European Commission

Peer Review of the Danish R&I System

Ten steps, and a leap forward: taking Danish innovation to the next level

Horizon 2020 Policy Support Facility

Research and Innovation

Peer Review of the Danish R&I System – Ten steps, and a leap forward: taking Danish innovation to the next level

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Directorate-General for Research and Innovation
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EUROPEAN COMMISSION

Peer Review of the Danish R&I System

Ten steps, and a leap forward: taking Danish innovation to the next level

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Christian has been a member of the Harvard Business School for 17 years, where he led the research team at Prof Michael Porter's Institute for Strategy and Competitiveness; he remains an affiliation as an HBS Visiting Executive. Christian earlier served as a Visiting Professor at the NUS Lee Kuan Yew School of Public Policy in Singapore and had further affiliations with BI Norwegian School of Management, EBS Business School in Germany, and the Stockholm School of Economics. He has been an advisor to national governments and international organizations including the World Bank, the European Commission, and the Nordic Investment Bank, and has been a visiting researcher at the IMF. Christian chairs the advisory board of TCI, a global network of public and private organization active in cluster-based economic development and is chair/member of a number of other advisory and public commissions.

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Margareta Drzeniek Hanouz is an economist, thought leader and expert on data-driven policy making, competitiveness, innovation and global risks. She led the World Economic Forum's economics portfolio and global risks work and worked with governments and business to define high growth strategies using indicators, analysis and insight, and through multi-stakeholder processes. She is lead author or editor of a number of globally recognized benchmarking and insight reports, including The Global Competitiveness Report and the Global Risks Report series. For over a decade, she studied the economic development of the Middle East and North Africa Region, Eastern Europe and CIS and developed joint high impact work with OECD, WB and EBRD. Margareta designed the economics sessions of the Forum's Annual Meeting in Davos and successfully developed, fundraised and implemented large-scale trade development projects in Central and Eastern Europe at the International Trade Centre UNCTAD/WTO. She is a frequent public speaker, international media commentator and facilitator.

Expert: Jackie Hunter

Jackie Hunter has over thirty years of experience in the bioscience research sector, working across academia and industry including leading neurology and gastrointestinal drug discovery and early clinical development for

GlaxoSmithKline. Before joining BenevolentAI Jackie was CE of the Biotechnology and Biological Sciences Research Council. BenevolentAI is a British held AI company which is using AI to augment the research capabilities of drug scientists, radically changing the way R&D is done. The company has raised $200m over the past 4 years and has offices in London and New York.

Jackie has also championed new business models, such as open innovation, establishing OI PharmaPartners Ltd to drive innovation in Life Sciences. She was awarded a CBE in the Queen's Birthday Honours list in 2010 for Services to the Pharmaceutical Industry and was recently recognized by Forbes Magazine as one of the top 20 Women Advancing AI Research. She is a member of the Biomedical Board for A*Star in Singapore, the Science Advisory Board for the Data Science Institute at Imperial College, London and a Board Director of the UK Bio-Industry Association. She is also a visiting Professor at Imperial College and at St Georges Hospital Medical School. She has had held Board positions for both private and public companies. She is a Fellow of the Royal Society of Biology, the British Pharmacological Society, Zoological Society of London and the Academy of Medical Sciences.

Expert: Stefan Kuhlmann

Stefan Kuhlmann is full professor of Science, Technology and Society at the University of Twente and chairing the Department Science, Technology, and Policy Studies (STəPS) since 2006. He is also Academic Director of WTMC, the Dutch Graduate Research School Science, Technology, and Modern Culture. Earlier he held leading positions at Fraunhofer Institute for Systems and Innovation Research, Germany, and was Professor of Innovation Policy at University of Utrecht.

He works on research and technological innovation as social and political processes, focusing on governance and politics, and he publishes widely in the field of research and innovation policy studies. He is editor of Research Policy (Elsevier), Associate Editor of the Int. J. of Foresight and Innovation Policy (IJFIP), on the Boards Science and Public Policy, Asian Research Policy, and Evaluation. Books include The Theory and Practice of Innovation Policy. An International Research Handbook (2010, with R. Smits & P. Shapira); Navigating Towards Shared Responsibility in Research and Innovation (2016, with R. Lindner et al.); Research Handbook on Innovation Governance for Emerging Economies: Towards Better Models (2017, with G. Ordonez); *Handbook on Science and Public Policy* (2019, with D. Simon et al.).

Expert: Tony Raven

Dr Tony Raven joined Cambridge Enterprise as Chief Executive in December 2011. Previously he was Director of Research & Innovation Services at the University of Southampton, where he helped establish Southampton’s international reputation as a leading entrepreneurial university, creating a portfolio of 11 spin-out companies with four listings on the London Stock Exchange.

After graduating with a First in physics from Manchester University, he obtained his MSc and DPhil from the University of Oxford. He worked at Rutherford Appleton Laboratories and Osaka University before joining Cambridge-based PA Consulting in 1983.

In 1985 he was a founder of Summit Technology, the market leader in laser refractive surgery, which was acquired by Nestlé Alcon in 2000 for $893 million. In 1987 he co-founded Cambridge-based Sagentia Group plc, a technical and management consultancy which is listed on the London Stock Exchange. In 1991 he founded Diomed Inc, a pioneer and world leader in therapeutic medical diode lasers and served as CEO and Deputy Chairman until 2000. Dr Raven is a Fellow of the Institute of Physics and a Member of the Institute of Directors.

Peer: Pieter Heringa

Pieter Heringa is a senior advisor at the Knowledge and Strategy Department of the Ministry of Education, Culture and Science in The Netherlands. His work focuses on the interface between research and policy, primarily in the domains of science, technology and innovation and recently also education.

Before joining the ministry of Education, Culture and Science, Pieter has been senior policy official at the Ministry of Economic Affairs, where he worked on analytical and strategic issues in Dutch innovation policy, with a specific focus on the governance of Research and Technology Organisations.

Pieter holds a PhD from Delft University of Technology. He started his career as a researcher at the Rathenau Institute; an independent institute that conducts research and organises debates on science, innovation and new technology.

Peer: Göran Marklund

Göran Marklund is Deputy Director General and Head of Operational Development at VINNOVA, which is the Swedish Innovation Agency. Dr. Marklund is also Swedish representative at and currently chairing the OECD TIP, Working Group on Innovation and Technology Policy. He has previously been Associate Professor in Economic History at Uppsala University with the focus on innovation and economic change. Dr. Marklund has also been Science and Technology Attaché at the Swedish Embassy in Washington DC and guest researcher at the Center for International Technology Policy (CISTP) at George Washington University. He often gives advice to the Swedish Government and to the EU on research, innovation and growth policy issues. As a researcher, Dr. Marklund has primarily specialized in innovation and economic change, globalization, and national competitiveness. In this function he has closely followed OECD's and Eurostat's indicator work and assisted at the meetings of OECD's group of national experts of science and technology indicators, NESTI. Dr. Marklund is currently chairman of the Advisory Board for R&D and Innovation Statistics at Statistics Sweden.

Peer: Uri Gabai, Chief Strategy Officer (CSO), Head of Strategy and Economics Division, Israel Innovation Agency

Uri Gabai is Chief Strategy Officer (CSO) at the Israel Innovation Agency. Uri is charged with assisting in the creation of the Authority's overall strategy and policy planning. He established this division and was one of the key players behind the establishment of the Innovation Authority. He is an expert in innovation economics, fiscal policy and game theory. Prior to his appointment at the Innovation Authority he led the fiscal team at the National Economic Council of the Prime Minister's Office for five years.

Peer: Christopher Palmberg, Program Manager, Business with Impact (BEAM) program, Business Finland

Christopher Palmberg heads the Business with Impact (BEAM) program at Business Finland to support sustainable solutions for developing markets. His prior responsibilities include Tekes RDI program portfolio management; funding and utilization of innovation research for strategy and Finnish innovation policy. He also holds expert positions in policy and program evaluation panels for the European Commission and various national funding agencies, he is a delegate to the OECD Working Party on Bio-, Nano- and Converging technologies and member of the Advisory Board of the United Nations Technology and Innovation laboratory in Finland.

Prior to Business Finland he worked as senior innovation policy consultant at Advansis Ltd, lead the Working Party on Nanotechnology at the OECD in Paris for the responsible development and use of nanotechnology. He has a background as senior researcher at ETLA, the Research Institute of the Finnish Economy and Technical Research Centre of Finland (VTT), with a focus on the ICT industry, internationalization of R&D and emerging technologies, S&T and innovation indicators, and policy evaluations.

Christopher Palmberg holds a Ph.D. in Industrial Economics and Management from the Royal Institute of Technology in Stockholm.

THE POLICY SUPPORT FACILITY SUPPORT TEAM

The project was overseen by the PSF Team in the EC's Directorate-General for Research and Innovation (Unit G1 – 'ERA and Country Intelligence'). Ana Correia coordinated the exercise and ensured liaison with the Danish authorities. The PSF contractor supported the EC's PSF Team in this activity. Bea Mahieu, Partner, Technopolis Group supported in terms of project management and Jari Romanainen acted as the quality reviewer.

The Policy Support Facility Support Team thanks Judit Kozenkow for her contribution to this report.

THE DANISH AUTHORITIES

The Background Report was prepared by the Peer Review project team of the Danish Ministry of Higher Education and Science (MHES). Tine Brüchmann Fønss, Chief Consultant, and Julie Gadegaard Christiansen, Head of Section, coordinated the MHES's part of the exercise including the two country visits. The Danish Advisory Group of the Peer Review supported the panel with professional feedback and discussions during the process.

SUMMARY AND MAIN POLICY MESSAGES

Ten steps, and a leap forward: taking Danish innovation to the next level

Motivation and structure of the review

This Peer review of the Danish science and innovation system delivers on a commitment made by the Danish Ministry of Higher Education and Science (MHES) in the 2017 strategy for research and innovation. It was conducted by a panel of international peers and independent subject matter experts under the European Commission's Horizon 2020 Policy Support Facility (PSF).

Two factors in particular motivated this review: First, while Denmark ranks high in measures of scientific performance, there are questions around its ability to fully leverage these strengths to generate economic outcomes. For Danish policy makers, there is also the related question as to whether the significant number of past policy actions taken in recent years have had the intended impact. Second, while the country performs well today, a growing concentration of Danish business R&D in a small number of research-intensive firms and a more polarized global R&D landscape with a small number of dominating hotspots signal challenges to Denmark's long-term position as a globally important innovation hub.

The panel was launched in early 2019 and finished its work in the summer. It had three key sources of information to draw on: A background report with key data and facts provided by the Danish Ministry of Higher Education and Science (MHES), qualitative interviews with a broad range of participants from across the Danish innovation system, mainly conducted during two country visits by the panel, and examples from effective policy approaches and practices in other countries contributed by the peers and experts in the Panel.

The review is organized in four chapters. Chapter 1 lays out the assessment of the current state of the Danish innovation system and the domestic and international context it is facing. Chapters 2 and 3 then proceed to the Panel's recommendations. Chapter 2 makes recommendations for enhancing performance within the context of the existing structures. Chapter 3 then challenges Denmark to outline a distinct strategic ambition and outlines key aspects on the path towards delivering such a strategy. Chapter 4 provides some concluding remarks on how Denmark could move forward with the results of this review.

Assessment of the Danish innovation system

Denmark has a thriving and stable economy and prioritizes inclusive and green growth. Danish strengths include its outward orientation and a sophisticated business sector with industrial strength in food, logistics services, and pharmaceuticals as well as the creative economy. The business environment is strong, providing a globally competitive context for firms. However, as many other advanced economies, Denmark experienced slow productivity growth in

recent years. And the high tax environment is often perceived as a barrier to business activity, especially for scaling start-ups.

Denmark's innovation system performs well, in particular in R&D related to life sciences, where Denmark is world class. There are also several other areas in which Denmark has evolved as an innovation hub, for example, in wind energy and robotics. Many strengths contribute to these achievements, such as a highly innovative business sector, strong human capital, and world-class research capacity. The analysis shows no immediate threats to this position, fully reflective of Denmark's position as a European if not global innovation leader. But while there is no burning platform, there is a sense that Denmark could do better in terms of how strengths are translated into results and in its response to structural changes in the global (innovation) landscape. The review identified a set of specific challenges and missed opportunities that show this tension:

- There is high reliance on a very small number of top R&D spending firms and in specific sectors (mainly life sciences) with limited diffusion to smaller companies and entrepreneurs.

- Global economic trends are raising the bar for attracting/retaining innovation activities to/in Denmark.

- Denmark's innovation performance has been deteriorating on some indicators recently, while the EU has been improving on average.

- The excellent outcomes in science insufficiently translate into commercial innovation, in particular in SMEs, start-ups and scale ups.

- Efficiency is lost due to a lack of strategic coordination with private sector foundations that fund a significant and growing share of R&D activity.

- Strengths in science could be leveraged more by attracting foreign companies to tap into the existing knowledge pools.

- Strengths in non-science driven innovation and entrepreneurship (creative industries, sustainability) are insufficiently integrated into the broader innovation strategy.

- Strengths in areas that have clear relevance for global societal challenges (urbanism, sustainability, social innovation) appear under-utilised.

These issues reflect in the view of the Panel an insufficiently systemic approach to innovation. There is no sufficiently clear, deliberate, overarching strategic direction of the Danish innovation system. The innovation policy system appears fragmented, despite high openness to dialogue and discussion, with no obvious central platform to discuss and take strategic, system-wide decisions. And while there has been significant policy action, the focus of recent reforms has been on reducing overlaps and interdependencies across different entities of the system, not on actively promoting collaboration and coordination at interfaces.

Recommendations

Based on this assessment, the Panel suggests a two-pronged approach for strengthening the Danish innovation system. The first set of recommended actions outlines ten actions to improve the performance of individual elements of the Danish innovation system. The second set of recommendations concerns defining a stronger strategic ambition for Denmark, providing a more coherent structure for aligning individual actions and policies towards a common goal.

The panel identifies **ten steps for improving the Danish innovation system** within the context of its current structure. The first group includes ***actions to enhance existing individual programs and structures:***

1. *Universities*

Universities are unclear about the expectations the Danish government has towards them on their role in the innovation agenda, and this drives universities to make decisions that are not optimal in driving innovation performance. Five specific recommendations address the clarity of universities' innovation mission, the dialogue with the central government on supporting innovation in universities, the resourcing of universities' knowledge exchange activities, the application of relevant EU State Aid rules into national law, and the approach towards celebrating success and creating role models related to innovation.

2. Strategic instruments to drive ecosystems and domain development

Past reforms in the Danish innovation system have led to a dominance of narrow, project-oriented funding streams that do not support the evolution of ecosystems and broader innovation domains that are becoming increasingly critical. Four specific recommendations address the develop of new Danish programs to support systemic agendas, the creation of platforms for multi-stakeholder collaboration, a revision of the role the Innovation Fund Denmark plays in this context, and a broadening of the relevant funding instruments available.

3. Science parks, physical ecosystems and incubators/accelerators

Denmark has a number of successful science parks but there is lack of clarity on their function, the responsibilities of different actors, and the nature of funding streams; there is also no clear mechanism for best practice sharing. We recommend a review of the physical innovation ecosystem strategy to clarify roles and processes.

4. Research and Technology Organisations (RTOs)

Denmark's RTOs (seven GTS Institutes) operate well in providing their services to firms but are currently not fulfilling their potential as an active and strategic interface between university-based research and technological innovation in companies. Three specific recommendations address the specific role of the RTOs in the innovation system, their collaboration with other related institutions, and the funding model that can support their mission.

The second group includes **actions to strengthen coordination across the system:**

5. Coordination with private foundations

Denmark's private foundations are an increasingly important funder of R&D activities, but they are not strategically integrated into the policy structure supporting innovation and there is no common understanding on their strategic role within the innovation system. We recommend building on existing structures to enhance coordinated across efforts funded by private foundations and public sector entities, and to create a dialogue about strategic collaboration.

6. Alignment across the system

Responsibilities for policies shaping the performance of the Danish innovation system are distributed across different ministries and levels of government, and the focus of past reforms has been to minimize the need for coordination rather than manage linkages that are growing in importance. Four specific recommendations address the creation of an integrated system of Key Performance Indicators (KPIs) across government, efforts to increase labour mobility across ministries, a joint foresight exercise across government, and the creation of an Inter-ministerial Committee at civil servant level to prepare discussions on priority setting, KPIs, etc.

7. International linkages for the Danish innovation system

Denmark's innovation system is internationally well connected, and the country has some strong policy instruments focused on international linkages. But the coordination across individual institutions and programs is limited, reducing the impact Denmark could have. Four specific recommendations address the creation of contact points for internationalisation within the emerging new business support structure across Denmark, efforts to ensure and enhance the ability of clusters and innovation networks to support internationalisation, the creation of a dedicated program to attract investments of foreign MNCs into R&D centres in Denmark, and a review of the additionality of incentives for attracting EU funds as well as other international funds into the R&D system.

The third group includes **actions to evolve the innovation policy toolkit:**

8. Danish strengths in non-science driven areas like design, urbanism, and social innovation

Denmark has considerable strengths in innovation areas that are not directly science or technology related, such as design thinking and practice, new urbanism and creative industries, and social innovation; their potential remains underutilized given the MHES' mission to focus on science-driven innovation. Three specific recommendations address the integration of the national cluster effort for the design and lifestyle sectors with industrial innovation-oriented policy programmes, linking the existing "Lifestyle & Design Cluster" with New Urbanism and sustainability-oriented bottom-up initiatives, and opening up support programs to existing social innovation grassroots initiatives.

9. Public procurement for innovation

Government procurement plays a large role in the Danish economy, but there are few systematic efforts to leverage its potential in supporting innovation. Three specific recommendations address embedding innovation into public procurement practices, appointing a point person for innovative public procurement within the MHES, and developing an action plan on how to achieve a greater, share of innovative procurement.

10. Impact assessment

Denmark has a strong tradition of impact assessment as a critical component of the innovation policy toolkit but is no longer among leading peer countries in terms of data-driven impact assessment and innovation system analysis. Three specific recommendations address the creation of an impact assessment strategy, focus on assessing the impact beyond narrow economic outcomes, and the creation of a central quantitative analysis unit to inform innovation policy.

The panel views these recommendations as important and effective to improve the performance of the Danish innovation. But such evolutionary changes within the given system will struggle to achieve more transformative changes in outcomes.

This is why the panel discusses in a second step the opportunities for Denmark to further elevate its performance by **outlining an overarching innovation strategy**. Despite many individual strategies and action plans Denmark currently lacks such a strategy, which is limiting the country's ability to create positive systemic effects from the alignment of individual innovation policy actions. Putting it in place would help unlock such benefits and enable a stronger prioritization of actions towards areas of highest potential impact.

The content of Denmark's strategy needs to be grounded in the reality of Denmark's existing strengths and weaknesses and of the opportunities and challenges that the global context offers. The review offers a perspective on the panel's observations about Denmark; a full assessment was beyond the scope of its work and should in any case be led by Danish stakeholders. Based on this assessment it is a creative task to develop different options for what role Denmark could play as a place for innovation. Again, the panel offers some illustrative ideas intended to serve as examples and inspiration, not as a short-list of the most relevant options.

Overall, the shift towards a more strategic innovation policy approach around a widely shared value proposition would aim to achieve change in three key dimensions:

- More systemic integration of individual innovation policy tools towards common goals vs enhancing the quality of individual programs or institutions;

- More systemic dialogue and collaboration across the entire innovation system vs creating a structure that aims to minimise the need for coordination;

- Focus on areas of innovation, including non-science driven areas, in which Denmark has clear strengths vs generic efforts to ensure academic excellence and effective technology transfer.

A strategic choice on a value proposition will affect the prioritisation across existing activities, programs, and institutions. It will require a look at some more ambitious new policy approaches that Denmark has not pursued very actively so far, such as mission-oriented approaches. And it will depend for its success on creating a new organisational structure, for example by establishing an innovation agency and creating a national innovation council as a strategic decision-making body.

Next steps

What can Denmark do to translate these ideas into action? The key question that Danish decision makers have to address is whether they see the need for action. The Danish innovation system is strong, and despite the challenges we have identified, there is no burning platform or impeding crisis. Instead, the costs of inaction are lost opportunities and a gradual erosion of Denmark's existing position.

The ten steps outlined in this report can be pursued without the need to elevate the role of innovation on the Danish political agenda. There is limited if any additional budget required, even if changes might lead to a difficult re-allocation of resources within the innovation system. But this does not make the changes suggested easy: they will only happen, if there is both a clear political signal that there is a willingness to push them through, and a consensus across the system that they are needed.

The ambitious jump towards a comprehensive new strategy is in the panel's view of a different nature. It requires a much broader engagement with stakeholders, which will also increase the expectations for real change. And it requires an all-of-government approach, with actions and ownership beyond one single ministry. This is more complex, but also more rewarding if Denmark wants to fully mobilize the significant qualities of its innovation system to generate economic value and contribute towards addressing the broad societal challenges of our times.

INTRODUCTION

This Peer review of the Danish science and innovation system delivers on a commitment made by the Ministry of Higher Education and Science (MHES) in the 2017 strategy for research and innovation. It was conducted by a panel of international peers and independent subject matter experts.

The review was conducted under the Horizon 2020 Policy Support Facility (PSF), a tool set up by the European Commission – DG Research and Innovation under the Horizon 2020 framework programme, to support Member States and Associated Countries in improving the design, implementation and evaluation of national R&I policies. The PSF peer review methodology is available in Appendix A and at https://rio.jrc.ec.europa.eu/en/policy-support-facility/peer-reviews.

The panel's mandate was to focus on science-based innovation and the policies under the remit of the MHES. Where needed, the panel was asked to also look beyond the boundaries of the MHES and identify where these policies interact with entities and policies that are the responsibility of other Danish ministries. The MHES defined two key tasks for the review:

- **Assess how Denmark can adjust public policy on knowledge-based innovation based on international best-practices**, and

- **Provide concrete recommendations on further developing the Danish public policy efforts on knowledge-based innovation**.

Why is Denmark, a country at the top of many international prosperity and innovation rankings, initiating a review of its innovation system? Two factors have been critical in motivating this review: First, while the country ranks high in measures of scientific performance, there are questions around its ability to fully leverage these strengths to generate economic outcomes. Second, while the country performs well today, a growing concentration of Danish business R&D in a small number of research-intensive firms and a more polarized global R&D landscape with increasing concentration of R&D in a smaller number of location signal challenges to Denmark's long-term position as a globally important innovation hub.

The review was launched in early 2019 and the Panel finished its work in the summer. It had three key sources of information to draw on:

- Key data and facts provided by the Danish Ministry of Higher Education and Science (MHES) in the Background Report;[2]

- Qualitative interviews with a broad range of participants from across the Danish innovation system;

[2] https://rio.jrc.ec.europa.eu/en/file/12745/download?token=GE80Jvqn

- Examples from effective policy approaches and practices in other countries contributed by the peers and experts in the Panel.

The peer review aims to complement the rich Danish debate on the future of the country's innovation system in some specific ways. It takes a holistic perspective across the system, which has not been done by the other narrower reviews underway within the Danish government. It provides a comparative perspective from the outside, where the debate in Denmark seems sometimes surprisingly inward-focused. And it raises fundamental questions that are hard for domestic actors to put on the table. In all of these dimensions, it can build on the last external review done in 2012 under the ERAC framework.[3]

This report summarises the Panel's findings and recommendations and is organised as follows:

Chapter 1 lays out the assessment of the current state of the Danish innovation system and the domestic and international context it is facing. This part is based on information received from MHES as well as data and analysis obtained from domestic and international sources and findings from interviews conducted during the two country visits.

Chapters 2 *and* ***3*** then proceed to the Panel's recommendations on how Denmark can make significant improvements to its approach for supporting innovation. It takes a two-pronged approach: Chapter 2 makes recommendations for enhancing performance within the context of the existing structures. It discusses a ten-step agenda for improvements related to individual elements of the system, better coordination and a broader innovation policy toolkit. Chapter 3 then moves further, and challenges Denmark to outline a distinct strategic ambition for what it aims to achieve as an innovation leader in the global economy. It then discusses how such a choice will drive decisions on activities as well as organizational structures. Chapter 4 provides some concluding remarks on how Denmark could move forward with the results of this review.

How is providing advice to an innovation leader different? What the Panel found, is that there is still a good deal of 'improving practices' that need to be considered. But while that is sufficient for a follower, it is unlikely to be enough for a country at the frontier of innovation. An innovation leader also needs to focus on genuinely new approaches, and on making choices that drive systemic changes, not just marginal improvements. Finally, there is a need to focus more on the motivation to act. A place that is already doing well in many dimensions needs a clear reason for why it should invest further energy and resources.

The Panel's ambition is to provide some practical ideas that can help Denmark to do better. It also aims to encourage Danish leaders to think differently about what they want their country to achieve within and through innovation, how the R&I system can contribute to making this ambition a reality, and what the key choices are that they are facing on their way there. It hopes to provide a spark to a discussion about the role of innovation that in Denmark, as well as in many other countries, always seems important but not urgent.

[3] https://rio.jrc.ec.europa.eu/en/library/erac-peer-review-danish-ri-system

1 PUTTING DENMARK'S INNOVATION SYSTEM INTO CONTEXT: PERFORMANCE, PROFILE AND PATHWAYS

This first chapter of the report reviews the current state of the Danish innovation system, seen in the context of broader trends in the country's economy. The ambition is to gain insights into whether there is a case for changes within the Danish innovation system, and what specific issues such efforts should focus on.

The diagnostic is organised into three parts:

- A brief contextual analysis of the **Danish economy**, its recent performance, structural elements and strengths and weaknesses based on a review of a range of indicators: *How is Denmark's economy doing?*

- An assessment of the Danish **research and innovation system** that reviews the performance, describes the system and identifies the potential drivers of these outcomes: *What characterises the country's innovation system, what explains its current performance, and what are the levers to enhance it?*

- A discussion of the domestic and global factors that shape the future **pathways** Denmark is facing: *What is the context that will affect which type of change agenda will likely be most effective?*

This section is based on initial inputs that the Panel received from MHES (Background Report),[4] interviews conducted by the PSF experts with key Danish stakeholders, and publicly available data and analysis. Where possible, it compares Denmark's performance to other selected countries (peers) and the EU-28 average.[5]

Based on this analysis, the chapter concludes by presenting an overarching **structure for the panel's recommendations**, based on a set of key challenges and opportunities Denmark is facing.

1.1 The economic and business context

Denmark's innovation system operates within the context of the country's broader economy and society. Its success has to be evaluated in the way it contributes to Denmark's overall prosperity, wellbeing, and societal progress. At the same time, its ability to create impact is shaped by the wider economic and societal conditions it is exposed to. To set the stage, this section reviews Denmark's current situation in terms of socio-economic performance, business structure and main sectors of the economy and the main strengths and weaknesses of the environment in which businesses operate.

[4] https://rio.jrc.ec.europa.eu/en/file/12745/download?token=GE80Jvqn

[5] Peer economies are Finland, Israel, Netherlands, Sweden, and the UK.

Denmark is one of the most prosperous and equitable countries in the world. Living standards – as measured by GDP per capita – are among the highest globally and well above the EU average (See Figure 1A).

Denmark does also well on dimensions of performance that are traditionally not captured by GDP, like environmental sustainability[6] and social progress.[7] Indeed, it is one of the best performers globally on multidimensional measures of economic progress, such as the Inclusive Development Index, where it ranked 5th and has seen an improvement in performance over the past five years.[8]

The Danish economic model stands out because of its strong social impact. A preference for widely shared prosperity and equal access to opportunities are deeply rooted in the Danish society and economy. The GINI coefficient, which measures the distribution of income (a lower GINI indicates more equality) is at 0.276, below the EU-28 average (0.307).[9] And the relatively low unemployment rates provide opportunities for economic participation to large parts of the working-age population (see Figure 1C).

Recent economic performance

In recent years, Denmark has shared the low growth experience of many advanced peer countries, especially after the global financial crisis (GFC) (see Figure 1). GDP growth dropped to 1.6% on average in the years following the GFC (from 1.9% in the years before the GFC). In the short term, Denmark experienced a more difficult recovery due to high levels of household debt that took longer to resolve.[10]

Structurally, the slowdown in productivity growth has been a critical factor. The growth of Danish total factor productivity (TFP) is similar to global trends. Moreover, between 2011 and 2018, labour productivity grew at only 1% per year on average, less than the pre-crisis period of 1.3% (see Figure 2).[11] The largest slowdowns in labour productivity growth were recorded in domestically oriented service sectors and the utility sector.[12] One reason cited for the slowdown in

[6] https://epi.envirocenter.yale.edu/epi-country-report/DNK

[7] https://www.socialprogress.org/

[8] http://reports.weforum.org/the-inclusive-development-index-2018/tables/?doing_wp_cron=1561023137.4782900810241699218750

[9] Data for 2017, Source: EUROSTAT http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di12&lang=en

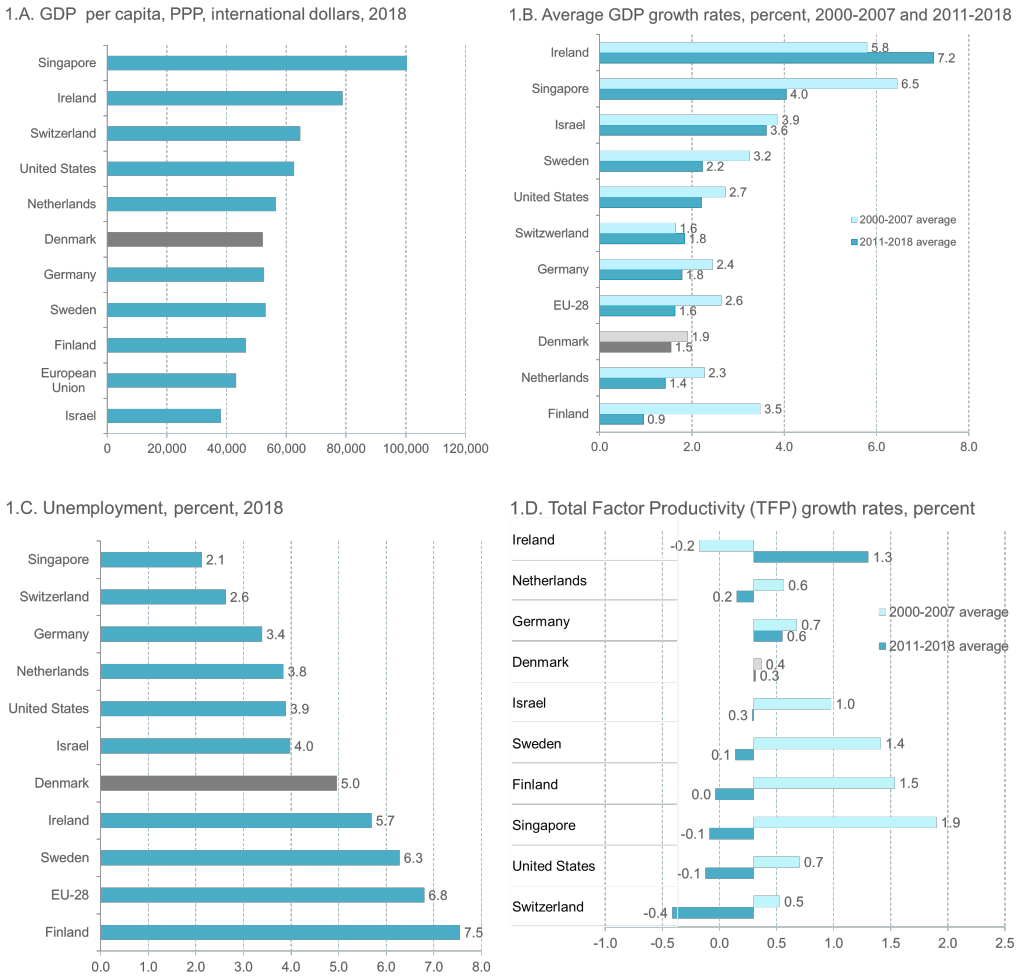
[10] https://ec.europa.eu/info/sites/info/files/file_import/2019-european-semester-country-report-denmark_en.pdf

[11] https://www.imf.org/en/Publications/CR/Issues/2018/06/20/Denmark-2018-Article-IV-Consultation-Press-Release-and-Staff-Report-46001

[12] https://www.imf.org/en/Publications/CR/Issues/2018/06/20/Denmark-2018-Article-IV-Consultation-Press-Release-and-Staff-Report-46001

productivity growth in Denmark is the slowing pace of technology diffusion.[13] Low investment following the GFC might also have contributed to the weak labour productivity growth. These trends are not unique to Denmark, and whether there are any meaningful Denmark-specific factors at play remains an issue of debate.[14]

Figure 1: Key structural economic indicators, 2000–2007 and 2011–2018

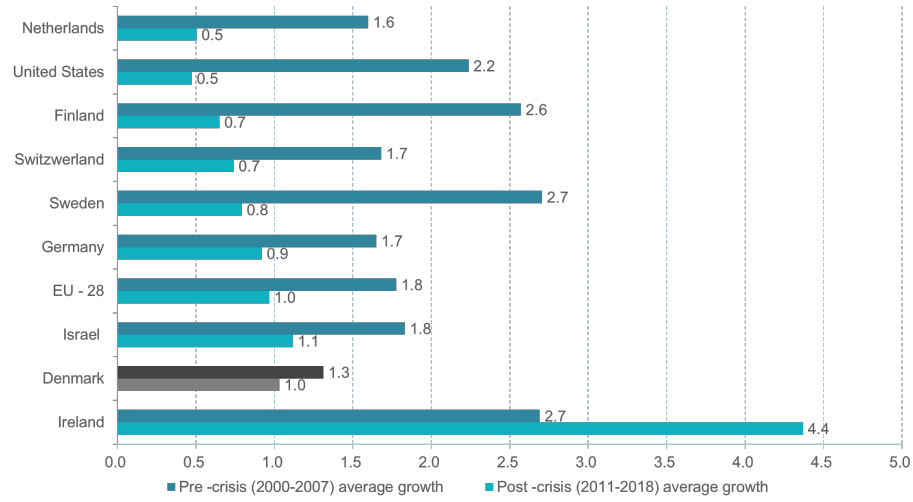


Source: IMF World Economic Outlook Database for GDP per capita, GDP growth, unemployment (Eurostat for unemployment EU-28), The Conference Board for TFP.

