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Christoph Grimpe

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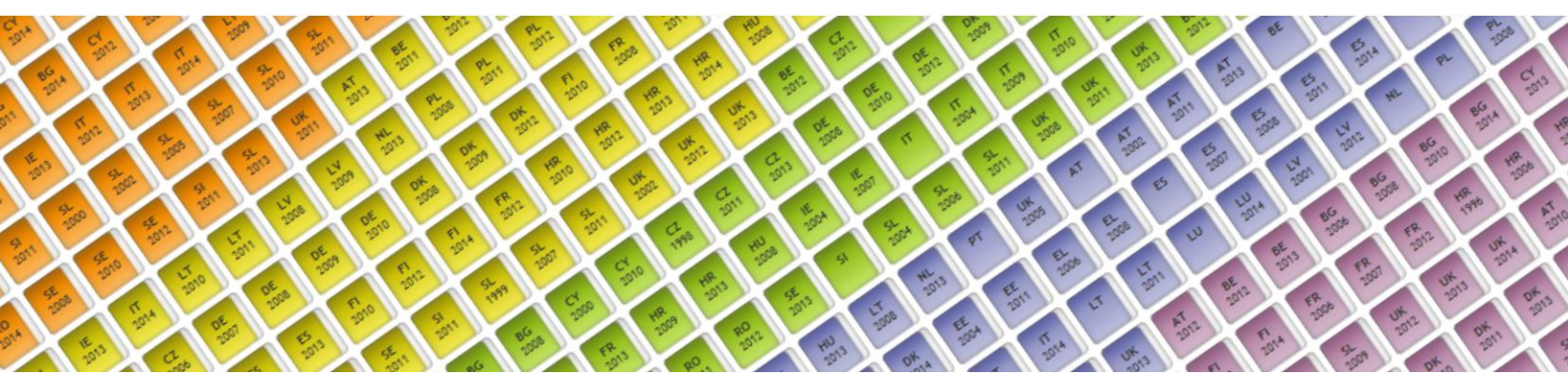

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Abstract

The report offers an analysis of the R&I system in Denmark for 2014, including relevant policies and funding, with particular focus on topics critical for two EU policies: the European Research Area and the Innovation Union. The report was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites etc. The report identifies the structural challenges of the Danish research and innovation system and assesses the match between the national priorities and those challenges, highlighting the latest policy developments, their dynamics and impact in the overall national context.

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Executive summary

This country report examines the research and innovation (R&I) system of Denmark and provides an up to date overview of the actors, institutions, and policies, including the funding of R&I. The report was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites, etc. The quantitative and qualitative data is, whenever possible, comparable across all EU Member State reports. In that regard, the report examines developments towards some topics central to two EU policies – the European Research Area and the Innovation Union.

The Danish R&I system has frequently been characterised as an excellent example of a well-performing R&I system. The country possesses a strong international position in most science, technology and innovation (STI) indicators. Considerable emphasis is placed on the education system with excellent higher education and research. Both the private and the public sector are committed to invest into education, research and innovation at a level necessary to maintain its current highly competitive position. Moreover, STI in Denmark are supported by a strong culture for innovation that reflects the country's open and dynamic welfare society. Denmark meets the national investment targets of 3% of GDP spent on R&D with two-thirds coming from the business sector. GERD reached 3.07% of GDP in 2009 and 3.06% in 2013. BERD contributed with about two thirds of this.

In 2013, the Danish Government has launched Denmark's first comprehensive innovation strategy 'Denmark – a nation of solutions' based on collaborative efforts between the involved ministries, i.e. the Ministry of Science, Technology and Higher Education (now the Ministry of Higher Education and Science), the Ministry of Business and Growth and other relevant sectoral ministries, as well as stakeholders from the Danish innovation system. The innovation strategy is the outcome of a strategy process that started in March 2012 and was completed by the end of 2012. The process involved an extensive consultation with relevant stakeholders and actors in the innovation system. The innovation strategy has been implemented during 2013 and has since then been guiding STI policy making.

In April 2014 the Innovation Fund Denmark ('Innovationsfonden') was established by joining research, technology development and innovation grants from the Danish Council of Strategic Research, the Danish National Advanced Technology Foundation and the Danish Council for Technology and Innovation into one new focused organisation. With an annual budget of approximately €200m, the Fund provides risk thematic funding for cooperation and innovation.

Denmark contributes strongly to the progress towards the realisation of ERA. Denmark is actively cooperating with other Nordic countries in joint programmes and institutions within the Nordic Council of Ministers as well as in a number of ERA related cooperative actions. The scientific labour market enjoys high flexibility to encourage mobility and provides attractive working conditions. The optimal circulation and access to scientific knowledge is fostered by the appropriate infrastructures and open access policy.

Denmark also actively contributes towards the realisation of the Innovation Union. The basis for this is laid out in the innovation strategy and the INNO+ catalogue which describes the co-evolution of supply and demand-side policies and instruments. The innovation strategy also provides the framework for knowledge transfer between science

and industry and for open innovation. Within this framework, public-private collaboration occurs mainly between firms and the eight Danish universities as well as the nine GTS institutes ('Godkendte Teknologiske Serviceinstitutter' – Advanced Technology Group). While the universities are the main research performers and major collaboration partners, the GTS institutes are the main providers of commissioned R&D for the private sector. The universities' income from commercialisation efforts remains relatively low compared to the GTS institutes and it has been fluctuating over the last couple of years.

In terms of its performance, the structural challenges of the R&I system pertain mainly to four aspects. First, although among the peak performers in Europe, Denmark still has a lower R&D intensity in the business sector than similar knowledge-intensive countries like Sweden and Finland. One explanation is a shortage of capital. Another explanation is the increased relocation of business R&D activities to countries with a lower level of salaries. Moreover, since the Danish market is small, relocation moves R&D also typically closer to the international markets of the respective companies. Second, Denmark has a comparatively low share of highly skilled labour in the private sector. While Denmark has increased the intake of new students into higher education, Denmark faces a growing challenge to ensure that more students and graduates will seek private sector employment. Moreover, students have to be encouraged to move more rapidly into and through tertiary education. Third, commercial cooperation between public science and the business sector could be improved. Denmark is at a lower level than the reference countries in the Innovation Union Scoreboard measured in terms of private funding of public research. There is a strong tradition for research collaboration between public research and private enterprises but limited private funding of public research activities. This is primarily due to the division of labour with the GTS system, which provides commissioned R&D services for the business sector that in other countries is provided by public research organisations. This is related to the fourth aspect, namely the rather weak commercialisation of public research results. However, the share of patent applications being exploited (through licenses, options, assignments and spinouts) has increased in recent years, as universities have become more professional and selective in regard to patenting, and international patent data suggest that Danish universities have become among the most active in Europe utilising the EPO system.

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1. Overview of the R&I system

1.1 Denmark in the European RDI landscape

Despite being small – Denmark has only 5.6m inhabitants – Denmark has generally been characterised as an excellent example of a well-performing research and innovation (R&I) system (e.g., European Commission, 2014a, 2014b). Denmark is one of the innovation leaders with above average performance according to the Innovation Union Scoreboard 2014, being grouped together with the peak performers Sweden, Germany and Finland. The country possesses a strong international position in most science, technology and innovation (STI) indicators (European Commission, 2014b). Considerable emphasis is placed on the education system with excellent higher education and research. Both the private and the public sector are committed to invest into education, research and innovation at a level necessary to maintain its current highly competitive position. Moreover, STI in Denmark are supported by a strong culture for innovation that reflects the country's open and dynamic welfare society. Despite this generally positive assessment, the Danish R&I system also exhibits several weaknesses, particularly regarding innovation outputs, that will be further elaborated upon throughout the report.

In 2013, Denmark's GDP reached €253bn[1], a steady increase over the past but a decrease of 0.5% compared to 2012.[2] GDP per capital reached €45,100. Denmark's gross domestic expenditure on R&D (GERD) reached 3.06% of GDP after 3.02% in 2012, well above the average for the EU-28 of 2.01% and above the 3% target set by the Danish Government. Business enterprise R&D expenditure (BERD), which decreased to 1.97% of GDP in 2010 after 2.14% in 2009 as a result of the global economic crisis, increased slightly to 2.00% in 2013. BERD contributed with about two thirds to GERD. The main public research performers are concentrated in the university system, performing 32% of the total R&D in 2013.[3]

1.2. Main features of the R&I system

Since the business sector contributes two thirds to GERD, the Danish R&D system can be said to be dominated by funding through the business sector. Nevertheless, the Danish Government is very active in promoting research and innovation which is reflected in a well-established and centrally organized funding infrastructure.

The Danish economy has a specialisation profile characterised by a mixture of low-technology industries such as food, furniture, textiles and toys (Kallerud, 2008) and more knowledge-intensive service areas, such as software consultancy or supply and engineering consultancy. The manufacture of pharmaceuticals and medical chemicals as well as software consultancy and supply are the largest sectors regarding intramural R&D expenditures. It is important to mention developments in the manufacturing industry, especially the R&D expenditure by high-tech and low-tech enterprises. Between 2001 and 2006 Denmark increased the knowledge-intensity in both high-tech/medium high-tech and

[1] Throughout the report, an exchange rate of 100 DKK = 13.43 EUR was used.

[2] For trend data covering the reference period see Table 2.

[3] Throughout the report, all figures – if not otherwise noted – were retrieved from Eurostat on March 30 and 31, 2015.

medium and low-tech sectors. 'Denmark shows changes in its economic structure with an increasing weight of the high-tech sector electrical machinery. However, a decreasing knowledge-intensity in more traditional sectors of the Danish economy, such as food products or machinery & equipment, should be noticed as well as the decreasing weight of many of the high and medium-high tech sectors (particularly noticeable for the Radio, TV and communication equipment sector)' (European Commission, 2011: 4).

The technical specialisation of Denmark as measured by patent specialisation is changing. When analysing patent applications to the EPO by priority year and by IPC sections it becomes clear that some technology fields have gained more attention, such as mechanical engineering and here especially machines or engines for liquids, wind, spring, weight, or miscellaneous motors; and electricity, and here especially generation, conversion, or distribution of electric power and electric communication techniques. This trend shows Danish activities in the field of wind energy technology, smart grid, energy efficiency and related technologies. Patent specialisation in the field of human necessities is still the most important technology field, but its importance is decreasing. Only the fields of medical or veterinary science and hygiene keep their position at the same level.

Compared with the world average, Danish scientific publications are highly specialised in clinical medicine, biomedicine and agriculture (Schneider, 2010). Denmark has a lower scientific specialisation in chemistry, material science, physics, mathematics, ICT and engineering, and Denmark is close to world average in geosciences and social sciences. In terms of scientific impact, Danish publications perform above average on a number of research fields, when it comes to citation impact. Citations are indicators of how researchers receive and use research from fellow researchers and are internationally often used as a proxy for research quality. It is especially within the subject fields of physics and mathematics, agriculture, fisheries and forestry and biology that the Danish research performance is extraordinary high, around 50% or higher above world average. But also within chemistry, engineering and materials science, geosciences and health sciences do Danish researchers perform well, around 40% above world average (Piro, 2014).

1.3. Structure of the national research and innovation system and its governance

The main responsibility for research and innovation is placed within the authority of the Ministry of Higher Education and Science. The Ministry of Business and Growth has certain tasks related to business development, and several sectorial ministries – the Ministry of Climate, Energy and Building, the Ministry of Food, Agriculture and Fisheries, the Ministry of Environment and the Ministry of Foreign Affairs – have larger RD&D programmes. The ministries have specific agencies which implement the respective policies. Regions do not play a decisive role in the R&D governance process. The main research performers in the public sector are the eight universities: Copenhagen University, Aarhus University, the Technical University of Denmark, the University of Southern Denmark, Aalborg University, Roskilde University, Copenhagen Business School and the IT University. The universities are organised under their own stakeholder organisation, Universities Denmark. The nine GTS institutes ('Godkendte Teknologiske Serviceinstitutter') – Advanced Technology Group are non-profit R&D organisations and the main collaboration partners of the private sector. They are under the auspices of the Ministry of Higher Education and Science. Other central players in relation to ensuring a solid foundation for Danish research and innovation are

several of the Danish hospitals, the three national laboratories and the nine independent academies of professional higher education.

