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RIO Country Report 2017: Denmark

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RIO Country Report 2017

The R&I Observatory country report 2017 provides a brief analysis of the R&I system covering the economic context, main actors, funding trends & human resources, policies to address R&I challenges, and R&I in national and regional smart specialisation strategies. Data is from Eurostat, unless otherwise referenced and is correct as at January 2018. Data used from other international sources is also correct to that date. The report provides a state-of-play and analysis of the national level R&I system and its challenges, to support the European Semester.

Summary

Key findings

Denmark's macro-economic situation is sound with low inflation, low unemployment, stable public finances and a positive balance of payments. After growth rates of 1.6% in 2015, 1.7% in 2016, and an estimated 2.1% in 2017, the European Commission foresees real GDP growth of 2.0% in 2018 easing to 1.9% in 2019.

One of the main challenges is to increase productivity growth, which has been weak for the last decade. Achieving stronger productivity growth would be important for addressing societal challenges such as the increasing costs from an ageing population and preserving the social welfare system at the current level. Moreover, higher productivity growth would alleviate some of the emerging problems with shortages of skilled labour.

Danish R&D intensity is relatively high, about 3% of GDP. Public R&D is projected to remain at around 1% of GDP. Denmark is an innovation leader in the EU, but there is still a potential to increase the innovation performance in particular of SMEs.

Challenges for R&I policy-making in Denmark

- Improve the innovativeness of firms and the commercialisation of research. Despite the good performance of the R&I system in terms of research quality and volume and good overall innovation performance, there is still a potential for improving the innovation performance of SMEs. One of the measures to accomplish this is strengthening the interactions between actors in the system.
- Increase the quality and availability of human resources. As growth has picked up after the economic and financial crisis, shortages of skilled labour have emerged in several industries as well as outside the larger cities.
- Support innovation to boost productivity growth. There is scope for further support to improve innovation management and implementation capabilities in the business sector, in particular amongst SMEs.

Main R&I developments in 2017

A new comprehensive R&I strategy "Denmark – Ready for the Future" ("Danmark - Klar til Fremtiden") was launched in December 2017 (Regeringen, 2017a). It has two main priorities:

- Increase the quality of R&D
- Increase the societal impact of R&D

Smart specialisation

Denmark does not have a single combined strategy for smart specialisation, but rather a collection of strategies, which together form the Danish Smart specialisation strategies. These include the Government's growth plans and the regional growth and development strategies. Smart specialisation priority areas for Denmark are: manufacturing and industry, energy production and distribution, sustainable innovation, health and social work activities, agriculture, forestry and fishing. In the 2014-2020 period, the INNO+ initiative supports smart specialisation investments in: transport, environment and urban development, food production and bio economy, health solutions, innovative production and innovative digital solutions. Danish research and innovation policies are in tune with the smart specialisation approach, but further coordination and alignment of strategies between the national and regional levels is recommended.

Foreword

The R&I Observatory country report 2017 provides a brief analysis of the R&I system covering the economic context, main actors, funding trends & human resources, policies to address R&I challenges, and R&I in national and regional smart specialisation strategies. Data is from Eurostat, unless otherwise referenced. The report provides a state-of-play and analysis of the national level R&I system and its challenges, and is used to support the European Semester.

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Contents

- 1 Economic context for R&I 4**
 - 1.1 Structure of the economy5
 - 1.2 Business environment.....6
- 2 Main R&I actors 7**
- 3 R&I policies, funding trends and human resources..... 10**
 - 3.1 Public allocation of R&D and R&D expenditure 10
 - 3.2 Private R&D expenditure..... 12
 - 3.3 Supply of R&I human resources 13
- 4 Policies to address innovation challenges..... 14**
 - 4.1 Challenge 1: Reinforcing the links between actors to improve the innovativeness of firms and the commercialization of research 15
 - Description 15
 - Policy response 15
 - Policy Assessment 16
 - 4.2 Challenge 2: Increase the quality and availability of human resources 16
 - Description 16
 - Policy response 17
 - Policy Assessment 17
 - 4.3 Challenge 3: Support innovation to boost productivity 18
 - Description 18
 - Policy response 18
 - Policy Assessment 19
- 5 R&I in National and Regional Smart Specialisation Strategies..... 19**
 - 5.1 Policies – levels of aggregation and coordination..... 19
 - 5.2 S3 priorities 20
 - 5.3 Related policies and prioritizations 21
 - 5.4 Assessment 21
- 6 References..... 23**
- Table 3: Abbreviations..... 26**
- Table 4: Factsheet 27**
- List of figures 27**
- List of tables..... 27**