[13] https://dors.dk/files/media/rapporter/2017/P17/p17_english_summary.pdf

[14] However, whether Denmark has a relative productivity weakness is still under debate, see Assessment of the Danish Productivity Council: https://dors.dk/files/media/rapporter/2017/P17/p17_english_summary.pdf

Figure 2: GDP per hour worked, USD constant prices, percentage growth, 2000-2007 and 2011-2018



Source: OECD

Note: Data for the year 2010 was omitted as it was a significant outlier.

Economic structure

Most of the Danish economy operates in the services sector that accounts for 77.7% of Danish output and 79,2% of employment. Important services sectors with particular Danish strengths are for example maritime transport services and tourism. Industry employs around 18.6% of employees and contributes 19.4% of output. Agriculture is less important in terms of jobs with only 2.2% of employment and 2.1% of output but provides critical inputs to the food industry.[15] The public sector plays an important role in the Danish economy, with the general government accounting for 15.4% of the total economy.[16]

Denmark's enterprise structure is to a large extent dominated by SMEs, which account for 64.3% of private sector employment. However, a small number of large enterprises, including strong, home-grown Danish multinational companies (MNCs) play a more important role than in the EU on average – they account for 35.7% of private sector employment.[17]

A particular feature of the Danish economy is the strength of its creative industries in comparison to other countries: Denmark ranks 5th in the latest

[15] Data for 2018, figures on share of output shares were calculated by the authors based on https://statistikbanken.dk/nabp10a and data on employment shares is from https://stats.oecd.org/viewhtml.aspx?datasetcode=ALFS_SUMTAB&lang=en. Figures include the public sector.

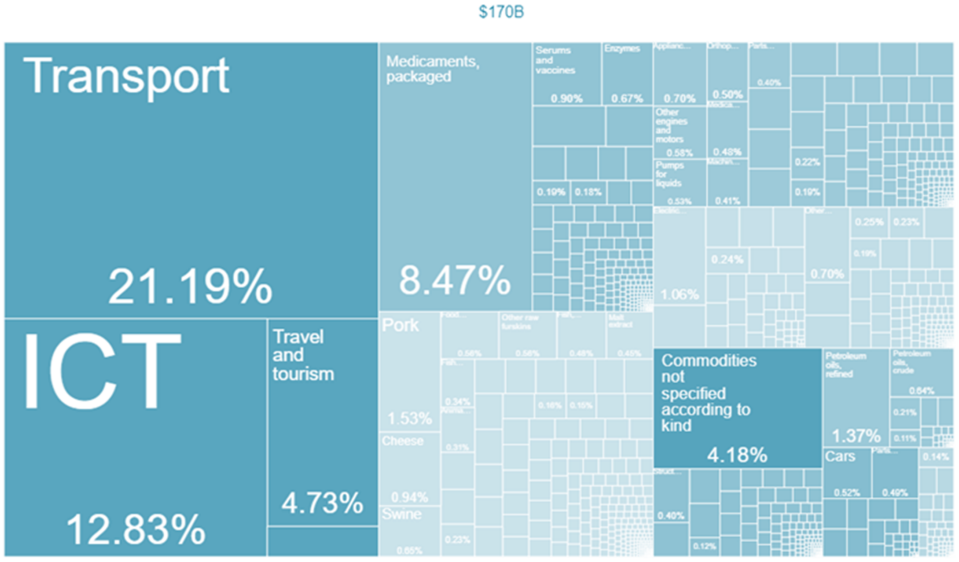
[16] https://statistikbanken.dk/nabp10

[17] https://read.oecd-ilibrary.org/industry-and-services/oecd-sme-and-entrepreneurship-outlook-2019_34907e9c-en#page296

edition of the Global Creativity Index[18] thanks to its strengths in design and high exports of creative goods and services.[19]

The Danish economy is highly open to trade and investment and strongly integrated into the EU-wide economy. Exports account for 54.7% of GDP, similar to the level in Sweden.[20] The country exports mainly to EU partner countries, notably its neigh bits.[21] Denmark is home to several internationally active MNCs that drive export performance to a significant extent – Danish MNCs account for 40% of exports, and foreign-owned firms for another third. [22]

Figure 3: Sector composition of Denmark's exports, 2017



Source: Atlas of Economic Complexity

Exports are diversified in terms of sectoral distribution, with the most important groups being transport, ICT and pharmaceuticals (see Figure 3). The pharmaceutical and chemicals industry is particularly internationally oriented and dominated by MNCs – over three-quarters of value added is exported, and MNCs – Danish as well as foreign-owned - account for almost two-thirds of exports.[23]

[18] http://martinprosperity.org/content/the-global-creativity-index-2015/

[19] https://unctad.org/en/PublicationsLibrary/ditcted2018d3_en.pdf

[20] https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS

[21] https://data.worldbank.org/indicator/ne.trd.gnfs.zs

[22] http://www.oecd.org/investment/Denmark-trade-investment-statistical-country-note.pdf

[23] http://www.oecd.org/investment/Denmark-trade-investment-statistical-country-note.pdf

http://atlas.cid.harvard.edu/explore/?country=64&partner=undefined&product=undefined&productClass=HS&startYear=undefined&target=Product&year=2017

Business Environment

Businesses operating in Denmark find a favourable environment in international comparison. Denmark is ranked 10th on the Global Competitiveness Index (GCI) that measures the factors and policies that drive productivity[24] and 3rd in the World Bank's Ease of Doing Business Index.[25] Key characteristics of the Danish business environment are:

- A stable macroeconomic environment and excellent infrastructure;
- Healthy, well-qualified human capital, including strong vocational training;
- A labour market that balances flexibility with equity and facilitates structural transformations by emphasising re-skilling (flexicurity model);
- Efficient markets for goods and services that ensure a healthy level of competition and openness;
- A financial sector that is sound and effectively provides financing for business activity;
- Strong institutions underpinned by a culture of transparency and efficiency which keeps corruption and red tape at bay; and
- low barriers in terms of the number and length of administrative requirements companies face.

Company taxation is in line with EU and OECD averages, the corporate income tax rate is at 22%. Personal income taxation is highly progressive with a top rate of 55.9% while capital income (excluding shares) is taxed at a top rate of 42.7%. The combined rate on dividends, including the Capital Income Tax paid before distribution (which is important for investment in businesses and start-ups), reaches 54.8%, which is high in international comparisons, just as the personal income tax.[26]

To sum up, Denmark has a thriving and stable economy and prioritises inclusive and green growth. Danish strengths include its outward orientation and a sophisticated business sector with industrial strength in food, logistics services, and pharmaceuticals as well as the creative economy. The favourable business environment stands out for excellent access to talent and therefore provides a good starting point for supporting innovation and translating it into business opportunities.

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[24] http://reports.weforum.org/global-competitiveness-report-2018/

[25] http://www.doingbusiness.org/en/rankings

[26] https://www.imf.org/~/media/Files/Publications/CR/2018/cr18178.ashx

However, as many other countries, Denmark experienced slow productivity growth in recent years. And the high tax environment is often perceived as a barrier to business activity, especially for scaling start-ups.

1.2 The Danish Innovation System: performance and policies

This section provides the core diagnostic of the Danish innovation system. It is divided into two parts. First, it discusses Denmark's innovation performance, and the key drivers of its achievements. Second, it analyses the policy system that supports Danish innovation.

This analysis lays the groundwork for identifying the opportunities and challenges, which the recommendations presented in chapters 2 and 3 of this review address. It summarizes key facts and data, based mainly on a review of relevant documents, existing evidence, the background information provided by MHES and primary research through stakeholder interviews.

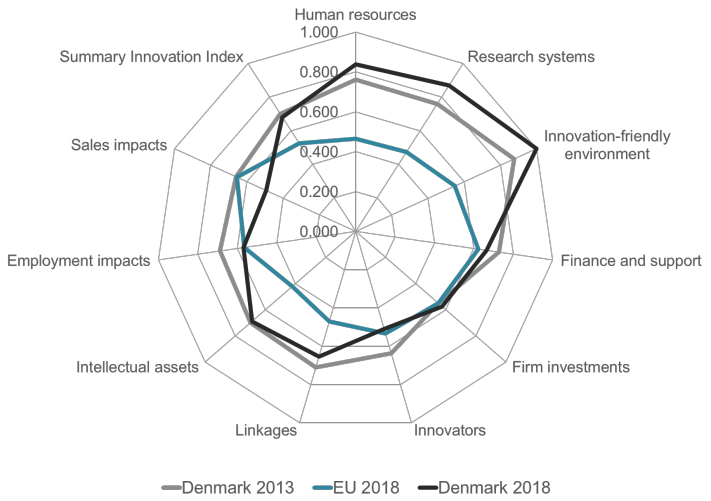
1.2.1 The Danish innovation system: performance and drivers

Denmark is ranked highly in key rankings of innovation (see Figure 4), with particular sectorial strengths in life sciences. According to the European Innovation Scoreboard (EIS), the main aspects of Denmark's strong performance on innovation are its strong research systems, intellectual assets (such as patents) and human capital, as well as an innovation-friendly environment that allows innovative companies to grow. At the same time, room for improvement remains with respect to the economic benefits from innovation, such as employment impacts, and the deployment of innovation in companies (Innovators) (see Figure 5).

Figure 4: Key results in innovation rankings

Source: WIPO, World Economic Forum, IMD, European Commission

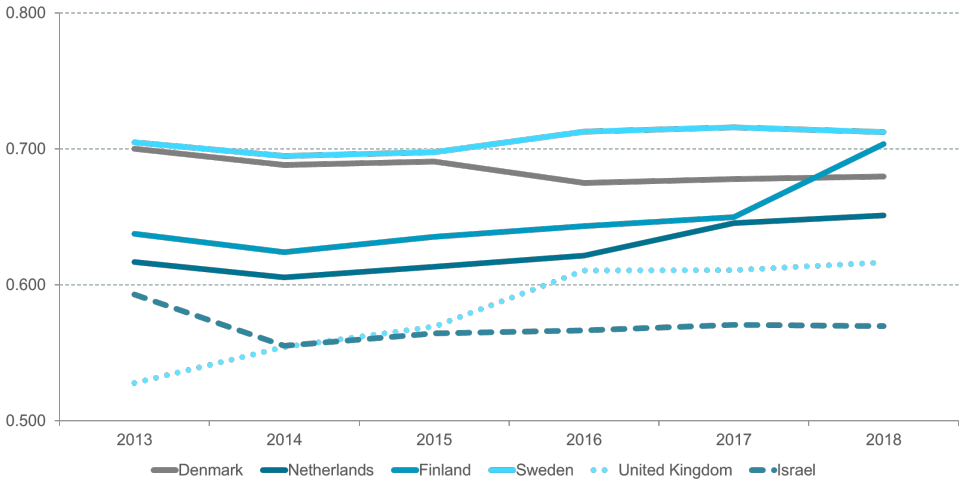
Figure 5: Denmark's performance in the European Innovation Scoreboard, 2013 and 2019



Source: European Commission, European Innovation Scoreboard 2019

The dynamics of Denmark's performance, however, are weak: After having improved between 2011 and 2013, since 2013, Denmark's overall score on the EIS has declined by 3 percentage points (see Figure 7), while its European peers have improved, with the United Kingdom and Finland improving the fastest. This drop masks mixed performance across the EIS indicators. Between 2013 and 2018, Denmark improved mostly on attractiveness of research systems, and firm investments. However, it deteriorated in terms of innovation within SMEs, as well as impacts on sales and employment. The EIS Scoreboard for Denmark is attached in Appendix B.

Figure 6: Innovation performance of selected countries, score from 0.0 to 1.0 (the best), 2013-2018



Source: European Innovation Scoreboard

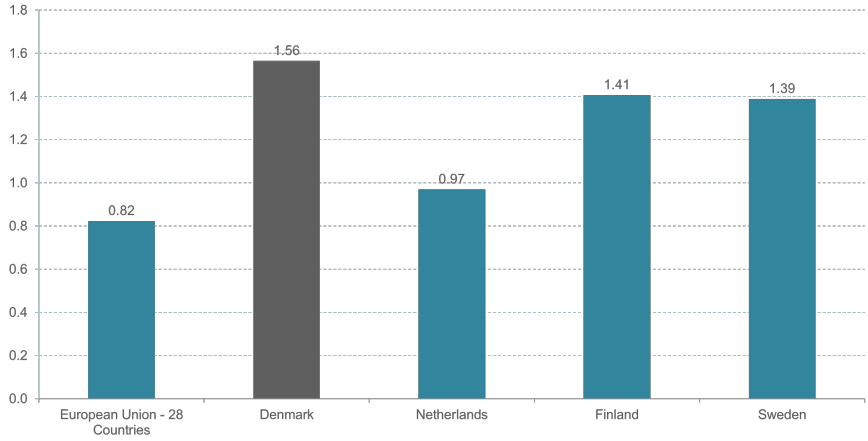
Skill base

Denmark's major advantage is its strong skill base: The percentage of researchers is well above the EU average and among leading European peers (see Figure 7). The number of people with tertiary education available for employment in the Danish labour force is around 800,000. This number is expected to rise to 1.2 million by 2040, an increase of 50% (MHES 2017).

Denmark is attractive for foreign human capital as well: Foreign students account for a significant proportion of those in tertiary education, and foreign students account for one-third of enrolled doctoral students. However, recent political decisions led to some limits on the number of foreign students coming to Denmark.

Access to high-quality talent, especially in new areas such as artificial intelligence, is important, and restrictions on the number of foreign students for Bachelor and Master programmes as well as short cycle higher education programmes could limit the talent pool that Danish companies can draw on.

Figure 7: Percentage of researchers within the active population, full-time equivalent, 2017



Source: Eurostat

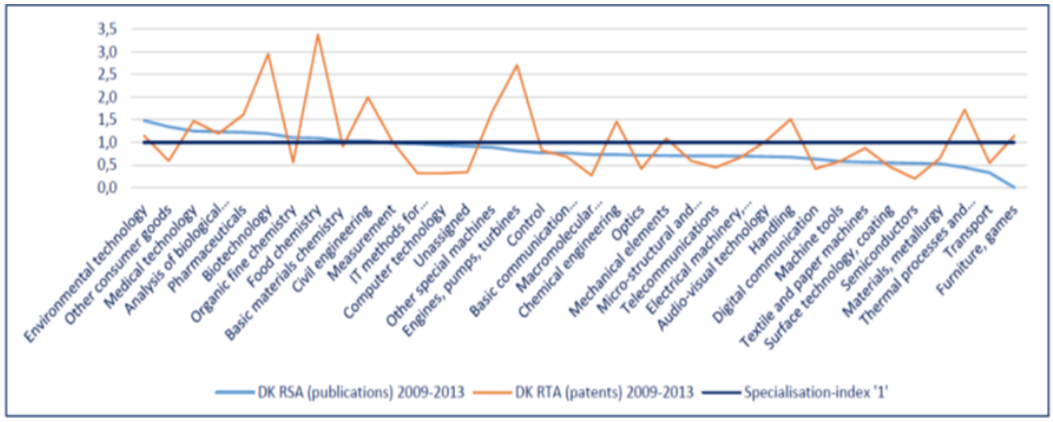
Note: According to Eurostat, the active population represents the sum of employed and unemployed people between the ages of 15-64.

Science base

Denmark boasts a world-class science base, in particular in life sciences, where it leads among OECD countries in terms of the quality of scientific publications (mainly in pharmaceuticals and biotechnology).[27]

Denmark also achieved an excellent 9th place in the world in terms of per capita patent applications.[28] Areas of technological advantage (as expressed in relative specialization of patent applications by sector in comparison to the world) include engines, pumps and turbines, food chemistry, civil engineering, thermal processes and apparatus, and other special machines (see Figure 8). Moreover, its academic institutions are well connected internationally. The number of international scientific co-publications is at 265% of the EU average in 2018,[29] the highest result in the EU.

Figure 8: Revealed Scientific Advantage and Revealed Technological Advantage in Denmark by sector



Source: H2020 project- consortium CWTS/Leiden University, KU Leuven

Note: Revealed Scientific Advantage (RSA) represents the relative importance of a sector/subsector in the publishing activity of Denmark. Revealed Technological Advantage (RTA) represents the relative importance of a sector/subsector in the patenting activity of Denmark. Specialization index '1' shows the world level and serves as comparison for the revealed advantages (RSA or RTA higher than 1 mean revealed advantage for Denmark). Calculations and methodology are based on the Fraunhofer 35 technology classification.

[27] Denmark has the highest proportion of publications within the life sciences among the top ten percent most cited publications among the OECD countries.

[28] Patent applications per million population. Source: Global Competitiveness Report based on OECD data: http://reports.weforum.org/global-competitiveness-report-2018/competitiveness-rankings/#series=IP5PATPOP

[29] International scientific co-publications are measured as the number of international scientific publications with at least one co-author based abroad (where abroad is non-EU for the EU28) per million population. (Source: European Innovation Scoreboard)

Investment in R&D

Denmark's high R&D spending (GERD) is another key strength. With an R&D intensity of 3.05% of GDP in 2017, well above the EU average (2.07%), Denmark reached the national R&D intensity target (3%) it had set in the frame of the EU 2020 strategy About one-third of R&D spending comes from the public sector and two-thirds from the private sector – a healthy combination in line with leading peers (See Table 1).

Table 1: Gross domestic expenditure on R&D (GERD), percentage of GDP

	2009	2010	2011	2012	2013	2014	2015	2016	2017	National 2020 TARGET
Denmark	3.06	2.92	2.94	2.98	2.97	2.91	3.06	3.1	3.05	3.0
Finland	3.75	3.73	3.64	3.42	3.29	3.17	2.89	2.74	2.76	4.0
Germany	2.72	2.71	2.8	2.87	2.82	2.87	2.91	2.92	3.02	3.0
Ireland	1.61	1.59	1.56	1.56	1.56	1.5	1.19	1.16	1.05	2.0
Israel	4.13	3.94	4.01	4.16	4.07	4.18	4.26	4.39	4.54	..
Netherlands	1.67	1.7	1.88	1.92	1.93	1.98	1.98	2,00	1.99	2.5
Sweden	3.45	3.21	3.25	3.28	3.3	3.14	3.26	3.27	3.4	4.0
Switzerland	..	..	..	3.19	..	..	3.37	..	..	..
United States	2.81	2.74	2.77	2.68	2.71	2.72	2.73	2.73	2.79	..
EUROPEAN UNION 28 countries	1.93	1.92	1.97	2,00	2.02	2.03	2.04	2.04	2.07	3.0

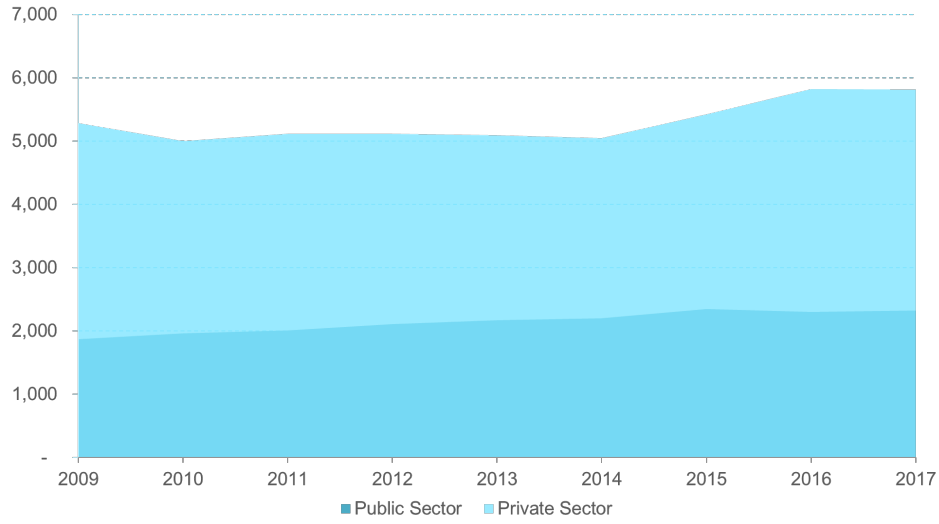
Source: Eurostat, OECD

Note: Israel: OECD, GERD

Public R&D funding has increased somewhat in recent years (See Figure 9). This is mainly due to increased funding by municipalities and regions, while central government funding for research and innovation remained stable. Fiscal pressures on the central government led to a re-distribution of some education funding away from universities. Since 2016 state funding for education has been cut by 2% every year. Public funding for R&D has increased in 2017 and 2018 after a decrease by 7% from 2015 to 2016.[30]

[30] https://www.dst.dk/da/Statistik/nyt/NytHtml?cid=26383

Figure 9: Denmark's R&D expenditure funded by public and private sectors, million USD, constant 2010 prices and PPPs, 2009–2017



Source: OECD, Statistics Denmark

Private sector R&D spending is concentrated in a relatively small number of large Danish companies (see Figure 10). The 50 largest R&D active companies accounted for 70% of the total Danish private R&D investment in 2016, significantly higher than in a range of other advanced economies (See Figure 12).[31] The eight largest companies alone accounted for about 39% of the total private R&D expenditures .

R&D activities funded by foreign entities (GERD financed from abroad) amount to 0.27% of GDP (in 2017), similar to the level found in the UK (0.26%, in 2016) or Netherlands (0.28 in 2016), but below the level found in Finland (0,33%, in 2016).[32] Israel[33] or Finland[34] seem to have attracted a more significant number of R&D centres of international MNCs, and achieved more visibility in this space. Such R&D centres are often attractive for international and national talent and can develop their locations into innovation hubs in their respective areas. They have particular potential if they can be linked with local companies, especially research-intensive SMEs.

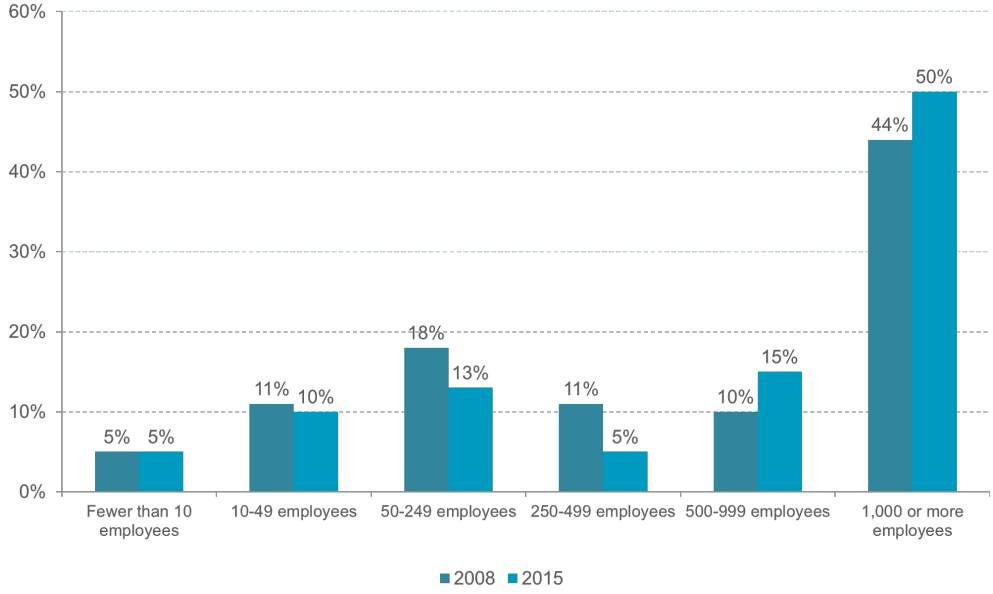
[31] The data refers to total R&D spending of these companies, both in Denmark and abroad.

[32] https://rio.jrc.ec.europa.eu/en/stats/total-intramural-rd-expenditure-gerd-financed-abroad

[33] In Israel, over 250 research centres were established by MNCs: https://en.wikipedia.org/wiki/List_of_multinational_companies_with_research_and_development_centres_in_Israel

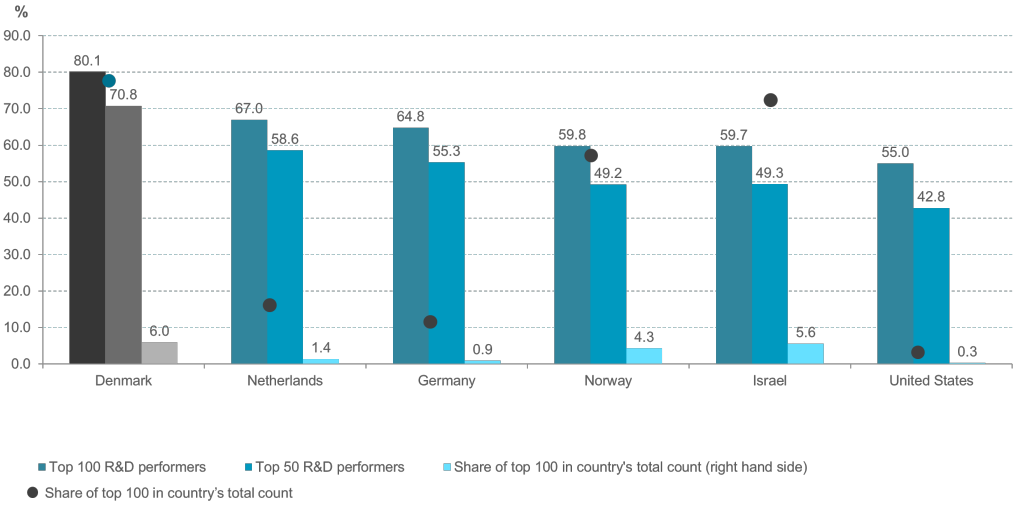
[34] https://www.helsinkibusinesshub.fi/foreign-owned-rd-centres-in-helsinki/

Figure 10: Share of private R&D expenditure by company size, 2008 and 2015



Source: SFU 2017

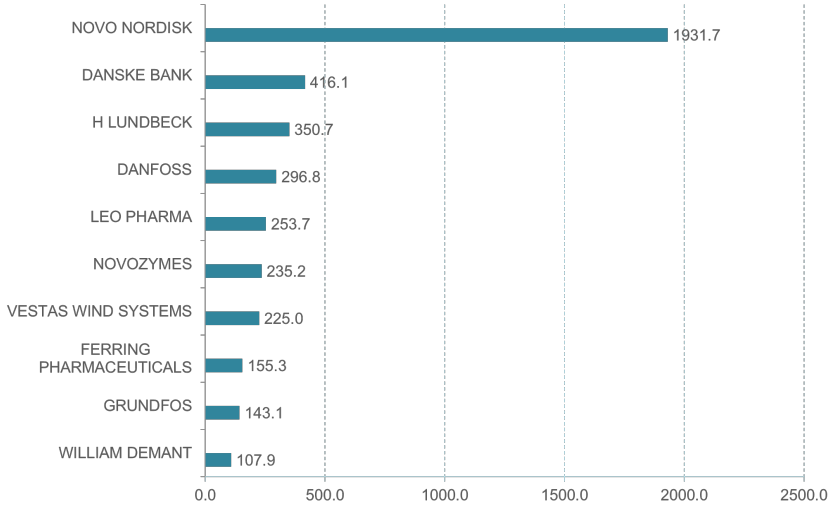
Figure 11: Share of total private R&D expenditure by top R&D performers



Source: OECD

Note: R&D expenditure performed by companies with HQ in the country, Figures can include R&D outside of the country (headquarters). Statistics do not differentiate.

Figure 12: Top 10 R&D companies with headquarters in Denmark, 2017/18 R&D expenditure, million Euros

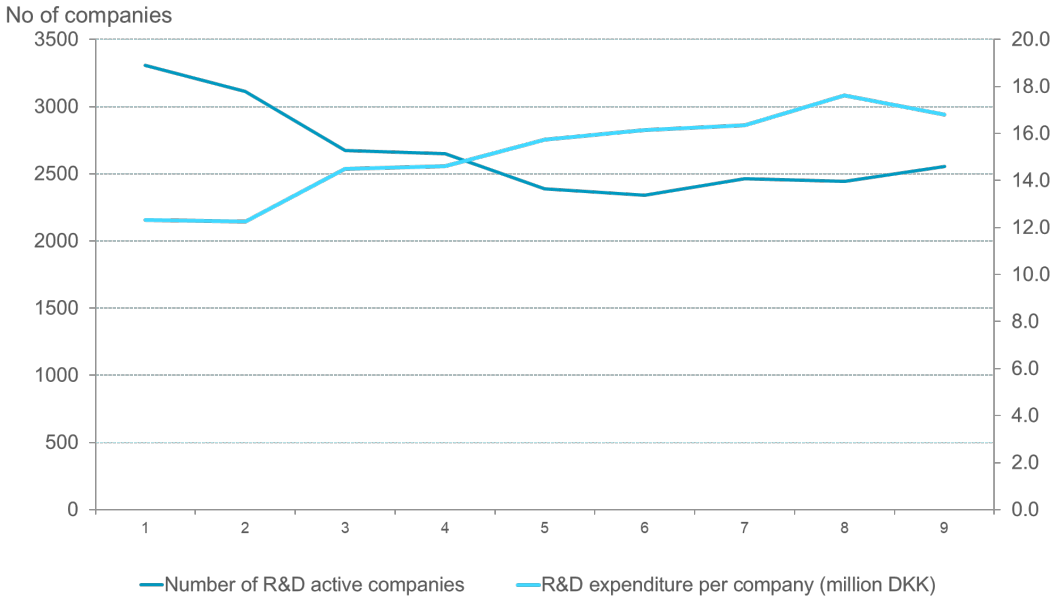


Source: EU Industrial R&D Scoreboard

Note: Does not include R&D by foreign owned companies in Denmark

Although Denmark has strong international players in innovation (see Figure 12), in recent years, the country has experienced an increasing concentration of R&D activity in a diminishing number of large companies (see Figure 13). Overall R&D spending remains high, but the absolute number of R&D active companies has declined since 2009, likely because smaller firms with limited R&D activities have stopped investing in R&D altogether. While data on R&D concentration is scarce, there are some indications that this is a global trend and thus not unique to Denmark. At the same time, this trend was not observed in Finland, where comparable data is available.

