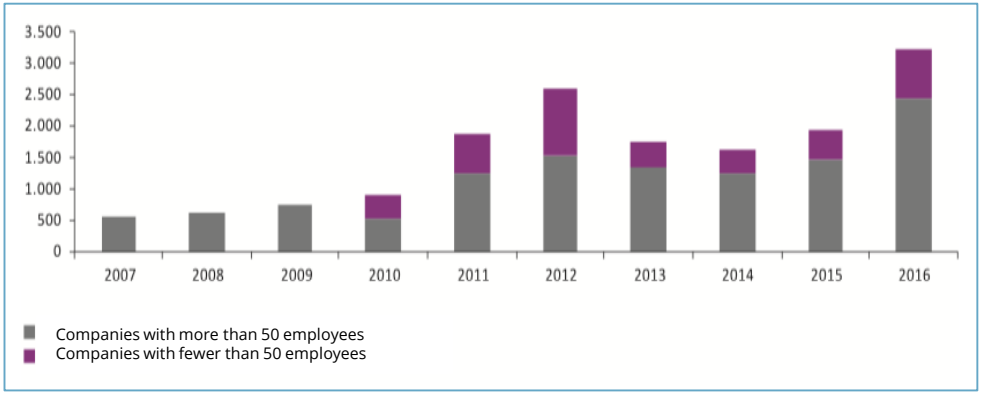
Impact assessment of the Danish Innovation Networks	
Estimated effects (statistically significant)	Compared to a control group of companies with similar profiles, participating companies increase their probability of: • Being innovative by a factor of 4.5 • Engaging in collaborative R&D effort by a factor of 4 A more recent study shows that participating companies realise a significant 3.6 percentage point increase in total factor productivity (TFP) 2-3 years after participation.
Year of publication	2011 and 2016
Period covered by the evaluation	2003-2008
Methodological level of the evaluation	Quantitative impact evaluation (difference-in-difference). 3,000 participating companies

Source: DASTI, 2011a; CEBR, 2016; Kongsted 2018.

Key insights on how the Innovation Networks generate impact

- In 2016, more than 11,000 companies participated in activities hosted by one of the 22 Danish Innovation Networks, of which more than 7,000 were small companies with fewer than 50 employees.
- A large number of participating companies enhanced innovation capacity through engagement in network activities. This number has risen in recent years.
- In 2016, approximately 33% of the participating companies (equal to 3,500 companies) acquired new skills. There is an overrepresentation of larger companies with more than 50 employees (see figure below).

Participating companies that acquire new skills and significantly enhance the company's innovation capacity



Source: SUI, 2017b.

Evidence of the impact of the Grand Solutions programme

Introduction

The Grand Solutions programme typically invests DKK 5-30 million at a time in R&D projects which address key challenges and innovation needs facing society and companies.

The programme was established in 2014, so it is too early to conduct a comprehensive impact assessment. The impact indicators below refers to the previous Innovation Consortia programme, which was in many ways similar to the Grand Solutions programme. The key insights listed on the right draw on a recent survey of companies and universities participating in Grand Solutions projects.

The Grand Solutions programme is described in Appendix A.