1 Economic context for R&I

The Danish economy is performing well on the macroeconomic fundamentals with low unemployment, low inflation and a strong positive balance of payments. Fiscal discipline and stable public finances have resulted in decreasing budget deficits and have created the pre-conditions for a moderately expansive fiscal policy in 2018. Despite low interest rates, investments and private consumption were subdued in the past years, but recent consumer confidence surveys and investment figures are slightly more positive (Danish Economic Councils ("De Økonomiske Råd"), 2017). After growth rates of 1.6% in 2015, 1.7% in 2016, real GDP growth is estimated to have been 2.1% in 2017. The European Commission expects real GDP growth of 2.0% in 2018 easing to 1.9% in 2019, driven by private consumption (1.9% annual change) and investments. There are signs of shortages for skilled labour for certain groups on the labour market. Despite labour market reforms, the shortages of labour in certain sectors may hamper growth in the medium term. In the longer term, the Danish Economic Council predicts an average growth slightly above 2% for the 2017-2025 period, and an improvement of the budgetary position resulting in a small budget surplus in 2025 (Danish Economic Councils ("De Økonomiske Råd"), 2016). Similarly, the latest OECD forecast of the Danish economy predicts annual growth rates at 2% in the coming two years, driven by private consumption and public investments (OECD, 2017a).

Consumer prices were flat in 2016, but the European Commission expects inflation to progressively pick-up with an increase of 1% in 2017, 1.4% in 2018 and 1.7% in 2019. Unemployment is forecast to drop from 5.9% in 2017 to 5.5% in 2019.

The financing of both a high level of social welfare and the needs of an ageing population are some of the main societal challenges for Denmark. This in turn results in challenges for the R&I-system and the labour market. One of the most pressing of these challenges is a relatively smaller supply of skilled labour to support the recovery after the financial crisis. In several industries and regions, a lack of skilled labour is starting to show. According to the European Centre for Development of Vocational Training the share of graduates with STEM skills is in the low end of the European ranking (CEDEFOP, 2017), and the demand for such competences in Denmark is expected to grow twice as much as the European average in the period until 2025. For this period, Danmarks Vækstråd (Danish Growth Council) estimates, based on the Danish macroeconomic model DREAM, that there will be a need for 85.000 additional skilled workers (Danmarks Vækstråd, 2016). Several other reports point in the same direction (Danske Regioner, 2016; Reg-Lab, 2016). The supply and quality of labour have been stimulated through several labour market reforms and tax incentives aimed at increasing work incentives, but the supply of skilled labour will still be a challenge in the short and medium-term.

Productivity growth in Denmark has been sluggish during the past two decades and has become a political priority. According to both the OECD and the European Commission, some of the reasons for the unsatisfactory growth in productivity are lack of competition in the building and construction sector and in domestically oriented service sectors (European Commission, 2017a). Moderate investment levels, and low inflation and interest rates have also contributed to sluggish productivity growth as these factors limit the reallocation of resources (Jensen & Jørgensen, 2016). Moreover, it is normal that productivity growth is reduced with increasing labour shortages as companies often are forced to recruit some labour with lower skills (ibid.). In general, technological progress through improved innovation performance, including technology diffusion, is considered crucial to achieve a higher rate of productivity growth.

Whereas the development of the general economic situation in Denmark with steadily rising GDP per capita remains positive, the overall figures hide marked differences not only between people in or out of the labour market, but also between regions. The Government launched in 2015 a strategy termed "Growth and development in the whole of Denmark", which focused on competitive advantages and framework conditions for regional areas outside the larger cities including the movement of public sector jobs out

of the capital, Copenhagen (Regeringen, 2015b). The Government has recently reinforced the focus on regional inequalities and opportunities including the announcement of a second wave of moving Government institutions, or parts of these, away from the Copenhagen area.

1.1 Structure of the economy

SMEs play an important role in Denmark with a slightly higher contribution to the economy in terms of value added compared to the EU average (59% vs. 56.8%). The share of micro-firms in the firm population is estimated to have grown to 88.7% in 2016. Large firms, above 250 employees, make up 0.3% of the firm population in 2016 (compared to 0.2% for the EU). The number of people employed in SMEs was somewhat below the EU average in 2016, at 63.6% compared to the EU average of 66.6% (Small Business Act (SBA), 2017). While Denmark is below the EU average on the share of firms classified within high-tech manufacturing, it is significantly above the average share within knowledge-intensive services.

Another key characteristic of the Danish economy is its openness. The World Bank Doing Business monitoring system for 2016 lists Denmark as number 1 in the world in 2015 and 2016 concerning 'Trading across Borders' (The World Bank, 2016). Also, according to the UNCTAD statistics for Denmark (UNCTAD, 2017), the level of FDI inflows has increased steadily over the last years even though it is still below its pre-crisis values¹. For the FDI outflows, the level has recovered following the economic and financial crisis and was in 2016 above the average level of the pre-crisis years reaching 14 543 million USD. The FDI outflows as % of GDP accounted for 4.7% in 2016.

Danish production is to a large extent knowledge-based. The manufacture of pharmaceuticals and medical chemicals as well as software consultancy and supply are the largest sectors regarding intramural R&D expenditures. Nevertheless, only a relatively small share of firms performs intra-mural, firm-based R&D which is concentrated in a few industries. Outside this group of R&D-performing firms technological, R&D-based knowledge is also used, but in a more indirect manner. The application of Danish industrial R&D in firms is supported by several branch specific, specialised R&D institutions who, through an efficient knowledge dissemination system, supply private firms with updated, R&D based knowledge. This applies e.g. to several sub-industries within agriculture such as slaughtering, which do not statistically account for a large share of firm-level R&D (Christensen, Dahl, Elisassen, Nielsen, & Østergaard, 2011). Hence, even if the Danish industry is well represented in what is usually classified as low-technology industries (e.g. food, furniture, textiles, and agricultural products) the production of these products is often highly knowledge-based and automated.