Figure 13: Number of R&D active companies and R&D expenditure per company in Denmark, 2009-2016

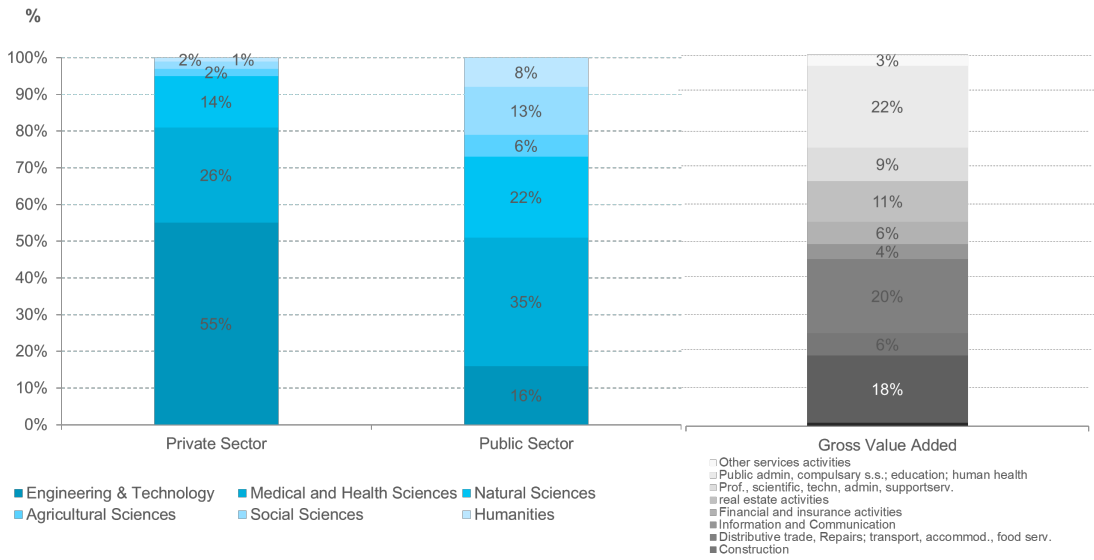


Source: Statistics Denmark, MHES

Note: R&D expenditure calculated at constant prices (2017).

From a sector perspective, medical and health sciences dominate Danish R&D spending with around one-third of the total R&D expenditure by both the private and the public sector. However, private sector R&D is more strongly geared towards the engineering and technology sector (see Figure 14). Denmark's overall industrial mix has no major impact on economy-wide private R&D intensity, while in peer countries (Figure 15), industrial structure is more biased towards high R&D spending sectors.

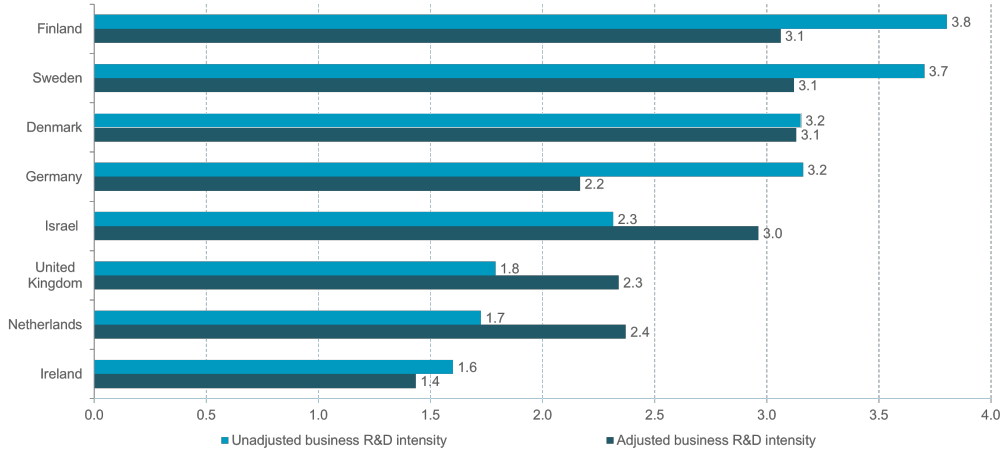
Figure 14: Public and private R&D expenditure by field of science and Gross Value Added at basic prices, in percentage, 2017



Source: Statistics Denmark, OECD

Note: 2017 data is preliminary for R&D expenditures.

Figure 15: Business R&D intensity, adjusted and unadjusted to industry structure, 2015



Source: OECD, Science, Technology and Industry Scoreboard 2017

Note: A country's industrial structure-adjusted indicator of R&D intensity is a weighted average of its sectoral R&D intensities (ratio of R&D to value added), using the OECD industrial structure – sectoral share in OECD value added for 2015 – as adjusted, common weights across all countries. The unadjusted measure of BERD intensity is an average based on each country's actual sector shares.

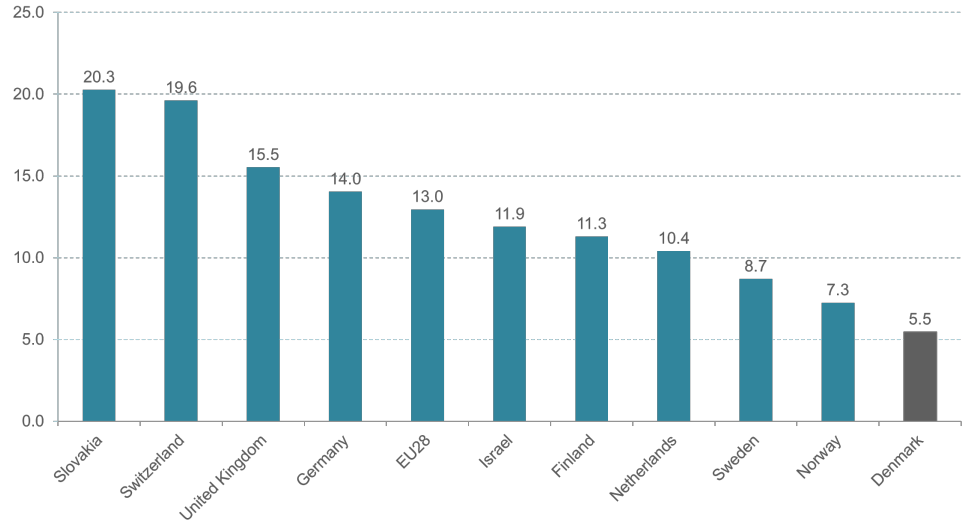
Commercial impact of R&D activities

In a number of dimensions that measure how well R&D is translated into commercial results, Denmark performs significantly less well than peer countries:

- Sales of products from new-to-market and new-to-firm innovations are significantly lower, as a share of total revenue, than the EU average (see Figure 16) and most of the peer economies. One structural reason is the industrial structure in Denmark, which has a large share of international trade services that tend to be less innovation intensive. However, this share has declined in recent years.[35]

- The export share of innovative and high tech exports remain below peer: The Danish export share of medium and high technology products (48%) is increasing but is below the EU average (56.7%).[36] Although Denmark exports more knowledge-intensive services than other EU countries, these exports are declining, while the EU shows a positive trend.

Figure 16: Sales of new-to-market and new-to-firm innovations as a percentage of turnover, 2018



Source: European Commission- European Innovation Scoreboard 2019

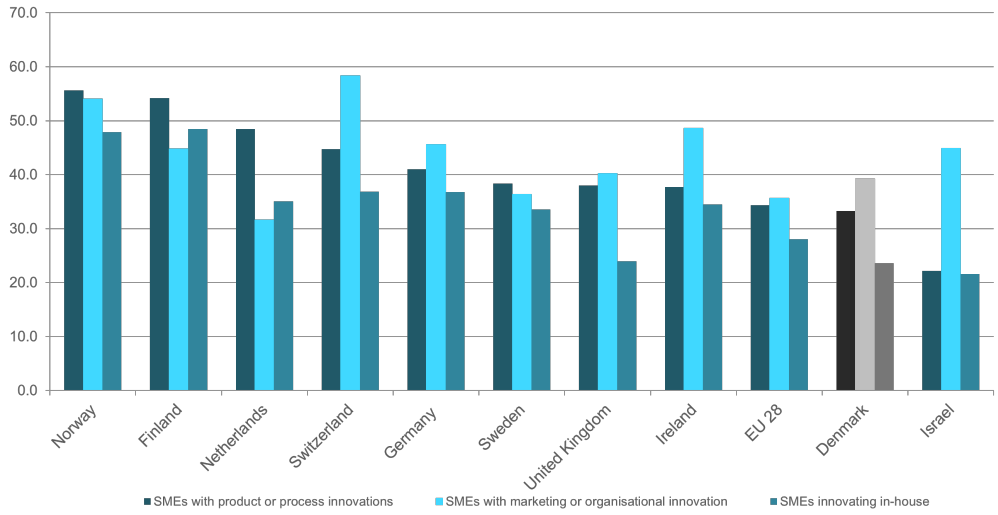
Note: Indicator is calculated as sum of total turnover of new or significantly improved products, either new-to-the-firm or new-to-the-market, for all enterprises.

[35] Some of the peers have also experienced decline (Finland, Sweden), while other countries have increased the share (Netherlands, Israel, etc.).

[36] However, the Danish export of medium and high technology products, as a share of total product exports, has increased from 41.7% in 2010 to 48% in 2017, but it remains below the EU average (56.7%).

Danish SMEs are less innovation-intensive than those in the European peer economies. Only 33% of Danish SMEs introduced product or process innovations, a smaller share than in Finland, Sweden or the Netherlands (see Figure 17). Since 2010 these innovation activities have even slightly decreased.[37]

Figure 17: Innovating SMEs as a percentage of total SMEs, 2018



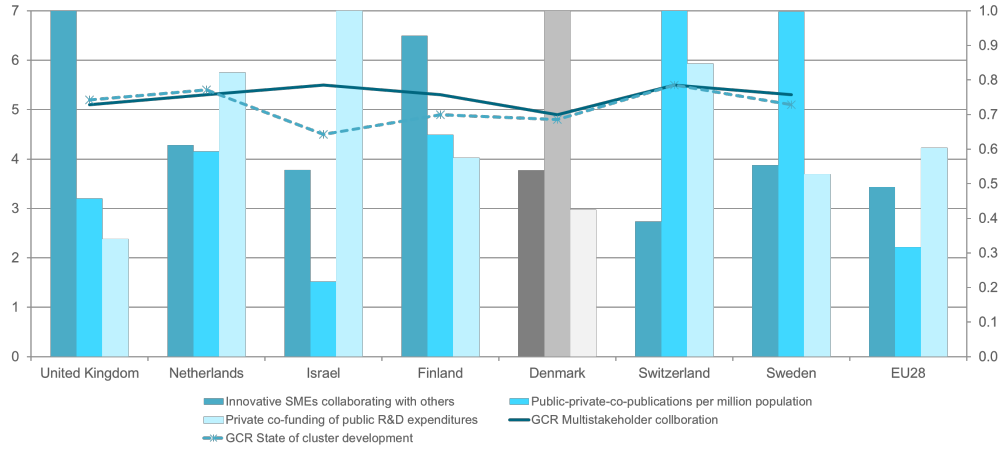
Source: European Commission- European Innovation Scoreboard 2019

Collaboration between stakeholders and linkages

Strong linkages across the innovation system encourage innovation and drive translation into economic value. Surveys of business executives on collaboration in innovation shows that Denmark does well on overall multi-stakeholder collaboration and that strong clusters exist. However, at the more granular level, there is room for improvement in terms of collaboration in R&D, as expressed for example by private co-funding of public R&D expenditures or the degree to which innovative SMEs collaborate with others (see Figure 18).

[37] Indicators shown in Figure 18 have declined about 4 percentage points on average from 2010.

Figure 18: Multi-stakeholder collaboration and state of cluster development (scale of 1 to 7 (best) on left axis); collaboration among stakeholders (scale of 0 to 1 (best) on right axis)



Source: Global Competitiveness Report, European Innovation Scoreboard

Note: Indicators 'Multi-stakeholder collaboration' and `State of cluster development' are based on surveys of business executives. For details see: http://reports.weforum.org/global-competitiveness-report-2018/appendix-c-the-global-competitiveness-index-4-0-methodology-and-technical-notes/

Entrepreneurship

Denmark has over recent years registered higher levels of new companies per capita than Sweden or Finland.[38] However, the overall share of early-stage entrepreneurs in the population remains rather low.[39] Surveys suggest that Danes have less entrepreneurial intentions, that fear of failure is higher and that people perceive themselves as not having sufficient entrepreneurial skills than their peers in other countries. Perhaps more importantly, a smaller share of businesses survives over the 1, 3 and 5-year mark than in most EU countries.[40]

Although many companies are created in Denmark, start-ups struggle to scale up and grow:[41] Firms lose their growth momentum after three years (as measured by employment), while firms in Sweden and the Netherlands continue

[38] In Denmark, 9.9 companies were registered per 1000 people in 2016 against 3.9 in Finland and 8.1 in Sweden. Source: World Bank https://data.worldbank.org/indicator/IC.BUS.NDNS.ZS

[39] https://www.gemconsortium.org/economy-profiles/denmark. Denmark is currently not covered in the Global Entrepreneurship Monitor, so the last internationally comparable data is from 2014.

[40] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Business_demography_statistics#Birth_rate

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Business_demography_statistics#Birth_rate

[41] EU Startup Monitor 2018. http://startupmonitor.eu/EU-Startup-Monitor-2018-Report-WEB.pdf

to grow after five and seven years.[42] The limitations to scaling up and to growth are also reflected in the fact that Denmark has no "Unicorn" company in comparison to Israel which has four, Switzerland (three) or Sweden (one).[43] One of the reasons is that successful Danish start-ups moved headquarters abroad (Tradeshift or JustEat).

Denmark provides rather favourable regulatory conditions for entrepreneurs. It takes, for example, only 3.5 days to register a company.[44] Yet, despite Denmark's well-developed financial system and easy access to finance, the risk capital availability is limited and private early stage (pre-seed and seed) investment in start-ups is low. Despite the efforts of the government to attract private venture capital (VC) and to provide early-stage funding through The Danish Growth Fund and incubators, VC expenditure is lower than in peer countries (0.06% of GDP in 2018, see Figure 19) and has been declining since 2010.[45] Data from surveys shows that businesses perceive VC capital as less available in Denmark than in peer countries (Figure 19). At the same time, data from the EIS shows an improvement of VC expenditure in Denmark between 2014 and 2018.

[42] https://www.oecd.org/eco/growth/Cross-country-evidence-on-start-up-dynamics.pdf

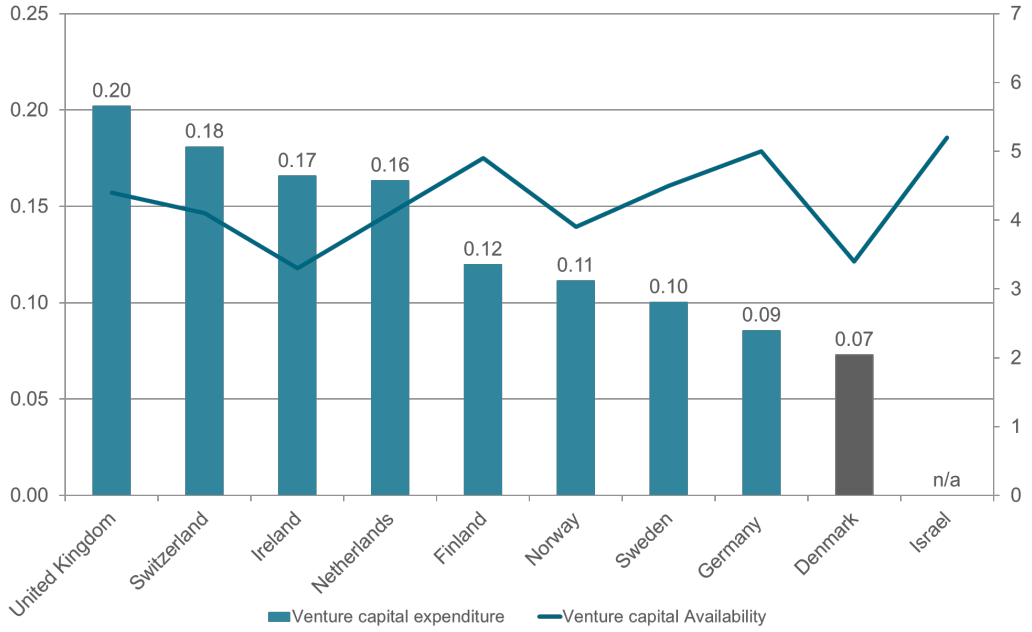
[43] Unicorn companies are start-ups with a valuation of over 1bn US$.

Source: https://www.cbinsights.com/research-unicorn-companies

[44] https://www.doingbusiness.org/

[45] It has to be noted that some sources suggest that early stage funding in individual ecosystem locations is increasing, notably in Copenhagen and Western Denmark.
Source:https://startupgenome.com/reports/global-startup-ecosystem-report-2019

Figure 19: Venture capital expenditure, percentage of GDP, 2018 and venture capital availability score, 2018



Source: European Innovation Scoreboard, Global Competitiveness Report

Note: Venture capital availability score ranges from 1 to 7, from lowest to highest. Venture capital expenditure is defined as private equity being raised for investment in companies. Management buyouts, management buy-ins, and venture purchase of quoted shares are excluded. Venture capital includes early stage (seed + start-up) and expansion and replacement capital. The original source is Invest Europe. Three-year averages have been used.

1.2.2 The Danish Innovation Support System

Denmark has a highly sophisticated and well-developed support system for innovation with many institutions that fulfil specific roles. Knowledge-driven innovation[46] is a particular focus for the Ministry of Higher Education and Science (MHES) and the related support system is mainly positioned under MHES, which is responsible for the knowledge-based innovation. The Ministry of Industry, Business and Financial Affairs (MIBFA), which is in charge of the business support system, focuses on translating knowledge-driven innovation into commercial results.

The MHES describes Denmark's knowledge-based innovation system as built around the following interconnected components (see Figure 20):

1. ***Institutions for collaborative research and innovation***. These include eight Danish universities that conduct research, offer research-based education, engages in external collaboration and 23 other higher

[46] The terms knowledge-driven innovation, RDI or R&D and Innovation are used interchangeably.

education institutions,[47] seven approved research technology organisations (RTOs) that conduct research in addition to technical services in specialised areas as well as public university hospitals and sector research institutions.

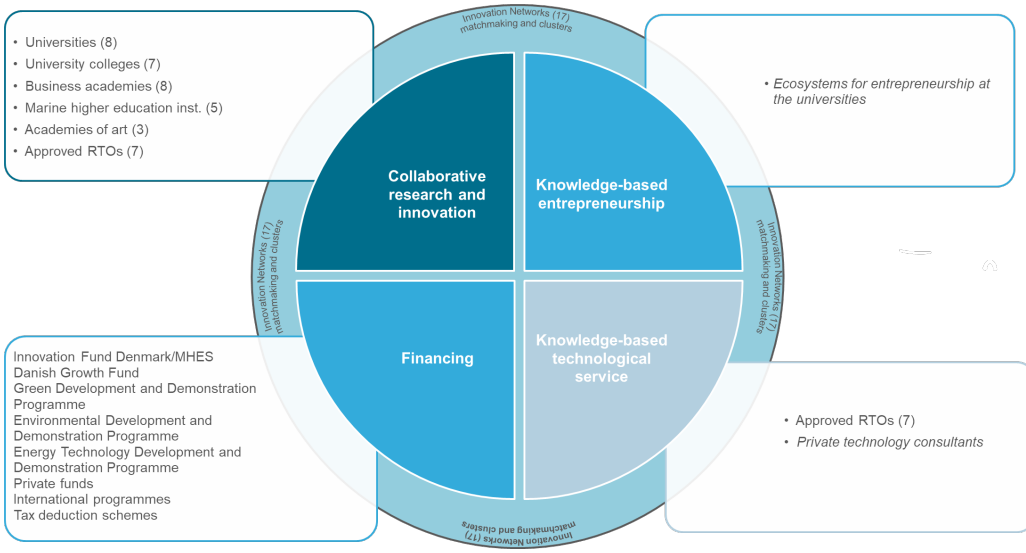
2. ***Knowledge-based technological services.*** These include RTOs, whose primary role it is to provide technical services such as laboratory testing, calibrations to ensure compliance with norms, etc. The higher education institutions are increasingly involved in this area.

3. ***Institutions supporting knowledge-based entrepreneurship***. Ecosystems for entrepreneurship exist at and around universities but are also set up by private players.

4. ***Sources of funding***, which are composed of public and private players.

5. ***Innovation Networks and clusters***, which connect actors in the system.

Figure 20: Schematic representation of the Danish National Innovation System



Source: MHES with adaptations by authors

[47] The 23 other research institutions encompass only those that have a research budget.

Institutions for collaborative research and innovation and knowledge-based technological services.

The eight Danish universities are the key research institutions, 23 other higher education institutions (university colleges, business academies, and other profession- and practice-based higher education schools, education institutions in architecture and art and finally the maritime education institutions) focus on education and applied research and development, and seven approved RTOs undertake research in addition to technical services in specialised areas.

Universities and other higher education institutions are state-funded, autonomous institutions. They are governed by boards with a majority of external members. Those under MHES have four-year strategic framework contracts with the ministry.[48] The purpose of the strategic framework contracts is to outline the most important strategic goals of the institutions. The strategic goals are established based on the specific strategies, strengths and challenges of each higher education institution.

The universities are funded through three sources:

- Basic funding for research
- Education funding
- External research funding

Universities including university hospitals account for the largest share of public R&D (95% of the total public R&D expenditure) with other HEIs playing only a minor role (less than 5% of the total public R&D expenditure).[49,50] Universities receive annual basic research funding amounting to 8.9 bn DKK (1.19 bn EUR) from MHES. Since 2016 state funding for education has been cut by 2% every year. Public funding for R&D has increased in 2017 and 2018 after a decrease by 7% from 2015 to 2016.[51] There is no formal connection between education and R&D funding. Basic funding for research and education funding are not earmarked for the research and education activities respectively. The universities can decide on the allocation of funding across activities.

All Danish universities have established Technology Transfer Offices (TTOs) or similar entities that scout, patent and commercialise research activities and provide counselling to researchers. Most universities have also established specific student incubators and actively promote student entrepreneurship

[48] The current contract is from 2018 to 2021.

[49] Iris Group: Literature review and assessment of the Danish knowledge-based innovation support system, 2018.

[50] These figures include R&D in the hospital sector.

[51] This mainly led to lower funding of IFD and the Independent Research Fund. The block funding remained unchanged.

through accelerator programmes, or competitions and events. Several of the other HEI also have innovation and entrepreneurial education programmes and encourage students to start their own company.

Although university-industry collaboration has been high on the agenda of MHES and has increased considerably since the mid-2000s,[52] indicators suggest that the businesses view the degree of collaboration in Denmark as lower than in other countries (see figure 18).[53] During the interviews the panel conducted stakeholders suggested that collaboration is not common among researchers. The main reason is a lack of incentives. One contributing factor is the perception among researchers that collaboration with industry may not help their academic careers and that incentives are not aligned. Indeed, researchers quote conflicting goals in industry and academia and conflicting timeframes as the main reasons not to collaborate.[54] In the interviews the panel had as part of this review, the fear of loss of academic independence was also mentioned.

RTOs (called GTS institutes) provide knowledge-based technology services to Danish companies. They are non-profit institutions but are run as private companies, so that services are provided on commercial terms. RTOs provide a range of services such as testing and validation (47% of GTS users), development of solutions to specific problems/challenges in development and production (32%), or certification (25%).[55] They are mandated to mainly target SMEs but 55% of their commercial revenue is generated from large companies.

RTOs are approved by MHES for up to three years, which enables them to apply for funding from performance contracts from the public research budget, which co-funds applied research, development and dissemination. Their total R&D revenue (in 2018) amounted to DKK 672 million (90 million EUR) of which DKK 357 million were from MHES performance contracts and DKK 315 million from other competitive funds. On top of that DKK 252 million were self-funded R&D.[56]

[52] Iris Group: Literature review and assessment of the Danish knowledge-based innovation support system, 2018.

[53] Denmark ranks 19th on the related indicator in the Global Competitiveness Report. This indicator is based on perceptions of business executives in Denmark. In terms of co-authorship of publications, a more up-stream indicator of collaboration, however, Denmark leads in the EU.

[54] https://dea.nu/sites/dea.nu/files/cbs_dea_survey_of_researchers_external_engagement.pdf

[55] "Analyse af GTS-nettets teknologiske ydelser set fra et brugerperspektiv" Iris Group, December 2016.

[56] GTS-net: Performanceregnskab for GTS-net 2019. [to be published at www.gts-net.dk. GTS-net. Performanceregnskab for GTS-net 2019. to be published at www.gts-net.dk.

Institutions supporting knowledge-based entrepreneurship.

Until 2019, several publicly funded incubator operators, which mainly invested risk capital in start-ups, existed and were complemented by ecosystems for entrepreneurship at and around universities and as part of private initiatives. As of 2019, public funding for the four incubator operators (PreSeed Ventures A/S, Syddansk Innovation A/S, CAPNOVA A/S and Borean Innovation A/S) is being phased out and new instruments for early support of knowledge-based entrepreneurship has been developed and transferred into other measures under the Innovation Fund Denmark and The Danish Growth Fund (see discussion on funding below).[57]

Entrepreneurship support at universities (which can include science parks, incubators, advisory, etc) are run by each university, and as a result, approaches differ from one institution to another. Generally, universities have worked with partners, including other HEI to establish incubators at/around universities to supply services to start-ups such as office space, advisory services, facilities, training, or funding and matchmaking support. Activities also target student entrepreneurship, for example, through student incubators and student competitions/events or advisory series, mentoring or small grants.

Other key players in knowledge-based entrepreneurship are the Danish Board for Business Promotion under MIBFA, which co-finance initiatives with MHES and private players, such as the Novo Nordisk Foundation, which invested DKK 392 million (EUR 52 million) into a new BioInnovation Institute that aims to support university-based start-ups in biotechnology. The Danish Industry Foundation's accelerator programme (Danish Tech Challenge) and the start-up programme of the Obel Fund at Aarhus University are other examples of private initiatives (amounts shown above in Figure 21).

Clusters, innovation networks and international linkages.

MHES is funding 17 national innovation networks that facilitate collaboration and matchmaking, mainly between knowledge institutions and business at the sector level, in Danish strongholds such as energy, food and ICT as well as emerging industries. They are independent secretariats operated by universities, RTOs or cluster organisations that receive basic funding from MHES under two-year framework contracts. Their budget (in 2016, when there were 22 such networks) amounted to DKK 235 million (31.48 million EUR), of which 37% was covered by MHES. In 2017, 5.804 companies acquired new qualifications and tools as a result of cooperating with one of the Danish clusters.[58]

Previously, Danish Regions also co-financed many innovation networks and regional clusters, whereby there were identified more than 60 publicly funded

[57] Although public funding for incubators was phased out, all four incubator operators are continuing as independent incubators with own funding.

[58] http://www.clusterexcellencedenmark.dk/da-DK/Quickmenu/Publikationer.aspx?PID=22&M=NewsV2&Action=1&NewsId=776

innovation networks and clusters in 2018. As part of ongoing reforms to reduce complexity and increase efficiency, the number of publicly funded national innovation networks will now be gradually reduced. Cluster organisations, too, are currently undergoing a major reform within MIBFA to reduce the number of clusters to 10-12 and focus on prioritized Danish strongholds and a few emerging industries in priority areas. The Danish Board for Business Promotion under the MIBFA is tasked with selecting the relevant Danish strongholds and emerging industries for the future, while MHES choose the best clusters within the strongholds to operate cluster activities.

To facilitate international linkages, MHES, in partnership with the Ministry of Foreign Affairs, has since 2006 gradually established now eight Innovation Centres abroad to support Danish businesses and researchers in accessing new knowledge from abroad and establishing international connections.[59] Universities support internationalization through their international offices that carry out activities related to education and talent. MHES also has an office in Brussels – DANRO. DANRO is a satellite office and part of the EU office at the Danish Agency for Science and Higher Education, which also incorporates the national contact point for the European framework program for research and innovation. The EU office mainly focusses on strengthening Danish research interests within the European Union as well as promoting and increasing Danish participation in the European framework program for research and innovation. While the first represents Danish research interests within the European Union, Like DANRO, the second Brussels Office, EuroCenter also promotes and increases Danish participation in Horizon2020 programmes mainly focussed on business advisory services.

Funding instruments

Public funding. Public funding is important as baseline funding for universities and is spread across several instruments. Figure 21 shows the main funding flows in the Danish R&I system. Basic funding of research amounts to 8.9 billion DKK (1.2 billion EUR). In addition to this, two main public funds exist. The Innovation Fund Denmark (IFD) funds strategic research and innovation and was created in 2014 through a merger of smaller funds to administer the main funding instruments. Moreover, The Danish Growth Fund (DGF, created in 1992 and under MIFBA) funds innovation in SMEs and provides early-stage funding. In addition, a number of other research funds operate such as the Danish National Research Foundation, Independent Research Fund Denmark, or the Development and Demonstration programmes.

IFD is the main public funding body for competitive funding of business focused research and innovation in the country. IFD has its own board of directors and is and independent council under the supervision of MHES. It is among its objectives to increase the proportion of companies investing in R&D and increasing the proportion of highly educated people in private companies. It also funds strategic

[59] The centres were established in Munich, New Delhi, São Paolo, Seoul, Shanghai, Silicon Valley, Tel Aviv, Boston.

research. In comparison to The Danish Growth Fund, IFD focusses on earlier stage R&D and innovation. It offers programmes for joint research and innovation programmes and projects between academia and established companies (Grand Solutions, Industrial Researcher, InnoBooster) and for new firms (InnoBooster and InnoFounder).[60]

IFD has undergone a strategic review following an evaluation of its performance in 2018. The main findings were that while the merger had been successful and that IFD programmes were deemed appropriate, the strategic direction and integration with different actors needed to be strengthened. The IFD should also improve data collection and strengthen its evidence base.

The DGF provides long-term equity funding on a commercial basis to support start-ups and existing companies in their expansion including the commercialisation of R&D, for example, to grow, scale and internationalise. The purpose is to support the private market and its development in areas and markets where the private investors often hesitate to enter. The DGF undertakes direct and indirect equity investments in technology companies, such as robotics and medical technology, but also VC investments in companies that are not science and technology-driven, for example, design and/or urbanisation. The DGF also provides loans and guarantee schemes. Since 2019, the DGF implemented a VC model internally, complementing the activity of private players such as business angels. The DGF works with private sector finance providers such as banks and VC funds, both domestic and from abroad, to encourage them to become more active in the Danish market.[61]

As mentioned above, the overall public funding for R&D (as share of GDP) has remained stable in recent years after growing historically. Funding by municipalities and regions has increased, compensating for less funding growth by the central government. This has likely triggered a stronger focus on addressing challenges that dominate the local government agenda such as for example SMEs or health care connected with hospitals.

Private foundations. A unique feature of the Danish National Innovation System (NIS) is the important role played by private foundations, which account for a significant share of the funding. There are numerous private foundations, notably the Novo Nordisk Foundation, that provide competitive funding to thematic research areas. The private foundations fund a major share of the privately funded R&D and also invest in related initiatives or physical spaces, such as incubators, networks, prizes or events. The Novo Nordisk Foundation (NNF) alone disbursed over DKK 1.7 billion (EUR 228 million) in 2018. Going forward, it aims to increase the annual pay-outs to about DKK 5 billion (EUR 671 million) by 2023. NNF invests mainly in life science related R&D and innovation projects at

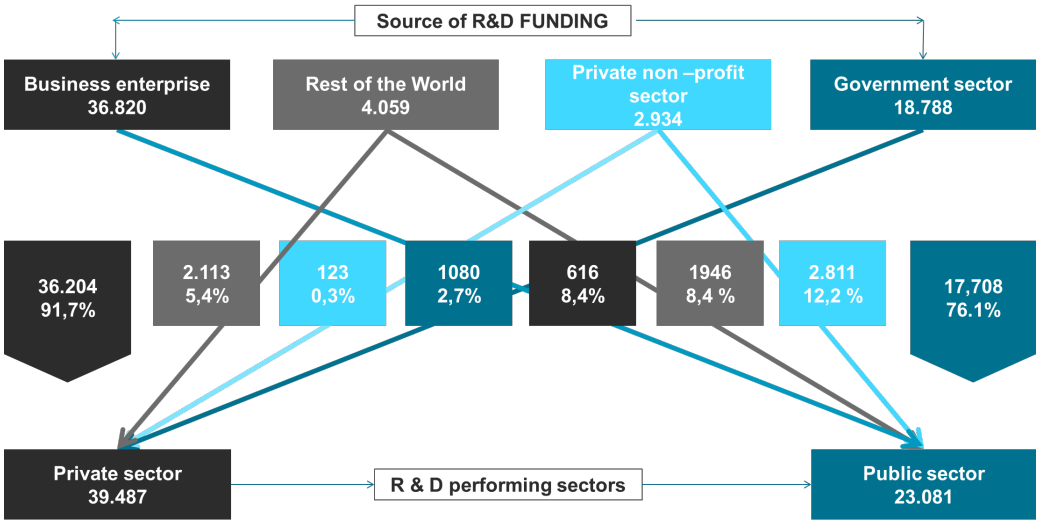
[60] InnoFounder targets new companies and InnoBooster both new and established companies. Grand Solutions and Industrial researcher programmes are open to established companies only.