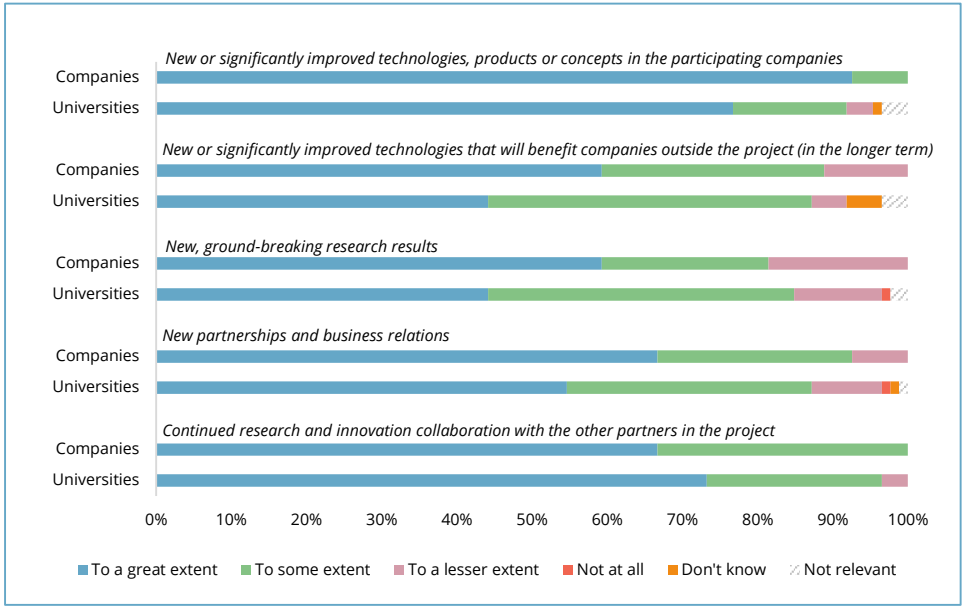
Impact assessment of the Innovation Consortia programme	
Estimated effects (statistically significant)	• Significant impact on growth in gross profit and employment for companies with gross profit less than DKK 150 million in the year before participation. • On average, the annual gross profit of participating firms in this group has grown by approx. DKK 2 million per annum relative to firms in the control group. • A significant 6 percentage point increase in total factor productivity (TFP) growth 2-3 years after participation.
Year of publication	2010
Period covered by the evaluation	Companies participating between 1995-2003
Methodological level of the evaluation	Quantitative impact evaluation (difference-in difference). 220 participating companies.

Source: CEBR, 2016; Kongsted, 2018.

Key insights on how the programme generates impact

- Almost all participating companies and universities have positive expectations about innovation outcomes.
- Expectations regarding ground-breaking research results are a little more modest. However, more than 80% of survey respondents expect that such results will be developed to some or a great extent.
- It would appear that Grand Solutions projects contribute to durable networks and co-operation. Approximately 66% of the survey respondents expect (to a great extent) to continue collaboration with other partners in the project.

Expected value creation from Grand Solutions projects



Source: IRIS Group, 2018a

Evidence of the impact of the InnoBooster programme

Introduction

The InnoBooster programme invests up to DKK 500,000 at a time in knowledge-based innovative projects run by small and medium sized companies (SMEs), start-ups and researchers.

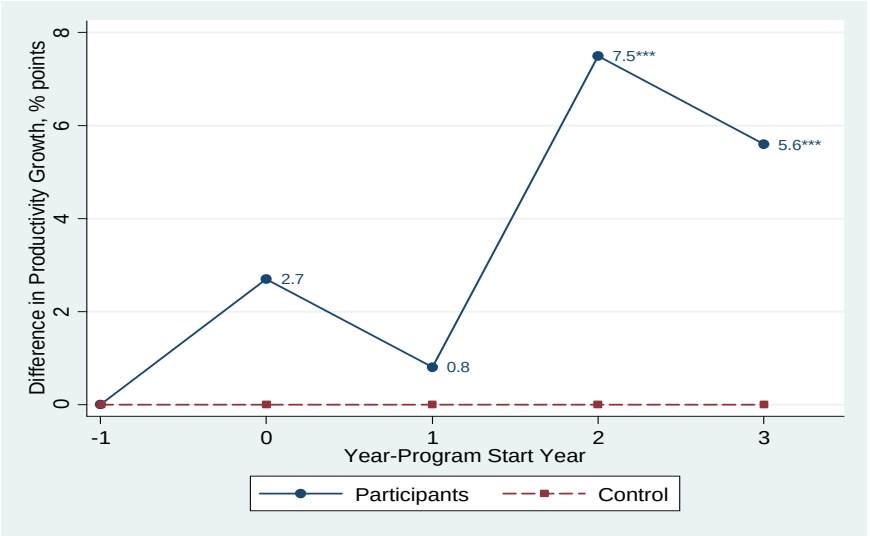
The programme was established in 2014, so it is too early to conduct a comprehensive impact assessment. The impact indicators below refers to the previous Innovation Voucher programme, which was in many ways similar to the InnoBooster programme. The key insights listed on the right draw on a recent survey of users of the InnoBooster programme.

The InnoBooster programme is described in Appendix A.