The European Innovation Scoreboard listed Denmark as second in Europe in both 2015 and 2016, and third in the latest 2017 Scoreboard after Sweden and Switzerland. Denmark scores above average on all 25 indicators in the scoreboard, but is not as well-performing on access to venture capital and the share of innovative SMEs as on the other indicators. Moreover, Denmark has experienced a decline in performance on the scoreboard from an all-time high in 2013 at 139.5 to the 136.7 in 2016.

The creation of new, Danish firms has picked up in recent years according to the Global Entrepreneurship and Development Index (GEDI) (The Global Entrepreneurship and Development Institute (GEDI), 2016). According to GEDI, Denmark has a strong entrepreneurship performance evidenced by the fact that the parameters of the overall GEDI rankings are consistently at or close to the top in the world. Denmark was in 2016 ranked 4th in the world of 132 countries, up from 6th of 130 in 2015. In 2017, Denmark was 5th.

¹ In 2016, inwards FDI decreased to only 921 million USD compared to 4 102 million USD in 2015. However, the FDI statistics are "lumpy" and therefore data for one year are not necessarily indicating a new trend.

According to Eurostat data, Denmark had a business birth rate of 11% in 2015, which is relatively high compared to other comparable EU countries. However, exit rates were also at a relatively high level (OECD, 2015), which has led the government to prioritise stimulating higher quality start-ups. The primary policy attention has been a relatively low share of high-growth entrepreneurial companies (Erhvervsministeriet, 2013).

Although Denmark is faring well in terms of the GEDI measurement of access to capital, according to the Government and data from European Innovation Scoreboard (see below), this is still a frequently mentioned barrier for entrepreneurs, especially among those with plans for rapid growth. Therefore, in September 2016, the Minister for Business and Growth announced in the draft government budget a range of policy initiatives addressing financial constraints for entrepreneurs. Subsequently, in August 2017 concrete proposals were made (Aug. 31, 2017) in three policy areas: tax reform, business promotion, fiscal budget (see further details in the sections on policy development). In November 2017, a political agreement on business growth and entrepreneurship was reached aiming at alleviating administrative burdens, promoting digitalisation, tourism, lower taxes on specific products/services, and improving access to capital. According to this agreement access to capital will be facilitated by way of increased tax incentives to invest in unquoted companies either directly or via institutional investors.

1.2 Business environment

Generally, Denmark has a favourable environment for doing business. In its "Doing Business" analysis, the World Bank ranks Denmark as the third best country in the world in 2017 (the same as in years 2014, 2015, 2016) (The World Bank, 2015, 2016, 2017). Denmark is faring well on all indicators used by the World Bank.

The favourable business environment makes it attractive also for foreign investors to invest in Denmark. According to a survey by The Danish Business Investment Authority "Invest in Denmark"² investors invest in Denmark, because they would like to leverage unique local knowledge and specialized competencies (Invest in Denmark, 2015). Moreover, Denmark's skilled workforce is highly appreciated among most investors surveyed. One third of the investors indicated that they would set up a R&D department, a centre of excellence, or research collaboration with a Danish university. Especially within the Danish industrial strongholds like renewable energy, pharmaceuticals, and the maritime industry, investors find Denmark attractive.

The favourable business environment is also due to a good performance regarding factors such as administrative procedures and regulation, access to finance, other resources (e.g. technological knowledge), and digital infrastructure and services. The latter is indicated by the leading position (no. 1) in the EC Digital Economy and Society Index (DESI) for the past three years (2014-2016). The EU SBA Fact sheet provides a range of parameters on what is broadly termed 'responsive administration'. This includes administrative burdens and regulations and assessment of the interaction SMEs have with public administration. Denmark performs generally better than the EU average on nearly all parameters (Small Business Act (SBA), 2017).

Establishing a business is easier in Denmark than in most OECD countries. Regarding administrative barriers for establishing a business, the World Bank Doing Business survey 2016 compared requirements and costs in Denmark with other high-income OECD countries and finds that this comparison is favourable for Denmark (The World Bank, 2016)³. In addition to several programmes for reducing administrative burdens, an extensive net of advisors and courses organised at the municipality level help overcoming barriers for entrepreneurs and small businesses.

² An organisation under the Ministry of Foreign Affairs, which actively promotes Denmark as a host country for FDI. Investing in Denmark assists about 45 investment projects in Denmark annually. The agency seeks to provide a one-stop service for foreign companies that intend to locate or expand a business in Denmark.

³ Similar conclusions can be derived from the evidence provided in the Small Business Act for Europe.

Denmark also offers a favourable framework for insolvency that includes short turn-over and less costly procedures for recovering debt. There has been no significant initiatives in this area in 2017, but the Danish Business Authority has introduced an early warning system that provides free, impartial and confidential counselling services for distressed companies (Small Business Act (SBA), 2016). Denmark is rated above the EU average on insolvency procedures.