The funding system is composed of several actors, such as the Danish National Research Foundation ('Danmarks Grundforskningsfond'), the Danish Council for Independent Research ('Det Frie Forskningsråd'), and the newly established Innovation Fund Denmark ('Innovationsfonden'). The Danish National Research Foundation provides primarily funding through a center of excellence approach. Funding is non-thematic and only oriented towards scientific excellence. In 2013, the Foundation handed out grants in the order of €56m, representing about 13% of the total funding that the funding bodies handed out. The Danish Council for Independent Research handed out (generic) grants amounting to €160m in 2013, representing 38% of the institutions' funding. The Innovation Fund Denmark was established in April 2014 by joining research, technology development and innovation grants from the Danish Council of Strategic Research ('Det Strategiske Forskningsråd'), the Danish Council for Technology and Innovation ('Rådet for Teknologi og Innovation') and the Danish National Advanced Technology Foundation ('Højteknologifonden'). The grants handed out by these institutions amounted to about €200m in 2013 (DASTI, 2014b). The reorganisation follows a recommendation made in the course of the ERAC peer review (European Commission, 2012). Overall, the Innovation Fund is intended to facilitate the development of knowledge and technology, including advanced technology, in order to foster growth and employment in Denmark. With an annual budget of approximately €200m, the Fund provides risk thematic funding for cooperation and innovation. Besides this reorganization, the government has reviewed the overall organisation of research under the auspices of the Danish National Research Foundation and the Danish Council for Independent Research, following international evaluations of the two bodies in 2013 and 2014. The conclusion of the evaluations and the political discussion is that the two bodies are well functioning and no major restructuring will be pushed through.

Another major change concerns the establishment of a new independent council in April 2014 called the Danish Council for Research and Innovation Policy (DFIR, 'Danmarks Forsknings- og Innovationspolitiske Råd'). The council is to promote the development of Danish research, technology development and innovation for the benefit of society as a whole. The Council is responsible for providing the Minister for Higher Education and Science with high level, independent advice on research and innovation including future needs and is responsible for ensuring that the advice incorporates relevant national and international experience and developments. A majority of the Council members including the chairperson must be recognised researchers or research experts. The DFIR replaces the Danish Council for Research Policy (DFR) and the policy advice function from the Council for Technology and Innovation.

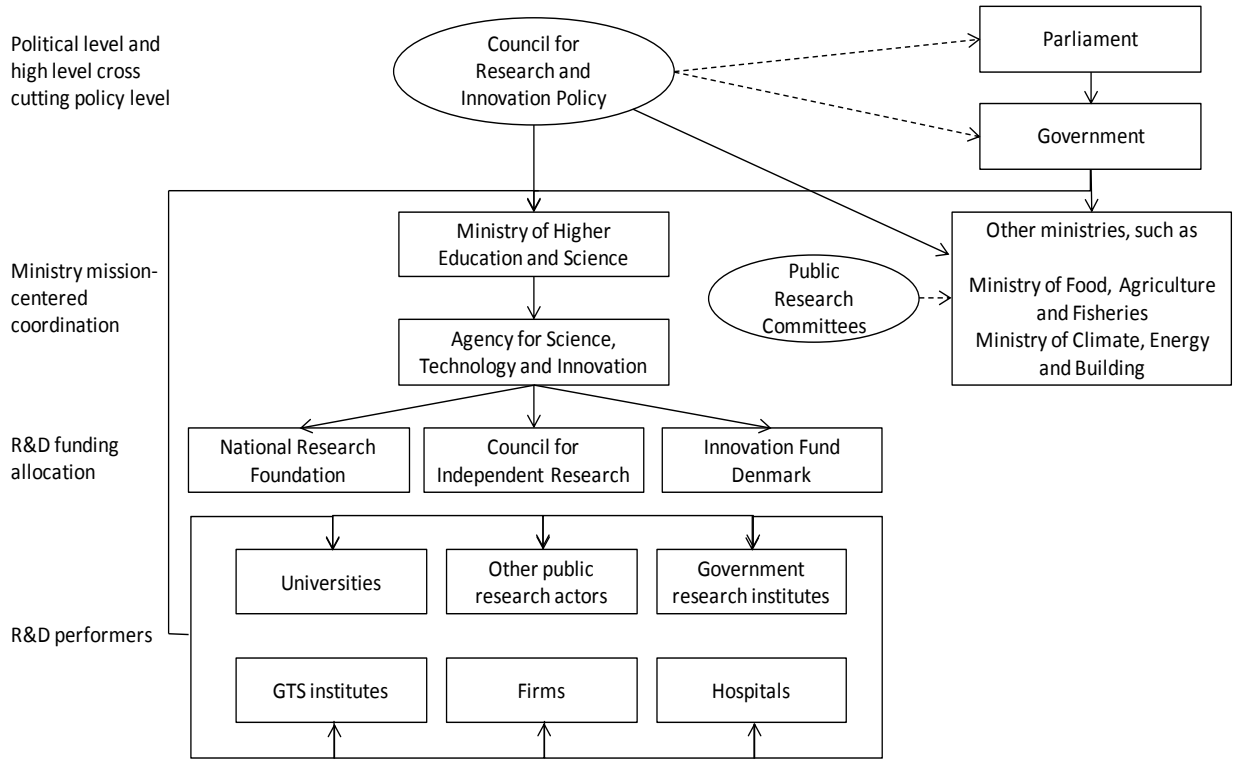
The changes introduced in 2014 have led to a streamlined, yet augmented R&I system which puts considerably higher focus on innovation funding and implementation which can be expected to provide stimuli for growth and employment. Table 1 gives an overview of the changes in the R&I system that had occurred since 2010. Most of the more substantial changes occurred only recently in 2013 and 2014. The changes relating to the new innovation strategy, the INNO+ catalogue and the RESEARCH2020 initiative will be detailed in the following sections.

Table 1: Overview of main changes in the R&I system

Main changes in 2014
Establishment of the Innovation Fund Denmark Establishment of the Danish Council for Research and Innovation Policy
Main Changes in 2013
Re-introduction of an R&D tax credit Launch of innovation strategy 'Denmark – a nation of solutions' INNO+ catalogue identifying priority areas for R&I
Main changes in 2012
Launch of the RESEARCH2020 initiative
Main changes in 2011
None
Main Changes in 2010
Establishment of the Business Innovation Fund (now Market Development Fund)

The structure of the Danish R&I system and details the interrelationships between the different levels of analysis is outlined below (Figure 1).

Figure 1: Organogram of the Danish R&I system



Source: Ministry of Higher Education and Science (2014), www.ufm.dk

2. Recent Developments in Research and Innovation Policy and systems

2.1 National economic and political context

Since February 2014, the government has consisted of members of the Social Democrat ('Socialdemokraterne') and the Social Liberal ('Radikale Venstre') Parties, following the exit of the Socialist People's Party ('Socialistisk Folkeparti') that had been part of the government since the elections in 2011. The main responsibility for research and innovation is placed within the authority of the Ministry of Higher Education and Science, currently headed by the minister Sofie Carsten Nielsen. The Ministry of Business and Growth has certain tasks related to business development, and several sectoral ministries – the Ministry of Climate, Energy and Building, the Ministry of Food, Agriculture and Fisheries, the Ministry of Environment and the Ministry of Foreign Affairs – have larger RD&D programmes. The ministries have specific agencies which implement the respective policies. Regions do not play a decisive role in the R&D governance process. The main research performers in the public sector are the eight universities. The nine GTS institutes ('Godkendte Teknologiske Serviceinstitutter') – Advanced Technology Group are non-profit R&D organisations and the main collaboration partners of the private sector. They are under the auspices of the Ministry of Higher Education and Science. Other central players in relation to ensuring a solid foundation for Danish research and innovation are several of the Danish hospitals, the three national laboratories and the nine independent academies of professional higher education

The global economic crisis affected Denmark considerably. The Danish government expects the economy to enter a relatively long period during which the economic situation is gradually normalized (Danish Government, 2014a). In 2013, the real GDP growth rate was -0.5% (after -0.7% in 2012), compared to 0.0% for the EU-28. From 2013 the government expects growth to become more self-sustaining with the largest contributions stemming from private consumption and business investment, both have been relatively low for a long period, as well as exports. In 2014, GDP growth has reached 1.0% and is expected to reach 2% in 2015 (Danish Government, 2014a). At the same time, the structural balance is expected to improve from a deficit of 1.5% of GDP in 2010 to balance by 2020. Due to the improvements, the EU ended its disciplinary budget action against Denmark in June 2014 after it met the Commission's 2010 recommendations. In 2013, Denmark posted a deficit of 0.9%, well below the mark of 3% of GDP.

As a consequence of the crisis, research and development (R&D) expenditures were also affected. GERD (in % of GDP) decreased from 3.07% in 2009 to 2.94% in 2010 and increased again to 3.06% in 2013 while BERD (in % of GERD) decreased from 70% in 2009 to 66% in 2013. Nevertheless, Denmark has achieved and sustained the target of investing 3% of GDP into R&D. Since 2011, BERD has stabilised at about 2% of GDP. The public research investments have generally increased since 2005 and are at a relatively high level in comparison with other countries. The government budget appropriations or outlays on R&D (GBAORD) have continuously increased from 0.7% in 2005 to 1.03% in 2013.

2.2 National R&I strategies and policies

In 2013, the Danish Government launched Denmark's first comprehensive innovation strategy based on collaborative efforts between the involved ministries, i.e. the Ministry of Science, Technology and Higher Education (now the Ministry of Higher Education and Science), the Ministry of Business and Growth and other relevant sectoral ministries, as well as stakeholders from the Danish innovation system. The innovation strategy is the outcome of a strategy process that started in March 2012 and was completed by the end of 2012 (Danish Government, 2012c). The process involved an extensive consultation with relevant stakeholders and actors in the innovation system.

The vision of the new innovation strategy is that Denmark should become a nation of solutions, in which innovative solutions for the grand societal challenges are converted into growth and employment (Danish Government, 2012e). With the new innovation strategy, the Danish government sets a focus on three areas:

- Innovation driven by societal challenges: Demand for solutions to concrete societal challenges must be given higher priority in public innovation policy;
- More knowledge translated to value: Focus on mutual knowledge exchange between companies and knowledge institutions and more efficient innovation schemes;
- Education as a means to increase knowledge capacity: A change of culture in the education system with more focus on innovation.

Within these focus areas, 27 individual policy initiatives are defined that the government has implemented in 2013. In order to measure the effectiveness of the innovation strategy, the Danish government translates the vision of the innovation strategy into the following STI policy goals:

- The share of companies introducing innovation should be increased, such that Denmark by 2020 is among the five European OECD countries with the highest share of innovative enterprises;
- Private investments into R&D should be increased, such that Denmark by 2020 is among the five OECD countries with the highest private investments into R&D as a share of GDP;
- The share of highly educated employees in the private sector should be increased, such that Denmark by 2020 is among the five European OECD countries with the highest shares of highly educated employees in the private sector.

It is worth noting that the research policy goals set out in the innovation strategy aim at a 'moving target' in the sense that the goals are oriented towards the 'best in class' in terms of innovation performance.

The innovation strategy presents an ambitious vision for the integration of innovation and entrepreneurial skills in courses and programmes throughout the Danish education system. The purpose is twofold: first, to ensure that the future Danish workforce has the competences required in a context where companies' competitiveness increasingly depends on their ability to be innovative; second, to ensure that students, also while they are studying, are being viewed as a resource that can benefit society and companies with their skills and knowledge. Among key initiatives, the strategy aims to extend practical elements to all educational programmes on all levels, e.g. in the form of internships, theses written

in collaboration with companies etc. Moreover, the strategy seeks to strengthen innovation and vocational skills among talents on higher education programmes, including PhDs.

INNO+: The Innovative Denmark

In connection with the new innovation strategy the Danish Government has started a process that led to the creation of the first INNO+ catalogue presented in September 2013 (Danish Government, 2013). Based on the involvement of a multitude of actors from the innovation system and made in arm's length to the politicians, INNO+ identifies 21 concrete focus areas for research and innovation that are geared towards finding solutions to the grand societal challenges. The thematic focus is on transportation, environment, urban development, food, bio-economy, health, production, digital solutions and energy. In that regard, INNO+ shares many of the main areas of the EU Framework Programme Horizon 2020. In 2013 the Parliament used the catalogue in the negotiations on the Budget Bill for prioritisation of five societal partnerships on innovation:

- Blue jobs via green solutions
  Intelligent, sustainable and efficient plant production
- Denmark as preferred country for early clinical testing and new medicines
- Water-efficient industrial production
- Innovatorium for building renovation of world class standard

In 2014 two new priority areas were added:

- Advanced materials as a basis for growth and the solution of societal challenges
- A smart society based on the exploitation of 'big data'

Funding for the partnerships will be allocated from Innovation Fund Denmark. Public authorities will contribute with knowledge and regulation.