[61] DGF operates on market conditions and cover their costs through the interests on their loans and returns on their investments (with the exception of a few initiatives). Their investment decisions are based on profit and social returns.

different stages of maturity. The foundation also provides an incubator for life science start-ups. The funding by private foundations is set to increase in the coming years. NNF estimates that it will triple funding in three years to match public funding. The foundations are independent institutions with their own strategic objectives and plans.

International funding. Most of the funding for R&D in Denmark comes from domestic sources. EU and other international sources (for example Horizon 2020 funding) account for only 8.9% of total R&D expenditure (in 2017), which is less than in Finland (12.1% in 2016) and the Netherlands (13.9% in 2016).[62] One reason is that at the aggregate level companies and research institutions and universities are not incentivised to tap into EU funds, because these crowd-out domestic funding due to regulations.[63]

Figure 21: Financing research, innovation and education, in million DKK



Source: MHES

Note: The percentages on the arrows indicate the share of the given R&D funding sector as share of the R&D performing sector. The percentages add up to 100 for each of the two R&D performing sectors. The figures are based on preliminary data from 2016 for public R&D investments and data for 2015 for the business enterprise sector.

[62] https://ec.europa.eu/eurostat/web/science-technology-innovation/data/database

[63] While this mechanism applies at the aggregate level, university block funding is to some degree dependent on external funding giving an incentive to attract it.

Governance and collaboration

Frequent and effective collaboration between different actors and institutions of the NIS are key to its effective functioning. They enhance efficiency, can give rise to new solutions and policy innovations and create an ongoing dialogue to align the activities of different actors towards strategic goals. They also contribute to structuring and interlinking institutions of the NIS to facilitate access to relevant services, funding and information for businesses that wish to innovate. These linkages are, therefore, an important element of the innovation strategy and need to permeate the governance, strategic and operational levels of the innovation system. These linkages can be formal or informal. In addition, for sectoral initiatives or for specific purposes, the Ministries of Energy, Foreign Affairs and Environment and Food are involved. There is little structured involvement of private sector entities, including the private foundations, in the discussions on the overall direction of innovation policy.

Although the relevant ministries are in an ongoing dialogue, a clearly visible formal platform for coordination of strategic efforts related to innovation at the highest level of government does not seem to exist. Much of the coordination across institutions is done informally. This approach to coordination is aligned with the country's small size and cooperative culture, and it is working, to some extent, at the operational level. But there has been a tendency to minimise the need for coordination across different parts of the system by defining clearly separated areas of responsibility. Consistent with this approach, recent reforms have focused on the efficiency of individual organisations and programs and on reducing the overlaps between them, not the overall effectiveness of the Danish innovation system.

1.3 Pathways: What forces will affect the further evolution of Denmark's innovation system?

Any efforts to improve Denmark's innovation performance must take into account both the domestic and the global contexts. Domestic factors will shape the political dynamics driving the willingness and ability to pursue change. International factors will influence how effective specific policy actions in Denmark will be in terms of achieving their desired economic impact.

1.3.1 The domestic context

Denmark's economy is performing well, and its innovation system is ranked highly. There is and was no burning platform that would trigger ambitious policy action to change the Danish innovation system fundamentally. There was, however, significant overall budget pressure in the post-GFC period. Institutionally, there were frequent changes in the political leadership of the MHES. As in many other countries, innovation was politically largely under the radar: an area left to technocratic discussion, viewed as positive across political party lines but not pushed as a top-level political priority.

This political context led to a significant number of reform efforts over the last two decades: the merger of funding instruments, changes in incentives in universities and colleges or the recent reform of business support structures. Box

1 presents the timeline of the main developments. The focus of these reforms was on raising the efficiency of individual parts, not on creating a clear system-wide strategy. While many positive results have been achieved, this approach has also led to some unintended consequences:

- **Increased institutional and procedural simplicity**, such as expressed in the merger of the funding instruments or the reduction of number of clusters, appears to have reduced room for experimentation and to have increased the power of existing funders or entities, which appears to have led to reduced diversity.

- **An implicit focus on SMEs in general as a target group**, supporting innovation in all SMEs, with a limited focus on the particular needs of key innovating businesses, such as larger firms or high-growth start-ups and scale-ups.

- **A focus on reforming individual programs and institutions has reduced the systemic interplay in the NIS**, which was implicit and to some extent self-organized. This introduced coordination failures as clarity about the role of each institution was watered down. For example, to increase collaboration with business, universities proposed support services (for example, laboratory testing) that were traditionally the role of the RTOs or focused more strongly on innovation needs of SMEs where colleges traditionally have stronger linkages. At the same time, the RTOs and colleges were incentivised by the government to undertake more research and innovation and as a result compete with the universities.

Box 1: Recent reform efforts

2001: Reorganisation of innovation policy with general innovation under the Ministry of Business and knowledge-driven innovation under the Ministry of Science, Technology and Innovation (now the Ministry of Higher Education and Science) with the objective of strengthening the nexus between education, research and innovation.

2003: First action plan by the government after the reorganisation: ”New paths between research and business - from thought to invoice” (”Nye veje mellem forskning og erhverv – fra tanke til faktura”)

2005: Establishment of the Advanced Technology Foundation.

2005: Establishment of the Globalization Council, which provided input for the Government globalisation strategy published in 2006.

2008: Merger and creation of national innovation networks.

2010: Business directed innovation strategy: “Enhanced innovation in the business world” (“Styrket innovation i virksomhederne ”).

2012: European Research Area Committee (ERAC) peer review of the Danish research and innovation system characterised the system as overly complex.

2012: Innovation strategy: "Denmark – a nation of solutions" introduced solutions to a range of significant societal challenges (in energy, health, education, transportation, etc.).

2013: Establishment of the Productivity Commission, which also makes some recommendations on the innovation system.

2014: Establishment of the Danish Innovation Fund by merging three funding bodies in response to recommendations of the ERAC review. (The Advanced Technology Foundation, The Council for Technology and Innovation and The Council for Strategic Research).

2014: Comprehensive external evaluation of university business collaboration and technology transfer.

2016: Start of the annual reduction of funding for higher education by 2% per student (FTE) as part of an effort to re-prioritise public spending. One off cut in state R&D budget by 6%.

2017: Publication of Strategy: "Denmark – Ready to seize future opportunities".

2017: In parallel: Establishment of the Danish Disruption Council by the Prime Minister.

2017: Strategy for research: "FORSK2025".

2018: Political agreement to reform the public business-promotion system, including the cluster organisations, incubators and innovation networks.

2018: Strategy for life sciences: "Vaekstplan for Life Sciences".

2018: "Denmark's Strategy for Digital Growth".

2019: Review of technology transfer from universities.

Evaluation of the Innovation Fund Denmark.

Reorganisation of the cluster system.

Findings of the committee review of the merit-based evaluation of researchers.

International expert committee proposal for result based element in basic funding for research (Fremtidssikring af forskningskvalitet)

International expert panel review of the Danish knowledge-based innovation system

The combination of slow evolution at the strategic level and frequent change on the operational level has resulted in an innovation system confronted with a quandary: On the one hand, there are several dynamic hotspots with high technology, strong innovation and high economic potential and performance, that fit in very well into the transformative societal and economic context observed at a global scale (see section 1.3.2). Examples are innovation and collaborations in the wind energy sector that leverages the increasing global transformation towards a low carbon economy, innovation in biotechnology driven by strong local players that leverages increasing innovation in health care or the robotics cluster in Odense that benefitted from increasing automatization in manufacturing sectors around the world.

On the other hand, however, other subsets of the system are less dynamic and remain somewhat stuck in the domestic context, characterised by local introversion and fragmentation and present opportunities for improvement. SMEs do not engage in innovation efforts to the degree possible (see section 1.2.1) and the linkages between SMEs and key actors in the broader innovation system remain limited.[64] For example, innovation opportunities in non-science driven areas (creative industries, social innovation or some aspects of sustainability) are

[64] see e.g. Knudsen et al. 2019: RIO Country Report Denmark 2018 [Draft]; Research and Innovation Observatory country report series; Joint Research Centre, European Commission

under-used and poorly linked with innovation hotspots in other sectors, notably with science-driven innovation. Denmark appears to be missing opportunities that emerge from cross-disciplinary approaches that reflect the country's strongholds.

What is more, the national institutional and political environment for innovation appears to suffer from a lock-in situation that results in short-termism and a focus on improving operational performance and efficiency. Denmark's NIS could significantly benefit from a shared, overarching long-term vision, and better coordination in selected innovation policy arenas.

A major challenge is that major strategic change would require a higher-level political commitment and there is currently no obvious actor or mechanism who could break this cycle. Frequent changes in leadership in government and ministries have aggravated the situation as they pushed actors to focus on technical and operational performance in the short term. What is more, the recent reforms insufficiently respond to the ongoing global economic, social, technological and political changes and their impact on Denmark's NIS. The disregard of the global context could result in Denmark losing its competitive edge in comparison to other countries that are moving ahead faster.

1.3.2 The global context

The impact of Danish innovation policy choices will to a significant degree depend on the broader context of the global economy and innovation system. There is a clear sense that this context is changing and doing so at a much higher pace than in the past.

The **geography of global innovation is changing**. Companies are increasingly investing globally in R&D.[65] In the past innovation was a domain where advanced economies excelled, now emerging markets, particularly in Asia, are quickly catching up. In 2017, Chinese firms increased R&D investment by 20% compared with 9% by US firms, and 5.5% in the EU[66] and the number of PCT patents increased by 13.5% in China against only 0.2% in the US.[67]

Innovation is also becoming increasingly intertwined with an ever more complex geopolitical situation. Much of the current trade tensions between the US and China have their roots in the perception that China is aggressively challenging the role of the US as the global innovation leader.[68] Innovative capacity is an

[65] http://iri.jrc.ec.europa.eu/scoreboard.html

[66] https://ec.europa.eu/info/news/2018-industrial-rd-scoreboard-eu-companies-increase-research-investment-amidst-global-technological-race-2018-dec-17_en

[67] https://www.wipo.int/edocs/pubdocs/en/wipo_pub_943_2018.pdf

[68] In 'China: A strategic outlook' the European Commission has discussed its view of how Europe should respond to China's growing role, also in regards to technology https://ec.europa.eu/commission/sites/beta-political/files/communication-eu- china-a-strategic-outlook.pdf

asset in the new geopolitical competition, and political power is being used to gain an advantage in the competition for technological leadership.

Within Europe, the new **European Innovation Council** is setting out a new structure under EU´s Framework Programs to support disruptive innovation across Europe. All EU member states, Denmark included, will have an opportunity to review how their national efforts can best be leveraged by the use of the new set of European instruments and platforms.

The cost of R&D is increasing, raising the barriers to entry. The effort required to come up with an idea is higher than previously, because, due to the rising stock of knowledge, "more stones need to be turned" to find a new idea.[69] This is consistent with innovation activity being increasingly concentrated in a small number of large firms[70], a process we also observe in Denmark. These firms hold significant market shares and market value, are more productive and pay higher wages.[71]

New technologies – mainly digitalization – drive innovation and transform many sectors. Established industries will have to transform significantly in the coming years to remain competitive. Technologies, including robotics or digital technologies such as AI, will fundamentally reshape business and production processes. Many of the digital technologies will benefit from large market size to be able to scale business solutions quickly. Patent data, for example, shows that the United States, China, Japan, South Korea and Germany have emerged as the global leaders for 3D printing, robotics and nanotechnology.[72] For European countries, international cooperation that can help scale solutions is crucial.

Innovation policies have seen an **increased focus of major societal challenges** such as climate change, environmental damage, health and longevity, urbanization, or income inequality. These challenges represent the societal objectives of innovation policy and will need investment and innovative solutions. Most of these challenges require transitions that are systemic in nature and require new approaches to innovation that have broadened and deepened the policy rationale for innovation policy interventions. Innovation policies have moved from addressing market failures and coordination failures to transformative system failures. Transformative innovation policies need a strong

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[69] Although, this may differ by industry, the overall number of researchers has increased since the 1930s by a factor of 23, but annual growth in productivity has declined.

[70] European Commission (2019), European Semester Country Report: Denmark

[71] https://www.kansascityfed.org/~/media/files/publicat/sympos/2018/papersandhandouts/jh%20john%20van%20reenen%20version%2020.pdf?la=en Mergers may lead to reduced competition (and hence innovation), if smaller firms cannot scale up to become competitors. There is some evidence of this as the rate of firm dynamism is declining in the United States.

[72] World Intellectual Property Organization (2015) *World Intellectual Property Report 2015. Breakthrough Innovation and Economic Growth.*
Available at: https://www.wipo.int/publications/en/details.jsp?id=3995&plang=EN

common vision that gives direction, strongly articulated demand, tightly coordinated policy and constant renewal (see Table 2).[73]

Table 2: Strategic shift in innovation policy rationales

Market failures (Neoclassical Perspective)	**Structural System Failures** (Innovation System Perspective)	**Transformative System Failures** (System Innovation Perspective)
1) Limited experimental economy Weak incentives, information asymmetries and capability deficiencies limit ideation and experimentation	**1) Infrastructural failures** Underinvestment in infrastructure due to large uncertainties, high risk, big scale and long-time horizons	**1) Directionality Failures** Weak incentives, lack of common visions and weak actor mobilization stop system transformation
2) Underinvestment in R&D and innovation Genuine uncertainty about results and appropriability make cost-benefit calculus impossible	**2) Institutional failures** Laws, property rights, regulations, trust, values, norms and attitudes could generate negative incentives	**2) Demand articulation failures** Weakly articulated user and societal needs and weak demand articulation capabilities limit system renewal
3) Negative externalities Societally negative effects if private actors do not have incentives to include such costs in their calculations	**3) Network failures** Weak cooperation limit knowledge exchanges, learning and empowerment – too strong clusters could lead to lock ins.	**3) Policy coordination failures** Under-developed processes for multi-level and horizontal policy coordination limit system renewal
4) Overexploitation of societal commons Societal commons – land, water, environment tend to be overexploited (if they are not priced)	**4) Capability failures** Lack of key competences, leadership and organizational capabilities limit absorption of new knowledge and innovation	**4) Reflexivity failures** Under-developed systems and renewal perspectives in policy evaluation and policy learning limit system renewal

Source: Based on Weber, RM and Rohracher H.: Legitimizing research, technology and innovation policies for transformative change, in Research Policy 41, 2012, p. 1037-1047.

[73] Edler, J. and Fagerberg, J.: Innovation Policy: What, Why & How. February 2017; Oxford Review of Economic Policy 33(1):2-23, available at: https://www.researchgate.net/publication/315498355_Innovation_policy_What_why_and_how

1.4 From diagnostics to action: Towards a structure for reform

This section first summarises key challenges and opportunities for Denmark as they emerge from the diagnostics in Chapter 1. It then outlines a two-pronged approach for how Denmark can up its innovation system in response. This two-pronged approach provides the structure for our recommendations: Chapter 2 outlines 10 areas of action that aim to achieve operational improvements within the existing innovation system structure. Chapter 3 raises more far-reaching questions about Denmark's strategic objectives and positioning within the global innovation system.

1.4.1 Challenges and opportunities for Denmark

The analysis above shows a Danish innovation system with considerable strengths, placed within a successful economy that is supporting high standards of living for its population. The overall performance of the Danish innovation system is strong, in particular in R&D related to life sciences, where Denmark is world class. There are also several other areas in which Denmark has evolved as an innovation hub, for example, in wind energy and robotics. Many strengths contribute to these achievements, such as a highly innovative business sector, strong human capital and world-class research capacity. The analysis shows no immediate threats to this position, fully reflective of Denmark's position as a European if not global innovation leader.

But while there is no burning platform, there is a sense that Denmark could do better in terms of how strengths are translated into results and in how the country prepares for the challenges emerging from structural changes in the global (innovation) landscape.

The initial diagnostic suggests several challenges and missed opportunities:

- **Challenges**
  - High reliance on a very small number of top R&D spending firms and in specific sectors (mainly life sciences) with limited diffusion of innovation to smaller companies and entrepreneurial activity (see Figure 6).
  - Global economic trends are raising the bar in terms of attracting/retaining innovation activities to/in Denmark that have a strong economic impact (see section 1.3.2).
  - Indicators suggest that on some elements innovation performance in Denmark has been deteriorating recently, while the EU has been improving on average (EIS 2018).

- **Missed opportunities**

  - The excellent outcomes in science insufficiently translate into commercial innovation, in particular in SMEs, start-ups and scale ups (see Figure 17). As we will see in section 2.1.1, one reason is that technology transfer offices in universities are on average not adequately resourced in terms of funding and capabilities to fully perform their role, and there is room for improvement in terms of better aligning universities towards innovation objectives.

  - Efficiency is lost due to a lack of strategic coordination with private sector foundations that fund a significant share of R&D activity (see section 1.2.1).

  - Strengths in science could be leveraged more by attracting foreign companies to tap into the existing knowledge pools; this is currently happening only to a limited degree (see section 1.2.2).

  - Strengths in non-science driven innovation and entrepreneurship oftentimes linked to other schools such as architecture or art academies (creative industries, sustainability) are insufficiently integrated into the broader innovation strategy; the country loses out on cross-pollination opportunities that could give rise to new products and services (see section 1.3.1).

  - Strengths in areas that have clear relevance for global societal challenges (urbanism, sustainability, social innovation) and opportunities for cross-pollination across Danish strongholds appear under-utilised (see section 1.3.2)

What are the root causes for these issues to emerge? In the view of the Panel, they reflect, to a large degree, an insufficiently systemic approach to innovation in the context of the entire RDI system:

- **There is no sufficiently clear, deliberate, overarching strategic direction of the Danish innovation system** that reflects rapidly changing global needs and developments in innovation or a perspective on how they may affect Denmark in future.

- **The innovation policy system appears fragmented, despite high openness to dialogue and discussion**. There is no obvious central platform to discuss and take strategic, system-wide decisions related to the NIS. The focus of reforms has been on reducing overlaps and interdependencies across different entities of the system, not on actively promoting collaboration and coordination at interfaces.

- **While many reform efforts were undertaken in recent years to enhance the functioning of the innovation system, their focus was on the efficiency of individual parts**. A clear, ambitious system-wide agenda to connect these individual efforts was missing, and there was insufficient

focus on their systemic repercussions. This has resulted in some unintended consequences:

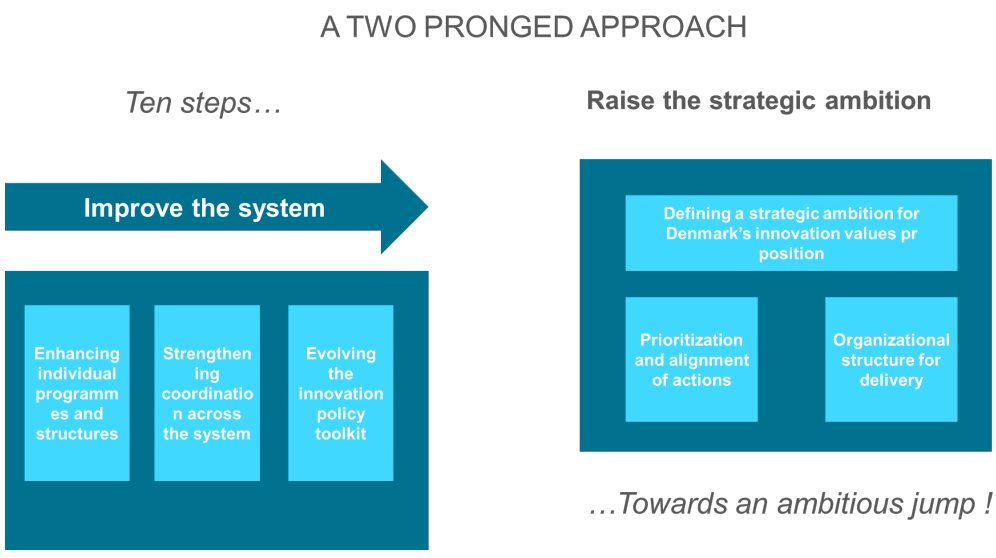
- Simplicity reduced room for experimentation and created the monopolistic power of funders.
- Implicit target group-thinking (focus on SMEs) misses the needs of large firms that are key innovators and that are insufficiently linked to the NIS and high-growth scale-ups.
- Focus on individual programs and institutions has eroded systemic interplay and has blurred boundaries between different players in the system as roles and responsibilities were changed but not well defined.

1.4.2 A two-pronged approach towards a stronger Danish innovation system

Denmark is doing well on innovation, but it can, and in some ways, should do better. But how to get there? Based on the analysis of where the Danish innovation system is today, the Panel suggests a **two-pronged approach for the future** (see Figure 22)**:**

- First, **improve the performance of individual elements of the NIS**. This implies a review of existing individual elements of the innovation system and their coordination and developing recommendations on how they can be improved and what new policy measures can be introduced.
- Second, **define a stronger strategic ambition**. This implies asking what Denmark aims for its innovation system to achieve and then developing recommendations for how it can achieve that ambition.

Figure 22: Two-pronged approach for Denmark



Chapter 2 'Addressing current challenges of the Danish innovation system' is about identifying room for improvement in the existing system that could boost performance. The chapter is organised into three sections: first, recommendations on how to upgrade individual elements of the system and raise their overall performance. Second, recommendations for better coordination across the individual actors in the national innovation system. And third, recommendations for a broadening of the innovation policy toolkit.

These recommendations will address many of the opportunities that are currently unlikely to be fulfilled in Denmark and improve the performance of the NIS in key areas. They can be pursued within the existing policy structure and are, to a significant degree, under the purview of the MHES.

Chapter 3 'Defining a strategic ambition for Denmark's innovation system' is about setting a clear goal and developing the unique strengths that Denmark needs to achieve it. The chapter is organised into two sections: first, a motivation of why setting out a clear strategic objective is important, and why Denmark's current policies do not provide sufficient direction. Second, a discussion on what the process to develop a strategy should entail, including some indicative thoughts on where it might go.

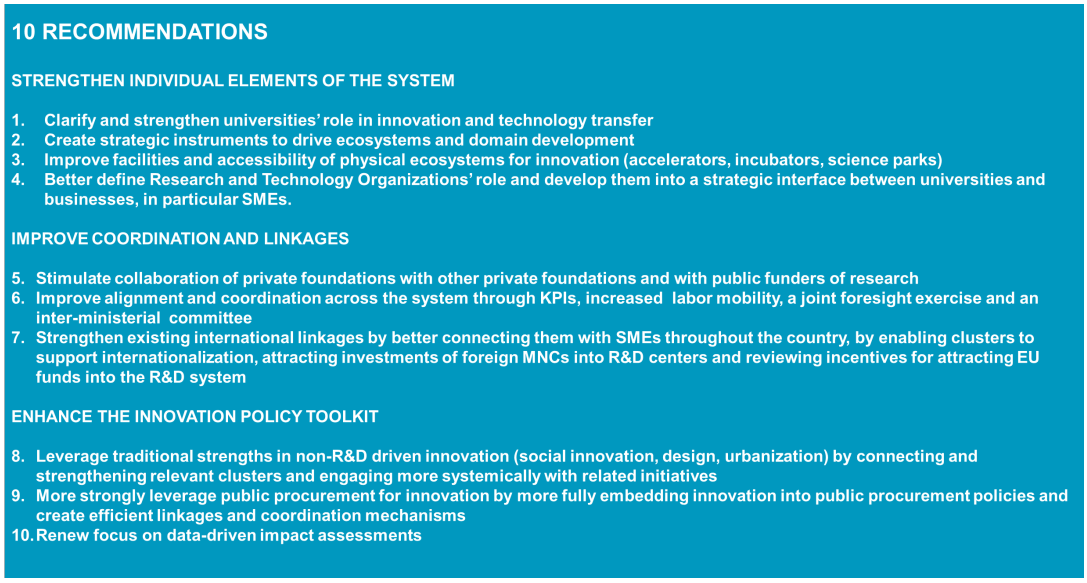
These recommendations are by their nature more explorative and focused on the process of how Denmark can set appropriate goals for its innovation system that are clear, take into account external developments and are widely accepted by stakeholders. These goals would then translate into action priorities and an alignment of organisational structures, both moving beyond the purview of the MHES.

2 ADDRESSING CURRENT CHALLENGES OF THE DANISH INNOVATION SYSTEM

Denmark has a history of continuously improving the performance of the innovation system. In light of the unfulfilled opportunities outlined above, the panel identified room for improvement in specific areas of the Danish NIS. These should be addressed independently of the decision regarding the strategic approach outlined in Chapter 3. They address challenges related to improving the performance of individual institutions or instruments, coordination challenges and an enhanced policy toolkit.

Figure 23 below provides a summary of these recommendations.

Figure 23: Summary of recommendations



2.1 Enhancing individual elements of the innovation system

The panel identified key elements of the innovation system, where there is clear room for improvement. Addressing the following recommendations will enable Denmark to increase performance within the framework of the current system. The recommendations are based on a review of documents, panel interviews as well as practices found in other countries.

2.1.1 Strengthening innovation-orientation of universities

Universities and other higher educational institutions are the sources of key inputs for research-driven innovation. They provide human capital, generate academic knowledge, provide access to the global pool of scientific information, and conduct application-directed research. University research is also a source of entrepreneurial ideas, spinouts and start-ups and the disruptive industries of tomorrow are more likely to come from the curiosity-driven basic research at the universities funded primarily by government and private foundations.

Spin-out companies based on academic research or scholarship (e.g. PhD or student projects) are an important contributor to creating the industries of tomorrow. Innovation thus needs to combine application-directed research for the industries of today together with curiosity-driven research for the industries of tomorrow. Enabling the translation of this innovation into economic impact is driven by entrepreneurship education and student support facilities in universities, and the services that university researchers can tap into to commercialise their research and ideas. It is also supported by performance-based incentive schemes, such as making entrepreneurial experience an advantage for research positions

The eight Danish universities are independent institutions within the public administration. They agree upon four-year framework contracts with the MHES to specify the strategic goals of each institution. The individual strategies differ by institution and take into account their respective strengths and challenges. The strategic framework contract sets the direction for the development and priorities of the university. It describes the expected impact at the end of the four-year contract and how to get there through prioritized strategic focus areas.

The compliance with strategic framework contracts is monitored in annual status reports and action plans submitted by the institutions. In the status report the institution evaluates the progress based on the goals, activities and indicators and pre-defined baselines for each of them. The specific indicators vary across the institutions, but all include metrics of increased collaboration with business and society. They include for example the number of spinouts, license agreements, and number of research collaborations with external actors.

Despite the strong focus on university-business collaboration, the regular debates between MHES and universities are focused mainly on education, research and governance. Innovation is not given primary attention in these debates. The following observations and recommendations emerged from detailed one-day discussions with the leadership and technology transfer offices of the eight Danish universities.

Clarity of the Universities' Innovation Mission

Challenge: The universities are unclear about the expectations the Danish government has towards them on their role in the innovation agenda. There is a lack of clarity on the universities understanding of their own function in the R&I system (e.g. more life science-intensive versus more technology-focussed universities), and on their potential contribution to knowledge-based innovation. While there are regular meetings between the Ministry and university leaders under the Danske Universiteter umbrella, the topic of innovation rarely appeared to be on the agenda.

Recommendation 1.1: Ensure universities and MHES have a commonly shared and clear understanding of what is expected of the universities in terms of innovation. This understanding needs to respect the diversity of the eight universities and the different ways they are able to contribute to knowledge exchange. It also needs to extend beyond technology-based innovation and include social, environmental and service innovations. Those mutually agreed expectations should then be reflected in the universities' missions.[74] This could, for example, be achieved by anchoring innovation more strongly as a strategic priority for the universities.

Responsible entity: MHES and university leadership

Budget implications: low

Technical complexity: low

Priority: medium

Strengthening dialogue on supporting innovation in universities

Challenge: Government and universities need to work together to create an environment and culture in universities in which knowledge exchange and innovation can flourish. At present there does not appear to be a person or group in the Ministry with sufficient seniority to influence policy and with a deep understanding of the complexities and challenges faced by the universities in effecting knowledge exchange. As a result, the interaction between universities and MHES on innovation are scarce and there is little focus on innovation as a strategic priority.

[74] The Knowledge Exchange Concordat in development in the UK is available as an example at https://bit.ly/2Iar2kg

Recommendation 1.2: Consider creating a dedicated university innovation role within MHES of sufficient seniority to be able to influence policy.

The role would be to become an expert and advocate within the Ministry specifically on knowledge-based university innovation. It should be the responsibility of such a role to establish a knowledge-sharing arena between the universities and the Ministry to design and develop policy options and be an advocate within the Ministry for those policies.

The person would develop a deep understanding of the knowledge exchange landscape within the universities, to establish an arena where policy options are co-developed with input from university professionals and to advocate those policies within MHES. The exact tasks are to be defined, but would include:

- Understand in detail the university knowledge exchange (and research) landscape with all its diversity and nuances, and the surrounding Government policy landscape;
- Develop policy proposals for the university innovation agenda;
- Act as a policy advisor in this space including on any unintended consequences of other policies in force or development (such as the State Aid issue);
- Build a close working relationship with the universities & their TTOs.

Responsible entity: MHES

Budget implications: low

Technical complexity: low

Priority: medium

Resourcing of knowledge exchange activities in universities.

Challenge: Knowledge exchange activities are funded by the universities out of their overall base funding provided by MHES. With cuts in education funding and in competitive research funds, the support for knowledge exchange activities is limited. This results in offices that are under-resourced to deal with all the potential opportunities being created by the research activity. See Table 3 for an overview of key data related to Danish universities.

Table 3: Key data on Danish universities

University		Invention disclosures	Priority Patent Applications filed	LOA's executed	Spinout companies established	Licence portfolio	TTO and contract staff (FTE)	IP protection expenditures (million DKK)	Commercial revenues (million DKK)	New R&D Agreements with industry	R&D Expenditures (1000 DKK)
Copenhagen Business School	2017	0	0	0	0	0	1	0	0	58	375,709
	2018	0	0	0	0	0	1	0	0	89	
Technical University of Denmark	2017	124	47	34	4	140	20	19,9	15,2	513	3.822.689
	2018	117	52	40	7	169	20	20,5	14,1	620	
IT University of Copenhagen	2017	4	0	0	0	12	3	0,5	0	31	107,713
	2018	0	1	0	0	0	2,5	0,8	0	26	
University of Copenhagen	2017	77	28	33	4	157	15	6,6	20,2	304	5.366.274
	2018	78	37	29	6	176	16	6,9	21,4	335	
Roskilde University	2017	0	0	0	0	1	1	0,5	0	58	348,042
	2018	1	0	0	0	0	1	0,3	0	47	

		Invention disclosures	Priority Patent Applications filed	LOA's executed	Spinout companies established	Licence portfolio	TTO and contract staff (FTE)	IP protection expenditures (million DKK)	Commercial revenues (million DKK)	New R&D Agreements with industry	R&D Expenditures (1000 DKK)
University of Southern Denmark	2017	33	13	3	2	35	12,7	1,7	1,3	128	1.758.793
	2018	36	13	4	3	28	14,5	3,3	0,9	170	
Aalborg University	2017	71	16	40	1	62	11,4	1,7	4,5	263	1.834.268
	2018	81	11	31	2	64	11,5	1,2	3,3	348	
Aarhus University	2017	54	19	8	2	75	22,5	5,5	3,4	490	3.033.186
	2018	68	26	16	3	81	24,5	4,4	2,4	506	

Source: Public research commercialisation data, Ministry of Higher Education and Science

This limitation of funding for TTO activities has also created a culture in which thinking is incremental – "if I had X much extra money I could do Y much more" – rather than holistic – "This is how much potential we think there is and realising it all would cost….." This is partly a consequence of the uncertainty of funding in the technology transfer offices which leads to short term tactical thinking rather than long term strategic thinking. Stable long-term funding will allow universities to invest in building and training professional knowledge exchange functions and create a secure professional career for the practitioners.