Denmark is among the top three EU performers on access to finance. Nevertheless, the European Innovation Scoreboard indicates that access to venture capital is not as well functioning as other parts of the capital market. Particularly with respect to the segment of high-growth, innovative firms the government has been keen to improve access to finance, and has addressed the just mentioned lack of equity funding in recent policy documents such as Uddannelses- og Forskningspolitisk Redegørelse (Styrelsen for Forskning og Innovation, 2017b), and the new R&I Strategy "Danmark – Klar til fremtiden" (Regeringen, 2017a).

A well-functioning and innovative public sector is important for the business environment. An innovation survey in the public sector was performed by Statistics Denmark in 2014 following the Oslo manual type of innovation surveys for the private sector. In general, a high frequency of innovation was identified across all types of public organisations. As could be expected, process innovations were the most frequent type of innovation. 80-90% of public sector organizations surveyed, such as Health, Culture, and Education, have introduced at least one innovation. In a harmonised survey in the Nordic countries, shares of public innovative organisations in Denmark and Iceland were slightly higher than in the other countries (Bugge, Mortensen, & Bloch, 2011). Similarly, the European Commission InnoBarometer for Europe 2010 shows that Danish public organisations innovate more frequently than the average EU public organisation (Gallup, 2010). Overall, Denmark performs well in public sector innovation. The policy initiatives include the establishment and support of the Centre for Public Innovation⁴, and the appointment of a Minister for Public Innovation and Modernisation within the Ministry of Finance with the objective to improve public sector innovation, digitalisation, and governance⁵.

Public procurement is used extensively for stimulating innovation. Among several policy initiatives is the scheme *Innovative public-sector purchases (The Market Maturation Fund, 2018)*, which aims to make it easier for public-sector institutions to obtain innovative new solutions. The InnoBarometer 2010 (Gallup, 2010) shows that Denmark performs best in the EU on using public procurement to stimulate innovation.

2 Main R&I actors

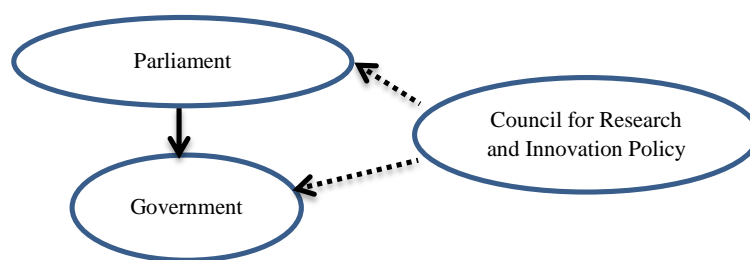
The Danish Government is active in promoting research and innovation, and there is a well-established and centrally organized funding infrastructure.

⁴ www.coi.dk

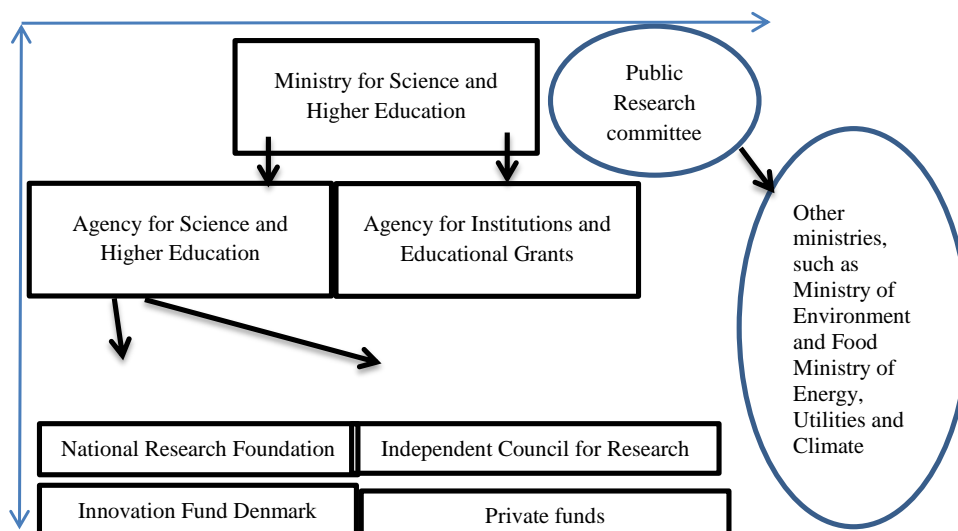
⁵ <https://www.fm.dk/om-os/minister-for-offentlig-innovation-sophie-loehde>

Figure 1: The Danish R&I system

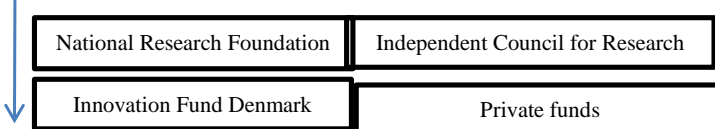
Political level and high-level cross-cutting policy level