INNO+ complements the previously introduced RESEARCH2020 initiative in that the catalogue focuses on the innovation policy that results from many of the same societal challenges and Danish strongholds in academia and industry that are outlined in RESEARCH2020. The RESEARCH2020 catalogue which was based on the involvement of a multitude of actors from the research system and made in arm's length to the politicians was published in June 2012 and contains a presentation of five visions for Danish strategic investments in research (Danish Government, 2012d):

- *A society with a green economy*

This vision is intended to push Denmark to adopt a green agenda as a cross-cutting theme through many different policy fields. Research is aimed at finding technological and knowledge-based answers to global challenges that ideally should contribute towards growth, welfare and employment in Denmark. Moreover, research should be able to contribute towards an efficient, competitive, and sustainable and health-promoting production of food and other biological products. Tackling the challenges of climate change and increasing competition for limited global resources is another priority within this vision.

- *A society with health and quality of life*

The vision is to create a society focused on health and the quality of life that is characterised by cost-effective healthcare and a health care sector that is oriented towards the individual citizen. Research should therefore be geared towards a fulfilment of these objectives. This is partly done by creating a connection between basic biological and medical research and the clinical research in order to more rapidly find targeted solutions to treatments. And partly it is done by developing innovative and citizen-centred welfare-technological and organisational solutions

- *A high-tech society with innovation capacity*

The vision is to develop Denmark into a high-tech society that develops knowledge, technologies and competences in order to secure long-term economic competitiveness. Research should therefore be directed towards exploring strategic growth technologies – such as the Key Enabling Technologies – as well as future production systems and new digital solutions. Being at the technological forefront has frequently been characterised as a cornerstone to competitive advantage.

- *An efficient and competitive society*

This vision is about creating an efficient and competitive societal organisation that is characterised by good resource utilisation, high productivity and strong competitiveness. Research should in this regard primarily be targeted towards preventing cost-intensive diseases and social problem, as well as strengthening productivity development and competitiveness. Such research should enable a high quality of life for the citizens while at the same time ensuring that more people remain in the labour market. Moreover, research should aim at allowing safe and efficient mobility for people and goods and the development of an attractive infrastructure.

- *A competent, cohesive society*

The last vision focuses on the level of education and competence of the individual citizen which should generally be raised in order to make use of the opportunities that the globalisation provides to Denmark. Research efforts should therefore be directed towards a well-functioning education system that holds opportunities for everybody to get involved as a citizen in a globalised world and that allows the acquisition of relevant competences and qualifications. The vision also aims at strengthening cultural understanding and cross-cultural competences so that businesses and society in general will be prepared to make proactive use of globalisation.

The RESEARCH2020-cataloque has been used to prioritise strategic research investments on the Budget Bills of 2013, 2014 and 2015. Most of the funding has been allocated for research within the vision of a society with a green economy.

2.3 National Reform Programmes 2013 and 2014

In the National Reform Programme, the Danish government has specified a target of investing 3% of the GDP in R&D. Moreover, at least 1% of GDP should be publicly financed research. The innovation strategy 'Denmark – a nation of solutions' also formulates the objective that Denmark should be among the five OECD countries in which private businesses invest most into R&D as a share of the GDP. Similarly, the share of innovative enterprises and the number of persons with a higher education employed in the private

sector should be among the top five European OECD countries by the year 2020 (Danish Government, 2014a).

As outlined before, Denmark has achieved the 3% target, and publicly financed R&D amounts to slightly more than 1%. In 2013 and 2014, the Danish Government has focused on implementing the innovation strategy, including the reform of the research funding infrastructure with the establishment of the Innovation Fund Denmark as described before. Further implemented and agreed measures include a simplification package in order to reduce the variety of funding programs and the administrative burden, a program promoting younger women for a university career, the establishment of a forum on Arctic research, the establishment of three new innovation centres in São Paolo (Brazil), Seoul (South Korea) and New Delhi/Bangalore (India). To further support research and innovation in the private sector, the INNO+ catalogue with the five societal partnerships has been formulated, efforts to strengthen clusters and networking activities have been made, the upper limit of the R&D tax credit has been increased from about €670,000 to €3.3m, a Strategic Platform for Research and Innovation (SPIR) in the area of production systems has been funded, growth plans have been devised, and the Market Development Fund (formerly the Business Innovation Fund) has been agreed to continue in the period from 2013 to 2015. Planned measures include the development of several new support instruments in connection with the Innovation Fund Denmark (Danish Government, 2014a).

2.4 Policy developments related to Council Country Specific Recommendations

There are no council country specific recommendations on research and development for Denmark.

2.5 Funding trends

2.5.1 Funding flows

Denmark meets the national investment targets of 3% of GDP spent on R&D with two-thirds coming from the business sector. GERD reached 3.07% of GDP in 2009 and 3.06% in 2013. BERD contributed with about two thirds of this. The table below gives an overview of key research and innovation funding figures. The figures suggest that the financial and economic crisis had a profound impact on the Danish economy. GDP decreased in 2012 and 2013 after two years of meagre growth. In the business sector the intramural R&D expenditure of the business sector (BERD) as a share of the GDP decreased from 2.14% in 2009 to 2.00% in 2013.

The budget bill for 2014, there have been notable increases in funding for Danish organisations working on innovation, such as for the Innovation Fund Denmark and the funding of energy research, development and demonstration under the Ministry of Climate and Energy. Examples of sectorial funding are the Energy development and demonstration programme, the GreenLab.dk programme and the Green development and demonstration programme.

The Structural Funds (SF), both the European Regional Development Fund (ERDF) and the European Social Fund (ESF), will be deployed only where there is a lack of national funding, and where such intervention is crucial to improving regional competitiveness. In the period

2007-2013 Denmark allocated €613m, a clear decrease compared to the previous programme period. Basic research activities will not receive financial support from the SF. However, SF investments will support the improvement of transfer of knowledge. The focus is primarily on the interaction between research and innovation.

There is no support foreseen for international collaboration between research institutions or for large research infrastructure. Denmark has launched two operational programmes: 'Innovation and Knowledge', which will receive €255 million from the European Regional Development Fund, and, 'More and Better Jobs', which will receive about €255m from the European Social Fund. The funding from the ERDF will be matched by the same amount from the Danish government (Klitkou, 2012).

Table 2: Basic indicators for R&D investments*

	2009	**2010**	**2011**	**2012**	**2013**	**EU28 (2013)**
GDP growth rate	-5.1	1.6	1.2	-0.7	-0.5	0.0
GERD (% of GDP)	3.07	2.94	2.97	3.02	3.06(ep)	2.01
GERD (euro per capita)	1,282.0	1,281.6	1,312.7	1,358.5	1,379.8(ep)	536.0
GBAORD - Total R&D appropriations (€ million)	2,199.82	2,286.36	2,458.89	2,517.23	2,612.14	92,094.21
R&D funded by Business Enterprise Sector (% of GDP)	1.91	1.79	1.81	1.81(e)	1.83(ep)	1.10(e) (2012)
R&D funded by Private non-profit	0.1	0.1	0.11	0.11(e)	0.12(ep)	0.03(e) (2012)
R&D funded from abroad	0.26	0.21	0.21	0.22(e)	0.22(ep)	0.19(e) (2012)
R&D performed by HEIs (% of GERD)	28	30	32	32	32	23.6 (2012)
R&D performed by Government Sector (% of GERD)	2	2	2	2	2	12.2 (2012)
R&D performed by Business Enterprise Sector (% of GERD)	70	67	66	66	66	63.3 (2012)
Share of competitive vs. institutional public funding for R&D	n/a	n/a	n/a	41 vs. 59	n/a	n/a
Employment in high- and medium-high-technology manufacturing sectors as share of total employment	5.0	5.2	5.4	5.1	5.0	5.6
Employment in knowledge-intensive service sectors as share of total employment	48.3	49.6	49.3	49.2	49.3	39.2
Data available for the years	**2004**	**2006**	**2008**	**2010**		
Turnover from Innovation as % of total turnover	13.8	15.9	15.9	15.0		13.4% (EU-27, 2010)

(e) estimate, (p) provisional

Danish partners were involved in 1,121 (2042) projects funded by FP6 (FP7). The financial contribution to Danish partners equalled €381m in FP6 and €1.1bn in FP7, indicating strong growth in the participation in the Framework Programme. In terms of Structural Funds, Denmark received €104m in the period from 2007 to 2012.[4] In 2012, Denmark received €2.9bn in FDI inflows after €12.7bn in 2011. No information on R&D related FDI inflows are available.

2.5.2 Project vs. institutional allocation of public funding

Institutional funding

The main share of government funding is traditionally channelled via institutional funding of universities: In 2014, 58% of GBAORD were allocated to universities as so-called basic funds ('basismidler') while the remainder were handed out on a competitive basis ('konkurrenceudsatte midler'). The most important competitive funding instruments are managed by the Danish Council for Independent Research (DCIR), the Danish National Research Foundation and the Innovation Fund Denmark (DASTI, 2014b). Expert evaluations and international peer review standards are applied according to the six principles formulated at the 'The May 2012 Global Summit on Scientific Merit Review'.[5]

In June 2009 a political agreement was reached on a distribution model of core funding to universities. The model is a modification of the former model, which covered indicators for education, external funding and PhD graduates. The model also includes bibliometric indicators and was introduced stepwise over the period 2010-2012. In 2013 it was agreed to continue the distribution model for five more years. The principles for the bibliometric indicator are summarised in a report published by the DASTI in October 2009. The most recent results for the bibliometric indicators are published on DASTI.

Project funding

Bottom-up project funding is either transferred to the universities directly or channelled through the Danish Council for Independent Research. The Danish Council for Independent Research consists of five area-specific research councils, a group of chairmen from each of the five research councils and a board of directors. The Danish Council for Independent Research supports research projects (competitive funding) based on the research initiatives of the researchers themselves. The main source of funding is the Ministry of Higher Education and Science.

The five area-specific research councils are:

- The Danish Council for Independent Research | Humanities;
- The Danish Council for Independent Research | Natural Sciences;
- The Danish Council for Independent Research | Social Sciences;

[4] The data on structural funds (RIO elaboration of DG REGIO data) is low in comparison to data reported elsewhere such as last year's country report. One of the explanations for this difference is the definition adopted. The data presented here refers to Core RTD (See Annex for categories included), whereas the information provided elsewhere adopts a broader definition of RTDI and linked activities. In addition the data reported here refers to ERDF funding only and does not include cohesion funds.

[5] See http://ufm.dk/forskning-og-innovation/rad-og-udvalg/det-strategiske-forskningsrad/for-ansogere/om-peer-review?searchterm=peer%0A%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20%20review

- The Danish Council for Independent Research | Medical Sciences;
- The Danish Council for Independent Research | Technology and Production Sciences.

Project funding is also provided by research programmes, such as the programmes managed mainly by the Innovation Fund Denmark, the Energy technology, development and demonstration programme (EDDP, launched in 2008) under the Ministry of Climate, Energy and Building, and the Green Development and Demonstration Programme (GDDP) under the Ministry of Food, Agriculture and Fisheries (launched in December 2009). The Innovation Fund Denmark finances research based on politically defined programmes. Programme committees allocate funding. Thematic priorities are:

- Sustainable Energy and Environment;
- Individuals, Disease and Society;
- Health, Food and Welfare;
- Strategic Growth Technologies;
- Transport and Infrastructure ;
- Peace and Conflict;

The research activities are carried out in public-private collaboration and with the involvement of end-users and international researchers.

Other allocation mechanism

Societal partnerships: Funding for collaboration between private sector enterprises, public sector research institutions and authorities on developing new innovative solutions in response to specific societal challenges. Societal partnerships may include elements of research, development and commercialisation. The Innovation Fund Denmark has financed four societal partnerships in 2014. The partnerships are the following:

- Blue jobs via green solutions
- Intelligent, sustainable and efficient plant production
- Denmark as the preferred country for early clinical testing of new medicines
- Water-efficient industrial production

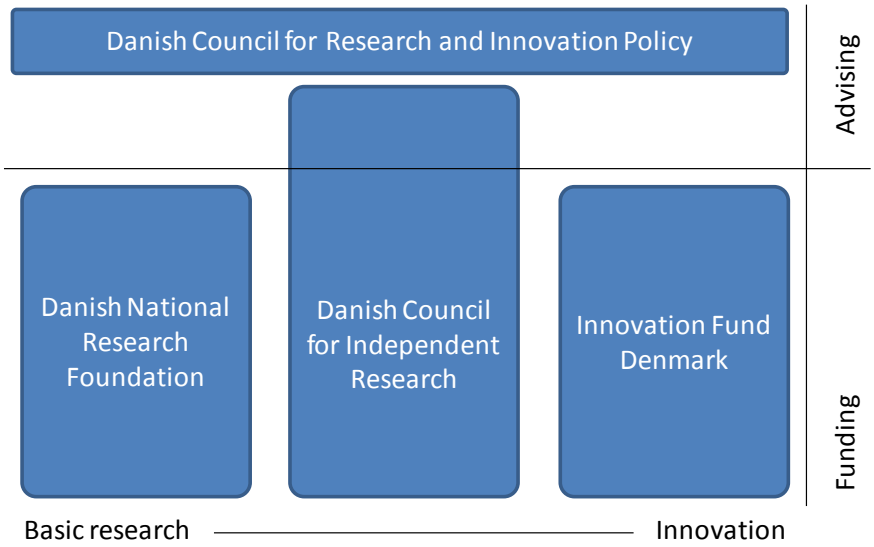
Assessment

The current balance of project and institutional funding seems appropriate since the Danish Government has introduced several recent reforms to make funding allocation more competitive.