Contrary to popular perception, knowledge exchange is not a cash generator for universities but a net cost. In the United States, 87% of offices lose money and the 13% that make money are the beneficiaries of (transient) serendipitous success.[75] The financial benefit is seen in the economy, not the universities, and can take 10-20 years to materialise. There is a strong argument therefore that the beneficiaries (i.e. Government through taxes on increased economic activity) should bear the costs. As noted above though, there is strong academic competition for the current base funding. Moves to allocate some of that current funding to knowledge exchange is likely to be academically unpopular and therefore counterproductive.

Recommendation 1.3: Consider creating an additional non-competitive hypothecated funding stream specifically to support the knowledge exchange activities.

The funding needs to be additional and hypothecated because otherwise it will be difficult for university leadership to implement it in an effective way. Non-additional funding would likely cause strong resistance among researchers in the university environment.

The amount of funding should be decided based on an assessment of the full potential, not on an incremental basis. Experience in other countries indicates that a figure of 2.5% of extra-mural research funding could be a rough guideline.[76] Such a funding would enable the offices to appropriately staff the key functions and to develop and pursue a strategic vision. One possibility to implement this would be to follow the UK model, where the government decides on the nominal allocation. Based on this, universities produce a plan on how they intend to use the funding. These plans are reviewed by Research England and approved or adjusted. This approach allows to account for different strengths of the individual universities.

[75] https://www.brookings.edu/research/university-start-ups-critical-for-improving-technology-transfer/

[76] The figure of 2.5% is based on the US requirement that federal agencies are required to hypothecate 2.5% of their extra-mural research spend to support its commercialisation through the Small Business Innovation Research Programme. In the UK this share is in practice higher – about 5% of Government research spend with universities is for supporting research translation.

The necessary funding could be built up over time to reach this level. The work programme could be developed in collaboration between the Universities and MHES including detailed performance metrics.

Responsible entity: MHES

Budget implications: medium

Technical complexity: low

Priority: medium

National Legislation and State Aid

Challenge: Some aspects of national legislation are perceived by universities as being not conducive to knowledge transfer. This includes restrictions on the use of university premises leased from Government to carry out commercial activities such as incubation and acceleration as a result of the interpretation of EU State Aid rules. Often the barriers are the unintended consequences of legislation introduced for other sound reasons. Changes of national legislation to reduce or remove unnecessary barriers is within the prerogative of the Government.

State Aid regulations are directly governed by EU rules; national legislation is merely translating these rules into domestic laws. However it did feature strongly as a significant barrier in discussions both with universities and with industry to an extent that is not seen for example in the UK. Danish universities initiated and paid for a review of the State Aid requirements by the law firm Bech Bruun (BB). The report which included guidelines on State Aid in knowledge exchange has been published recently. The Ministry was only involved in the very earliest stages of the project.

The State Aid regulations are sufficiently imprecise as to require interpretation and there is a paucity of case law to assist in that interpretation. It has not been possible in the time available to get to the bottom of why State Aid is seen as a major issue in Danish knowledge exchange but not in other EU countries such as the UK. It may be down to different levels of pragmatism in interpreting the regulation. What is clear from conversations with the European Commission is that innovation is a high priority, that it does not want to impede knowledge transfer in support of innovation and that since 2014 the Commission's desire to become involved in giving exemptions outside the General Block Exemption Regulation (GBER) has declined.

Given the problems that State Aid issues were attributed with creating and the interest of the European Commission in facilitating and fostering innovation in the EU member States, there is an opportunity to bring greater clarity to what is and isn't required through conversations between the Commission, the Ministry and the universities.

Recommendation 1.4: Review with the universities where Danish legislation is not helpful to the university innovation agenda and consider what changes could be made without impairing the wider objectives of the legislation outside of university activity. This review should complement the recent joint review by universities and MHES on IP and tech transfer.

Initiate a dialogue with the Commission and the universities to clarify the application of State Aid requirements to university knowledge exchange. From that, develop clear Government guidelines on the application of State Aid to knowledge transfer so that there is a common understanding by all parties set nationally rather than differing interpretations set locally by different parties.

Responsible entity: MHES with universities

Budget implications: low

Technical complexity: medium

Priority: high

Celebrating success and creating role models

Challenge: Within the academic community, the traditional academic culture focussed on research and education prevails. Nevertheless, there have been some significant successes which are not necessarily widely known or understood. There is much more that can be done to reveal and celebrate the successes and create academic role models. Few academics would not aspire to a senior academic position in a leading international university such as Stanford, MIT, Oxford or Cambridge in all of which entrepreneurship is an integral part of the academic culture.

There are some successful examples in Denmark. The University of Southern Denmark (SDU) allows academics on permanent contracts at the university to return to the same position if they leave to start a company. This allows founders, with the knowledge required by the spin-out, to go with the spinout for a period of time, which can be vital in the early stages of a company's life. However, founders are not always the right people to drive scale-up and having an option to return to academic life is important.

In revealing and celebrating such success, it will be important that entrepreneurship is seen as inclusive of the breadth of academic activity, including the arts, humanities and social sciences, not just a technology/STEM/life sciences focus. Revealing and celebrating success will also strengthen the perception among the public and politicians of the role of research in innovation.

Recommendation 1.5: Develop in addition the existing innovation awards, a dedicated programme to reveal and celebrate the success of academic entrepreneurship in Denmark aiming at a culture change with the academic community but also with the general public and politicians. This programme should also provide a stronger incentives for academics to innovate as part of the recent review.

Responsible entity: MHES

Budget implications: low

Technical complexity: low

Interrelation with other activities: connected to the review of the academic merit system

Priority: low

2.1.2 Strategic instruments to drive ecosystems and domain development

The emergence of new sectors and the solutions to broader societal challenges are increasingly the result of a systemic set of linked innovations, not just one technological breakthrough or scientific discovery. The full value of individual discoveries in these domains is only revealed if they are combined with complementary research activities or business model innovations.

Funding mechanisms that support only narrow research efforts by an individual entity fail to adequately support research with the potential for such systemic effects. Strategic funding programs need to be based on a vision of an entire innovation agenda and pathway, moving beyond individual projects assessed in isolation.

In addition, many of today's challenges are too complex to solve with governance approaches that involve only a few, or one, implementation agencies. Moreover, the next generation of science, technology and innovation policies will not be the sole responsibility of governments but rather a concerted action of all actors in the entire knowledge and innovation system.[77] This drives the need for strategic instruments to promote multi-stakeholder interactions across sectors and industries as new policy instruments.

With strategic instruments, we refer to Research, Development and Innovation (RDI) promotion schemes that have an explicit intent to consolidate R&D and innovation activities in specific directions, for example, related to a technological, economic or broader societal aim. To achieve this goal they have to operate at the systemic level. Good examples are schemes to support different types of

[77] Kuhlmann, S. and A. Rip, 2018, Next generation Innovation Policy and Grand Challenges, *Science and Public Policy,* pp. 1-7.

public-private and multi-stakeholder partnerships at the interfaces of research, industry and technology or industry sectors (see Box 2).

Strategic instruments have a set of specific characteristics:[78]

- They mobilize a **broad array of academic institutions, firms, and other entities** that are connected through a different types of linkages and shared interests in a specific market or technology domain.

- They often have a **stronger element of top-down steering**, such as earmarked government funding and prioritisation, linked to specific government strategies and objectives. Good examples of these types of programs include the Finnish SHOK program, the Swedish Sectoral programs, the German Spitzencluster program as well as the Austrian Compact program.[79]

- **Actors in the field**, rather than RDI funding agencies, **are empowered** to draft road maps, identify key stakeholders and propose thematic focuses and strategic initiatives. Strategic instruments combine therefore a top-down with a bottom-up approach.

- They explicitly **aim to utilise the power of digital and other types of platforms** (for example, data platforms, biobanks) as a new source of innovation that goes beyond more traditional approaches such as for example university research and technology transfer used to boost entrepreneurship and innovation.

- They also **focus on cross-sectoral collaboration and enabling technologies**. In many countries these new strategic instruments have replaced previous and more traditional models, such as the SHOK in Finland and the Sector program in Sweden, which previously had a sectoral narrower R&D focus and top-down governance model.

The following observations are based on interviews with stakeholders and users, a review of strategic documents of different organizations, notably the IFD and the recent IFD review. The Panel also drew on the experience of peer countries, such as the Netherlands and Sweden.

[78] This list is based on the experiences of Sweden, Finland and the Netherlands.

[79] https://www.taftie.org/sites/default/files/Taftie_TF_CompAct_Final_Report%20_LV.pdf

Examples of systemic instruments in Sweden

Four kinds of systemic instruments, which complement each other could be considered. These are based on the experience in Sweden, which has implemented a systemic approach to innovation. Importantly, while each of these tools has particular strengths and weaknesses, and each of them can achieve impact individually, they work best when there is a high-level ambition they can contribute to.

Mission processes – mobilising actors across industries, across disciplines, across ministries and across agencies to formulate bold missions for societal outcomes related to systemic challenges, which requires system transformation. Such missions and mission processes could, (through the missions formulated and through the co-creation processes leading up to them) serve as fundamentally important policy directions across government ministries and agencies as well as mobilizing the commitments, resources and trust between different actors that would be necessary to successfully mobilise towards reaching the missions.

Mission processes are a meta approach for the other tools described below. However, a new approach and experimentation is needed to define missions, because no recognized methodology for doing so exists.

Strategic Innovation Programs – aiming at catalysing long-term, broad-based strong commitment of key innovation actors towards a common vision connected to an area with substantial potential (or importance) for future competitiveness. The agendas and the consecutive roadmaps should generate cross-sectoral, cross-industrial and cross-technological fertilisation. They should be implemented in a series of calls and other measures and steered strategically by the key stakeholder groups responsible for the agendas (bottom up). The main partners are firms and HEIs but also the public sector. Firms are often the main drivers but administratively the managing organisation differs, based on specific legitimacy.

Strategic innovation programmes allow for large scale collaboration between leading firms and academia based on foresight and have an important demonstration effect for the system as a whole. They are flexible and evolving approaches that allow for addressing the key challenges across different policy arenas, for example regulation instead of funding. However, their systemic impact is very hard to evaluate and given the novelty of these approaches, there is a need for deep learning and constant improvement to ensure that the objectives and measures are not oversimplified.

Societal Challenge Consortia – aiming at catalysing stepwise, targeted, strongly committed consortia in addressing urgent specific societal challenges that could be practically addressed in the country, but which could have potential for scaling towards corresponding international challenges. This could be based on the concrete potential of public sector benefits and private firm revenues, if successful in generating the envisaged solutions. The public sector, in the form

of parts of municipalities and county councils, are almost always in forefront, together with innovative firms. There are often several firms, which need to connect their solutions in order to generate viable businesses and contribute to solving the societal challenge. The main partners are public sector agents and private firms, often together with HEIs and or research institutes, and increasingly with public regulatory institutions.

These consortia can generate key niches solutions on the way towards large scale solutions, allowing for problem-oriented approaches. They play an important role in demonstrating that certain solutions for transformational challenges that require changes across the system can work.

Competence Centres – aiming at generating and supporting strong hubs of excellence in key competence areas characterized by high, international, attraction gravity on companies, talent and capital. These could drive the directions of the strategies and behaviour of firms and HEIs and their overall patterns of relationships, and which could stimulate innovative HEI-research and HEI-research agendas. The main partners in competence centres are private firms and public HEIs. HEI-based steering and location of activities.

The competence centres were successful in driving progress in basic science in collaboration with industry and academia. However, the Swedish example shows that they were too small compared to the investment of science centres globally and that this limits attractiveness to MNCs.

Challenges

Following the changes undertaken across the Danish NIS in recent years, ministries and their agencies have streamlined their processes and become increasingly specialized within their specific mission and mandates. This has also led to the development of new policies within these specific missions and mandates.

These reforms, the specialisation across ministries and agencies and fine-tuning of policies and instruments, have largely been driven by a desire to increase the efficiency of the RDI system. However, they lacked a strategic approach that would leave more room for new instruments that incentivise cross-industrial and cross-sector collaborations across many stakeholders in areas of strategic importance.

There are examples of some new Danish cross-industrial and multi-stakeholder instruments, such as the INNO+ initiative,[80] grand solutions scheme of the Danish

[80] INNO+ is an initiative promoting mission-driven societal partnerships implemented by IFD. Although it has not yet been evaluated, it gave rise to first partnerships including: Trialnation - http://www.trialnation.dk/ - (improving environment for clinical trials) and Future Cropping - https://futurecropping.dk/en/about-future-cropping/ - (future intelligent regulation for precision farming).

Innovation Fund and the MADE initiative.[81,82] However, by and large, it seems that the focus has been predominantly on funding narrower R&D projects within sectors or industries. As a result, the Danish R&I system comprises a mix of interesting and efficient individual instruments rather than a strategic policy mix of instruments that creates collaborative platforms for key actors and stakeholders across sectors in areas of strategic importance.

The dominance of narrow, project-oriented funding streams does not support the evolution of ecosystems and innovation domains that move beyond individual technologies or solutions. At a time when the more disruptive industrial developments currently unfold at the interfaces of industries and sectors, where enabling technologies such as artificial intelligence, neuro- and nanotechnologies, clean technology and new business models have their most pervasive impact, the lack of appropriate models of promoting innovation may lead Denmark to lose much of its innovative edge. Further, the lack of strategic instruments may also lead to a suboptimal utilisation of Danish capabilities and their creative combination and thereby hinder the emergence of new innovation and business ecosystems.

The shift from traditional R&D project-based funding models to new strategic instruments that promote multi-stakeholder interactions across sectors and industries is very clear in many other advanced countries in the Nordics and Europe. Recent examples include especially the Strategic Innovation Programs[83] in Sweden and business ecosystem promotion[84] in Finland and the top sector policy in the Netherlands.[85]

[81] The MADE initiative brings together different actors in the innovation space and industry to work together on making Danish manufacturing future-ready through innovation, education and research.

[82] https://ufm.dk/en/publications/2013/inno-catalogue/inno/inno-a-platform-for-inspiration-and-prioritisation-for-strategic-investments-in-innovation?set_language=en&cl=en

[83] https://www.vinnova.se/en/m/strategic-innovation-programmes/

[84] https://www.businessfinland.fi/en/for-finnish-customers/services/ecosystems/

[85] https://www.government.nl/topics/enterprise-and-innovation/encouraging-innovation

Recommendations

Recommendation 2.1: Building on the experience with the INNO+ initiative, develop a specific Danish approach to promoting systemic (i.e. longer-term, multi-partner and multi-project) agendas based on actor-driven roadmaps that facilitate networks, actors and stakeholders across technological and industrial sectors in areas of strategic importance. This new approach should look beyond narrow funding of R&D projects to include needs for orchestration, possibilities to maximise new types of platforms and other new sources of innovation that rely on ecosystem dynamics. It should take stock of lessons learnt from previous similar programs in peer countries.

Recommendation 2.2: Include a platform approach within the model in Recommendation 2.1 that links stakeholders, sectors and industries through enabling technologies (for example, digital platforms, public data, biobanks) and supports new types of ecosystems from the 'bottom-up'. This type of structure may need seed funding from government; it should also include a dedicated effort to more strongly link MNCs with SMEs.

Recommendation 2.3: Further empower Innovation Fund Denmark with the mandate and mission to develop such a systemic model and platform approach across governmental silos, technology and industry boundaries. In Denmark, the MADE initiative is one good example of such an approach, the Finnish ecosystem and Swedish Strategic Innovation programs are other good examples. As a first step, the government should take stock of existing digital and other types of platforms, testbeds and emerging networks that can be leveraged further through a clear mandate. It should also be accompanied by new and more robust impact assessment approaches and metrics (see Section 2.3.3).[86]

Recommendation 2.4: Extend current RDI funding models and their interlinkages to support a more systemic mix of policies and instruments that covers a broader spectrum of RDI activities (road maps, R&D, testbeds, network facilitation, ecosystem orchestration, innovative procurement, linkages to global value chains etc.). Possible extensions may include a need to notify new instruments with the European Commission.

Responsible entity: Government

Budget implications: medium

Technical complexity: medium

Priority: medium

[86] Compare with https://innovationsfonden.dk/sites/default/files/2019-03/evalueringsrapporten-002.pdf , see also the evaluation of the Finnish SHOK programs https://rio.jrc.ec.europa.eu/en/library/licence-shok-external-evaluation-strategic-centres-science-technology-and-innovation).

2.1.3 Science parks, physical ecosystems and incubators/accelerators

Science Parks, physical ecosystems and incubators/accelerators are an important part of a country's innovation ecosystem. One of the most important roles they play is to stimulate the flow of knowledge and technology between universities and companies and provide a conducive environment for the creation and scaling up of spinouts.

Effective science parks, like the High-Tech Campus based on the Phillips Research site in Eindhoven, provide shared infrastructure, including prototyping facilities, to help young companies access mentoring and finance. The. Investment in science parks can also drive investment into companies by providing them with incubation and follow-on space. The Stevenage Bioscience Catalyst science park opened in 2012 with an investment of just over £40m from the UK government, GlaxoSmithKline and the Wellcome Trust. Over the past seven years, it has attracted key tenants, both large and small, such as Life Arc, GE and Freeline, and overall companies on the park have attracted over one billion pounds of inward investment.

The following observations and recommendations are based on interviews with users of the system, a one-day visit of Panel members to the Robotics Cluster in Odense as well experience in other countries, notably the UK.

Challenges

Within Denmark there are science parks and other physical ecosystems that support many sectors, for example, the Copenhagen Bio Science Park COBIS , DTU Science Park, Symbion, the robotics clusters at Odense or the Agrobusiness Park. These appear to have grown up relatively independently and not as a part of a coordinated national innovation strategy across the whole ecosystem. For example, the robotics cluster was established as a response to a downturn in the Lindo shipyard.

There is also a strong demand for such science parks and incubators/accelerators in Denmark, especially among the young entrepreneurs and would-be entrepreneurs interviewed for this review. In some areas, there is a clear shortage of physical space and infrastructure that would enable more rapid growth of new companies, for example, lack of prototyping or demonstrator space.

There appears however, to be a lack of clarity about how public-private collaboration in the context of physical innovation infrastructure should work. Roles and responsibilities of the different actors and structure of funding streams are unclear. Moreover, there does not appear to be a mechanism by which best practice and sharing of information across science parks within and between sectors can occur. Clearly, there are some very successful science parks with good examples of innovative business models, effective mechanisms to stimulate entrepreneurship and ways to incentivise spinouts from universities, but how widely these are communicated is not clear.

There is also a need for clarifying funding streams and how they could be structured between different actors. Facilities like incubators are generally not commercially profitable. However, they are essential for early stage incubation of young companies that then move on to follow on spaces that can be operated commercially as they attract larger companies (e.g. MNCs) as well. The requirement for incubation facilities and funding for such parks would be clearer, and these could also be accessible to start-ups originating from non-academic institutions since it did not appear to be easy for industry derived start-ups to obtain some of the benefits afforded spinouts from academia, for example, accelerators and incubators.

There were some good examples of best practice that could be more widely adopted. The University of Southern Denmark (SDU) promotes mobility between physical spaces and the university by allowing academics on permanent contracts at the university to return to the same position. It also allows young companies to incubate within the university for as long as they require. However, this is not usual as there are certain legal constraints on the time (due to interpretation of EU State Aid rules, see section 2.1.1) that companies once formed and funded can remain within an academic institution. The SDU also runs courses and mentorship programmes that help new entrepreneurs, for example, in design.

Although a number of factors mentioned in more detail elsewhere, for example, finance and technology transfer capabilities (see Section 2.1.1), are important in driving the ecosystem, they are especially important for incubators and accelerators.

Finally, the recommendation in section 2.1.1 for a review of the application of State Aid rules is also applicable to incentives for the physical ecosystem and for companies wishing to scale.

Recommendation 3.1: Government should consider reviewing the physical innovation ecosystem strategy and provide clearer mandates for actors (e.g. universities and private sector partners) and develop a set of guidelines for best practice as well as greater clarity on funding streams and their potential structure. In particular it should consider the following:

- Universities should be able to provide incubation facilities and training in the skills and competencies required for start-ups under conditions that are optimal for the companies
- Ways in which non-university derived start-ups could be incentivised and helped to grow should be explored
- A mapping of existing infrastructure needs for key sectors, for example, for prototyping, should be carried out

Responsible entity: Government in collaboration with universities and regional funders.
Budget implications: high

Technical complexity: medium

Priority: medium

2.1.4 Research and Technology Organisations (RTOs): better definition of roles

In many advanced countries, the national innovation system includes a bridging function between academic research institutions and industrial or societal organisations. In the UK, for instance, this bridging is mostly performed by organisations within the academic eco-system. In Germany and other countries, particular RTOs act as an intermediary bridge. The function of RTOs is *"to harness science and technology in the service of innovation, to improve quality of life and build economic competitiveness with high impact for society"*.[87]

RTOs cover a broad spectrum of technologies and scientific fields. Normally their work ranges from applied research to the development of new products and services. *"RTOs thus take a unique position in the deployment process from science to innovation. They closely cooperate with industries, large and small, as well as a wide array of public actors. With their open-innovation business model, one of the core missions of RTOs is to transfer research and technology to the market with high impact for society"*.[88] Although the potential impact of RTOs in boosting innovation is much less studied than that of other policy instruments, there is evidence that interactions with an RTO can have a strong, positive effect on both the turnover and productivity of companies.[89]

The following observations are based on interview with the leadership of most of the Danish RTOs as well as information provided by MHES to the Panel on the performance and key data of the RTOs.

Challenge

Denmark's RTOs (seven GTS Institutes) need a revision of their strategic positioning and the funding and operating modes. The RTOs generally service Danish companies, and especially SMEs. More than 16,000 private Danish companies buy services from the RTOs each year.[90] The institutes offer their clients mainly R&D-based and testing services, and they provide access to technological facilities. About 41% of turnover is generated in testing services.[91]

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[87] IDEA Consult 2015. "EARTO Economic Footprint Study: Impact of 9 European RTOs in 2014", Brussels (EARTO).

[88] Idem.

[89] Comin, D, G. Licht, M. Pellens, and T. Schubert 2019. "Do Companies Benefit from Public Research Organisations? The impact of the Fraunhofer Society in Germany". ZEW Discussion Papers, no 19-006, ZEW-Leibniz Zentrum für Europäische Wirtschaftsforschung, Mannheim. https://www.econstor.eu/bitstream/10419/193962/1/1067840613.pdf?mc_cid=5bf67d4de4&mc_eid=e767d08f32

[90] However, almost 80% of the customers make purchases of less than 3400€ in value (and 40% less than 700€ in value). See Self-Assessment of the Danish knowledge-based innovation system.

[91] GTS 2018. "Performance statement by the GTS institutes 2018". Taastrup (GTS-foreningen). In detail: 47% of GTS-users buy services within testing and validation. 32% buys development/solutions referring to specific problems/challenges in development and production. 25% of users buys certifications. 22% of GTS users participate in publicly financed RDI-projects.

They are less involved in strategic technological and innovation-oriented research (although there are notable exceptions such as robotics).

While the GTS Institutes perform by and large well in this current profile, compared to their organisational counterparts in other European countries, the Danish RTOs:

- *Cannot* to the same degree be considered as an active and strategic *interface* between *university*-based research and technological innovation in *companies*. In other countries, the bridging function of RTOs includes the mobility of young researchers from universities to RTOs and further to companies and back, as a mode of 'absorptive capacity'[92] and knowledge transfer in both directions.[93]

- Earn most of their *income from company services (76.6% of turnover is generated by commercial sales to the private sector, 6% is from commercial sales to public sector.)*.[94]

- Receive relatively *little public funding* (mainly via performance contracts and project grants), so their capacity to create their own new knowledge is limited. There are large differences in the amount of funding of the individual GTS institutes, but on average, about 10% of turnover of the GTS comes from R&D performance contracts – *de facto* the state basic funding.[95] This is low compared to other European RTOs. That may also explain why several of the interviewees indicated that the investment in state-of-the-art research infrastructure seems under pressure. In the long run, this can further threaten the already weak strategic position of GTS institutes as an interface between university-based research and company-based technology development.

Moreover, the position and mission of the GTS institutes in the Danish innovation system have become less clear cut. Since 2013, the university colleges and business academies have a mandate to conduct applied research. The maritime higher education institutions have conducted applied research since 2015. Like the RTOs, the HEI focus on SMEs but also on public institutions like for instance hospitals, primary schools and social municipal offices where the graduates from the university colleges primarily find jobs. The university colleges have steadily developed their operational model (in terms of staff, partnerships, etc.) to fulfil their mandate to conduct applied research. The business academies and maritime HEI are smaller institutions and the adaptation to the enlarged mandate takes more time. Meanwhile, the universities are also stimulated to become more

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[92] Cohen, W. M., & Levinthal, D. A. (1990). „Absorptive capacity: A new perspective on learning and innovation". *Administrative science quarterly*, *35*(1), 128-152.

[93] As for Denmark, a recent study [Videnskabeligt personales karriereveje, Damvad 2018] documents that approximately 1 pct. of researchers (young and old) leave the university sector annually for other public or private employment. Of these, 18,4 pct. leave for employment in private R&D services. The study does not follow the flow of researchers further from private R&D-services to industry or back. This finding is based on the interviews conducted by the panel.

[94] "Performance statement by the GTS institutes 2018". Taastrup (GTS-foreningen)"

[95] Idem.

entrepreneurial and establish closer links with industry. They increasingly provide services that are similar to those the RTOs traditionally provide, such as facilities for laboratory testing.

The literature review suggests that Danish RTOs may have the potential to reach more companies, if access to facilities were improved, and if the technological skills of the staff were supplemented with stronger business skills.[96] However, the literature review also indicates, that companies that are already advanced technology users within their industry experience greater value creation from using RTOs than companies that consider themselves as technological "followers". Technological followers are more likely to use the RTOs for more traditional tests, calibration services, etc. rather than R&D projects, while larger companies and technology leaders are more likely to work together with the RTOs in research and development projects.

Recommendations

Recommendation 4.1: Rethink and clarify the role of the different actors in the research and innovation system, with special attention on the role of both RTOs, and university colleges, business academies and maritime HEI with respect to universities.[97] As the self-assessment report already states: *"Companies may find it unclear which institutions to cooperate with and how the different types of institutions can contribute to their innovation processes. There may be a potential to establish a clearer division of labour, while at the same time provide incentives for the different actors to collaborate"*.[98] RTOs could, for example, have a clear role in applied, "mission-oriented" research. Universities of Applied Science or polytechnic institutes in some countries (for example, Finland) have a stronger focus on their regional role. The optimal role in Denmark depends on the overall strategy (see Chapter 3). The OECD has gathered many inspiring examples on the role of higher education institutes and public research organisations in case studies on the Knowledge Triangle approach.[99]

Budget implications: low

Technical complexity: low

Interrelation with other activities: medium-high; should fit in overall strategy development

Priority: medium

[96] See IRIS 2918. "Literature review and assessment of the Danish knowledge -based innovation support system. Prepared for the Danish Ministry of Higher Prepared for the Danish Ministry of Higher Education and Science", November 2018

[97] These recommendations would complement the Recommendation 1.1 "Clarity of the Universities' Innovation Mission"

[98] See Self-Assessment of the Danish knowledge-based innovation system (p. 15).

[99] OECD 2016. "Enhancing the contribution of Higher Education and Research Institutions to Innovation. Background document, case studies".
Paris: OECD. https://www.oecd.org/sti/Case%20studies%20-%20KT%20Event_FINAL2.pdf

Recommendation 4.2: Enable inter-institutional collaboration: Ensure that coordination mechanisms and communication channels are established, put more systemic incentives for collaboration between RTOs and universities in place. One can think of (1) new institutional vehicles (such as institutes, merged organizations or new organizations) to promote new sectors and disciplines, (2) funding levers for collaborative research proposals (see the case study on the Dutch top sector policy in Section 2.3 of this report), or (3) the development of joint road maps for large research infrastructures. In the latter approach, the shared facilities can initiate further interactions (joint research projects, etc.). In specific cases, depending on the role and mandate that is allocated to the actors in the system, it is also possible to explore further horizontal integration (mergers, shared subsidiary organisations, etc.) – Denmark has merged a few research institutions with higher education institutes before.[100]

Budget implications: medium

Technical complexity: medium

Interrelation with other activities: medium

Priority: medium-high

Recommendation 4.3: Review the funding model of the RTOs. Currently, the GTS institutes receive two forms of public funding: based on performance contracts (ca. 10% of turnover) and competitive project funding (for example, the Innovation Fund and Horizon2020, also about 10%, including international funds). If the GTS institutes are to play a bigger role as a strategic interface between basic research and commercial innovation activities, they will need the means to invest in maintaining and developing a state-of-the-art knowledge base (including large research infrastructures). The funding model should ensure that the RTOs can build up knowledge to increase their absorptive capacity (for example, by hiring more PhD students) with similar conditions as universities for example by providing RTOS with base funding from the state. They need that to remain a relevant strategic partner for industry in the long term. The funding model can also be used to provide incentives for collaboration with universities and to keep the RTOs in their hybrid position between the public and the private sphere and between the academic and the 'civilian' sphere.[101]

Budget implications: medium-high

Technical complexity: medium

Interrelation with other activities: low

Priority: medium-high.

[100] Idem.

[101] Gulbrandsen, M. 2011. "Research institutes as hybrid organizations: central challenges to their legitimacy" Policy Sciences (2011) 44: 215. https://doi.org/10.1007/s11077-011-9128-4

When considering a revision of the institutional and financial set-up of Denmark's RTOs (and in particular the current GTS institutes), it can be useful to reflect on the funding and operating modes of the Fraunhofer Society in Germany and the RTOs in the Netherlands (see Boxes 3 and 4).

Box 3: Case Study: Operational model of the Fraunhofer Society (Germany)

Case Study: Operational model of the Fraunhofer Society (Germany)

With a total budget of more than €2.5 billion in 2019, Fraunhofer is the largest contract research organisation in Europe. Fraunhofer conducts applied research in the areas of health, security, communication, energy and the environment in 72 institutes and research units at locations throughout Germany. The Society employs a staff of more than 26,600.[102]

Fraunhofer's budget has three main sources. Roughly one-third is provided through **basic funding by the German government**. The other **two-thirds** are acquired by the individual institutes, either through **publicly funded projects** within consortia or through bilateral **contract research with industry**. Fraunhofer has a highly decentralised governance model. Individual institutes may set their strategic and scientific focus largely autonomously, as long as they manage to balance their budget and stay in line with Fraunhofer's general strategic scope.

Compared with other publicly funded research organisations in Germany, the share of industry revenues is relatively high and a unique feature of Fraunhofer. To foster this role, a more or less self-regulating financial model is used to allocate basic funding among the institutes: "A large amount of the basic funding from government is distributed to the institutes via a competitive key which encourages them to operate within a specific ratio of industrial revenues. When institutes acquire 25–55% of their total budget through contract research with industry, they are rewarded with a higher share of basic funding than institutes operating outside that corridor, i.e. with a share of less than 25% or more than 55% of their revenue from industry." (Cuhls et al. 2012, 235).[103] This formula "strengthens the competitiveness of the individual institutes in the industrial contract research market, but also leads to a certain degree of competition between them.".[104]

At the same time, cooperation between various knowledge domains within the 72 Fraunhofer institutes is needed to address complex interdisciplinary system approaches in R&D. Hence, Fraunhofer fosters and intensifies cooperation between institutes to fully utilise the strength of its broad R&D portfolio with

[102] https://www.fraunhofer.de/en/about-fraunhofer/profile-structure/facts-and-figures.html (approached March 25, 2019).

[103] Cuhls, K., Bunkowski, A., & Behlau, L. 2012. „Fraunhofer future markets: From global challenges to dedicated, technological, collaborative research projects". Science and public policy, 39(2), 232-244.

[104] idem

various measures.[105] Institutes of similar scientific and technological scope form a total of eight knowledge domain groups (defence and security, information and communications technologies, innovation research, life sciences, materials, light and surfaces, microelectronics and production). Within the groups, institutes plan and strategically align their respective R&D portfolios. Another platform of cooperation is built by the 22 Fraunhofer expertise alliances, in which institutes team up to represent specific fields of expertise to the market (e.g. water systems, cloud computing, lightweight structures etc.). Members of an alliance often come from different institute groups, thus exhibiting the transdisciplinary nature of the alliances. Moreover, Fraunhofer headquarters fund internal research programmes for joint R&D projects in order to support cooperation between the institutes.