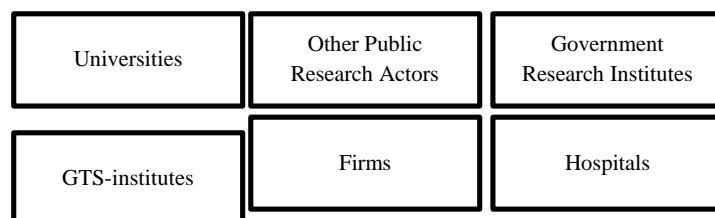
Ministry mission-centered coordination



R&D funding allocation



R&D performers



The main responsibility for research and innovation lies with the Ministry of Higher Education and Science. As of January 2017, the Ministry is divided into two Agencies: The Danish Agency for Science and Higher Education and The Danish Agency for Institutions and Educational Grants.

Furthermore, the Ministry of Industry, Business, and Financial Affairs have tasks related innovation. Several sectoral ministries; the Ministry of Energy, Utilities and Climate, the Ministry of Environment and Food, and the Ministry of Foreign Affairs, all have larger R&I programmes. These ministries have specific agencies, which implement the respective policies.

The regional level has increased the funding substantially for business development. In 2016, the regions provided 1.1 billion DKK, (€148 million) compared to 2.9 billion DKK from the national level. In total, 4.9 billion DKK (€658 million) was available for business development in 2016 (Uddannelses- og Forskningsministeriet, 2016). The regional and local levels have also increased the funding for research by 40% over the last 10 years to a total of 3.6 billion DKK (€483 million). These funds are primarily financing research at hospitals.

The eight universities are the main performers of public R&D. Other important public research performers are the Danish University hospitals. Since 2014, the university colleges of higher education and the business academies have been required to engage in stronger knowledge supplying roles and have started to build research capacities, but these are still in their early development.

The Danish government is also co-financing seven private certified Advanced Technology Group's - ATG's (research and technology organizations). Their primary objective is to stimulate primarily SMEs to become more competitive and innovative⁶.

The private sector performs about two thirds of all R&D in Denmark, and although a large share of private R&D is performed by Novo Nordisk A/S (as seen from table 1 below Novo Nordisk performs as much R&D as the other 9 firms in the top-ten R&D ranking together) many firms are highly R&I intensive.

According to Statistics Denmark (2015), 44% of all companies in Denmark had innovation activities in 2015. 30% were engaged in product or process innovation, 27.5% in organizational innovation, and 28% in marketing innovation. The indicator is somewhat lower for SME's according to the European Innovation Scoreboard (European Commission, 2017b) where only 34.7% of SME's have introduced a new product or process. The index for EU in 2010 is set at 100. For Denmark the index was 110.7 in 2010. After initially increasing to 118.8, it has decreased to 97.9 in 2016; a significant decrease over a relatively short period.

To some extent this drop may be a statistical phenomenon. Linkages for innovation are important gateways to access and transfer knowledge. Compared to the EU average, the European Innovation Scoreboard 2017 (European Commission, 2017b) indicates that Denmark has experienced one of the largest declines on this indicator from index 152.6 in 2010 (EU index 100 in 2010) to 114.8 (2016), while the index for the EU has only decreased slightly in the same period to 95.3. However, in this period there was a merger of research entities. This will by definition statistically result in fewer linkages. More importantly, relatively few companies collaborate with knowledge institutions like universities (15.4% in 2014) representing a small increase compared to 2012 (14.9%). On the other hand, collaboration with public organizations including research and technology organizations has decreased since 2012 from 11.1% to 6.8% in 2014. The level of collaborative patterns with research and technology organizations therefore remains a persistent challenge.

To stimulate innovation performance, the Government has established both demonstration programs (e.g. the EUDP program) and the Market Maturation Fund (MMF) to stimulate commercialization efforts. The Market Maturation Fund has in 2016 funded 38 new projects with 172m DKK. The MMF supports projects with co-financing (up to 45%) and supports only prototype testing and adaptation of innovative solutions towards the market. An evaluation of the Fund showed that 25% of the participating firms were able to enter the market faster due to the funding and 26% of the participants stated that they would not have reached the market without the funding (The Market Maturation Fund, 2017).

To stimulate collaboration between R&I actors, the Danish government has since 2007 supported more than 22 nation-wide innovation networks. These networks are designed to facilitate interaction between universities, RTO's and firms and are topically defined e.g. focusing on transport, production, energy including offshore technologies, food, and service innovation. The innovation networks are therefore as such not R&D performers, but are designed to facilitate knowledge exchange between R&D performers including firms. An application round was completed in the spring of 2014 for a further four-year period (2014-2018) with a total funding of €39m supporting 22 networks. A report on the performance of the innovation networks from the Ministry of Higher Education and Science showed that after a period (2010-2014) more firms were engaged in

⁶ As of January 1st. 2017, DELTA was merged with Force Technology resulting in a reduction from eight to seven ATG's in Denmark <https://dk.madebydelta.com/om-os/kundeinformation/>

collaborative projects and more companies engaged in collaborative projects for the first time, a decrease was registered from 2014 to 2015. This decline continued according to the most recent performance account of the networks (Styrelsen for Institutioner og Uddannelsesstøtte, 2017). Even though the number of companies becoming innovative, based on participation in the innovation networks, increased over the period from 2007 to 2015, the networks had the best performance in the years from 2011 to 2014. The current innovation networks have been offered a 6-month extension (until end of 2018). It is expected that a new application round will follow offering network funding for 2019-2020. The Government's new strategy for research and innovation (Regeringen, 2017a) points to the innovation networks as one measure for increasing the links in the research and innovation system further in order to address the challenge of the lacking innovation performance of small and medium sized companies.