2.5.3 R&I funding

With the reorganisation of the research council system in Denmark in April 2014, funding for basic research, development and innovation has been allocated to three institutions: the Danish National Research Foundation ('Danmarks Grundforskningsfond'), the Danish Council for Independent Research ('Det Frie Forskningsråd'), and the Innovation Fund Denmark ('Danmarks Innovationsfond'). Figure 2 gives an overview of the current system.

Figure 2: The research council system in Denmark



Source: Ministry of Higher Education and Science (2014), www.ufm.dk

The figure shows that basic research is funded by the National Research Foundation while Innovation is funded by the Innovation Fund. The Danish Council for Independent Research funds projects oriented to both more basic and more applied research. The latter council together with the Danish Council for Research and Innovation Policy ('Danmarks Forsknings- og Innovationspolitiske Råd') also provide advisory services to STI policy.

Government direct versus indirect R&D funding

The ministry with the highest share of R&D funding is the Ministry of Higher Education and Science. The Danish Council for Independent Research is responsible for researcher-driven research. This council funds research based in a responsive mode (without predefined focus, thematic areas or policy-related goals). The Innovation Fund Denmark administers strategic research programmes in areas of political priority. It funds research projects and gives advice to applicants. The Fund is also contributing to increased university-industry collaboration. Finally, there is the independent Danish National Research Foundation, which funds research of a high international standard. In May 2014, the government announced that it is planning to allocate about €400m to the National Research Foundation in the next growth package. The amount is intended to finance 10 additional centres of excellence until the years 2026/2027.

There are other special policy instruments, aside from general RD&I support, implemented and administered by the Innovation Fund Denmark which target R&D and innovation in SMEs, such as:

InnoBooster (including previous knowledge pilots/innovation vouchers):

Until August 2014 the knowledge pilot regulation was in effect. A grant could be given to SMEs with limited experiences in hiring highly educated employees to cover some of the salary of a new employee with a higher education and who was to execute a development or innovation project in the enterprise. The measure was to enhance the cooperation between SMEs and knowledge institutions and to increase the share of highly educated employees at SMEs. The enterprise could be given €1,333 a month for the salary of the new knowledge pilot, for a period of 6-12 months. The new Innovation Fund has taken over

this measure and integrated it into a new program called InnoBooster. InnoBooster now also includes a measure that was known as innovation voucher. The measure consisted of a 40% co-funding of development projects applied for by SMEs who wished to use the funding for knowledge acquisition from a public research organisation or a member of the GTS-network. It is an objective to expand the utilisation of collaboration with knowledge organisations to a wider group of the Danish SMEs and to raise the attention of SMEs of the opportunities within utilisation of the knowledge of public research and technology institutions. The voucher could fund a maximum amount of about €14,000. The schemes will be changed and further developed in 2015.

Market Development Fund (previously Business Innovation Fund):

A Business Innovation Fund of €100 million has been established in the period 2010-2012 with the aim of supporting innovation and market maturity within the green and welfare areas. The Fund has since then been converted into the Market Development Fund which helps firms bringing their new products to the market faster and which makes it easier for public-sector institutions to obtain innovative solutions. An amount of €20m is allocated for the Market Development Fund each year from 2013 up to and including 2015.

R&D tax credit:

In 2013, a new system came into force that features a tax credit on R&D expenditures. In 2014, the upper limit of the R&D tax credit has been increased from about €670,000 to €3.3m (Danish Government, 2014a).

2.6 Smart Specialisation (RIS3)

During the programming process Denmark justified the fulfilment of this ex ante conditionality by arguing that there is not a single combined Danish strategy for smart specialisation but a series of strategies which jointly describe Denmark's actions for smart specialisation. These strategies are e.g. the Government's growth plans and the regional growth and development strategies of the regional growth forums. There are five regions in Denmark: the Capital Region, Region Zealand, the North Denmark Region, the Central Denmark Region, and the South Denmark Region.

The regional growth forums and the Danish Government have agreed that the regional growth forums must contribute in following up on the growth plans in areas which also support the unique regional positions of strength (regional smart specialisation). It will be possible for the regional growth forums, on the basis of the regional growth and development strategies, to target their actions in relation to regional business strengths and to address special challenges in the area, thus supplementing and contributing to the implementation of national growth actions based on the possibilities within the individual areas. In this way, the regional growth forums contribute to converting the Government's growth plans in selected business areas into specific actions under consideration of the strengths existing within the region.

The regional growth forums have the right of recommendation over most of the European Regional Development Fund (ERDF) and European Social Funds (ESF) appropriations. The resources must be used within the framework of the ERDF and ESF programmes, both of which emphasize the significance of supporting regional strengths, and they must be used within the regional growth and development strategies which enumerate the regional

strengths. Against this background, it must be expected that ERDF and ESF resources will in essence support smart specialisation in Denmark.

2.7 Evaluations, consultations, foresight exercises

Evaluations provide essential information to policy makers with regard to the viability of policy measures and their effectiveness and efficiency for reaching the stipulated goals. In this regard, the production of analytical reports and evaluations has been strengthened substantially over the last years by the Danish Agency for Science, Technology and Innovation (DASTI). For instance, there have been several reports on the impact of policy measures and the productivity effects of STI policy schemes and corporate investment in R&D (Alslev Christensen, 2011; DAMVAD, 2011; DASTI, 2011, 2013; Frosch and Alslev Christensen, 2011; Klitkou, 2011a). These reports show that the policy measures had a significant impact on productivity, production, export and employment of Danish companies. Moreover, the number of inventions and patent applications from public research has been shown to have increased considerably.

DASTI commissioned an evaluation of the knowledge and technology transfer (KTT) activities of the Danish universities in 2014 (DASTI, 2014a). The evaluation concludes that many university researchers already collaborate with industry, that all universities have support infrastructures in place, and that the overall KTT framework functions well. Nevertheless, university researchers and industry personnel may face difficulties collaborating because they may have different motives and interests and do not always 'speak the same language'.

Another recent evaluation has been carried out by the GTS system (GTS, 2014) on the functioning of the GTS system as service institutes for contract research commissioned by industry. The evaluation shows that after falling numbers of research contracts for several years, the number of commissioned research projects has increased from 2012 to 2013.

In 2014, the Danish Ministry of Higher Education and Science also commissioned an evaluation of the performance of the Danish Council for Independent Research (DASTI, 2014c). The council was evaluated by a panel of six distinguished experts from Europe and North America that analysed the role and function of the council in the Danish research system employing a bibliometric study, a self-evaluation report, desk studies and numerous interviews with researchers and stakeholders. The evaluation concludes that the council plays a key role in the Danish research funding system. It succeeds in supporting the most qualified applicants and most talented researchers.

Moreover, in 2014 DASTI published a collection of systemic analyses of the Danish innovation system and the Nordic business investments in R&D. The first study, entitled 'The Short-run Impact on Total Factor Productivity Growth of the Danish Innovation and Research Support System', is the first attempt to estimate the economic impact of innovation and research support programmes in Denmark. The study finds that firms which make use of the research and innovation support system show higher growth rates than those not making use of it. The second study, entitled 'Economic Impacts of Business Investments in R&D in the Nordic Countries', offers insights regarding the effect of investments in private R&D across the four Nordic countries. The results show that there is a positive return on additional investments in R&D. This implies that in each of the four Nordic countries for the average company an additional euro invested in R&D has a

positive net-return while Danish companies obtain the highest marginal rate of return on R&D.

Another important evaluation has been the ERAC peer review of the Danish research and innovation system, carried out in the period from April to September 2012. The peer review highlighted strengths and weaknesses of the Danish research and innovation system and provided several recommendations for future action. In that regard, the ERAC peer review sets a focus on increasing the innovation capacity throughout the educational system (European Commission, 2012). Ensuring the employability of graduates – in the light of the ambition to increase the intake of students considerably – poses significant challenges to Danish higher education. Particularly innovative and entrepreneurial skills of future graduates are to be fostered in order to support economic growth. Moreover, the ERAC peer review pointed to difficulties in increasing the innovation capacity and growth of SMEs (European Commission, 2012). Danish support for innovation in SMEs was considered relatively underemphasized and the instruments were deemed too small. There was further found a need to stimulate collaboration between SMEs and larger businesses, also internationally, in order to grow into a better position in the global market place.

Subsequently, the evaluations in question have been followed by major policy initiatives such as the Government's innovation strategy and the creation of the new Innovation Fund Denmark.

3. National progress towards realisation of ERA

Information on ERA Priority 1 is provided in Chapter 2. Information on knowledge transfer and open innovation (part of ERA Priority 5) is provided in chapter 4.

3.1 ERA priority 2: Optimal transnational co-operation and competition

Denmark is actively cooperating with other Nordic countries in joint programmes and institutions within the Nordic Council of Ministers. Moreover, Denmark is active in a number of ERA related cooperative actions, such as European Technology Platforms (ETP), Joint Technology Initiatives, Article 169 initiatives, ERA-NETs, and ERA-NET Plus. The Ministry of Higher Education and Science (former Ministry of Science, Innovation and Higher Education) initiated several collaboration agreements and other policy measures to ensure an improved knowledge exchange between Danish and knowledge communities outside Europe.

Denmark has established innovation centres in hotspots around the world; in Silicon Valley, Munich, Shanghai, New Delhi/Bangalore, Seoul and São Paulo plus a satellite office in Tokyo. The innovation centres assist Danish companies and research and education institutions in surveying the market for technologies, potential research and innovation partners, assessing companies' business model and growth potential as well as offering advice on global growth opportunities. In addition the innovation centres work for establishment of partnership agreements with leading foreign research environments, attracting talent and collaboration on student mobility in a broader sense, facilitation of exchange agreements, organization of various network activities such as workshops, conferences, delegation visits locally, etc.

Further, Denmark participates actively in the pan-European network EUREKA. EUREKA is an intergovernmental organisation for market-driven industrial R&D. It is a decentralised network facilitating the coordination of national funding on innovation aiming to boost the productivity & competitiveness of European industries, for instance by means of the Eurostars support program. The network integrates over 40 pan-European economies, but also includes Israel, Turkey, South Korea, South Africa and Canada. During Eurostars 1 (2008-2013), 113 Danish companies and research institutions have participated in approx. 78 projects financed via the Eurostars program.

According to the JOREP project report, Denmark has participated in 22 joint programs in 2009 which corresponds to a total funding volume of 24m EUR or slightly more than one% of GBAORD (JOREP Consortium, 2012). Denmark is found to have a stronger tradition of bilateral cooperation in comparison to European-level programs.

The aforementioned INNO+ catalogue shares many of the main areas of the EU Framework Programme Horizon 2020. It identifies 21 concrete focus areas for research and innovation that are geared towards finding solutions to the grand societal challenges. The thematic focus is on transportation, environment, urban development, food, bio-economy, health, production, digital solutions and energy.

3.2 ERA priority 3: An open labour market for researchers. Facilitating mobility, supporting training and ensuring attractive careers

3.2.1 Introduction

The share of persons working in science and technology of the total workforce in Denmark has constantly increased over the last couple of years, from 36.2% in 2009 to 40.5% in 2013. In 2012, 85,959 R&D workers were employed in Denmark, about 1.5% of the total population. The number of R&D workers has steadily increased over the past couple of years.

Danish universities enjoy high institutional staffing autonomy. Providing attractive employment and working conditions are priority areas in Denmark, since the employment system for public researchers generally displays a high level of flexibility (Steering group on human resources and mobility, 2009). When considering the cost of living, the level of remuneration for researchers in Denmark is high, but still below remuneration levels in the U.S. (European Commission, 2007). There are huge differences between the remuneration levels for the different levels of education in the public and the private business sector, both for employees with long-cycle higher education and for employees with PhDs. The promotion of talent at higher education institutes is one of the priorities in the innovation strategy. A better framework for the development of a culture of talent shall be developed. Funding for increased enrolment in tertiary education programmes is provided for in the national budget for 2014.