Box 4: Case Study: RTOs in the Netherlands

Case Study: RTOs in the Netherlands

A substantial part of applied research in the Netherlands is performed by five so-called applied research organisations (TO2): TNO, Wageningen Research, NLR, Deltares and MARIN. These organisations coordinate their activities toward government in the 'Federation TO2' and align their research to provide added value in the area of applied knowledge.

The TO2 institutes each have their own profile and differ greatly from one another. Not only in size (between 368 and 2715 FTE, in 2015), but also in terms of funding. Generally speaking, all have at least three different sources of funding: a lump sum provided for by the national government, public funding that is earned in competition (for example, H2020, national grants, etc.) and private funding.

Their lump sum government contribution was between 9% and 41% of turnover (in 2015). The RTOs are encouraged to use the lump sum as a lever to attract other forms of funding, within boundaries of, for example, state aid rules, but also requirements regarding economic sectors, and sometimes tasks that are imposed upon the RTOs by law or societal issues that need to be covered by the institutions. The amount of the lump sum is not influenced by the success rate in attracting private funding, but some of the other forms of public funding are (notably the "PPS-toeslag", see Section 2.3.1). The most recent evaluation of the RTOs (2017) concluded that there is insufficient space in the portfolio of the TO2 institutes for societal issues which are not driven by a direct demand (and financing) from companies. The emphasis of the government on the financial performance of the TO2 institutes, and declining public funding of most TO2 institutes, forced the institutes to obtain more funding from the market, resulting in an increasing focus on topics with a quick financial return. Partly in response to this evaluation, the total funding has been increased with an additional 75 M€ per annum since 2018, largely for improving the long-term knowledge base and

[105] idem

investments in research infrastructures, and for activities on societal challenges (mission-based).

There is limited overlap in (economic) sectors covered by the different TO2 institutes. In societal areas where multiple TO2 institutes are active, each TO2 institute generally has its own specialisation.

The TO2 institutes are just one of the players in the public knowledge and innovation ecosystem (besides, for example, universities and universities of applied sciences). The classic bridging function of the applied research institutes (the translation of basic knowledge into the applications in the market) is subject to change because universities have also moved towards applied research (higher TRL) and some universities of applied sciences also increasingly focus on research. Not all TO2 institutes have been able to accommodate these changes to the same extent. This may, from a societal perspective, result in a suboptimal situation, where government-funded institutions may work past each other, and sometimes even compete with each other, instead of working together.

2.2 Strengthening coordination across the system

In the past, much of the coordination in the Danish innovation system took place through informal structures. The rising complexity of the system and subsequent reforms that aimed at simplifying it and making it more efficient have reduced interaction and coordination. The panel identified several instances where increased coordination would lead to higher efficiency. Examples include the alignment of procurement, a cross government innovation policy, or better coordination with private foundations.

The next set of recommendations addresses the need for better coordination across the individual actors of the Danish NIS, in particular, coordination with private foundations, better alignment across the system, and strengthening international linkages by establishing international innovation contact points in municipalities.

2.2.1 Coordination with private foundations

Private foundations fund a significant and growing share of research carried out at universities and other public institutions; they play an important role in the research and innovation ecosystem across all Europe.[106] While there are a very large number of private Foundations, most are small with an average income of 0.2 million EUR. In 2012, Foundations provided approximately 4.5 billion EUR to research and 0.5 billion EUR to innovation across the EU. Importantly, the Foundations from four countries (UK, Germany, Sweden and Denmark) account for two-thirds of EU Foundation spend on R&I in the EU. This highlights the importance of Foundations in the Danish ecosystem. An important finding from the EUFORI study of Foundations across the EU[107] was that there is generally a

[106] http://euforistudy.eu/

[107] http://euforistudy.eu/

lack of coordination between private and public initiatives, which leads to inefficiency and potential imbalances in the ecosystem.

In the future, it is anticipated that private foundations will not only continue to play an important role in the Danish ecosystem but in fact will grow in significance as they broaden the portfolio of research they support and increase their funding level. For example, the Novo Nordisk Foundation, which is the largest Foundation in Denmark, has broadened its remit from healthcare and life sciences to include natural and technical sciences and sustainability.[108] Since 2007 it has supported the development of the Copenhagen Bioscience Cluster with over EUR 850 million invested in four research centres and two infrastructure projects. Since 2010, the Foundation has donated more than DKK 13 billion (EUR1.7 billion), primarily for research within biomedicine and biotechnology and diabetes treatment at universities and hospitals in Denmark and the other Nordic countries.[109]

Universities and public research institutes are the primary recipients of funding from private foundations. Much goes to research, but there appears to be an increase in the amounts provided for innovation and entrepreneurs. For example, the Lundbeck Foundation has a venture capital arm with a portfolio of small biotech companies based on Danish university research funded by the Lundbeck Foundation, called Emerge.[110]

Two initiatives have been recently launched in this space. In November 2018, MHES together with public and private foundations started a platform for strengthening collaboration, the Forum for Research Funding. It will address questions ranging from external funding in Danish universities, but also how to improve researchers' career paths and research infrastructure. In May 2019, the public Danish National Research Foundation and four of Denmark's major research-funding private foundations have agreed on funding the Pioneer Centres a joint national research initiative at the level of 1 billion DKK, 134 million EUR. The initiative was developed with MHES and initial focus is on artificial intelligence and climate/energy.[111]

The following observations are based on interviews with private foundations and public funders, a review of strategic documents and web pages of the foundations as well as receivers of funding of private foundations.

Challenges

Coordination among private foundations and the MHES can be strengthened in Denmark and given the large size of the Danish private foundations, this is an

[108] https://novonordiskfonden.dk/en/strategy-and-goals/

[109] http://cph-bioscience.com/en/about

[110] https://www.lundbeckfonden.com/en/about/organisation/

[111] The Danish National Research Foundation will administer the initiative. The total public funding contribution is 400 million DKK and the Carlsberg Foundation, the Lundbeck Foundation, the Novo Nordisk Foundation, and the Villum Foundation will contribute 600 million DKK.

issue of even higher importance than in the rest of Europe. Consultations with stakeholders from the current exercise and the 2019 review of the IFD[112] confirmed that there was very little dialogue at the strategic level with government or other funders and foundations, like the Novo Nordisk Foundation or the Danish Industry Foundation.

The current situation is that foundations are not strategically integrated into the Danish innovation ecosystem. They do not fund infrastructure components in the way the Wellcome Trust does in the UK (see Appendix C). They are not consistently at the table when innovation strategies are discussed and formulated, and they do not work with public funders to strengthen existing areas and build capacity in new areas of research and innovation.

Given the importance of foundations to R&I funding in Denmark (for example, the NovoNordisk Foundation[113] paid out 1.7bn DKK in 2018, and aims to increase its pay-outs to 5bn DKK by 2023;[114] the Carlsberg Foundation[115] gave out approximately 400 million DKK in grants in 2018;[116] and the Lundbeck Foundation[117] gave more than 500 million DKK),[118] there are real opportunities for synergies in terms of seeding new areas, supporting research and innovation capability development and co-funding of infrastructure (see the Wellcome Trust case study in Appendix B). For example, in the late 1990s, it was clear that there was a need for significant funding for infrastructure renewal in UK universities. The Wellcome Trust made funds available which were matched by the government and became the Joint Infrastructure Fund. This demonstrated that such funding was important and made a significant difference to the universities' research capabilities. At this point, the Wellcome Trust funding was reduced, and the government supplied the necessary funding via a Higher Education Funding stream.

Dialogue and collaboration take place at the operational level, but there are currently no initiatives to establish a dialogue or common understanding on the strategic role of the private foundations within the NIS and on the overall shared objectives that both the public sector and private foundations aim to achieve. There is also room for better exploiting complementarities and explore ways in which they can learn from each other. For example, foundations can be more flexible and innovative in their funding strategies; other funders could involve the foundations more in their strategic processes. This does not mean that the

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[112] https://innovationsfonden.dk/sites/default/files/2019-03/evalueringsrapporten-002.pdf

[113] https://novonordiskfonden.dk/en/

[114] https://novonordiskfonden.dk/en/news/novo-nordisk-foundation-increased-payouts-by-30-in-2018/

[115] https://www.carlsbergfondet.dk/en

[116] https://www.carlsbergfondet.dk/en/About-the-Foundation/Finance/Revenue-and-distribution-of-funds

[117] https://www.lundbeckfonden.com/en/

[118] https://www.lundbeckfonden.com/en/business-activities/invest/investments/

independence of Foundations would be compromised, but it would potentially enable them to have a greater influence on the whole ecosystem in a more co-ordinated way.

Recommendation 5.1: Building on existing initiatives and structures such as the Forum for Research Funding the government should: (1), Explore the potential for government policy initiatives to further stimulate strategic collaboration between foundations and public funders of research while maintaining the independence of the foundations and not using their funds to substitute for government funding. (2) Seek ways of increasing strategic alignment and interaction by inviting cross-participation in policy and strategy processes. This will help the foundations to identify common interests and thereby facilitate future collaboration.

Other public funders, such as the Innovation Fund Denmark, should explore how they can better work together with the foundations to shape new, important areas of research that will drive innovation and capability building in Denmark.

Given that the foundations themselves, while independent, play such a central role in research funding in Denmark in a way that is different to that in other countries, it is suggested that they explore ways in which they could better work together and seek opportunities to contribute to national policy making and strategy without compromising their independence.

Budget implications: low

Technical complexity: low

Interrelation with other activities: development of an overarching strategy; science park and incubation strategies

Priority: medium

2.2.2 Alignment across the system

Governance structures and arrangements play a critical role in either enabling or preventing reform and performance improvement in the Danish system. A key role of these governance structures is to ensure a clear split of roles and responsibilities and coordination across the different actors, as well as strategic alignment towards objectives. These aspects are important for ensuring that impact is maximized, and resources are used efficiently.

In the 2012 ERAC peer review of the Danish research and innovation system,[119] the existing system was assessed as overly complex. The report also stated that activities were not coordinated effectively and pointed out that instruments

[119] ERAC peer review of the Danish research and innovation system, Expert Group Report prepared for the European Research Area Committee, 2012: https://ufm.dk/publikationer/2012/peer-review-of-the-danish-research-and-innovation-system-strengthening-innovation-performance

overlapped. Several measures have been taken since then to simplify the system and avoid overlapping instruments, yet the coordination of the institutions involved remains an issue, as the panel could note during interviews with main users of the NIS.

Challenge

The need for coordination and alignment is broader than the division of tasks between the MHES and MIBFA, as almost every ministry interacts with the innovation ecosystems, not to mention agencies, local authorities and many semi-public stakeholders. Yet several stakeholders have indicated that a clear common approach continues to be absent between MHES and MIBFA. It seems that the decision has been made (whether implicitly or not) to divide tasks between the units, and to minimise the interface between them. This also implies that the ministries lack a shared vision and aspirations, and their strategies are partial and fragmented, while there is overlap in the stakeholders that they serve and in the goals that they aim to achieve. Interviewees both from within and outside government state that there is a need for an overarching strategy but also for more horizontal coordination. This becomes especially apparent, for example, in the domain of public-private partnerships (where technology is developed, and prototypes are tested, in the pre-commercial phase). The same holds in the area of innovative public procurement (the government acts as a launching customer, see section 2.3.2 in this report) because such activities go across the border between the competences of different ministries.

Perhaps the greatest need is for a systemic overview of the governance structures that Denmark will need to both improve performance across the whole research and innovation system and mount a serious response to complex and global societal challenges in a world where innovation has become more of a distributed process (involving various contributing firms and organisations) and where general purpose, enabling technologies are eroding traditional industry structures. Many advanced countries face difficulties in aligning the different institutions involved in their respective innovation systems, and Denmark could become a leading example if it manages to develop a well-coordinated approach.

Recommendations

Recommendation 6.1: Develop an integrated set of innovation policy Key Performance Indicators (KPIs) at the national level, with specific mandates for each ministry and agency.

Monitor progress on these KPIs at a level above that of a specific ministry (for example, in a ministerial council or in the Cabinet). The system of KPIs could be nested with a few broad guiding principles at the national level (for example, related to societal functions that need to be addressed), see also the section on impact assessment 2.3.3. At the national level, most challenges are systemic in nature and are hard to capture by predefined, quantitatively measured KPIs. The high level KPIs (e.g. contribution to SDGs, patenting rates, or private leverage of public R&D investments as a proxy for demand articulation) could then be combined with KPIs at a level that reflects the specific tasks of a ministry or

agency within those guiding principles (e.g. share of innovative products in firms). To avoid high administrative burdens, align the KPIs with data that is already monitored (for the European Union Innovation Scoreboard, for OECD purposes, etc.) and choose unified indicators across the entire STI-system (from top-cited scientific articles to availability of venture capital, depending on the chosen strategy). Set priorities in terms of challenges, areas of technology, clusters and value chains rather than attempt to pre-judge market outcomes as part of research and innovation policy.

Such an approach would create more clarity across stakeholders about their roles in supporting the overall aims of Danish innovation. It also forces the stakeholders to discuss their respective responsibilities in realizing the KPIs. The process of selecting and deciding on KPIs is as important as the KPIs themselves in this respect. The challenge of using KPIs is that they can lead to oversimplification and that some qualitative, complex or highly interconnected objectives are more difficult to measure. This is often the case for systemic objectives. The monitoring and interpretation of KPIs should therefore be carried out with care, paying attention to the broader context and strategy, as most KPIs are a proxy for a much broader phenomenon.

Recommendation 6.2: Encourage labour mobility between ministries (and agencies). The Netherlands, for example, has the so-called 3-5-7 principle, implying that all managers in national public organisations switch to a new position at least every 7 years. This stimulates labour mobility across organisations, and this, in turn, improves the mutual understanding, informal exchange of information, shared networks, etc.

Recommendation 6.3: Conduct a joint foresight exercise to support priority setting. This could be in conjunction with incentives for joint knowledge development (for example, a funding lever for ministries that jointly send out a call for research proposals on topics at the intersection of their policy domains). Finland has been quite successful with such an approach (Finnsight and other national foresight activities).

Recommendation 6.4: Create an Inter-ministerial Committee at civil servant level to prepare discussions on priority setting, KPIs, etc. In the Netherlands, for example, the Ministry of Economic Affairs has prepared the recent shift to a mission-driven innovation policy, yet the other ministries that are most involved have defined the scope, context etc. of the societal missions. The letter to parliament on the shift is discussed and agreed upon both at civil servant level and at ministerial level, with all ministries involved. This process deliberately builds upon structures that have been developed earlier, for example, in the Top sector initiatives, so that it is relatively easy to tap into existing networks and cross-organisational collaborations.

Budget implications: low to medium

Technical complexity: low to medium

Interrelation with other activities: depends on the approach chosen

Priority: high

2.2.3 International linkages for the Danish innovation system

One of the key aspects of globalisation is the global nature of knowledge. Ideas and codified information are more widely available than ever, and the academic community has become increasingly connected globally.

For innovation, this has profound implications: Innovators can tap into a global pool of knowledge, not 'only' the research and scientific expertise that is available locally. This does not mean that local conditions are any less important – they are still critical in providing insights on how new scientific insights can be used to serve market needs, and in facilitating the process from idea to economically viable offering. It does mean, however, that Danish innovators would be significantly constrained if they would only tap into local knowledge: 0.3% of all patents (0.6% of all patents from foreign inventors) filed in the US are from Denmark (USPTO, 2019).

In parallel, the global corporate R&D landscape is in flux: There is a growing dominance of MNCs in global R&D activity. These large companies have access to large markets and deep global value chains, both key conditions to justify the high fixed costs of R&D on a global scale. R&D activities globalise; that is, they move from traditional locations in OECD countries to be present in some key emerging economies like China and India. At the same time, global R&D activity is concentrating in a relatively small number of places. The pressure on 'marginal' locations to keep their R&D hubs is growing, especially if they do not have a large domestic market.

There is significant evidence that Denmark's research system is highly international. Co-publications with authors from outside of Denmark are high, more than two and a half times higher than EU average,[120] and there is a significant number of foreign researchers employed in Danish academic institutions. Denmark also plays an active and successful role in the EU Horizon 2020 program.[121] Despite the fairly small size of the country, Danish institutions submit 6.63% of all eligible EU proposals and have a success rate of 15.27%, above the EU average of 11.98%.[122]

There are also a number of policy instruments that Denmark has established to support internationalisation. Innovation Centre Denmark[123] is present in eight global innovation hotspots and provides support for researchers, companies and entrepreneurs. Denmark's presence in global innovation hotspots compares well

[120] https://ec.europa.eu/docsroom/documents/35886

[121] http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=country-profiles-detail&ctry=denmark#profile

[122] https://webgate.ec.europa.eu/dashboard/sense/app/a976d168-2023-41d8-acec-e77640154726/sheet/0c8af38b-b73c-4da2-ba41-73ea34ab7ac4/state/0

[123] https://thetradecouncil.dk/services/innovation

with peers like Switzerland,[124] Germany[125] and the UK.[126] The Danish clusters and innovation networks have, over time, supported a large number of international linkages; the last annual report[127] mentions almost 1000 international collaborations in more than 70 countries. The opportunities of the Danish innovation system are also being touted as a key reason to locate in Denmark by Invest in Denmark.[128]

However, the Panel's interviews with users painted a mixed picture of where Denmark currently stands in terms of leveraging its innovation system internationally and tapping into international knowledge flows:

- The **financing structure** provides, at the system-level, limited incentives to attract EU funds. Any additional EU funding leads to a direct reduction of national funding.

- The **Danish Innovation Centres** achieve integrated action across ministries abroad but lack a coherent dissemination approach in Denmark. In particular there is no systemic rollout of contact points toto where innovation is happening, for example in SMEs across the country, innovation networks or cluster organizations.

- **Young, high-growth innovative companies** are perceived as leaving Denmark as they scale, sometimes as the result of foreign acquisitions.

- There are a number of **foreign investments into Denmark-based research** (wind energy, IT) but no sufficiently prioritized strategy to systematically leverage Denmark's research assets by deliberately attracting global R&D centres.

- In recent years, the **role of clusters and innovation networks** in internationalisation has been recognised in funding structures. The 2018 MHES call provided seed funding for internationalisation as part of the general funding streams. The funding is perceived as very limited and not long-term enough to justify efforts that require multiple years to generate results, especially in more difficult foreign markets.

[124] https://www.swissnex.org/

[125] https://www.dwih-netzwerk.de/de/

[126] https://www.gov.uk/world/organisations/uk-science-and-innovation-network

[127]http://www.clusterexcellencedenmark.dk/da-DK/Quickmenu/Publikationer.aspx?PID=22&M=NewsV2&Action=1&NewsId=776

[128] https://investindk.com/set-up-a-business/test-and-innovation

Activities of peer countries

Internationalisation has become an increasingly important aspect of innovation policy. A few examples show how the specific challenges faced by the Danish innovation system have been addressed elsewhere.

Finland has created dedicated domestic contact points for internationalisation.[129] These offices provide a simple window into the Finnish innovation system and are fully integrated with the overall business support activities available to firms.

Germany has launched a specific support program[130] to help clusters in their internationalisation efforts. The program is open to all networks and clusters and provides competitive funding for the establishment of specific linkages to foreign innovation hotspots.

Israel has a focused program to attract R&D centres[131] from globally active MNCs. This is one of the central vectors of Israel's FDI attraction efforts and complements a range of other instruments at the science and bilateral level.

Recommendations

Denmark has a strong knowledge platform, robust international linkages, and a global reputation as an innovation leader in science and non-science driven areas. The following four steps will enable the country to leverage these assets significantly more in the global innovation arena, something that happens now only to a limited degree:

Recommendation 7.1: Embed contact points for internationalisation into the emerging new business support structure across Denmark to connect the Danish Innovation Centres to businesses throughout the country. The role would involve acquiring knowledge about what innovation centres offer to companies, organize networking events, connect businesses with innovation centres, etc.

Responsible entity: MHES, Ministry of Foreign Affairs (MFA), MIBFA

Budget implications: low

Technical complexity/need for new capabilities: medium to high

Priority: high

[129] https://www.ely-keskus.fi/en/web/ely-en/

[130] https://www.bmbf.de/de/cluster-netzwerke-international-547.html

[131] https://innovationisrael.org.il/en/our-value-propositions/enterprise

Recommendation 7.2: Ensure and enhance the ability of the changing cluster and innovation landscape structure to support internationalisation

Responsible entity: MHES, MFA, MIBFA

Budget implications: low

Technical complexity/need for new capabilities: medium to high

Priority: high

Recommendation 7.3: Assess the creation of a dedicated program to attract investments of foreign MNCs into R&D centres in Denmark

Responsible entity: MFA, MHES

Budget implications: Medium to low

Technical complexity/need for new capabilities: medium

Priority: medium to high

Recommendation 7.4: Review the additionality of incentives for attracting EU funds as well as other international funds into the R&D system

Responsible entity: MHES, MFA

Budget implications: medium to high

Technical complexity/need for new capabilities: low

Priority: medium to low

The impact these steps can achieve relies to some degree on progress in other parts of the action agenda outlined in this report. An overall strategy that defines Denmark's positioning and value proposition as a place to innovate and run innovation-driven businesses would send a much clearer signal to foreign partners and investors as to what they can gain from working with Denmark. A clear structure for collaboration across the different parts of the Danish government system delivering on this value proposition would ensure that Denmark is not only more present at the interface of international collaboration but is also organised to deliver once projects are underway.

2.3 Evolving the innovation policy toolkit

The panel found that there is a need to evolve and modernise the innovation policy toolkit of the Danish government. Stronger mission and demand orientation would enable the country to align efforts better and to more fully leverage traditional Danish strengths in urbanism and design, strengthening MNC-SME collaboration, as well as public procurement for innovation. In some areas, this will require new instruments, in others, it can draw on existing efforts that have the potential to be strengthened.

2.3.1 Leverage Danish strengths in non-science driven areas like design, urbanism, and social innovation

Denmark could better leverage its strengths in innovation that are not directly science or technology related, such as (1) design thinking and practice (2) new urbanism and creative industries and (3) social innovation.

These areas were selected based on interviews, literature review and a comparison with peer economies (for example, Finland). Their implementation will require a process to select these areas that involves different stakeholders and parts of government. These efforts could be made in a rather incremental and evolutionary way, like the other areas described in this chapter. Or they could become major pillars of a strategic national value proposition choice as outlined in Chapter 3.

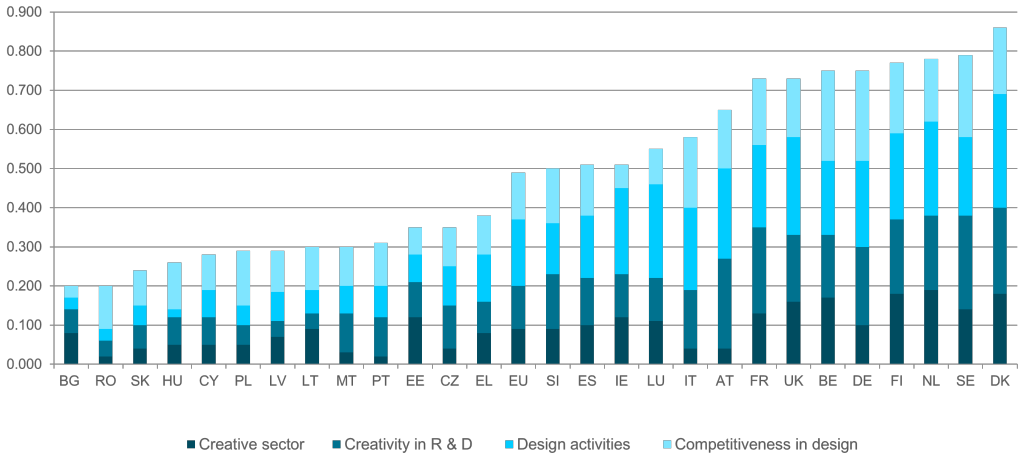
Design thinking and practice.

Challenge: A stronghold of Denmark has been its design tradition. Famous functionalistic design and architecture were developed in the mid-20th century, influenced by the Bauhaus school (see also Figure 24). Many Danish designers used new industrial technologies and combined them with ideas of simplicity and functionalism to design buildings, furniture and household objects, many of which have become iconic and are still in use and production. Scoreboards show that Denmark is the best-performing country in Europe in creativity and design.[132,133] Given this legacy and its innovative potential for future economic development of the country, in 2007, the Minister for Economic and Business Affairs presented 'DesignDenmark', a government white paper on the direction for design policy in Denmark.

[132] Hollanders, H., and A. Van Cruysen 2009. "Design, creativity and innovation: A scoreboard approach." Pro Inno Europe, Inno Metrics: Holanda, Hui, D., Ng, C., Mok, P., Ngai, F., Wan-kan, C., & Yuen, C. 2005. A study on creativity index. Hong Kong: Home Affairs Bureau.

[133] Macoun, A. et al. 2007. : "The Danish Design Cluster", Final paper for Microeconomics of Competitiveness, https://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/Denmark_DesignCluster_2007.pdf, accessed June 14, 2019.

Figure 24: Countries' relative performance in Creativity and design



Source: Hollanders, H., and A. Van Cruysen 2009

Via funding for innovation network activities, MHES is currently supporting the "Lifestyle & Design Cluster". This cluster is promoting innovation and sustainable growth, primarily in small and medium-sized interior and clothing companies as well as in the creative industries.[134] This effort could be reinforced by and strategically linked with industrial innovation-oriented policy programmes, e.g. the strong Danish efforts and achievements in the field of innovative robotics, or agro-food-related innovation efforts.

Recommendation 8.1: Strategically link the national cluster effort for the design and lifestyle sectors with industrial innovation-oriented policy programmes, potentially jointly with the Danish Design CENTER. Establish inter-sectoral platforms of key actors in industries, research, society and government to explore opportunities and demand for design/technology integration and innovation and the spread of user design centred principles across industries, and to develop and implement related initiatives (see e.g. Box 5: Dutch Top Sector Creative Industry).

Budget implications: medium

Technical complexity: medium

Interrelation with other activities: high

Priority: high

[134] See https://ldcluster.com/en/about-us/.

New urbanism and creative industries

Challenge: Denmark, and in particular greater Copenhagen, has become an esteemed site of vibrant initiatives towards sustainable modes of transportation, urban design and development ('Copenhagenisation')[135] and lifestyle (for example, Nordic Food), a Northern European variation of 'New Urbanism'.[136] So far, these developments have been spurred by rather diverse actor groups in society and the economy, partly supported by municipalities, and yet hardly linked with national innovation policy or the activity of corporations. There is a growing recognition that solutions to the increasingly complex and new societal and business challenges require interdisciplinary thinking and collaboration. Denmark will miss out on these opportunities if this type of thinking is not encouraged.

The Government could help to connect corporations or other more traditional innovation actors more strategically with the design sector, Sustainable Development Goal (SDG) initiatives and social innovation protagonists (see section below), knowledge institutions, start-up platforms, and incumbent industries. The required clustering process could be inspired by the Dutch experience with the 'Top Sector Creative Industry' (see Box 5).

Recommendation 8.2: Link the existing "Lifestyle & Design Cluster" with New Urbanism and sustainability-oriented bottom-up initiatives, for example, modelled on the Dutch Creative Industry Top sector (see Box 5).

Budget implications: medium

Technical complexity: medium

Interrelation with other activities: high

Priority: high

[135] E.g. Colville-Andersen, M. 2018. "Copenhagenize: the definitive guide to global bicycle urbanism". Island Press.

[136] Scott, A.J. 2014. "Beyond the creative city: cognitive–cultural capitalism and the new urbanism." Regional Studies 48.4: 565-578. https://doi.org/10.1080/00343404.2014.891010

Case Study: Dutch Top Sector Creative Industry

The Dutch government has named nine so called "top sectors" in which it wants the country to excel, among them the Creative Industry. "Government, experts and companies are looking for ways to strengthen one another in a structured way. That joining of forces has yielded a rich knowledge infrastructure for the sector. The parties receive targeted support from the Dutch government. Moreover, the sector is heavily organised around an internationalisation agenda." "The Creative Industry has a top team as a medium for innovation. This team includes representatives of science, government, business and in many cases also education and other parties."[137]

A sponsor of the Top Sector is 'Creative Industries Fund NL', the Dutch cultural fund for architecture, design and digital culture, as well as every imaginable crossover. The Fund strives to make a substantial contribution to the quality of professional design practice within and especially between the disciplines of architecture, design and digital culture. Part of this endeavour is the interdisciplinary interplay between the cultural, social and economic domains. The Fund supports exceptional and innovative projects and activities of designers, makers and cultural institutions in the creative industries.[138]

Social Innovation: Working towards sustainable modes of transportation and development, and other SDGs, will often also require social innovation, i.e. new social practices that aim to meet social needs in a better way than the existing solutions. Social innovation "encompasses 1) a change in social relationships, systems, or structures, and 2) such changes serve a shared human need/goal or solve a socially relevant problem."[139] Denmark's current innovation policy portfolio does not include proactive measures to engage with socially driven innovation efforts in society.

Here Danish innovation policy could draw on and strengthen existing grassroots initiatives, for example the Danish Social Innovation Club. So far, such initiatives have been able to establish supportive linkages with municipalities, civil society organisations and companies, yet hardly with the NIS.

[137] see https://www.holland.com/global/meetings/holland-in-congres/creative-industries/top-sector-creative-industries.htm

[138] https://stimuleringsfonds.nl/en/the_fund/organization/about_the_fund/

[139] van der Have, R.P., and L. Rubalcaba 2016. "Social innovation research: An emerging area of innovation studies?"

Research Policy 45.9: 1932. https://doi.org/10.1016/j.respol.2016.06.010

Recommendation 8.3: (1) Link national innovation policy with and strengthen existing social innovation grassroots initiatives, and (2) make sure that the younger generation can engage with such efforts. Include actively social innovation organisations in deliberations about future innovation policy priority setting. Allow social innovation initiatives to actively participate in research funding programmes and schemes of the Innovation Fund Denmark (IFD). Budget implications:

Budget implications: low

Technical complexity: medium

Interrelation with other activities: high

Priority: medium

2.3.2 Public procurement for innovation

Public procurement can offer a tremendous market for innovative products and services and can be an integral part of a demand-driven innovation policy. The potential market is particularly large in Denmark, where government spending accounts for 55.5% of GDP,[140] the third highest in the EU, and the Danish public-procurement market is equivalent to 16% of GDP. Public procurement for innovation is an important instrument for creating demand for innovation particularly at a time when many societal challenges call for increasing public investment and solutions that are innovative and unique and require interdisciplinary approaches and the collaboration of different stakeholders. However, successful approaches to public procurement for innovation involve numerous measures and are challenging and complex to implement because they touch on many policy areas and levels of government and require long term commitment.[141]

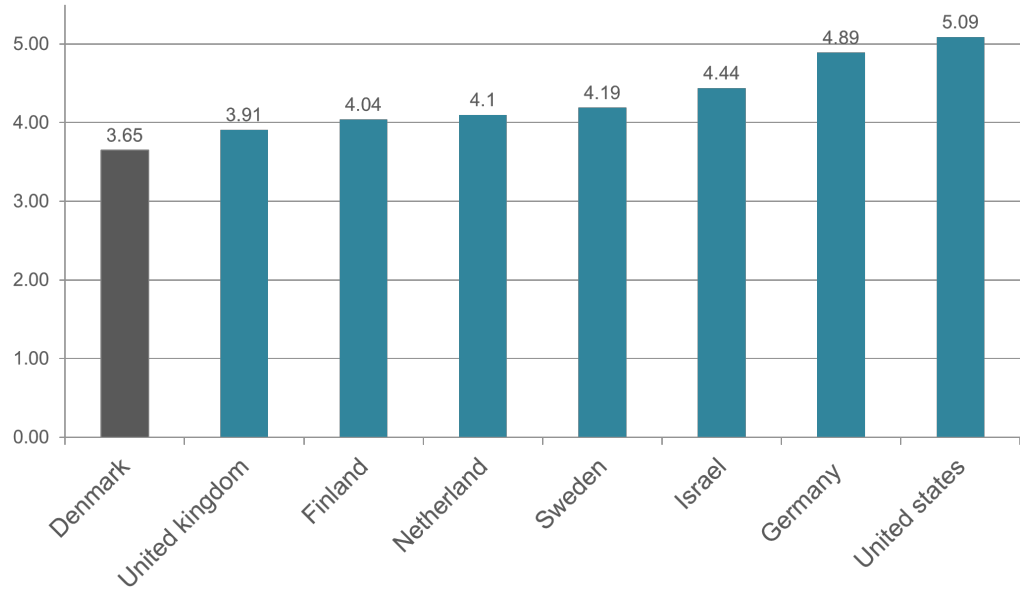
In Denmark, this potential appears underutilised. Public procurement decisions are not driven to great degree by considerations related to fostering innovation than in other countries as indicated by perceptions of business executives (see Figure 25). A recent benchmarking exercise by the European Commission has shown that Denmark is a low performer (rank 20) in terms of leveraging public procurement for innovation.[142]

[140] OECD: https://data.oecd.org/gga/general-government-spending.htm

[141] For an overview of good practices, see for example: https://read.oecd-ilibrary.org/governance/public-procurement-for-innovation_9789264265820-en#page1

[142] https://ec.europa.eu/digital-single-market/en/news/benchmarking-national-innovation-procurement-policy-frameworks?utm_source=e-mailnieuwsbrief&utm_medium=email&utm_campaign=AWTI+e-mail+alert

Figure 25: Government procurement of advanced technology products, 2017, 1-7 (best)



Source: World Economic Forum, Executive Opinion Survey 2017

Note: Data based on a survey of business executives responding to the question: In your country, to what extent do government purchasing decisions foster innovation? [1 = not at all; 7 = to a great extent]

Public procurement is mainly taking place at the local government level. The Danish Competition and Consumer Authority offers guidance on the public procurement regulation and the Agency for Modernization of Public Services (under the Ministry of Finance) is in charge of procurement policy. SKI (The Danish State and Municipalities Procurement Services) acts as a central purchasing body.