Finally, larger societal partnerships involving public actors as co-creators and public-private innovation efforts have been established and are notable. Examples include the Danish MADE initiative, which focuses on production and Internet of Things for manufacturing; and BloxHub, which aspires to bridge architecture, design, construction and digitization by connecting companies, researchers and organizations to create solutions for a good city life. A recent mid-term evaluation of MADE (Innovation Fund Denmark, 2017a) showed that the participating firms were more innovative and productive than the industry as a whole. The evaluation highlights several positive benefits that hold a large potential for industry, if implementation and dissemination of the developed technologies can be ensured.

The Danish research & innovation (R&I) system has undergone upgrading in all respects and, as indicated by bibliometric statistics, the quality of scientific outputs in Denmark is world class. The Danish R&D and innovation system is also very productive. Patents constitute an indicator of R&D output performance. Due to its small size, Denmark only accounts for a small proportion of World patents (0.61 in 2015), but if patent applications are normalized by billion GDP, the share was 6.24 in 2015, which is well above the EU average of 3.53. The number of international scientific co-publications per million population has shown an overall increase from 1166.12 (2009) to 2228.92 (2016). Hence, the level of research in Denmark is high regardless whether it is measured by the number of scientific publications per inhabitant or citations per publication. Overall, on the research excellence composite indicator, Denmark is ranked 5th, which is similar compared to previous years (Vertesy & Tarantola, 2012). The Government will, though, according to the recent Strategy for Research and innovation (Regeringen, 2017a), increase the excellence of research further and broaden it to more research areas (see section 4).

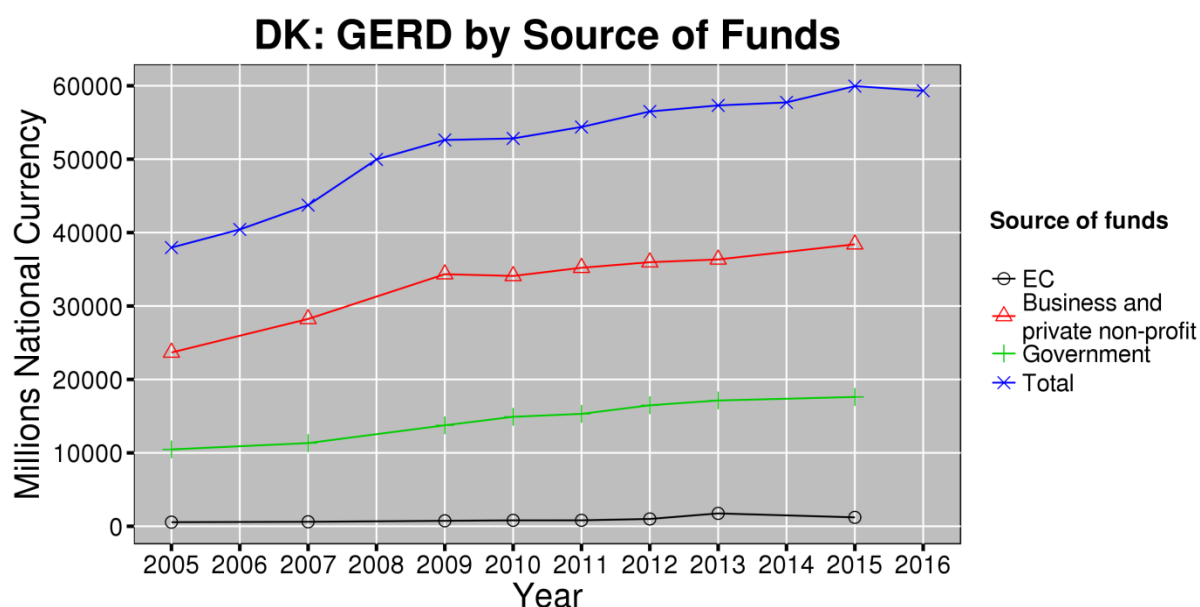
In sum, despite the high quality and relative volume and effort in research, there is still potential for improvement on the innovation output side, particularly concerning the innovation performance of SMEs, as well as the level and availability of human resources for R&I; notably in the private sector.