3.2.2 Open, transparent and merit-based recruitment of researchers

Open and competition-based recruitment of researchers is implemented at Danish higher education institutions and other public research organisations. In fact, Denmark has attracted increasing numbers of researchers from EU-28 and third countries. About 80% of the new international PhD students 2012/2013 enrolled in natural sciences or engineering. 32.9% of the enrolled PhD students 2012/2013 came from outside Denmark, and here mostly from the EU-28, Norway, Iceland and Asia. The Danish language is mostly not an important obstacle because of the high level of English proficiency in the country. The latest statistics on international students are based on new and improved data and the methods used to produce the statistics have been altered. Therefore, the new statistics are not directly comparable with the previously published statistics.[6]

3.2.3 Access to and portability of grants

Danish funding schemes are open to researchers based abroad, regardless of their nationality, provided that their research is judged to be of benefit to Danish research. Accordingly, the Danish Council for Independent Research and the Innovation Fund Denmark welcome applications that comprise elements of international research cooperation, to support the best researchers and groups of researchers in their efforts to coordinate and develop their cross-border research collaboration. Both funding bodies therefore make no requirements regarding the applicant's citizenship, to the registered

[6] Source: Statistics Denmark, http://www.dst.dk/da/Statistik/NytHtml.aspx?cid=18797

office of the research institutions or to a specific geographical location for the implementation of the research activities in question, but in all events, the application will be assessed on the basis of whether the project applied for benefits Danish research. All the strategic research programmes with recent calls promote this openness. The rationale for this openness is to strengthen Danish research groups through cooperation with excellent researchers from third countries.

The Danish Council for Independent Research participates in the EUROHORCS initiative and its follow-up Science Europe, authorizing researchers moving to other countries to take the remainder of any awarded grant with them ('Money follows researchers') (Steering group on human resources and mobility, 2009).

3.2.4 EURAXESS

Denmark has placed strong political priority on attracting foreign talent, which is why EURAXESS Denmark is of high importance. EURAXESS and its portal provide on-line information and practical assistance for researchers coming to Denmark as well as Danes seeking to work abroad. A national network has been formed in order to provide researchers coming to Denmark with the best possible assistance. In Denmark there are eight EURAXESS Contact Points that are part of the European network EURAXESS and follow the EURAXESS Declaration of Commitment. All eight Contact Points are placed at universities.

The EURAXESS Contact Points support the staff of their own institution by providing assistance to researchers coming to or leaving the institution. They offer hands-on-support on matters with mainly a local dimension and are often in face-to-face contact with the researchers and/or their families. EURAXESS Denmark has a steering group with representatives from the eight Contact Points, the Danish Agency for Science, Technology and Innovation, and the Danish Agency for Labour Retention and International Recruitment.[7]

3.2.5 Doctoral training

Doctoral training in Denmark features both the 'traditional' model of PhD education oriented towards internationally competitive education standards and a path referred to as the Industrial PhD Programme. The Industrial PhD Programme was established in Denmark in 1970 and has been a growing success ever since. It is internationally recognised for its combination of industrial experience and academic research. Since 2002, it has been part of the Danish Council for Technology and Innovation's umbrella of innovation promotion initiatives, and has been run on behalf of the council by the Danish Agency for Science, Technology and Innovation. The programme has been evaluated several times and in 2011 an impact assessment was conducted. It was found that the programme has contributed to an increased absorptive capacity in the private sector that can be expected to facilitate knowledge and technology transfer from academia to industry and hence to foster innovation in firms. The Industrial PhD program has since 2014 been administered by the Innovation Fund Denmark.

[7] See http://euraxess.dk/

3.2.6 HR strategy for researchers incorporating the Charter and Code

Universities Denmark declared its commitment to the European Charter for Researchers and the Code of Conduct for the recruitment of researchers in January 2009. Prior to this endorsement, the Charter and Code were debated by the Human Resources group, the Danish Committee of University Directors and the Danish Rectors' Conference. Universities Denmark and the Danish Agency for Universities and Internationalisation (UI) both argued that, overall, Danish universities met the European Commission's standards with regard to the Charter and the Code of Conduct. However, to date only one of the eight Danish universities, Copenhagen Business School (CBS), has been added to the list of 'HRS4R Acknowledged Institutions'. The recognition was awarded in 2012.

The Danish Council for Independent Research as well as the precursor organisations of the Innovation Fund Denmark participate in the EUROHORCS initiative and its follow-up Science Europe, authorizing researchers moving to other countries to take the remainder of any awarded grant with them.

3.2.7 Education and training systems

Considerable emphasis is placed on the education system with excellent higher education and research. Both the private and the public sector are committed to invest in education, research and innovation at a level necessary to maintain its current highly competitive position. The education system offers several different educational routes. Besides the university system, there are institutions such as Academies of Professional Higher Education ('Erhvervsakademier') and University Colleges offering two to two and a half year long Academy Profession (AP) degree programmes and Professional Bachelor degree programmes. A recent evaluation concludes that the academies play an important role in achieving the government's objective that 60% of a youth cohort should undergo a higher education programme. While the general quality of the education provided by the academies is assessed as good, the evaluation also shows quite some heterogeneity in the extent to which the academies achieve their objectives. The evaluation outlines how those academies lagging behind may implement more systematic and strategic practices to assist them in the design of their educational programmes (Rambøll, 2013).

The reform of the university system in Denmark has led to a high level of autonomy regarding management of research budgets and hiring of research personnel. The universities sign development contracts with the Minister of Higher Education and Science, lasting for 3 years. These contracts are based on mandatory and self-imposed targets and describe the level of ambition for the universities in the included areas. A share of the universities' funding is based on performance indicators, with funding received as a lump sum, allowing autonomy to decide on its distribution. The government is not involved and does not interfere with the appointment of new researchers, but has defined the overall framework for how to proceed. However, this management process is due to the reforms of the university sector and not based on staff democracy but on professional management. Decisions about researchers' salaries are delegated to the universities, but salary negotiations are determined by an agreement between the government and trade unions. The decision on research agendas or research specialisation is reserved by the university to ensure that the research is independent. However, the increased share of competitive funding for mission-oriented research, based on strategic priorities, means

that universities in these strategic areas have an inventive to align their research specialisation with nationally agreed priorities.

Entrepreneurship education is widely available, for example through the Copenhagen School of Entrepreneurship (CSE) which is hosted by the Copenhagen Business School (CBS).[8] CSE is the largest student incubator in Denmark, open to entrepreneurs from higher education and on a mission to help develop ideas into business. CSE prepares students for future employability, establishes commercial relationships and creates teaching methods, entrepreneurial knowledge and tools.

Moreover, the Danish Foundation for Entrepreneurship - Young Enterprise is the national knowledge centre and focal point for the development of entrepreneurship teaching at all educational levels. It works to ensure that the ability to be innovative becomes a fundamental element in all educations from primary school to PhD. The Foundation allocates funding for the development and further development of education with a focus on innovation and entrepreneurship at all levels of the education system. The Foundation also develops and publishes its own educational material, advises on the implementation of entrepreneurship in teaching, and facilitates the cooperation and networking about entrepreneurship education.[9]

3.3 ERA priority 5: Optimal circulation and access to scientific knowledge

3.3.1 e-Infrastructures and researchers electronic identity

Since 2012, the Danish e-Infrastructure Cooperation (DeIC) has coordinated Denmarks activities as an e-Science nation by consulting on and delivering of e-infrastructure (computers, data storage and networks) for research and teaching. DeIC's vision, goals and tasks are based on an agreement between the Danish Agency for Science, Technology and Innovation and the Danish universities. In February 2015, DeIC deployed the strategy for the years 2015-2018 which aims at improving the e-infrastructures at all Danish research environments according to international standards.

Denmark participates in the eduGAIN and eduROAM initiatives that are both aimed at easing the access to services and resources for the global research and education community. While eduGAIN enables the trustworthy exchange of information related to identity, authentication and authorisation by coordinating elements of the federations' technical infrastructure and providing a policy framework that controls this information exchange, eduROAM provides both researchers and students at registered institutions with wireless internet access at all participating institutions. The Danish eID federation WAYF joined eduGAIN in July 2013.

3.3.2. Open Access to publications and data

In 2007, the Danish Government approved the Council of the European Union's conclusions about scientific information in the digital age. As a result of this, in March 2011 an appointed Open Access Committee published its recommendations on how to implement

[8] See http://cse.cbs.dk/
[9] See http://eng.ffe-ye.dk/the-foundation/about-the-foundation

Open Access in Denmark. In 2012, all the Danish public research councils and foundations implemented their joint Open Access policy. Based on the green model of Open Access, this policy requires grant holders to seek permission to archive their research articles in institutional or subject-specific repositories no later than 6-12 months after publication. Through dialogue and collaboration with relevant stakeholders DASTI has been monitoring and analysing the implementation of Open Access across Danish research institutions. In the period from 2008-2013, 64.6% of all publications in Denmark (adjusted) were Open Access publications (total was 56.4%). This is considerably higher than the EU-28 average of 58.8% (or total of 51.3%) (Archambault et al., 2014). These figures, however, have been criticised as being too high and exaggerating the number of Danish scientific articles which are Open Access because of the specific methodology chosen by the authors. It is planned to introduce a Danish Open Access indicator at the beginning of 2016.

The Ministry of Higher Education and Science analysed possible scenarios concerning the further implementation of Open Science in Denmark. As a result, in December 2013 a decision was taken to appoint the National Steering Group on Open Access. With representatives from all Danish universities, research councils and other relevant stakeholders the task of this group is to streamline the implementation of Open Access in Denmark based on the Danish National Strategy for Open Access which the Minister of Higher Education and Science announced in June 2014. The National Steering Group on Open Access commenced its work in 2014 and has been appointed by the minister for three years so far (Danish Government, 2014b).

Open Access to knowledge is an important issue for SMEs. In June 2011 a study was published on the levels of access to and use of research and technical information by knowledge-based SMEs in Denmark. The study revealed 'barriers to access, access difficulties or gaps, and the costs and benefits involved in accessing research findings' (Houghton et al., 2011). The study was based on an online-survey and interviews and gave policy recommendations: '(i) addressing information literacy and improving the capacity of SMEs to navigate the information landscape; (ii) addressing accessibility and affordability of access for SMEs; and (ii) responding to the expressed concerns and wishes' of SMEs.

4. Innovation Union

4.1 Framework conditions

Framework conditions for innovation in Denmark are primarily influenced by the Danish innovation strategy 'Denmark – a nation of solutions' which was presented above in detail. The vision of the new innovation strategy is that Denmark should become a nation of solutions, in which innovative solutions for the grand societal challenges are converted into growth and employment (Danish Government, 2012e). With the new innovation strategy, the Danish government sets a focus on three areas:

1. Innovation driven by societal challenges: Demand for solutions to concrete societal challenges must be given higher priority in public innovation policy.
2. More knowledge translated to value: Focus on mutual knowledge exchange between companies and knowledge institutions and more efficient innovation schemes.
3. Education as a means to increase knowledge capacity: A change of culture in the education system with more focus on innovation.

The ambition of the innovation strategy is to enhance cooperation and to provide improved frameworks for innovation in firms. The strategy contains 27 policy initiatives regarding research, innovation and education. It focuses on a better knowledge exchange between companies and knowledge institutions, across borders and between the public and private sector (Danish Government, 2012e).

The INNO+ catalogue, presented in connection with the innovation strategy, represents an example of co-evolution of supply and demand-side policies and instruments (Danish Government, 2013). The catalogue is based on the involvement of a multitude of actors from the innovation system and made in arm's length to the politicians. INNO+ identifies 21 concrete focus areas for research and innovation that are geared towards finding solutions to the grand societal challenges. The thematic focus is on transportation, environment, urban development, food, bio-economy, health, production, digital solutions and energy.

4.2 Science-based entrepreneurship

The main policy measures to support knowledge transfer between the public and the business sector are administered by the Innovation Fund Denmark, established in April 2014. Several of these policy measures are particularly aimed at SME's and include the Industrial PhD and Industrial PostDoc programmes, InnoBooster, as well as public-private partnerships for innovation and strategic R&D projects. These measures are detailed in section 4.4.

Other schemes are dedicated to start-ups and young innovative companies. They address market failures in the venture capital market and have proved to have some positive impact (Alslev Christensen, 2011). These schemes are detailed in section 4.5.

Denmark has several science parks which provide combined office- and laboratory facilities and focus on bringing innovative firms and research institutions together. An example is the Copenhagen Bio Science Park which was significantly expanded in 2014. The aim is to increase Copenhagen's profile as a hub for biotechnology research. It is co-located with the Copenhagen Biotech Research and Innovation Centre which has been

publicly financed. Another example is the NAVITAS park, opened in Aarhus in 2014, which is focused on bringing public research and private firms in the area of energy research together.