In the field of innovation procurement, the key actor is the Danish Business Authority, which managed the Market Development Fund (MDF). This fund was created based on the 2012 innovation strategy. It co-finances projects in companies to test innovative solutions and adapt them to markets, and it was given a mandate to foster innovation through public procurement. In the past, the MDF has provided grants to public procurers to prepare and implement Pre-Competitive Procurement (PCP) and Innovation Partnerships (PPI). In October 2013, Denmark launched the Strategy for Intelligent Public Procurement, which outlined the objectives for public procurement as efficiency, innovation, sustainability, and social responsibility. The Ministry of Environment has a programme on green procurement, which can support innovative solutions in the environmental space.

Challenge

MDF financed some innovative solutions in the areas of health, environment and social innovation at the municipal and regional levels as pilot projects. MDF was liquidated 1st of January 2019 and the target group previously funded by the MDF became the responsibility of the IFD.

At the same time, other measures that are considered best practice are not used in Denmark. These include:[143] ensuring that innovation procurement is included in horizontal and sectoral policies; developing an action plan with quantitative targets and better connecting the public procurement agencies to innovation expertise. During the interviews conducted as part of the review, the panel got a sense that innovative public procurement is under-utilised in Denmark and not on the agenda of the MHES.

Currently, the Competition and Consumer Authority is undertaking a review of the legal guidelines for public procurement that will be published in early 2020. Although establishing a policy mix that successfully uses procurement as a driver of innovation requires action at many levels (including target setting for innovative procurement, IP regime, review of legal definitions, etc.), the current review provides an opportunity to re-think the legal guidelines in a way that allows for a stronger focus on innovation. The new procurement guidelines should be elaborated with inputs from key players in the innovation system to ensure that the link between innovation and public procurement is strengthened.

Recommendation 9.1: Embed innovation into the public procurement practices to ensure that public procurement can play a key role in creating a market for innovative solutions, starting with pilot programmes.

Recommendation 9.2: Consider appointing a point person for innovative public procurement within the MHES tasked with instilling the innovation agenda into procurement policies, developing tools supporting innovative procurement and who could bring hands-on expertise in this space.

[143] https://ec.europa.eu/digital-single-market/en/news/benchmarking-national-innovation-procurement-policy-frameworks?utm_source=e-mailnieuwsbrief&utm_medium=email&utm_campaign=AWTI+e-mail+alert

Recommendation 9.3: Consider developing an action plan on how to achieve a greater, share of innovative procurement based on data and recommendations from existing policy reviews,[144] with the involvement of relevant stakeholders. The action plan should include a quantitative target.

Budget implications: low

Technical complexity: medium

Interrelation with other activities: IFD review, ensure alignment towards societal objectives; need to align across many different policy areas

Priority: high (due to an ongoing review of procurement guidelines and the window of opportunity related to the restructuring of MDF.)

2.3.3 Impact assessment

Successful innovation policy needs to be evidence-based; it cannot simply rely on general principles. Data is critical for policy decisions at different levels:

- Impact assessment for **individual programs** based on strong analytical methods is critical to assess their effectiveness;
- Impact assessment on the **systemic level** of the innovation system is critical to assess the complementarity and completeness of the overall policy mix;
- A related **system of** preassigned **KPIs** aligned with expected impact of each initiative/institution helps to monitor the performance of different institutions in the space and helps align activities around the most important goals, as suggested in Recommendation 6.1;
- **Contextual data** on existing Danish strengths and weaknesses as well as global opportunities and threats is critical to making overall decisions on the strategic priorities across the innovation system.

Denmark has a strong tradition of impact assessment as a critical component of the innovation policy toolkit. The Danish Agency for Science, Technology and Innovation started doing methodologically advanced impact assessments in 2006. The Danish Commission for Technology and Innovation published an overall strategy for evaluation and impact assessment[145] in 2010. The Danish

[144] https://ec.europa.eu/digital-single-market/en/news/benchmarking-national-innovation-procurement-policy-frameworks?utm_source=e-mailnieuwsbrief&utm_medium=email&utm_campaign=AWTI+e-mail+alert and https://ec.europa.eu/regional_policy/sources/policy/how/improving-investment/public-procurement/study/country_profile/dk.pdf

[145]https://ufm.dk/publikationer/2010/innovationdanmark-strategi-for-evaluering-og-effektmaling

Productivity Commission[146] then also argued for a stronger focus on impact assessment in its recommendations for innovation policy in 2013. The foundations laid down in that year have informed a range of studies since then, for example the assessment of the Danish Innovation Incubator Programme[147] in 2015, the R&D tax credits[148] in 2019, and two systemic assessments in 2014[149] and 2016.[150] A review of the quality of impact assessments[151] done in 2018 found them to be of generally high quality but also narrowly focused on individual instruments. The main recommendations of this review was to establish a general evaluation protocol. The few studies done on more systemic impact were generally older.

Despite these robust foundations, Denmark is no longer among leading peer countries in terms of data-driven impact assessment and innovation system analysis (see also Appendix A). This view is in line with similar recent observations made by the Commission reviewing the Innovation Fund Denmark.[152] Apart from the Innovation Denmark Database, which compiles information on R&D spending of Danish companies, data on the overall effects of innovation policy seem to be fragmented, and there is no obvious central place within the government to track overall trends in performance and the global context in which the Danish innovation system operates.

Peer countries including Norway, Sweden, the Netherlands, Ireland, and Singapore have, in the meantime, put an increasing focus on evidence and impact assessment. NESTA in the UK has been at the forefront of developing new tools and methodologies. In Denmark, the private foundations have launched their own efforts on impact assessment, and often also on broader assessments of the wider innovation system.

Recommendation 10.1: Launch a renewed effort to create an impact assessment strategy, building on the previous work done in 2010 and focused specifically on assessing systemic effects of innovation policy actions.

[146]http://produktivitetskommissionen.dk/media/159695/Faktaark_8_Anbefalinger%20vedrørende%20innovationsområdet.pdf

[147]https://ufm.dk/publikationer/2015/econometric-analysis-of-the-danish-innovation-incubator-programme

[148] https://ufm.dk/publikationer/2019/evaluering-af-skattekreditter

[149]https://ufm.dk/publikationer/2014/the-short-run-impact-on-total-factor-productivity-growth-of-the-danish-innovation-and-research-support-system

[150]https://ufm.dk/publikationer/2016/the-effect-of-multiple-participations-in-the-danish-innovation-and-research-support-system

[151] https://ufm.dk/publikationer/2018/review-af-viden-om-okonomiske-effekter-af-virkemidler-til-fremme-af-privat-fou

[152]https://ufm.dk/publikationer/2019/innovation-fund-denmark-report-of-the-international-evaluation-panel-2019

Recommendation 10.2: Widen the focus on assessing the impact beyond narrow economic outcomes to include a broader range of societal goals on Climate Change, Social Inclusion, etc., for example, by connecting the assessment to the SDGs.[153]

Recommendation 10.3: Evaluate the creation of a central quantitative analysis unit to inform innovation policy with a mandate, including centralisation of KPIs to inform impact assessment (database/dashboard), context analysis and the development of new indicators to track innovation performance.

Budget implications: low

Technical complexity: medium to high

Interrelation with other activities: limited, important input towards a strategy process

Priority: medium to high

[153] It has to be noted, however, that data and assessment methodologies on broader societal objectives are scarce. Denmark could take a leading role globally in terms of developing such methodologies.

3 DEFINE A STRATEGIC AMBITION FOR DENMARK

The recommendations of Chapter 2 suggest improvements to individual elements of the innovation system, to the overall coordination across different players and proposes a broader set of innovation policy tools. These recommendations are important and will improve the performance of the NIS. But such evolutionary changes within the given system will struggle to achieve more transformative changes in outcomes.

This chapter discuss the opportunities for Denmark to further elevate its performance by outlining an overarching innovation strategy. The lack of such a strategy is limiting the ability to create positive systemic effects from the alignment of individual innovation policy actions. Putting it in place would help unlock such benefits and enable a stronger prioritization of actions towards areas of highest potential impact.

3.1 Many strategies, but no strategy

A central observation that has emerged in this review is that Denmark has no clearly defined articulation of what it aims to achieve as an innovation leader. In short, **there is no holistic innovation strategy**. This might be a surprising statement, given that there are quite a number of often high-quality policy documents that are called 'strategy', and many initiatives that have a strategic ambition. What they all lack, however, is an overarching vision across the whole of government that clearly spells out what Denmark wants to achieve within the global innovation landscape, and how it intends to get there.

In late 2017, the Danish government published 'Denmark – ready for the future', laying out its objectives for Danish research and innovation. The document included a range of new initiatives in both areas, including the launch of several reviews to propose more specific actions in the fields identified. This report is the result of one of those reviews; others focused specifically on the Innovation Fund Denmark and other aspects of the innovation system (see Chapter 1).

Earlier, in 2012, Denmark approved an innovation strategy with more than 25 policy initiatives. The strategy triggered, what was, in many ways, a successful upgrading of several key institutions and activities across the innovation system. Many of the observations that motivated the actions outlined in the 2012 strategy continue to ring true today, for example, the need for a stronger demand-pull perspective. Some high-quality strategies exist for parts of the innovation system, for example in life sciences (Vaekstplan for Life Sciences, 2018) or in the space of renewable energies. Denmark's Strategy for Digital Growth from 2018, however, makes surprisingly limited references to the role of innovation and research.

In parallel, there are a number of entities that have discussed the strategic challenges of the Danish innovation system. The Danish government's Disruption Council (created in 2017) convened key leaders from politics, business, and beyond, and covered a range of topics deeply intertwined with innovation. Earlier the Danish Productivity Commission (created in 2013) also made recommendations on the innovation system. Specifically, within the innovation

area, there is a range of advisory groups, one example being the Danish Council for Research and Innovation Policy, that has provided focused advice on innovation policy.

What, then, is missing? It is, in our view, a systemic perspective on what value Denmark aims to provide as a location for innovation in a global and European context, and what it wants to achieve by playing this role. Without such a perspective it is hard to prioritise across different activities, it is hard to achieve systemic synergies across individual tools and entities, and it is hard to assess whether Denmark is fundamentally successful in its innovation policies.

These issues are particularly important because Denmark is an innovation leader. Innovation leaders need to do more than fix inefficiencies in existing activities or copy successful practices by others. They **need to chart out the 'next level' of what leading practice means**. And this next level, in most cases, does not mean a new program design, but a better way to deploy and synchronise actions across the innovation system towards an ambitious goal and value proposition.

A **value proposition** is useful because it helps to select and prioritise among the large number of potential measures that can be taken to 'support innovation'. Is it best to focus on a general R&D tax credit, attract foreign researchers, fund a cluster program, or launch a national venture capital fund? All have merits in principle, but their relative contribution depends on what value a location aims to offer, and what other instruments it is thus using. Without a guiding principle to navigate across them, the allocation of especially funding easily becomes a matter of path-dependency and political power. This is a reality in Denmark as in many other countries; a clear strategy can create a countervailing dynamic.

Without a value proposition as a guiding principle, locations can still gain benefits from a strong innovation system and from improving individual policies or actors that are part of it. And many steps that need to be taken and initiatives to launch will be useful across a wide range of strategies. But such efforts alone will fail to leverage the full opportunities that arise from a systemic integration of such efforts towards a common goal. In the panel's view, this is a reasonable description of where the Danish innovation system is at the moment.

Denmark is, in the Panel's view, **not only in need of an innovation strategy that sets out a more sharply nuanced value proposition**, but it also **needs to develop a clear structure to develop and implement the strategy**.

The view from stakeholders consulted as part of the current review is that the existing strategies trigger only limited action across the system. They tend to address individual issues often in a disjointed manner and thus fail to have the support and deeper impact that a systemically coordinated and broadly shared strategic agenda could achieve.

The **absence of a clear positioning choice** could be the result of disagreements on where Denmark should go among key stakeholders or a lack of access or communication. The Panel found little evidence that either of these is the case. An alternative explanation is that this choice and the debate leading

towards it has just not been had in a structured way and at a sufficiently high level of political authority. The evidence collected by this review suggests that it is a matter of structure: **systemic action across a loosely connected structure like an innovation system requires the establishment of a central, politically empowered process to**:

- Achieve a common view of the current situation and opportunities and ensure buy-in from stakeholders;
- Take visible decisions on an overall strategic direction and action priorities that can guide the individual decisions actors across the system will take in their own authority;
- Follow-up on the actual implementation and impact of actions.

Box 6: The role of strategic positioning in innovation policy

The role of strategic positioning in innovation policy

What does strategic positioning in innovation policy mean? It means specifying the value your location sets out to deliver in the global innovation landscape. This value proposition identifies in what parts of the innovation journey a location aims to make its major impact (idea generation, prototyping and market testing, start-up, scale-up) and for whom (geographic focus, thematic focus, firm type, specific societal challenge). It also builds on a country's strengths. The value proposition thus reflects a choice; you cannot deliver everything to everyone, even as an innovation leader. It is about picking what value you want to offer, not what 'winner' or sector you want to support.

For globally successful innovation hubs, there is often a fairly clear notion of what their value proposition is. And as it turns out, their positioning in innovation tends to be closely linked to the overall role that the country plays in the global economy:

- For **Israel**, it is acting as a **tech hub** – deeply integrated into the global tech and financial scene – that "manufactures" new companies and technologies based on top local talent
- For **Ireland**, it is serving as a **platform for global** (mainly US) **MNCs' innovation-driven activities targeting the European market**, leveraging access to the Single Market and providing attractive fiscal conditions
- For **Finland**, it is leveraging the country's inherent **IT and engineering skills** to create companies that can serve global markets, building on a strong skill base and effective mechanisms to leverage local strengths

- For **Singapore**, it is providing an efficient platform to **marry global skills with Asian market needs**, offering a top-notch business environment and a location right at the heart of South-East Asia

- For **Germany**, it is constantly **enhancing the country's existing industrial strengths** through new materials, technologies and approaches, building on existing key clusters and a robust research infrastructure well-linked to business

Making a choice aligned with your circumstances as a country is more important than making one that is completely unique. This choice, and the value proposition that embodies it, is in many cases more an implicit understanding across the innovation system than a formal decision written up in a public document. Its effectiveness is not so much a matter of its formal nature, but of the way it gets generated and is then shared and 'lived' across the innovation system. But if an implicit understanding does not exist, it needs to be formalized.

3.2 Towards a Danish value proposition in innovation

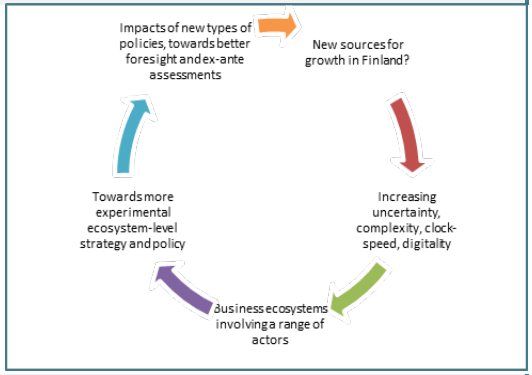
Suggesting a specific value proposition as the foundation of a Danish innovation strategy goes beyond the scope of this Panel because it should be the outcome of the political process in Denmark. What this chapter aims to do instead, is to provide some thoughts on both process and content and examples from other countries, keeping in mind that many different approaches to developing strategies exist.

3.2.1 Key elements of an innovation strategy process in Denmark

The content of Denmark's strategy needs to be grounded in the reality of Denmark's existing strengths and weaknesses and of the opportunities and challenges that the global context offers. Figure 26 summarises some of the key observations from the Panel's work, pulled together from different parts of this report. In an ideal case, such an exercise would be undertaken through stakeholder consultations and would be informed by analysis. Given the complexity of global developments, the analysis would need to be forward-looking. A foresight exercise could help think about what strengths Denmark could bring to the table in light of rapid global developments. Foresight has played an important role in the Finnish Strategy process (see Box 7). Boxes 8 and 9 provide additional examples from Ireland and Germany.

Case Study: Renewing innovation policies – the case of Finland and the SUUNTA strategy

In 2013, the main innovation policy agencies (Academy of Finland, Tekes, Sitra, Finnvera, and Finpro) in Finland decided to join forces and develop a new joint strategy (the so-called SUUNTA strategy) with the aim of shifting the focus of RDI support beyond individual projects, companies and sectors towards broader business ecosystems in areas of key importance to Finland. This SUUNTA strategy work was preceded by extensive sense-making and foresight work related to megatrends, significant business opportunities and challenges that Finland is facing, and it aims to create innovative new ways to implement policy. Increasing uncertainty and complexity in the global economy, coupled with rapid digitalization and tightening competition implies that companies increasingly build their competitiveness through symbiotic relationships with collaborators, competitors and other actors within business ecosystems. This is challenging current innovation policy thinking, implementation and impact assessment.



In Finland, the SUUNTA strategy has identified natural resources and resource efficiency, digitalisation, wellbeing and health as areas where there is most potential for new business ecosystems to emerge, and also considers ways through which these ecosystems can connect to global hubs and attract investments to Finland. The emphasis of the SUUNTA work is on identifying emerging business ecosystems and boosting these through better coordination between the main innovation policy agencies, for example, by mandating ecosystem orchestrators, creating physical or virtual platforms for ecosystem extension, identifying and addressing barriers for developments, securing political support where needed, and by developing policy instruments so that the agencies can work more seamlessly together.

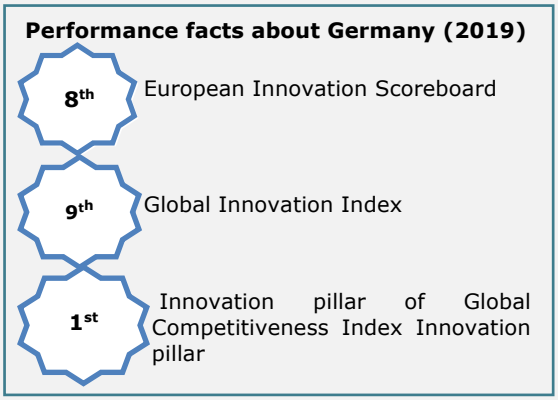
At Tekes, the Finnish Funding Agency for Innovation, the SUUNTA strategy is being implemented in a range of new programs. For example, the 'Bits of Health' program wishes to enable new business ecosystems related to digital health care solutions, the '5th Gear' program seeks to nurture new business ecosystems related to next-generation ICT telecommunications standards, while the 'IoT' program addresses new opportunities related to the Internet of Things. Further, the 'Business with impact (BEAM)' program is co-funded by the Ministry of Foreign Affairs, with the aim of building business ecosystems for inclusive innovation in collaboration with developing countries. Meanwhile, work is also ongoing to utilise new types of 'ex-ante' impact assessment approaches for better sense-making and real-time monitoring.

Source:https://tem.fi/documents/1410877/4430406/Christopher_Palmberg_Sylvia_Schwaag_Serger_PPP_Models.pdf/9ef8ff59-0519-4ea0-a270-6e09d7908ef4)

Case study: Germany and its 'High Tech Strategy 2025'

According to the Global Competitiveness Report 2018, Germany is the world leader in innovation. The country's declared goal is to move from an inventor country to a global innovation leader. As Germany has a long-standing and extended national innovation system, it may serve as a case for successful cooperation among its actors. We described one of the elements, the Fraunhofer Society in details in Section 2.1.4 in Box 3.

The latest innovation strategy of Germany, '*High Tech Strategy 2025*' aims at promoting cutting-edge innovations and technologies and transferring them to the people as increase in prosperity, growth and quality of life. Therefore, it targets areas such as health care, sustainability, climate change, energy, mobility, security, etc.[154]



The Strategy is an orientation to all actors in the German society with cooperation being one of its central element. Cooperation is of high priority for the German Government, which involves all federal ministries through thematic missions[155] and connects business, science and society through continuous dialogue. The Strategy is therefore dynamically developed along the ideas of the public, advisory boards, industries, researchers and government entities.

Cooperation elements for implementing the **High-Tech Strategy 2025**:

1. **Involving the society**:[156] As innovations are more and more originating from citizens, the German government made it its priority to promote the participation of the civil society in innovation besides industry and research.
   There are increasing number of digital platforms available for the citizens, including the possibilities provided by the framework of the 'Year of Science': exhibitions, competitions, forums.

[154] https://www.hightech-strategie.de/de/hightech-strategie-2025-1726.html

[155] https://www.hightech-strategie.de/de/missionen-1725.html

[156] https://www.hightech-strategie.de/de/kommunikation-und-partizipation-1710.html

The traditional dialogues are now accompanied by new formats to involve the society into other activities: agenda settings, independent research activities, projects, and even strategic exchange.

2. **High-Tech Forum**:[157] The German Government is committed that a continuous and expanding strategic dialogue between politics, science, industry and society is crucial element of the success of the innovation strategy.

   To dynamically develop the Strategy, a High-Tech Forum of 20 experts from science, industry and civil society was set up and it serves as an advisory board for research and innovation co-led by the Federal Ministry of Education and Research and the Fraunhofer Society.

   The High-Tech Forum is responsible for supporting the innovation policy with implementation and action plans and advising on specific areas of future importance.

3. **Communication concept**: To maintain transparency of and to increase involvement in the implementation of the Strategy, the Government set up a communication concept for continuous information provided for all stakeholders.

Box 9: Case study: Ireland and its 'Innovation 2020' strategy

Case study: Ireland and its '*Innovation 2020*' strategy

Ireland's strategy creation process described below may serve as a guideline for Denmark to form its own strategy with a vision and mission by strengthening its existing capacities and developing new ones for further success.

The '*Innovation 2020: Excellence Talent Impact*' strategy of Ireland for research and development, science and technology for the period of 5 years (2015-2020) was launched to build on the notable success of the Irish government's previous science strategy during the past decade. It has resulted in a significant improvement of Ireland's innovation performance in the European Union and globally.

The current strategy is part of the Irish comprehensive strategy (*Enterprise 2025*) to reach full employment on a sustainable basis with the vision for Ireland to become global innovation leader. The innovation strategy's main objective is to build on existing infrastructures and forming significant private-public collaborations by increasing the total investment in R&D in Ireland to 2.5% of GNP by 2020 (double of the 2014 level), mainly delivered by the private sector. The strategy follows a whole-of-government approach in terms of implementation.

[157] https://www.hightech-strategie.de/de/steuerung-und-begleitung-1709.html

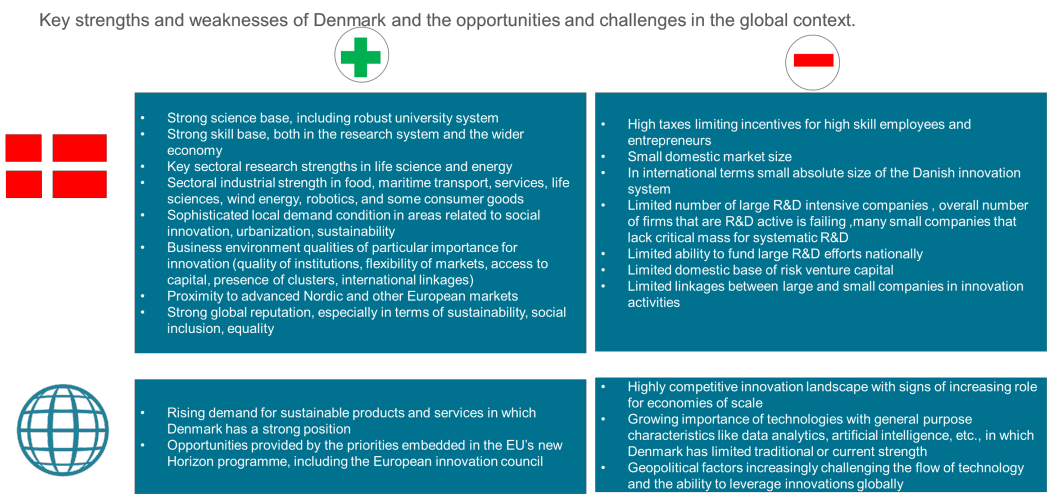
The Irish process of forming '***Innovation 2020'*** **strategy**:[158]

1. End of Strategy for Science, Technology & Innovation (SSTI) 2006 to 2013.
2. Launch of **Research Prioritization** to identify the Government's primary science, technology and innovation policy goals with the greatest potential economic returns.
3. Establishment of the **Interdepartmental Committee** on Science, Technology and Innovation (IDC) in 2014. Participants:
    a. Department of Jobs, Enterprise and Innovation (chair)
    b. Other key Government Departments, including Education and Skills, Finance, Health, Foreign Affairs and Trade, etc.
    c. Chief Scientific Adviser to the Government
    d. Higher Education Authority
4. Development of **studies** for the strategy in areas, such as:
    a. Ireland's future research infrastructure needs
    b. Independent review of Research Prioritisation
    c. Strengthening enterprise R&D
    d. Market focused research centre landscape
    e. IP capability of Irish firms
    f. Ireland's participation in international research organizations.
5. Launch of a written **consultation** process and the Consultative Forum in early 2015:[159]
    a. A consultation document with key thematic areas was sent to stakeholders from industry, public sector and academia.
    b. A Consultative Forum was held involving 120 major stakeholders to discuss the issues appeared from the work of the IDC and the written consultation process (Summary Report).
6. **Publication** of the Strategy Innovation 2020: Excellence, Talent, Impact in 2015.
7. Establishment of the Innovation 2020 **Implementation Group** in 2016, by merging the Interdepartmental Committee on STI, the Research Prioritisation Action Group and the Horizon 2020 High Level Group, chaired by the Department of Jobs, Enterprise and Innovation, for a coherent, streamlined and coordinated execution of the Strategy.

[158] https://www.enterprise-ireland.com/en/News/PressReleases/2015-Press-Releases/Government-publishes-ambitious-Innovation-Strategy-Innovation-2020-Excellence-Talent-Impact.html

[159] https://dbei.gov.ie/Djei/en/Consultations/Consultation-for-Successor-to-Strategy-for-Science-Technology-Innovation.html

Figure 26: Key strengths and weaknesses of Denmark and the opportunities and challenges in the global context.



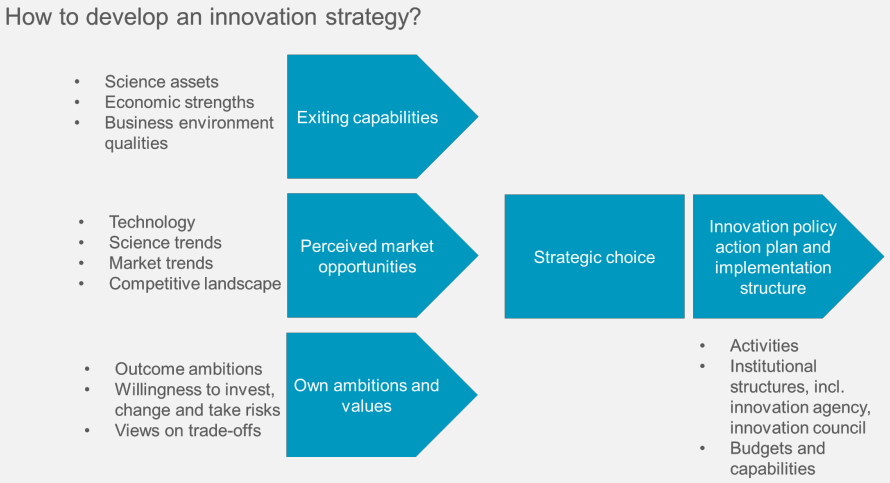
Source: Authors

This is a high-level overview, not a full assessment. And it is one that for most in the Danish innovation system has few surprises – most elements draw on existing sources, like the analyses done by the Danish Council for Research and Innovation Policy and the private foundations that can be used. Nevertheless, it will be valuable for key decision makers in the Danish Innovation System to review this assessment together to identify where different groups, for example, the large R&D-intensive firms in Denmark, have a different view on the importance and quality of Danish conditions.

Based on this assessment of the current situation and possible futures, it is a creative task to develop different options for what role Denmark could play as a place for innovation. Box 8 outlines key steps in the process of developing a strategy.

Developing an innovation strategy

The exhibit below outlines some of the key dimensions in the process of developing an innovation policy strategy. It is important to capture both the domestic and the global context; focusing only on one of these two creates choices that are myopic or illusionary. It is also critical to explicitly capture the ambitions and values that are needed to move from data to strategic choice. And finally the strategy needs to be more than a statement of intent; it needs to be underpinned by a concrete set of actions and an implementation structure that is able to deliver them.



The process of developing a strategy is often at least as important as the final outcome. Inclusiveness and active engagement are critical:

- The information needed to make the appropriate choices is dispersed across the many different parts of the innovation system. Bringing this information together opens the door to a common view of the current situation that the Danish innovation system is in.

- The resources and decision-making power to then drive action in line with the strategy is also dispersed. Aligning actions across government is only one part, aligning actions across firms, universities and research institutions, private foundations, and many others is at least as critical. While government policy can influence the non-government parts of the innovation system, its influence is limited

While data is crucial, it is important to understand that at its core, strategy is always about choice: **Where does the Danish innovation system aim to create real value, be differentiated, and how does it plan to achieve this**

goal? There might be a range of options that are all feasible for Denmark. Data can help identify those that are relevant, and then allow an evidence-based decision to be made between different real options. **This is a decision that only the stakeholders in Denmark can make**.

Figure 27 presents four illustrative options to describe distinctly different possible directions for Danish innovation policy. These are intended to serve as examples and inspiration, not as a short-list of the most relevant options. Box 11: Sustainable Development Goals as a positioning for Denmark describes in more detail how an SDG focus as an anchor for Denmark's positioning could look like.

Box 11: Sustainable Development Goals as a positioning for Denmark

Sustainable Development Goals as a positioning for Denmark

One potential anchor for Denmark's vision are the Sustainable Development Goals (SDGs). There is no doubt that public and private investment in initiatives directed at attaining SDGs is increasing which creates demand for innovative solutions.

Addressing the SDGs requires an inclusive perspective, beyond the classical focus of innovation policy for industry. Grand societal challenges and SDGs are "transformative" in the sense that they are part of overall societal development rather than just arguments for setting priorities in ongoing research and innovation systems (in policies, in practices). Grand Challenges are also occasions (and incentives) for new constellations of innovation actors to emerge and become active".[160] Denmark's 'Research 2025' aims to create new technological opportunities, green solutions and better health and welfare through transforming global societal challenges into new opportunities for growth and export for Danish companies.[161] Still, overarching efforts to foster new actor constellations and launch major transformative initiatives with major investments have remained limited.