3 R&I policies, funding trends and human resources

3.1 Public allocation of R&D and R&D expenditure

Denmark's gross domestic expenditure on R&D (GERD) reached 2.87% of GDP in 2016, which is a small decrease from 2015 (2.96%) and 2014 (2.91%). The level remains well above the EU average (2.03%). The public research budget for 2017 was 21.5bn DKK (€2.9 billion) or 0.92% of GDP in 2016 (Statistics Denmark, 2017b) down from 1.01% in 2015 and 1.0% in 2014 due to budget cuts in 2016. For 2018, the proposal for the fiscal budget is 22.2bn DKK (€ 3.0 billion) of public expenditures on R&D, which is estimated to amount to about 1.0% of GDP. In the new R&I strategy, the Government has confirmed its commitment to the 1% target for public R&D expenditures.

Figure 2: GERD by Source of Funds for Denmark



Source: Eurostat, November 2017

The share of total public R&D performed by the higher education sector (HES) has increased in total, but experienced a slight decrease in 2016 as % of GDP. The flows from business to higher education for R&D purposes has decreased from financing 5.0% of public R&D in 2008 to 4.4% in 2015 (Regeringen, 2017b), despite a significant policy focus on increasing collaboration between business and universities. Private non-profit organizations account for a significantly larger proportion of the funding of R&D performed by HES compared to the investments from business. According to a recent mapping of private funding 12 private non-profit foundations contributed around €1.3bn for research, innovation and higher education in the three-year period, 2012-2014, and have doubled their contribution in the 2007 to 2014 period. These funds are mainly invested in the eight universities. The external share of funding of university research is, according to the Government, the highest in the OECD and the new R&I strategy (ibid. p. 12) states that the regulatory framework for such investments will be assessed with a view to further smoothen the investment process. Three foundations invest more than a third of their funds directly on innovation (about €52m). "Industriens Fond" (The Danish Industry Foundation) funds initiatives strengthening the competitiveness of Danish industry. Based on open and thematic calls, the foundation funds some €15m per year. The two other foundations are Realdania and Novo Nordisk Fonden.

Public funds contribute directly around €300m to innovation. These funds support the innovation networks, the ATG-institutes and the InnoBooster scheme of the Innovation Fund Denmark among others. The InnoBooster scheme is directed at SME's and on average award 170 000 DKK (€23 000) kr. to the awarded applications. In 2016, the scheme received 1475 applications and awarded 351 grants (Innovation Fund Denmark, 2017b), which by far is the largest volume of the schemes in the Innovation Fund. In total, the scheme has received more than 4200 applications since program inception in 2014. In total, 580 million DKK (€78 m) have been awarded to InnoBooster applications. A recent evaluation of the InnoBooster program highlights that for many of the

participating SME's, the instrument provides the "necessary push" to move forward on innovative initiatives (Iris Group & The Danish Innovation Foundation, 2017: 8).

Denmark is a member of the European Spallation Source (ESS), which is part of a European investment in research facilities oriented towards research in new materials. It is expected to be finalized by 2019. Denmark will invest 2bn DKK (€ 269 million) from 2014-2022 on this initiative. The Government launched in 2015 a strategy to ensure that Denmark makes the most out of these substantial investments.

Public funding of R&I is also provided through international programs. The Danish share of total EU contribution from the EU framework programs has been stable at 2.37% from FP6 and 2.36% from FP7. However, in absolute terms, there was an increase in EU contribution to Denmark of almost 168% from €396.1m in FP6 to €1,060.6 million in FP7. Regarding Horizon 2020, the Danish share of total EU contribution is €726 million, equaling about 2.5%, which makes Denmark the fourth most successful Member State in the competition for FP fund relative to the size of its population (Uddannelses- og Forskningsministeriet, 2016).

3.2 Private R&D expenditure

Business enterprise R&D expenditure (BERD) had increased to a level of 1.96% of GDP up to 2011, but decreased to 1.89% in 2016. BERD contributes about two thirds to overall GERD. The investment in R&D by the business sector is an important driver of innovative performance, and especially relevant for realizing a higher innovative performance of SMEs. Hence, the decrease over the last 5 years may in part explain the challenges of increasing the overall innovative performance of SME's.

The government funding of private business R&D has been decreasing (from 0.06 in 2009 to 0.05 in 2015), similarly to the business sector's own funding that has also been slightly decreasing. In terms of sectoral distribution, manufacturing of basic pharmaceutical products and pharmaceutical preparations is the most important R&D performer in the Manufacturing sector, followed by manufacturing of computer, electronic and optical products, and manufacturing of machinery and equipment. In the Services sector Information and communication and Financial and insurance sectors are the primary R&D performers. Table 1 shows the top-ten R&D performing firms in Denmark. As mentioned, Novo Nordisk is dwarfing the rest of the firms in terms of the R&D volume. It is also seen from the table that pharmaceuticals is the most important R&D performing sector in Denmark.