A new scheme under the Innovation Fund Denmark with so-called Entrepreneurial Pilots initiated in 2014 provides financial support and coaching for young graduates who wish to explore the possibility of creating a start-up.

4.3 Knowledge markets

In relative terms the patent intensity (PCT applications per million population) is at a lower level in Denmark than in the reference countries Finland and Sweden (European Commission, 2014a). In recent years, the share of patent applications being exploited (through licenses, options, assignments and spinouts) has increased, as universities have become more professional and selective in regard to patenting. A report from the Danish government shows that particularly in 2011 the number of inventions, patent applications, spinouts and licenses has increased considerably (DASTI, 2013). And international patent data suggest that Danish universities have become among the most active in Europe in utilising the EPO system. Nevertheless, the universities' income from commercialisation efforts remains relatively low compared to the GTS institutes and it has been fluctuating over the last couple of years (DASTI, 2013). This reflects the basic division of labour between universities and the GTS system, the latter providing a wide range of R&D-related services. To avoid unfair competition with the private sector, budgetary provisions allow Danish universities only to engage in commissioned research when this is directly linked to the basic activities of the university.

4.4 Knowledge transfer and open innovation

Framework for knowledge transfer

The innovation strategy 'Denmark – a nation of solutions' provides the framework and contains 27 individual policy initiatives that have been implemented since 2013 and that target knowledge transfer and open innovation activities of Danish scientific institutions and companies. The individual initiatives can be grouped under the following headings (Danish Government, 2012c):

(1) Increased cooperation between knowledge institutions, companies and other stakeholders to foster growth and employment; a higher focus on utilising research results, commercialisation and market maturation.

(2) Integration of innovative competences and entrepreneurship in education programmes; closer coordination of education, research and innovation policy.

(3) Active participation in the global knowledge and innovation network; better preparation of Danish companies and knowledge institutions for global development.

(4) Securing better cohesion and impact in the innovation system; alignment of the innovation system with political priorities and the needs of users.

Within this framework, public-private collaboration occurs mainly between firms and the eight Danish universities as well as the nine GTS institutes ('Godkendte Teknologiske

Serviceinstitutter') – Advanced Technology Group. While the universities are the main research performers and major collaboration partners, the GTS institutes are the main providers of commissioned R&D for the private sector. The universities' income from commercialisation efforts remains relatively low compared to the GTS institutes and it has been fluctuating over the last couple of years (DASTI, 2013). This reflects the basic division of labour between universities and the GTS system, the latter providing a wide range of R&D-related services. To avoid unfair competition with the private sector, budgetary provisions allow Danish universities only to engage in commissioned research when this is directly linked to the basic activities of the university. The Danish business sector invests in R&D conducted at universities to a small, even though increasing, extent (Universities Denmark, 2012).

According to Eurostat, private funding of public R&D doubled between 2002 and 2012 to about €300m, which corresponds to 4.4% of GERD. Denmark also features considerably more public-private co-publications that the EU-28, indicating a high degree of collaboration. Nevertheless, turning public research results into business opportunities requires more investments into research, development and innovation by the larger business enterprises. This refers to both R&D in collaboration with public research and the purchase of research results from public science. Moreover, Danish firms collaborate more with foreign universities than with Danish universities (Danmarks Forskningspolitiske Råd, 2011). However, those firms which cooperate with Danish universities, mainly for applied research projects, assess the cooperation as positive (Oxford Research, 2011). These are mainly larger companies and not small firms.

Over the last years technology transfer has been strengthened and possible conflicts of interests have been addressed in standard agreements on IPR and in strategic collaboration agreements between universities and industry partners. There are technology transfer organisations located at all universities with major patenting activities.

In 2009 the commercialisation strategy of the Danish Council for Technology and Innovation (DCTI) suggested that the remaining obstacles in the field of commercialisation are not primarily related to the technology transfer system and legislation (DASTI, 2009). DCTI recommends instead fostering an innovative culture and changing the mindset at the universities via incentive systems, research management and entrepreneurship training. This perception has been confirmed in a recent evaluation commissioned by DASTI on the knowledge and technology transfer activities of the Danish universities (DASTI, 2014a). The evaluation concludes that many university researchers already collaborate with industry, that all universities have support infrastructures in place, and that the overall KTT framework functions well. Nevertheless, university researchers and industry personnel may face difficulties collaborating because they may have different motives and interests and do not always 'speak the same language'.

The Danish innovation system is relatively weak on patent intensity, which is at a lower level than in the reference countries Finland and Sweden (European Commission, 2014a). In recent years, the share of patent applications exploited (through licenses, options, assignments and spinouts) has increased, as universities have become more professional and selective in regard to patenting. A report from the Danish government shows that particularly in 2012 the number of inventions, patent applications, spinouts and licenses has increased considerably (DASTI, 2013). However, only the GTS system is a major provider of commissioned R&D services for the business sector. Presently, innovation policy is facilitating innovation in SMEs in collaboration with GTS institutes.

Measures for R&D collaboration and knowledge transfer

The main measures to support R&D collaboration between the public and the business sector are administered by the Innovation Fund Denmark, established in April 2014. These policy measures are the Industrial PhD and Industrial PostDoc programmes, InnoBooster, as well as public-private partnerships on innovation and strategic R&D projects.

- Industrial PhD and PostDoc: Doctoral training in Denmark features both the 'traditional' model of PhD education oriented towards internationally competitive education standards and a path referred to as the Industrial PhD Programme. The Industrial PhD Programme was established in Denmark in 1970 and has been a growing success ever since. It is internationally recognised for its combination of industrial experience and academic research. The programme has been evaluated several times and in 2011 an impact assessment was conducted. It was found that the programme has contributed to an increased absorptive capacity in the private sector that can be expected to facilitate knowledge and technology transfer from academia to industry and hence to foster innovation in firms. The Industrial PostDoc programme focuses on creating career paths in the private sector for personnel who have already accomplished their doctoral degree in public research activities.
- InnoBooster: Until August 2014 the knowledge pilot regulation was in effect. A grant could be given to SMEs with limited experiences in hiring highly educated employees to cover some of the salary of a new employee with a higher education and who was to execute a development or innovation project in the enterprise. The measure was to enhance the cooperation between SMEs and knowledge institutions and to increase the share of highly educated employees at SMEs. The enterprise could be given €1,333 a month for the salary of the new knowledge pilot, for a period of 6-12 months. The new Innovation Fund has taken over this measure and integrated it into a new program called InnoBooster. InnoBooster now also includes a measure that was known as innovation voucher. The measure consisted of a 40% co-funding of development projects applied for by SMEs who wished to use the funding for knowledge acquisition from a public research organisation or a member of the GTS-network. It is an objective to expand the utilisation of collaboration with knowledge organisations to a wider group of the Danish SMEs and to raise the attention of SMEs of the opportunities within utilisation of the knowledge of public research and technology institutions. The voucher could fund a maximum amount of about €14,000. The schemes will be changed and further developed in 2015.
- Public-private partnerships on innovation and strategic R&D projects: The Innovation Fund offers support for problem-oriented strategic research projects, high-technology projects involving firms and public research institutions, and innovation partnerships within certain thematic areas (blue jobs and green solutions; intelligent, sustainable and effective plant production; Denmark as a preferred country for early clinical trials of new drugs; water-efficient industrial production; innovatorium for world-class building renovation).

The nine GTS institutes furthermore provide support through so-called innovation agents. The agents offer SMEs a free 'innovation check-up', which is meant to identify innovation opportunities and challenges, and provides specific action proposals for ways of realizing such potentials. Moreover, the program shall help firms with the establishment of contact

with the right scientific institution or advisory expert, or to apply to a public pool for a grant for such innovation activities.

Moreover, a group of 22 national Innovation Networks ('Innovationsnetværk') provides matchmaking and facilitates joint innovation projects in professional clusters of enterprises and research organisations within specific fields of technology or industrial branches. Approximately 7,000 enterprises participate in the 22 networks, of which two thirds are small enterprises with less than 50 employees. Six of the 22 networks have achieved the so called Gold Label for Cluster Excellence Management, which is given by the EU to cluster organisations that are able to document excellence on 31 quality and performance indicators. The networks are co-funded by DASTI.

Education as an enabler of knowledge transfer

An important prerequisite for knowledge transfer to happen is a critical supply of human resources. Especially engineers are perceived as being essential for a future growth of new knowledge intensive sectors (DASTI, 2014a). The Danish government has focused on this challenge for a number of years and the issue is pervasive in policy debates and documents. The shortage of human resources in science and technology and here especially of engineers has been addressed by stakeholders in the private sector. The government has addressed this problem especially via education policy and as a result of this policy the number of newly enrolled students increased significantly over the last years and the numbers of PhD candidates in engineering doubled from 2003 to 2010. The successful Industrial PhD programme has contributed to an increased absorptive capacity in the private sector. Education is also a key priority for the new government (Danish Government, 2014a). The government has as a goal that 95% of a year group shall complete at least a youth education programme, 60% shall complete higher education and at least 25% shall complete a long-cycle higher education (Danish Government, 2012b). In 2007 the government set specific goals for increasing the employment of R&D personnel in the Danish business sector, such as the goal that 12% of small enterprises and 70% of medium sized enterprises should employ R&D personnel. In 2010 it could be reported that both goals have been accomplished (DASTI, 2010). Job-training is accepted as a standard and successful procedure for the continuous development of skills. Life-long learning has been a policy priority for several years in the National Reform Programmes. Denmark is a country with a flexible, mobile labour force and it also has a long tradition of on-the-job training and funding schemes. In this policy context, the Quality Reform (agreed in 2007) further institutionalised the processes for upgrading of skills, qualifications and further education amongst the labour force.

4.5 Innovation framework for SMEs

In 2012, the ERAC peer review pointed to difficulties in increasing the innovation capacity and growth of SMEs (European Commission, 2012). Danish support for innovation in SMEs had been relatively underemphasized and the instruments were deemed too small. There was considered to be further need to stimulate collaboration between SMEs and larger businesses, also internationally, in order to grow into a better position in the global market place. Nevertheless, there were many support schemes available addressing market failures in the provision of private funding for innovation, particularly for SMEs. They had proved to have some positive impact (Alslev Christensen, 2011). Initiatives that target private R&D investments today include the new InnoBooster program administered by the

Innovation Fund (see section 4.4), and initiatives under the Market Development Fund. The decreasing knowledge-intensity in traditional business sectors can be explained by the lack of financial incentives. The introduction of tax incentives for business R&D expenditures in 2012 provides a greater incentive for investing in R&D. Another explanation for the decreasing knowledge-intensity in traditional business sectors is the political focus on high-tech firms while policies supporting an increased innovativeness in low-tech firms might provide much greater effects.

4.6 Venture capital markets

Denmark has developed a policy focus on turning knowledge into business by supporting the commercialisation of public and private research results. Four Innovation Incubators offer early stage gap-funding for start-ups form universities and beyond. The incubators invest pre-seed and seed capital accompanied by counselling for entrepreneurs. The funding of approx. EUR 25 million annually is provided by DASTI. The Growth Fund, a state investment fund, provides venture capital to entrepreneurial growth companies. Since 1992 the Growth Fund has, in cooperation with private investors, co-financed growth in 4,500 Danish companies with a total commitment of approx. €1.6bn. The Growth Fund invests equity or provides loans and guarantees in collaboration with private partners and Danish financial institutions. The companies which the Fund has co-financed since 2001 represent a total turnover of approx. €3.6bn and employ approx. 22,000 people all over the country.[10]

A recent evaluation of the Growth Fund's activities shows that the fund's investments led to short-term direct effects of €270m increase in GDP and the creation of 3,000 jobs (DAMVAD, 2013). Moreover, indirect effects materialise since the Growth Fund has been instrumental in the establishment of 18 of the 21 Danish venture capital funds, leading to an even higher increase in GDP and creation of jobs.

4.7 Innovative public procurement

The innovativeness of the public sector has great importance for the innovativeness of the business sector. There has been an increased focus on easing the bureaucratic burden of the private sector by further digitalisation of public services. Denmark has implemented policy initiatives related to public procurement of green innovations and in the health sector.

One of the new policy initiatives that has also been highlighted in the NRP 2012 and the ERAC peer review is the development of an intelligent public procurement strategy in order to foster innovation. The government makes active use of the potential of public demand in order to enhance innovation in the public and private sector (Danish Government, 2012).