Impact assessment of the Innovation voucher programme	
Estimated effects (statistically significant)	Participating companies realise: • A 20% increase in labour productivity • Higher growth in operational profitability 3 years after participation. Another study finds a significant 5-7 percentage point increase in total factor productivity (TFP) 2-3 years after participation (see diagram to the right).
Year of publication	2016
Period covered by the evaluation	Participating companies 2002-2012
Methodological level of the evaluation	Quantitative impact evaluation (difference-in-difference). Random assignment to treatment through a lottery with 130 lottery winners and 48 lottery losers.

Source: CEBR, 2016; Kongsted, 2018.

Impact on yearly growth in TFP 1-3 years after programme participation



Source: CEBR, 2016.

Key insights on how the programme generates impact

A survey of users of the InnoBooster programme (IRIS Group, 2017b) shows that:

- The InnoBooster grant has been of high importance to most companies (high additionality). Without the InnoBooster grant most users would either have 1) abandoned their innovation project due to its high risk, 2) deferred the project, or 3) reduced their own investment and ambition level.
- Many companies use InnoBooster as a starting point for the acquisition of new skills or for initiating co-operation with knowledge institutions.
- Many companies describe their investment from InnoBooster as "the necessary push" to get started.

Evidence of the impact of the Industrial Researcher programme

Introduction

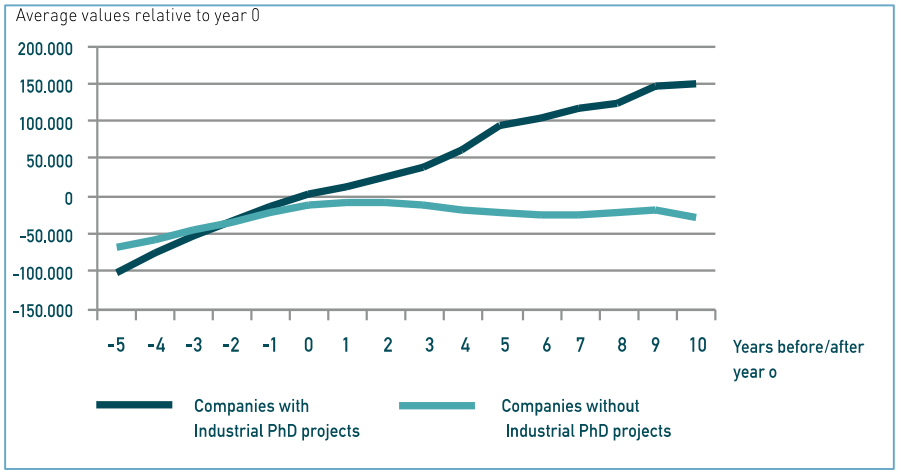
The Industrial Researcher programme comprises an Industrial PhD programme and an Industrial post doc programme, but only the first of these is considered here. The Industrial PhD programme dates back to 1971 and has undergone only minor changes. The purpose of the programme is to facilitate network and research collaboration between universities and private sector companies, and to encourage more companies to employ trained researchers.

The Industrial Researcher programme is described in Appendix A.

Impact assessment of the Industrial PhD programme	
Estimated effects (statistically significant)	• Individuals with an Industrial PhD obtain 7-10% higher income than other PhDs. • Companies with Industrial PhD projects realise on average a additional growth in gross profit of approx. DKK 2 million over the five-year period following the establishment of an Industrial PhD project.
Effects on total factor productivity (TFP)	A more recent study finds no significant effect on TFP
Year of publication	2011
Period covered by the evaluation	Industrial PhDs completed from 1997-2006
Methodological level of the evaluation	Quantitative impact evaluation (difference-in-difference). 442 individuals and 270 companies. Industrial PhDs are compared to a control group of ordinary PhDs.

Source: Oxford Research, 2012; ; DASTI, 2011b; Kongsted, 2018.

Gross profit developments (DKK 1,000)



Source: DASTI, 2011b.

Key insights on how the programme generates impact

- The programme is successful in assisting Industrial PhDs to find job in the private sector. By 2010, four in five Industrial PhDs worked in the private sector (*DASTI, 2011b).*
- Most Industrial PhDs work in large companies. By 2009, more than half of graduates from the programme had found employment in companies with more than 250 employees and 72% worked in companies with more than 100 employees.
- The mobility of Industrial PhDs between companies is in line with patterns in other sectors. Approximately 20% of Industrial PhDs move to a new job in another company every year. The pattern is similar in conventional PhDs.

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