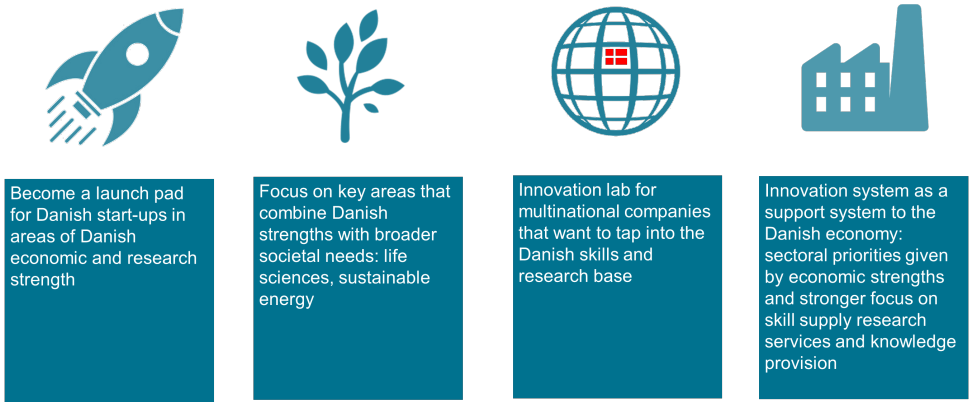
Societal Challenges are weakly or at best incrementally addressed, while requiring substantial transitions and cross-sectoral, cross-industrial, cross-technological in silo-breaking thinking and decision-making processes. At the same time, they contain great opportunities for development of business opportunities and capabilities in emerging and future rapid growing markets, as global needs related to corresponding societal challenges transform into actual demand for solutions.

[160] Kuhlmann, S., and A. Rip 2018. "Next-generation innovation policy and grand challenges." Science and public policy 45.4: 448-454. https://doi.org/10.1093/scipol/scy011

[161] See https://ufm.dk/en/publications/2018/research2025-summary

In order to catalyse such innovation processes, instruments of a different kind than have previously been dominating would be needed. They should be characterized by challenge defining lead users and business firms, consortia partners relevant and broad enough to efficiently address solution search. Their development should, in turn, be characterized by stage gate processes with increasing consortia partner commitment, related to key strategic priorities in partnering organizations.

Figure 27: Illustrative strategic options for Denmark



These and other options should be evaluated in a process that involves stakeholders and based on the ambitions Danes have for their country, and what matters to them as they evaluate the potential steps necessary to achieve them. All of the options developed should be attractive, otherwise they will not enable a real choice. But they will require different trade-offs to be made. Consider the following illustrative questions:

- Is there a willingness to create stronger incentives and space for experimentation, including through lower taxes and weaker regulation in certain areas, if that is what is needed to strengthen entrepreneurship?
- Is it acceptable for a significant share of public support to go to efforts that are risky and where, thus, a given number of them will fail?
- Is it important to make a contribution to addressing global or European societal challenges, or should specific options be evaluated by their impact on Danish GDP and job creation?
- Is it relevant whether the major beneficiaries of Danish research funding are Danish companies and citizens or those from other countries?

A decision for any such choice enables a clear prioritisation of activities towards achieving the specific goal defined. This is why choosing to go after all the options developed for Denmark is not a useful decision: it would fail to create focus on

any particular set of activities, and would not be able to communicate externally what in particular Denmark is strong in.

However, it is important to recognise that a significant part of the innovation system provides more 'generic' activities that are not dependent on this choice. The focus on a specific value proposition is fully compatible with an academic system that contracts research and provides education in a wide range of fields, respecting academic freedom. It is also fully compatible, and indeed needs to be combined with, programs that help Denmark's economy to master new cross-cutting technologies like AI even when this is not part of the unique positioning that Denmark is pursuing. Strategic choice in public policy is about setting priorities.

Overall, the shift towards a more strategic innovation policy approach around a widely shared value proposition would aim to achieve change in three key dimensions:

- **More systemic integration of individual innovation policy tools** towards common goals vs enhancing the quality of individual programs or institutions.
- **More systemic dialogue and collaboration across the entire innovation system** vs creating a structure that aims to minimise the need for coordination.
- **Focus on areas of innovation, including non-science driven areas, in which Denmark has clear strengths** vs generic efforts to ensure academic excellence and effective technology transfer.

The ambition, then, is to elevate the many assets of the Danish innovation system and enable them to make a more sustained impact, not to dramatically deconstruct what exists to create an entirely new system.

3.2.2 From choosing a value proposition to action

The value of any strategy and value proposition ultimately depends on how it changes actions and behaviour. A pre-condition to changing behaviour is that the relevant stakeholders are involved throughout the process so that they feel co-ownership of the strategic outcomes. Choices need to be broken down into specific efforts, into responsibilities for specific institutions, and in budgets and investments needed to create the necessary capabilities.

The strategy should also define clear goals and metrics that describe the outcome to be achieved. This is important for two reasons: first, it makes it possible to monitor progress, and check whether the actions chosen are effective in getting Denmark closer to where it aims to be. Here, there is a clear connection to the new push on a cutting-edge system for impact assessment and performance tracking proposed in chapter 2.3.3. And second, it can inspire broader support for the strategy. While some might be motivated by the value proposition itself, for many, it will be the impact that Denmark can achieve for itself and for others that will be the key reason to rally around the strategy.

A strategic choice on a value proposition will affect the prioritisation across existing activities, programs, and institutions, such as, for example:

- A focus on start-ups and their acceleration requires specific action on science parks, incubators. risk capital, taxation, physical infrastructure for testing, export promotion, procurement procedures for start-ups, and the like.

- Leveraging Danish strengths in non-science driven areas of innovation depends on the availability of policy platforms across ministries, support programs that are neutral as to their science linkages, and a dedicated program to leverage these strengths internationally.

- Operating as an R&D lab for MNCs is much more a question of the infrastructure for expats, tax rules specific to R&D, and clear & simple rules for the collaboration of firms with academic institutions.

- Orienting the Danish innovation system around Denmark's existing industrial profile would raise the importance of RTOs and science parks, create more urgency around rules and regulations for technology transfer, and could have implications for where science investments are made.

It will also require a look at some more **ambitious *new policy approaches*** that Denmark has not pursued very actively so far. Mission-oriented approaches that stress the role of government in creating demand for innovation have gained significant traction across the EU. They will feature in Horizon Europe, and they have been included in the recent UK industrial policy. Denmark should consider using such an approach as a way to spearhead its activities around a specific domain.

At a more tactical level, a challenge-driven innovation programme can translate this idea into reality. Such instruments exist in Denmark in the space of renewable energy and could be applied to other areas of societal importance as well. The challenge-driven innovation programmes catalyse stepwise, targeted, strongly committed consortia addressing urgent, specific societal challenges that could be practically addressed in a national context, but which could have the potential of scaling towards corresponding international challenges. This could be based on the concrete potential of the public sector benefits and private firm revenues, if successful in generating envisaged solutions. The public sector, including parts of municipalities and county councils, are almost always in the front seat, together with innovative firms. Groups of firms often need to connect their solutions in order to generate viable businesses and to contribute to solving the societal challenge. The main partners are public sector agents and private firms, often together with HEIs and or research institutes, and increasingly with public regulatory institutions. Innovation tournaments are an interesting new option. They define a specific problem and provide economic benefits for its solution without prescribing any particular technology or approach.

Critically, more or less any strategy will depend for its success on creating *a new organisational structure* across the Danish innovation system that enables more effective dialogue, decision making, and impact tracking towards the new goals.

The need for strategic alignment encompasses MHES and the MIBFA, as well as almost every ministry as all of them, interact with the knowledge and innovation system, not to mention agencies, local authorities and many semi-public stakeholders.

Below we sketch two institutional setups that Denmark could consider. They are meant as source of inspiration to devise a solution that fits the institutional and political ecosystem of Denmark. They imply that innovation policy is elevated within government to a level that is above any single ministry. Two options should, in the Panel's view, be further analysed:

- **Establish an innovation agency:** Sweden (Vinnova) and Norway (Innovation Norway) have national innovation agencies that have a leading role in the design and implementation of their countries innovation policies. Germany has recently announced the creation of a new Agency for Disruptive Innovation as a joint effort of the ministries for the economy (BMWi) and research (BMBF).[162]

Important features of innovation agencies, which are semi-independent from and functioning outside the ministries, of the kind that exist in other Nordic countries are:

- Good conditions and capacity for learning from a long history of past experiences and making use of that learning in strategy development, even when Governments and other institutional structures change.

- Strategy and program design capacity based on systems analysis that allows identification of areas and targets that are important for the innovation system to address/aim for. Such capacity also allows for continuous improvement based on learning from evaluations and monitoring of past and on-going strategies and programs.

- Experimentation and experiment-based learning that is possible because of the quasi-autonomous mandate of the agency. This allows for trying out new directions and program designs at smaller scales both in terms of new kinds of initiatives and within existing programs.

Alternatively, some countries also created innovation councils led by the Prime Minister and involving all ministries. These are frequently set up to formulate strategies and coordinate at the national level. Coordination mechanisms do seem to work best when there is a real willingness to align strategically and to coordinate. The remit and the authority given to an Innovation Council should truly reflect a commitment to drive change at the level of the whole research and innovation system.

Moreover, Denmark could consider creating an innovation agency. The different options should be carefully considered and discussed within Denmark. One option

[162] https://www.gouvernement.fr/en/france-s-ambitions-for-investment-and-innovation

– but not the only one to consider - could be to expand the mandate of the IFD to also cover the role of an innovation agency. This would require additional funding for IFD, but more importantly, a new set of capabilities and a significant change in culture, as funds operate based on different objectives.

- **Create a powerful national innovation council as a strategic decision-making body** or broaden the mandate of existing structures like the Danish Council for Research and Innovation Policy (DFiR) accordingly. Currently, the council does not have decision making competence and provides independent and expert advice capacity to policy makers on research, technological development and innovation. The council should consist of members representing the composition of the cabinet that could be appointed by each involved minister. This council would need to be led by the Prime Minister to ensure sufficient decision-making power. It would have a mandate to take strategic decisions related to innovation across the different government entities and to develop and implement the strategy. It should be supported by a secretariat and the analytical unit proposed in Section 2.3.3 as well as foresight capacity.

Such a council could also include members from abroad in an advisory capacity, or a separate international board could be created. External views are often invaluable and catalyse more dynamic reflections and discussions. Some OECD countries use their councils to develop strategic priorities and/or to coordinate within both government and non-public stakeholders (see OECD, 2018 for possible configurations of a research and innovation council).[163] The Finnish Technology and Innovation Council, for example, has adopted guidelines and visions with influence at the national level. France has, in 2018, announced the creation of an Innovation Council to assist the Government in its strategic choices.[164]

While there are many different ways to ensure strategic alignment, it is the Panel's view that an institutional structure that sits above the minister level could provide strategic direction, coordination, alignment, and future-orientation to the actors of the NIS that is missing in Denmark today.

To sum up, it is the panel's view that such a strategic exercise and a more precise definition of the vision behind Denmark's NIS can be highly beneficial for Denmark. It would take the overall contribution of individual elements such as agencies or funding entities towards societal and economic objectives to a new level. It would also allow for a more deliberate targeting of instruments and for strengthening the linkages and coordination of the system to work towards a vision that stakeholders have bought in.

[163] OECD, 2018: Science Technology and Innovation Outlook: Adapting to technological and societal disruption. OECD Publishing, Paris. https://doi.org/10.1787/sti_in_outlook-2018-en

[164] https://www.gouvernement.fr/en/france-s-ambitions-for-investment-and-innovation

4 CONCLUSION

Reviewing the performance of an innovation leader is a request to provide advice, but it is also a source of learning and inspiration. The peer review of the Danish innovation system has provided ample opportunities for both.

Denmark's innovation system has key strengths, especially in scientific research, some research-intensive industries, but also in non-science driven innovation, that many other countries envy. These strengths are embedded in a successful economy that is supporting a high and widely shared quality of life for Denmark's population. And they are anchored in a robust business environment and a well-developed policy support system for innovation.

What we found in this peer review is that **Denmark is despite all of these strengths facing a dual challenge:**

- First, **it is missing out on generating the full socio-economic value of the strong innovation system the country has developed**. This is a challenge that the Danish policy system has recognized, and that provided the impetus for this review.

- Second, **it is failing to respond to a range of broader changes in the global innovation and innovation policy landscape**, which in our view could challenge Denmark's current position. This is a danger that in our view has received insufficient attention in the Danish debate.

What can Denmark do in response? We propose a **two-pronged approach** or, as the title of this report frames it, **'A leap into the future: Ten steps towards taking Danish innovation to a new level** .

The 'ten steps' are actions that can be taken with the existing structures of the current Danish innovation system and its policy support environment. They are more evolutionary changes, and in many instances draw on existing momentum and efforts. But they also add some elements that in our view have been left unattended recently. Most importantly, the system needs to raise its ability to act as a system addressing more systemic challenges, not as a collection of efficient but independent individual programs and entities. For all of them, we have aimed to provide concrete and actionable recommendations.

The 'leap into the future' is then challenging Denmark to outline a clear and differentiated ambition for its innovation system, and the role Denmark is aiming to play in the global innovation game. Building on the previous ten steps, it sharpens both the internal prioritisation and delivery structure and the external communication of what value Denmark is able to offer to foreign talents, research institutions, companies, and societies. To successfully 'leap', Denmark has to mobilize and involve the breadth of its innovation system participants in discussion, decision, and action. A process like this may seem revolutionary, and maybe even risky. But many individuals and organizations we have met during this review seem ready to take up the challenge; in fact, there seems a widespread yearning to take the Danish innovation system to a new level. We

have aimed to provide a structure and a starting point for such a major process to be successful.

What can Denmark do to translate these ideas into action? The key question that Danish decision makers have to address is whether they see the need for action. The Danish innovation system is strong, and despite the challenges we have identified, there is no burning platform or impeding crisis. Instead, the costs of inaction are lost opportunities and a gradual erosion of Denmark's existing position. This type of situation does not create momentum for major change, but rather for continuity. Danish decision makers will have to weigh these costs against the priorities they see in other policy areas.

The ten steps outlined in this report can be pursued without the need to elevate the role of innovation on the Danish political agenda. There is limited if any additional budget required, even if changes might lead to a difficult re-allocation of resources within the innovation system. But this does not make the changes suggested easy: they will only happen, if there is both a clear political signal that there is a willingness to push them through, and a consensus across the system that they are needed.

The ambitious jump towards a comprehensive new strategy is in the panel's view of a different nature. It requires a much broader engagement with stakeholders, which will also increase the expectations for real change. And it requires an all-of-government approach, with actions and ownership beyond one single ministry. This is more complex, but also more rewarding if Denmark wants to fully mobilize the significant qualities of its innovation system to generate economic value and contribute towards addressing the broad societal challenges of our times.

APPENDIX A: METHODOLOGY OF THE REVIEW

The Review was part of the EC's Horizon 2020 Policy Support Facility (PSF). The objective is to provide recommendations for how Denmark's effort in knowledge-based innovation can rank among the global elite, and support stakeholders working effectively and in close cooperation towards common overall objectives.

The PSF Panel kicked off its work on 28 January 2019 and finalized in September 2019. The process started with a review of existing evidence based on desk research. The Ministry of Higher Education and Science provided a background report as well as additional resources analysing main indicators, a literature review as well as a historical overview of the development of the Danish National Innovation System. The panel complemented this information with relevant data and insight from international organizations (e.g. Eurostat, OECD, World Economic Forum) and other pertinent published data and analysis.

In the course of the review, additional evidence was collected during two field visits to Denmark. The panel held extensive consultations and interviews with a wide range of stakeholders and users of the Danish Research and Innovation system. The purpose of the first visit (4-7 March 2019) was to gain a sense of the main challenges and strengths of the Danish NIS. During the second visit (5-8 May 2019), initial recommendations were tested with key stakeholders and remaining information gaps were filled to ensure that the recommendations are relevant and timely.

The consultation process included a wide range of stakeholders, including but not limited to:

- Companies ranging across the entire company life cycle, i.e. from (student) start-ups to multinationals as well as relevant business associations;
- University and college leadership, technology transfer professionals and researchers;
- Main public and private R&I funding entities as well as main operators in the system (RTOs, cluster, networks), and
- representatives of government agencies and other ministries relevant to the R&I, members of councils and ongoing initiatives;
- Institutions and companies involved in the Robotics cluster at the University of Southern Denmark in Odense.

In total, nearly 200 stakeholders were interviewed or consulted either individually or in small-group interviews during the country visits or over the phone. In addition, individual organizations provided written inputs into the process.

The panel paid particular attention to ensuring complementarity with the numerous ongoing reviews targeting individual elements of the R&I system were

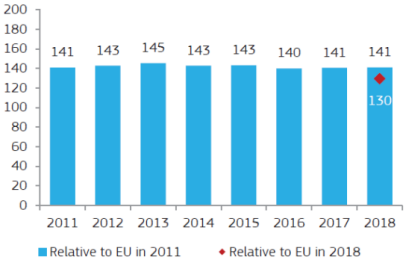
under way in Denmark. While the panel reviewed the innovation system as a whole, university hospitals and the Geological Survey of Denmark and Greenland (GEUS) were not part of this review. The relevant members of these reviews were consulted and overlaps of findings are referenced in the report.

Individual panel experts contributed to individual recommendations based on their expertise while national peers mainly contributed based on the expertise of their countries.

In the process of collecting evidence, the panel noted that many data limitations exist in Denmark, when it comes to the main characteristics of the innovation system and to assessing the impact of innovation policies on a regular basis. Some of the Panel's requests for data on indicators that are standard KPIs in other countries could not be fulfilled within a reasonable timeframe or not fulfilled at all. Despite a wealth of evaluations that are undertaken regularly, data on impact of key elements of the system is scarce and scattered across different institutions, which makes a systematic assessment difficult.

APPENDIX B: EUROPEAN INNOVATION SCOREBOARD 2019: DENMARK

Denmark is an **Innovation Leader.** Over time, performance has remained the same compared to that of the EU in 2011.



Attractive research systems, *Innovation-friendly environment* and *Human resources* are the strongest innovation dimensions. Denmark scores particularly well on Public-private co-publications, International scientific co-publications, and Lifelong learning. *Sales impacts* and *Innovators* are the weakest innovation dimensions. Overall, Denmark's lowest indicator scores comprise Sales of new-to-market and new-to-firm product innovations, Non-R&D innovation expenditures, and Venture capital expenditures.

Structural differences with the EU are shown in the table below. GDP per capita and top R&D spending enterprises per 10 million population are well above the EU average. Enterprise births and FDI net inflows are well below the EU average.

Denmark	Relative to EU 2018 in 2018	Performance relative to EU 2011 in 2011	Performance relative to EU 2011 in 2018
SUMMARY INNOVATION INDEX	**129.5**	**140.7**	**140.9**
Human resources	**180.4**	**192.5**	**220.6**
New doctorate graduates	157.2	146.2	228.3
Population with tertiary education	143.1	167.2	170.9
Lifelong learning	262.2	267.7	267.7
Attractive research systems	**183.8**	**160.0**	**207.0**
International scientific co-publications	265.1	257.0	385.6
Most cited publications	143.5	144.1	157.1
Foreign doctorate students	174.0	120.2	166.4
Innovation-friendly environment	**182.3**	**244.6**	**288.1**
Broadband penetration	177.8	266.7	355.6
Opportunity-driven entrepreneurship	187.0	229.6	242.2
Finance and support	**106.7**	**128.2**	**116.7**
R&D expenditure in the public sector	174.7	141.1	161.6
Venture capital expenditures	49.1	112.9	63.5
Firm investments	**104.5**	**119.7**	**124.6**
R&D expenditure in the business sector	145.7	166.1	166.9
Non-R&D innovation expenditures	45.3	45.9	52.9
Enterprises providing ICT training	126.3	153.3	160.0
Innovators	**95.7**	**103.4**	**86.9**
SMEs product/process innovations	96.1	109.1	93.3
SMEs marketing/organizational innovations	114.2	100.2	97.5
SMEs innovating in-house	77.5	100.9	69.8
Linkages	**139.2**	**175.5**	**144.6**
Innovative SMEs collaborating with others	109.8	215.5	117.2
Public-private co-publications	315.1	349.3	369.7
Private co-funding of public R&D exp.	70.5	71.5	67.7
Intellectual assets	**163.8**	**152.4**	**159.3**
PCT patent applications	175.1	171.7	159.3
Trademark applications	142.6	135.2	158.9
Design applications	173.2	146.5	159.7
Employment impacts	**100.7**	**127.3**	**105.1**
Employment in knowledge-intensive activities	110.6	120.5	120.5
Employment fast-growing enterprises	93.0	132.1	94.0
Sales impacts	**75.3**	**91.2**	**77.6**
Medium and high-tech product exports	79.8	68.1	86.1
Knowledge-intensive services exports	112.8	123.1	116.4
Sales of new-to-market/firm innovations	23.7	82.0	22.9

The colours show normalised performance in 2018 relative to that of the EU in 2018: dark green: above 120%; light green: between 90% and 120%; yellow: between 50% and 90%; orange: below 50%. Normalised performance uses the data after a possible imputation of missing data and transformation of the data.

	DK	EU
Performance and structure of the economy		
GDP per capita (PPS)	37,400	29,500
Average annual GDP growth (%)	1.8	2.2
Employment share manufacturing (NACE C) (%)	11.8	15.5
of which High and medium high-tech (%)	42.9	37.5
Employment share services (NACE G-N) (%)	41.4	41.8
of which Knowledge-intensive services (%)	34.8	35.0
Turnover share SMEs (%)	40.7	37.9
Turnover share large enterprises (%)	40.7	44.4
Foreign-controlled enterprises – share of value added (%)	10.6	12.6
Business and entrepreneurship		
Enterprise births (10+ employees) (%)	0.5	1.5
Total Entrepreneurial Activity (TEA) (%)	n/a	6.7
FDI net inflows (% GDP)	1.3	4.3
Top R&D spending enterprises per 10 million population	63.1	19.6
Buyer sophistication (1 to 7 best)	3.7	3.7
Governance and policy framework		
Ease of starting a business (0 to 100 best)	84.0	76.8
Basic-school entrepreneurial education and training (1 to 5 best)	n/a	1.9
Govt. procurement of advanced tech products (1 to 7 best)	3.5	3.5
Rule of law (-2.5 to 2.5 best)	1.9	1.2
Demography		
Population size (millions)	5.7	511.3
Average annual population growth (%)	0.6	0.2
Population density (inhabitants/km2)	135.4	117.5

EU targets for 2020

Indicator	2014	Latest	Target[1]
Gross domestic expenditure on R&D (% of GDP)	2.91	3.05	3.00
Tertiary educational attainment (% of population aged 30-34)	44.9	49.1	40.0

1 Sources are provided in the introduction to the country profiles.

European Semester country report and country specific recommendations:

https://rio.jrc.ec.europa.eu/en/library/research-and-innovation-analysis-european-semester-2019-country-reports

https://rio.jrc.ec.europa.eu/en/library/country-specific-recommendations-2019-research-and-innovation-analysis

APPENDIX C: CASE STUDY: THE WELLCOME TRUST

The Wellcome Trust is a private charitable foundation dedicated to improving health for all (https://wellcome.ac.uk).

The Constitution of the Trust outlines its objectives:-

1. To protect, preserve and advance all or any aspects of the health and welfare of humankind and to advance and promote knowledge and education by engaging in, encouraging and supporting: (a) research into any of the biosciences; and (b) the discovery, invention, improvement, development and application of treatments, cures, diagnostics and other medicinal agents, methods and processes that may in any way relieve illness, disease, disability or disorders of whatever nature in human beings or animal or plant life

2. To advance and promote knowledge and education by engaging in, encouraging and supporting: (a) research into the history of any of the biosciences; and (b) the study and understanding of any of the biosciences or the history of any of the biosciences.

The Trust is funded by an endowment portfolio of ~£26B, which is managed by an experienced investment team. The returns generated at present provide an income of ~£1B per annum to be spent on research and strategically important areas. The Wellcome trust is, therefore, the largest Foundation in Europe in terms of funding. Its funding for researchers is split into streams:-

- **A primary fund** which funds applications in responsive modes, offering grants across biomedical science, population health, medical innovation, humanities and social science, and public engagement.

- **A reserve fund** which is used to fund long-term research leading to change within 5-10 years to make a real difference in areas of strategic importance, e.g. antimicrobial resistance (https://wellcome.ac.uk/sites/default/files/call-action-antimicrobial-resistance-2018-report.pdf)

Development of Wellcome Trust's strategic research agenda

This is done in consultation with a range of different stakeholders, and the Trust, through its independence, can fund things very flexibly in line with different strategic requirements and across geographies. However, it always funds in line with the Wellcome Trust's mission. An example was the funding of the Sanger Centre and the human genome project at a time when this was very early and not being funded to a significant degree by other funders. This led to capacity building in genomics within the UK and demonstrated the importance of this area. This has now been followed by significant government investment in, for example, the 100K genomes project and really catalysed the whole area of genomics.

The Trust is not there to fund areas as a substitute for government funding but can drive government to fund important areas by adding to available government funding. For example, in the late 1990s, it was clear that there was a need for significant funding for infrastructure renewal in UK universities. The Trust made funds available which were matched by government and became the Joint Infrastructure Fund. This demonstrated that such funding was important and made a significant difference to universities' research capabilities. At this point, the Wellcome Trust funding was reduced, and government supplied the necessary funding via a Higher Education Funding stream.

Influence of the Trust on the Government Research Strategy and that of other funders

The Trust has an ability to think long term and work with other funders when the Government, by its very nature, is more focussed on short-term priorities. It can partner with other funders and also influence how they fund, for example, even when the Trust contributed a relatively small amount of funding, it was able to influence the construction, design and mode of working of the DIAMOND light source so that the facility answered the needs of a broader research community.

In terms of innovation, the Trust has been involved in driving new funding models, for example, helping to create the optimum environment for the Bioscience Catalyst campus at Stevenage adjacent to GlaxoSmithKline.

The Trust also has a strong influence on training and skills and frequently takes the lead in shaping thinking, for example, they were the first to move to 4 years' funding for PhDs, which is now common policy in the UK Research Councils; driven thinking around the role of IP and outputs and inputs of research funding. The Trust works with government and other funders to shape and lead policy, for example, in open access and bringing the patient voice to the table.

In terms of working with other Foundations, the Trust is part of the Hague group of European Foundations and does have discussions with them on common themes. In the past, they have had conversations with the Novo Nordisk and Carlsberg Foundations. Most recently they have been in discussion with the Novo Nordisk Foundation on data science skills.

Lessons for Denmark from the Wellcome Trust

- While each Foundation is very different and its way of working is dependent on its mission and charter, the Wellcome Trust appears nimble among the Foundations and Charities in terms of how it builds its strategy and the flexibility of its funding modes.

- The Trust actively engages with a wide range of stakeholders to set its strategy and is, in fact, undergoing a consultation at present on its future priorities and mechanisms of funding.

- The Trust uses co-funding with other funders and government to shape the innovation ecosystem in the UK. This has led to significant capacity building

in areas of strategic importance and allowed a longer-term perspective than government alone can provide.

- The Trust plays an active role in driving policy and influencing thinking across government and other funders.

APPENDIX D: KEY CHARACTERISTICS OF SELECTED PEER COUNTRIES

Country	Strategic focus	Governance	Agency organisation	Funding models
Finland	Dual approach to foster cross-sectoral business ecosystem and SME growth. University-industry collaboration, digitalisation, various platforms (e.g. data), and intangible value creation are considered key enablers.	Top-down approach where the Prime Minister's Office, the Research and Innovation Council and ministries define broad priorities, in coordination with a limited number of agencies, public research organisations and think-tanks	A recent consolidation of agencies under the virtual Team Finland organisation. Business Finland (a merger between Tekes and Finpro) is the main innovation policy agency and covers RDI funding, export and FDI promotion.	Roughly half of all funding is assigned to thematic areas and programs. Academy of Finland provides grants for basic research, Business Finland provides grants, soft loans, matchmaking and internationalisation services.
Switzerland	Based on thinking that innovation is the task of industry, not the state, hence, limited state funding, mainly for public institutions in basic research and limited state intervention in the innovation process. Public sector provides training, connections with international markets, networking.	Bottom-up approach funded by business mainly. Government intervention is limited to providing funding for basic research and some networks.	Innosuisse is an independently run agency that has an external Board, an Innovation Board that cover renowned experts across different areas of innovation and is evaluated by the revision unit of the government regularly.	Majority of funding is private, most public funding is attributed to public research institutions for basic research. Funding of public-private projects is possible.

Country	Strategic focus	Governance	Agency organisation	Funding models
Netherlands	Be among the top five knowledge economies in the world by maintaining supportive frameworks for innovation and entrepreneurship. Threefold approach: (I) providing generic benefits for innovative industry (tax schemes); (II) stimulating the provision of risk capital (seed capital policy, Dutch Venture Initiative);(III) promoting public-private collaboration (top sector approach). Compared to the targeted approach of innovation policy, the approach of science policy is more bottom-up and horizontal, aiming for top-class science, global impact, close connections to society and being a breeding ground and harbour for talent. Collaboration is one of the key features of science policy, including collaboration between science and industry.	Consensus-based approach. Ministries define societal challenges and missions in close consultation with stakeholders. Research and innovation agendas defined by (triple-helix-based) top teams. A consensus-based approach is also taken in science policy, with consultations that involve universities, RTOs and industry, but also non-profit organisations and citizens. This led to a national research agenda (NWA) that contains a diverse set of 25 research areas ('routes') for scientific breakthroughs and solutions for society. Another example is the 'sector plans' in which universities coordinate their activities, partly by means of strengthening the (unique) profile of individual universities, and by increasing cooperation.	RVO (an agency of the Ministry of Economic Affairs) is the central 'gateway' for entrepreneurs. Research council NWO (an independent agency reporting to the Ministry of Education, Culture and Science) covers a large part of the funding of academic research. NFIA is responsible for FDI promotion.	NWO provides grants for basic research and combinations of basic research and applied research (by means of open and thematic calls and prizes). RVO provides business-oriented services and schemes (incl. vouchers, matchmaking, services in capital provision, etc.). The ministries provide lump-sum contributions to universities, RTOs etc.

Country	Strategic focus	Governance	Agency organisation	Funding models
UK	The 2017 UK Industrial Strategy calls for the UK to become the world's most innovative economy through an increase in R&D spend from 1.7% to 2.4% of GDP by 2027 Within that are (currently) 4 Grand Challenges: • AI & Data • Ageing Society • Clean Growth • Future Mobility and sector deals in aerospace, AI, automotive, construction, creative industries, life sciences, nuclear, offshore-wind and rail. https://www.gov.uk/government/publications/forging-our-future-industrial-strategy-the-story-so-far/forging-our-future-industrial-strategy-the-story-so-far	Top-down objectives and incentives with bottom-up delivery. The Government sets out its overall objectives and incentives, but universities as autonomous institutions develop their own individual delivery strategies. Business innovation is supported by grants and loans from InnovateUK and finance from the state-owned British Business Bank.	UKRI (UK Research and Innovation) brings together the research funding councils with Research England, both of which are Higher Education facing, and InnovateUK, which is business facing. The devolved administrations of Northern Ireland, Scotland and Wales have their own arrangements in place of Research England. The state-owned British Business Bank increases access to funding for SMEs up to £25m revenue as a fund of funds for financial institutions.	Research funding is based on the Haldane Principal that research funding should be allocated by researchers not politicians. Knowledge Exchange in universities is funded from Research England by the £250m p.a. Higher Education Innovation Fund. Universities are rewarded for impact through the Research Excellence Framework £1Bn "QR" funding stream Need to add the Industrial Challenge Fund here where money to UKRI was assigned to fund priority areas of the industrial strategy

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Denmark is among Europe's innovation leaders, with a strong science base, high overall investments in R&D activities, and particular strengths in a range of fields. While this position is under no immediate threat, this review finds Denmark failing to fully leverage its strengths and to adjust to a changing global innovation landscape. The review recommends a number of specific changes – evolving the role of particular parts of the Danish innovation system, enhancing the coordination across them, and adding particular new features. More importantly, however, the review suggests a broad-based effort to create an overarching Danish innovation strategy, and an institutional architecture to underpin it. The lack of such an integrating structure has left the Danish system perform below its potential, despite good or even excellent performance in individual parts. Filling this gap promises significant rewards but will take strong political will beyond one ministry.

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