[10] Source: http://www.vf.dk/

5. Performance of the National Research and Innovation System

5.1 Performance of the National Research and Innovation system

According to the Innovation Union Scoreboard 2014, Denmark is part of the group of innovation leaders that exhibit above average innovation performance (European Commission, 2014b). In this regard, Denmark's innovation performance has been persistent over the past couple of years, occupying a top-ranking position in the EU-27. Denmark is grouped together with the peak performers Sweden, Germany and Finland. Denmark also holds a top-ranking position in the Innovation Union Competitiveness Report 2013, in which the country is grouped together with the peak performers Finland, Sweden and Switzerland (European Commission, 2014a).

On average in 2012, Denmark produced 34.75 publications per 10,000 inhabitants, well above the EU-28 average (13.8). They are also internationally orientated with 55% of publications internationally co-published. In 2012, Denmark had about 1916 international scientific co-publications per million population, the highest number of all EU-28 countries. In the period 2002-2012, more than 16% of Danish scientific publications were in the top 10% most cited publications worldwide in comparison with 11% of top scientific publications produced in the EU-28 (Science Metrix, 2014)[11]. The share of public-private co-publications in Denmark is 5% in the period 2008-2013 against 2.8% for the EU28.[12] Table 3 gives an overview of selected Innovation Union Scoreboard indicators.

While statistics on applications to national patent offices are not always comparable across countries, they can provide some indication of technological development activities that are not captured by EPO/PCT data. In Denmark approximately 11,500 patent applications were made at the EPO in the period 2000-2010. Approximately 12,000 patent applicants took the PCT route. The National Patent Office received over 16,000 applications in this period (these three figures are based on fractional counting).[13]

[11] These publication data are based on Elsevier's Scopus database. ScienceMetrix, Analysis and Regular Update of Bibliometric Indicators, study conducted for DG RTD. They represent an update of the data displayed in the table below. See also http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=other-studies.

[12] Scival 2014, Scopus based publication indicators derived from Elsevier's SciVal platform, www.scival.com, last accessed December 2014.

[13] Source: KU Leuven, Bocconi University, 'Patents and Licensing study' for DG RTD – data release summer 2014.

Table 3: Assessment of the Performance of the National Research and Innovation System

1. ENABLERS	Year	DK	EU
Human resources			
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	2011	2.30	1.70
Percentage population aged 30-34 having completed tertiary education	2012	43.00	35.80
Open, excellent and attractive research systems			
International scientific co-publications per million population	2012	1,839.61	343.15
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	2009	14.54	10.95
Finance and support			
R&D expenditure in the public sector as % of GDP	2012	1.02	0.75
Venture capital (early stage, expansion and replacement) as % of GDP	2012	0.09	0.08
2. FIRM ACTIVITIES			
R&D expenditure in the business sector as % of GDP	2012	1.96	1.31
Linkages and entrepreneurship			
Public-private co-publications per million population	2011	196.74	52.84
Intellectual assets			
PCT patent applications per billion GDP (in PPS€)	2010	6.50	3.92
PCT patent applications in societal challenges per billion GDP (in PPS€) (climate change mitigation; health)	2010	2.12	0.85
3. OUTPUTS			
Economic effects			
Contribution of medium and high-tech product exports to trade balance	2012	-3.34	1.27
Knowledge-intensive services exports as % total service exports	2011	65.11	45.26
License and patent revenues from abroad as % of GDP	2012	0.79	0.59

Source: European Commission, IUS Database (2014).

5.2 Structural challenges of the national R&I system

Despite the excellent performance of the Danish research and innovation system, there are several challenges to be addressed. Structural challenges can only be addressed in the long term which is why they have been rather stable over the past few years.

1. R&D intensity in the business sector

Although among the peak performers in Europe, Denmark still had a lower R&D intensity than similar knowledge-intensive countries like Sweden and Finland according to the Innovation Union Scoreboard 2014 (European Commission, 2014b). The share of business enterprise expenditure on R&D (BERD) as percentage of GDP has increased markedly over the last decade, with an average annual growth rate since 2000 that is even higher than the reference group, the European Union and the United States (European Commission, 2014b). However, growth slowed down markedly with the global economic crisis. The Innovation Union Competitiveness Report highlights that knowledge-intensity in more traditional sectors of the Danish economy is decreasing, such as food products or machinery and equipment. In addition, the weight of several of the high and medium-high tech sectors in the overall Danish economy is decreasing (particularly noticeable for the Radio, TV and communication equipment sector) (European Commission, 2014a).

Certain barriers to private R&D investments may explain this lower share of BERD as percentage of GDP compared to similar knowledge-intensive countries. One explanation is a shortage of capital. Another explanation is the increased relocation of business R&D activities to countries with a lower level of salaries. Moreover, relocation moves R&D also typically closer to the market of the respective companies (Klitkou, 2011b). The lack of government incentives may be a third factor contributing to this problem. The introduction of a new business R&D tax-incentive in 2012 addresses this barrier. Moreover, the Danish government has heavily relied on innovation policy instruments that focus on the supply side (i.e. technology-push) and largely disregarded a demand-driven innovation policy (Danish Government, 2012a). Such measures are still at a very early stage and require further development to support business R&D. Nevertheless, with the INNO+ catalogue, the Danish Government has set considerable focus on the co-evolution of supply and demand-side innovation policy and instruments.

Moreover, the ERAC peer review of the Danish research and innovation system pointed to difficulties in increasing the innovation capacity and growth of SMEs (European Commission, 2012). Danish support for innovation in SMEs had been relatively underemphasized and the instruments were deemed too small. There was further a need to stimulate collaboration between SMEs and larger businesses, also internationally, in order to grow into a better position in the global market place.

2. Comparatively low share of highly skilled labour in the private sector

The increased intake of new students in the last five years means that Denmark is en route to fulfil the government's national target that by the year 2020 60% of a youth cohort must complete a higher education and 25% must complete long-cycle higher education. The share of new doctoral graduates has increased in Denmark over the past years due to an investment made in doubling the admission of PhD students from 1,200 in 2003 to 2,300 in 2013. But due to the low share of highly skilled labour in the private sector, the significant increase in the number of students and the resulting growth in graduates that must be expected in the coming years, Denmark faces a growing challenge to ensure that more students and graduates will seek private sector employment. This challenge is amplified by the increase in unemployment including high unemployment numbers for recent graduates since the beginning of the financial crisis. Also, students have to be encouraged to move more rapidly into and through tertiary education (OECD, 2009) and formal and informal barriers to immigration, particularly for non-EU citizens, may endanger the attraction of foreign researchers (Klitkou and Kaloudis, 2009). The low share of non-EU doctorate students compared to EU-28 confirms this assessment (European Commission, 20114a).

By including the educational system in the innovation strategy, committing to increase innovation- and entrepreneurial skills in courses and programmes throughout the education system and setting targets for the share of highly skilled labour in the private sector, the Danish government is already on the right path. Reform of the student grant scheme will support this. However, it will be important for Denmark to continuously focus on creating high levels of the knowledge and skills of graduates and secure a good match with the needs of businesses including small and medium sized businesses in order to support increased value creation and growth.

3. Cooperation between public science and the business sector which aims to turn research results into viable businesses

Many university researchers have been found to collaborate with industry and to engage in KTT activities, which is why the overall KTT framework has been suggested to function well (DASTI, 2014a). Difficulties in collaboration nevertheless exist, particularly due to different 'institutional logics', i.e. university scientists are primarily rewarded for publication output and peer recognition which is not necessarily an outcome of industry-science collaboration since industry will likely have rather an interest in keeping research results secret in order to commercialise them.

Turning public research results into business opportunities requires more investments into research, development and innovation by the larger business enterprises. The Danish business sector invests in R&D conducted at universities only to a small extent (Universities Denmark, 2012). This refers to both R&D in collaboration with public research and the purchase of research results from public science. There is evidence that joint R&D increases the innovation performance of participating firms (Frosch and Alslev Christensen, 2011). The GTS system is currently a major provider of commissioned R&D-services for the business sector.

4. Commercialisation of public research results

In relative terms the patent intensity is at a lower level in Denmark than in the reference countries Finland and Sweden in the Innovation Union Competitiveness Report (European Commission, 2014a). In recent years, the share of patent applications being exploited (through licenses, options, assignments and spinouts) has increased, as universities have become more professional and selective in regard to patenting. A report from the Danish government shows that particularly in 2011 the number of inventions, patent applications, spinouts and licenses has increased considerably (DASTI, 2013). And international patent data suggest that Danish universities have become among the most active in Europe in utilising the EPO system. Nevertheless, the universities' income from commercialisation efforts remains relatively low compared to the GTS institutes and it has been fluctuating over the last couple of years (DASTI, 2013). This reflects the basic division of labour between universities and the GTS system, the latter providing a wide range of R&D-related services. To avoid unfair competition with the private sector, budgetary provisions allow Danish universities only to engage in commissioned research when this is directly linked to the basic activities of the university.

5.3 Meeting structural challenges

Several policy actions have been developed to meet the identified structural challenges. Table 4 provides an overview of how the policy mix addresses these challenges.

Table 4: Assessment of the policy mix

Challenges	Policy measures/actions addressing the challenge	Assessment in terms of appropriateness, efficiency and effectiveness
1. Lower R&D intensity than the peak performer reference group	R&D collaboration with GTS system InnoBooster administered by Innovation Fund Market Development Fund Growth Fund (Vækstfonden) Intelligent public procurement Tax incentive for business R&D	Decreasing knowledge-intensity in traditional business sectors is not prevented by existing policy measures – focus on high-tech firms and SMEs may be too narrow. Low-tech firms should be targeted. The Growth Fund is an appropriate measure for supporting on-going business development in sectors of high societal importance. Intelligent public procurement will probably strengthen R&D intensity through demand-pull innovation incentives. The Innovation Fund has been a significant step forward in terms of providing efficient and effective funding.
2. Comparatively low share of highly skilled labour in the private sector	Innovation strategy Reform of study grants Industrial PhD and Post-Doc programme Doubling of PhD student intake Increasing university enrolment Strategy for life-long learning	Denmark is en route to fulfil its ambitious goals for tertiary education levels and has doubled its number of PhDs. The industrial PhDs and Post-Docs are an effective measure and will over time probably succeed.
3. Cooperation between public science and the business sector	Innovation Fund Denmark Public-private partnerships on innovation and strategic R&D projects Environmental technology development and demonstration programme Strengthening of GTS system Innovation networks InnoBooster Strategic Research Centres Strategic Research Alliances GreenLabs DK	Cooperation with the GTS-system has developed very well, andbut cooperation of firms with Danish universities is comprehensive. However, some Danish firms prefer to cooperate with foreign universities. The 2014 evaluation concludes that legal framework is OK. Barriers relate to university management, lack of economic and other incentives and cultural differences. The new policy measures address this, but it is too early to say if they can succeed.
4. Commercialisation of public research results	The Danish Foundation for Entrepreneurship – Young Enterprise (FFE-YE) Expansion of the capital base for the innovation incubators Growth Fund Strategy for education and training in entrepreneurship Strategy for strengthening of entrepreneurial universities Entrepreneurial pilots	Only a few universities do succeed (DTU and Aalborg University). There is a need for a better entrepreneurial culture and education at Danish universities. A swift accreditation of new entrepreneurship education needs to be prioritised. A new accreditation system that will fulfil this has been proposed by the government and an agreement reached in parliament.

To support these actions, the production of analytical reports and evaluations has become pivotal. Particularly the Danish Agency for Science, Technology and Innovation (DASTI) has been responsible for facilitating such policy developments over the last couple of years. For instance, there have been several reports on the impact of policy measures (Alslev Christensen, 2011; DAMVAD, 2011; DASTI, 2011, 2013, 2014a, c; Frosch and Alslev Christensen, 2011; Klitkou, 2011a; GTS, 2014). These reports show that the policy measures had a significant impact on productivity, production, export and employment of Danish companies. Moreover, the number of inventions and patent applications from public research has been shown to have increased considerably. Initiatives that target private R&D investments include increased 'intelligent' public procurement, the InnoBooster program for SMEs to interact with public science, an innovation network for SMEs, support for large demonstration facilities, the launch of the Innovation Fund Denmark and the Business Innovation Fund.

It is clear that an important prerequisite for sustaining growth in the prioritised sectors is a critical supply of human resources. Especially engineers are perceived as being essential for a future growth of new knowledge intensive sectors. The Danish government has focused on this challenge for a number of years and the issue is pervasive in policy debates and documents. The shortage of human resources in science and technology and here especially of engineers has been addressed by stakeholders in the private sector. The government has addressed this problem especially via education policy and as a result of this policy the number of newly enrolled students increased significantly over the last years and the numbers of PhD candidates in engineering doubled from 2003 to 2010. The successful Industrial PhD programme has contributed to an increased absorptive capacity in the private sector. The Industrial Post-Doc programme can be expected to even better contribute to absorptive capacity in the private sector because of the higher educational level of the employee. Education is also a key priority for the government. The government has as a goal that 95% of a year group shall complete at least a youth education programme, 60% shall complete higher education and at least 25% shall complete a long-cycle higher education (Danish Government, 2012b). Job-training is accepted as a standard and successful procedure for the continuous development of skills. Life-long learning has been a policy priority for several years in the National Reform Programmes. Denmark is a country with a flexible, mobile labour force and it also has a long tradition of on-the-job training and funding schemes. In this policy context, the Quality Reform (agreed in 2007) further institutionalised the processes for upgrading of skills, qualifications and further education amongst the labour force.

The Ministry of Higher Education and Science has introduced several measures to foster R&D collaboration between public research organisations and business enterprises, with the overall aim of stimulating greater R&D investments in the private sector. Currently, however, only the GTS system is well functioning as a domestic R&D provider for the business sector. Presently, innovation policy is facilitating innovation in SMEs in collaboration with GTS institutes and universities via participation in the 22 national Innovation Networks. Policy measures are intended to enhance the R&D intensity of Danish firms and are administered by the new Innovation Fund Denmark.

Finally, more than a decade of policy has focused on turning knowledge into business by supporting the commercialisation of public research results. However, the rather low patent intensity of Danish universities, with the exception of the Technical University of Denmark (DTU) and Aalborg University, remains a challenge if increased university patenting is the goal. Technology transfer offices (TTO) at the different universities have very different

framework conditions, the formation of spin-off companies is rather low and only the DTU has actually made significant profits from licensing. Only few universities have defined specific targets on research commercialisation in their performance contracts. Moreover, most TTOs are subcritical in terms of the size of patent and technology portfolios to be commercialized which suggests benefits from higher collaboration between universities in this area.

Annex 1 – References

Alslev Christensen, T. (2011): Business Research, Development and Innovation in Denmark - policies and effects. Copenhagen, Danish Ministry of Science, Innovation and Higher Education.

http://ufm.dk/en/publications/2011/files-2011/rdandinnovationindenmark_7-october2011.pdf

Archambault, E., Amyot, D., Deschamps, P., Nicol, A. Provencher, F., Rebout, L. And Roberge, G. (2014): Proportion of Open Access Paper Published in Peer-Reviewed Journals at the European and World Levels – 1996-2013, Brussels. http://science-metrix.com/files/science-metrix/publications/d_1.8_sm_ec_dg-rtd_proportion_oa_1996-2013_v11p.pdf

DAMVAD (2011). Service innovation: Impact analysis and assessment indicators. Copenhagen, DAMVAD. http://ufm.dk/en/publications/2011/files-2011/episis-report-service-innovation-impact-analysis-and-assessment-indicators.pdf

DAMVAD (2013). The Danish Growth Fund's (DGF)activities – Mapping the effects of DGF, Copenhagen. http://www.vf.dk/~/media/files/analyser/evalueringer%20og%20effektanalyser/mapping%20the%20effects.pdf

Danish Government (2012a): The National Reform Programme Denmark 2012, Copenhagen. http://ec.europa.eu/europe2020/pdf/nd/nrp2012_denmark_en.pdf.

Danish Government (2012b): Self-Assessment of the Danish Research and Innovation System, Copenhagen. http://ufm.dk/aktuelt/temaer/innovationsstrategi/arbejdet-med-danmarks-innovationsstrategi/analyser-og-baggrundsmateriale/self-assessment-danish-research-innovation-system.pdf

Danish Government (2012c): Denmark – a nation of solutions: The innovation strategy, http://ufm.dk/en/publications/2012/files-2012/innovation-strategy.pdf

Danish Government (2012d): RESEARCH2020 – Strategic Research Horizons, Copenhagen. http://ufm.dk/en/publications/2012/files-2012/research2020.pdf

Danish Government (2012): Danmark – Løsningernes land. Styrket samarbejde og bedre rammer for innovation i virksomhederne. Copenhagen. http://ufm.dk/publikationer/2012/filer-2012/danmark-loesningernes-land.pdf

Danish Government (2013): INNO+: Det Innovative Danmark, Copenhagen. http://ufm.dk/publikationer/2013/filer-2013/innova_hovedkatalog_interaktiv_web.pdf

Danish Government (2014a): The National Reform Programme Denmark 2014, Copenhagen. http://ec.europa.eu/europe2020/pdf/csr2014/nrp2014_denmark_en.pdf.

Danish Government (2014b): Danmarks Nationale Strategi for Open Access, Copenhagen, http://ufm.dk/forskning-og-innovation/samspil-mellem-viden-og-innovation/open-science/danmarks-nationale-strategi-for-open-access.pdf.

Danmarks Forskningspolitiske Råd, Ed. (2011): Det værdiskabende universitet - forskningens rolle i en vækstdagsorden. København, Danmarks Forskningspolitiske Råd.

DASTI (2009): Styrket kommercialisering af forskningsresultater: en strategi fra Rådet for Teknologi og Innovation. København: Forsknings- og Innovationsstyrelsen. http://ufm.dk/en/publications/2010/files-2010/strategy-for-education-and-training-in-entrepreneurship.pdf

DASTI (2010): InnovationDanmark 2009: Resultater og evalueringsstrategi - tillæg til InnovationDanmark 2007-2010. København, Forsknings- og Innovationsstyrelsen.

DASTI (2011): The impact of cluster policy in Denmark: an impact study on behaviour and economical effects of Innovation Network Denmark. Copenhagen, Danish Agency for Science, Technology and Innovation. http://ufm.dk/publikationer/2011/filer-2011/indsat-the-impact-of-innovation-networks-docx.pdf

DASTI (2013): Public Research Commercialisation Survey, Denmark 2012. Innovation: Analysis and Evaluation 5/2013, Copenhagen, http://ufm.dk/en/publications/2013/files-2013/public-research-commercialisation-survey-2012.pdf.

DASTI (2014a): Vidensamarbejde under lup – Evaluering af universiteternes erhvervssamarbejde og teknologioverførsel, Forskning og Innovation: Analyse og Evaluering 19/2014, http://ufm.dk/publikationer/2014/filer-2014/vidensamarbejde-under-lup.pdf.

DASTI (2014b): Tal om forskning 2013, Copenhagen, http://ufm.dk/publikationer/2014/filer-2014/tal-om-forskning-2013.pdf.

DASTI (2014c): Evaluation of the Danish Council for Independent Research – Report of the Evaluation Panel, Research and Innovation: Analysis and Evaluation 17/2014, Copenhagen, http://ufm.dk/en/publications/2014/files-2014-1/evaluation-of-the-danish-council-for-independent-research.pdf.

European Commission (2007): Key Figures 2007: Towards a European Research Area. Science, Technology and Innovation. Luxembourg, Office for Official Publications of the European Communities.

European Commission (2011): Innovation Union Competitiveness report: Denmark. Luxembourg, European Commission.

European Commission (2012): Peer-Review of the Danish Research and Innovation System: Strengthening Innovation Performance, Copenhagen and Brussels.

European Commission (2014a): Innovation Union Competitiveness Report 2013, DG Research and Innovation, Brussels.

European Commission (2014b): Innovation Union Scoreboard 2014, DG Entreprise and Industry, Brussels.

Frosch, H. and T. Alslev Christensen, Eds. (2011): Økonomiske effekter af erhvervslivets forskningssamarbejde med offentlige videninstitutioner. Innovation: Analyse og evaluering København, Forsknings- og Innovationsstyrelsen.

GTS (2014): Performanceregnskab for GTS-net 2014, Copenhagen, http://ufm.dk/publikationer/2014/performanceregnskab-for-gts-net-2014

Houghton, J., A. Swan and S. Brown (2011): Access to Research and Technical Information in Denmark. Copenhagen, Danish Agency for Science, Technology and Innovation. http://ufm.dk/en/publications/2011/files-2011/adgang-til-forskningsresultater-og-teknisk-information-i-danmark-access-to-research-and-technical-information-in-denmark.pdf

JOREP Consortium (2012): Joint and Open REsearch Programs, unpublished draft, Brussels.

Kallerud, E. (2008): Norden som forsknings- og innovasjonspolitisk foregangsregion – med fokus på Danmark og Norge. Oslo, NIFU STEP.

Klitkou, A. (2011a): TendChart Mini Country Report: Denmark. Brussels, Technopolis.

Klitkou, A. (2011b): ERAWATCH Country Report 2011: Denmark, ERAWATCH Network. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/reports/countries/dk/report_0005

Klitkou, A. (2012): ERAWATCH country fiche: Denmark. Brussels, Technopolis. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/dk/country.

Klitkou, A. and A. Kaloudis (2009): ERAWATCH Country Report 2008: An assessment of research system and policies - Denmark. Luxembourg, Office for Official Publications of the European Communities. http://www.eurosfaire.prd.fr/7pc/doc/1240904773_jrc_erawatch_danemark.pdf

OECD (2009): ECD Economic Surveys: Denmark. Paris, OECD.

Oxford Research, Ed. (2011): Private virksomheders samarbejde med danske universiteter, Danske Universiteter. http://techtrans.dk/fileadmin/webmasterfiles/techtrans/Temahæfter/Private_virksomheders_samarbejde_med_danske_universiteter_2011.pdf.

Piro, F. N., Ed. (2014): Comparing Research at Nordic Universities using Bibliometric Indicators. Norway, Nordforsk.

Rambøll (2013): Evaluering af erhvervsakademistrukturen: Rapport til Styrelsen for Videregående Uddannelser og Uddannelsesstøtte, Copenhagen. http://ufm.dk/publikationer/2013/filer-2013/evaluering-af-erhvervsakademistrukturen.pdf

Schneider, J. W., Ed. (2010): Bibliometric Research Performance Indicators for the Nordic Countries. The use of bibliometrics in research policy and evaluation activities. Copenhagen, NordForsk.

Steering group on human resources and mobility (2009): Report on the implementation of the European partnership for researchers (EPR) by member states and countries associated to FP7 ERA Steering Group on Human Resources and Mobility.

Universities Denmark (2012): Hvordan finansieres forskningen? Copenhagen. http://www.dkuni.dk/Statistik/~/media/Files/Statistik/Faktaark_statistik/Hvordan%20finansieres%20forskningen.ashx.

Annex 2 – Abbreviations

BERD	Business Expenditures for Research and Development
BRIC	Brazil, Russia, India and China
CERN	European Organisation for Nuclear Research
COST	European Cooperation in Science and Technology
DASTI	Danish Agency for Science, Technology and Innovation
DCIR	Danish Council for Independent Research (Det Frie Forskningsråd)
DCSR	Danish Council for Strategic Research (Det Strategiske Forskningsråd)
DCTI	Danish Council for Technology and Innovation (Rådet for Teknologi og Innovation)
DEFF	Denmark's Electronic Research Library
DK	Denmark
DTU	Technical University of Denmark
EBST	Danish Enterprise and Construction Authority (Erhvervs- og Byggestyrelsen)
EDDP	Energy Technology, Development and Demonstration Programme (Energiteknologisk Udviklings- og Demonstrationsprogram)
EPO	European Patent Organisation
ERA	European Research Area
ERA-NET	European Research Area Network
ERP Fund	European Recovery Programme Fund
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EU-27	European Union including 27 Member States
FDI	Foreign Direct Investments
FP	European Framework Programme for Research and Technology Development
FP	Framework Programme
FP7	7th Framework Programme
GBAORD	Government Budget Appropriations or Outlays on R&D
GDDP	Green Development and Demonstration Programme
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
GTS	Godkendte Teknologiske Serviceinstitutter (Advanced Technology Group)
GUF	General University Funds
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
HES	Higher education sector
HRST	Human resources for science and technology
IP	Intellectual Property
IPC	International Patent Classification
IPR	Intellectual Property Rights
NICE	Nordic Innovation Centre
NRP	National Reform Programme
OECD	Organisation for Economic Co-operation and Development
PRO	Public Research Organisations
R&D	Research and development
RD&I	Research, Development and Innovation
RD&D	Research, Development and Demonstration
RI	Research Infrastructures
RTDI	Research, technological development and innovation
STI	Science, technology and innovation
SF	Structural Funds
SME	Small and Medium Sized Enterprise

SPIR	Strategic Platforms for Innovation and Research (Strategiske forsknings- og innovationsplatforme)
TRI	Top-level Research Initiative
TTO	Technology transfer office
UNIK	University Research Investment Capital (UNiversitetsforskningens InvesteringsKapital)
VC	Venture Capital

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