Table 1: The largest R&D performers in Denmark

EU RANK 2017	EU RANK 2016	EU RANK 2015	Company name	Industry	R&D exp. 2016 (€m)	R&D 1-year growth	R&D intensity %
22	26	22	NOVO NORDISK	Pharmaceuticals & Biotechnology	1.996	14,7	13,3
81	80	86	H LUNDBECK	Pharmaceuticals & Biotechnology	355	-7,7	16,9
89	87	84	DANSKE BANK	Financial Services	329	-8,2	4,9
121	114	118	NOVOZYMES	Pharmaceuticals & Biotechnology	237	-0,4	12,5
129	126	141	DANFOSS	Industrial Engineering	221	2,4	4,2
144	170	159	VESTAS WIND SYSTEMS	Renewable Energy	198	26,9	1,9
188	193	165	GRUNDFOS	Industrial Engineering	140	4	56,7
233	212	240	GN STORE NORD	Technology Hardware & Equipment	114	-6,2	9,1
251	216	264	ARLA FOODS	Food Producers	101	-12,9	1,1
253	244	255	WILLIAM DEMANT	Health Care Equipment & Services	100	2,6	6,2

Source: (IRI - Economics of Industrial and Economic Research, 2017)

3.3 Supply of R&I human resources

Increasing the education of PhDs has been a political priority. The share of new doctoral graduates per 1000 of the young population was 2.23 in 2016 above the EU average of 1.07 (2013) and has increased from 1.14 since 2009. A review of the Danish Doctoral Education from 2017 (Styrelsen for Forskning og Innovation, 2017b) found the Danish system to be well functioning, and Danish doctorate thesis to be of a very high international standard. Furthermore, the share of new graduates in STEM per 1000 population has increased from 1.89 to 2.58 in 2015. For new graduates in STEM per 1 000 persons aged 20–29 years, both the shares of men and women are above the EU average (EUROSTAT, 2014). According to Eurostat (2014), with 10.6 researchers per 1000 population Denmark is ranked 2nd in Europe only after Sweden and at the same level as Finland, and Denmark is considerably above the EU level of 5.6 researchers per 1000 population (ibid.).

The recovery after the crisis combined with an ageing labor force is expected to progressively lead to an emerging under-supply of certain types of skills in the labor market (Ministry for Economic Affairs and the Interior, 2017). For highly skilled people with a tertiary education the employment situation is in general good.

Despite a challenge in securing an adequate labour force for the long term, there is also a positive development in key indicators of the supply of high-skilled human resources. The share of new doctoral graduates per 1000 of the young population is above the EU average and has increased since 2010, as has the new graduates in STEM per 1000 of the young population (EUROSTAT, 2017). In November 2017, the Government made a new political agreement on the distribution of funds for higher education (Uddannelses- og Forskningsministeriet, 2017). This agreement focuses on quality in education as well as employability of the new students. A special emphasis is on increasing the number of study places for STEM students.

	2009	2010	2011	2012	2013	2014	2015	2016
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	1.14	1.41	1.52	1.47	2.04	2.25	2.26	2.23
New graduates in science, maths, computing, engineering, manufacturing, construction per 1000 population		1.89	2.09	2.23	2.43	2.59	2.58	3.06
Number of researchers per thousand of population			10.22	10.31	10.29	10.44	10.6	
Public expenditure on education (% GDP)	6.9	7.1	6.8	7	6.9	7.1	7	6.9
Public expenditure on tertiary education (% GDP)	1.4	1.4	1.4	1.6	1.6	1.7	1.7	1.8
Population age 25-34 having completed tertiary education (ISCED 5-8) (%)	37.6	37.6	38.6	40.2	41.2	42.7	44.5	45.3
Employment rates of population age 25-64, having completed tertiary education (%)	86.8	85.7	85.8	86.4	86.5	86	85.9	86
Share of employees age 25-64 having completed tertiary education (%)	35.2	36	36.7	37.7	38.1	38.9	39.9	39.2
Share of scientists and engineers in the age group 25-64 as % of active population (%)	7	7.1	10	10.2	10.6	10.4	10.1	10.7
Share of female researchers	31.75	32.59	33.13	35.41	34.52		32.47	
Share of tertiary degree mobile graduates from abroad (%)					12	11.7	11.9	12.9

Table 2: Supply of human resources

The Danish Government established the Disruption Council in May 2017 to advise on how to better address the challenges and utilise the opportunities created by new technologies and increased globalization (Regeringen, 2017b). One theme on the Disruption Council's agenda is the "Competencies of the future", where the focus is particularly on the future competencies needed, when taking the future automation of work tasks and functions into account. At present, no detailed analysis has been presented on this, but one premise of the Council's work seems to be that Denmark has not sufficiently exploited its strong digital position to increase productivity growth.

4 Policies to address innovation challenges⁷

The Danish Government on 6 December 2017 launched a comprehensive new strategy for research and innovation (Regeringen, 2017a). The strategy has two main goals:

1. Danish research must be at the highest international quality (The "Nobel" goal).
2. Research must benefit society (The Relevance goal).

These two goals are supported by 28 initiatives. It is part of the Nobel goal to set up a 'Nobel pact' with the objective to reach the highest level of research quality and rewarding excellence. For the Nobel goal, the specific initiatives include creation of individual career paths, recruitment, and incentives for talented researchers as well as a new performance based funding model for the universities, new research system infrastructures, and stimulating international research collaboration. The Relevance goal is supported by activities related to strategic funds and capacity for technological research, focus on digitalisation as well as value creation in firms from research and focus on the connectivity and coordination between public and private funding of research. Moreover, technology transfer from higher education for societal use will be stimulated, and both higher education quality and more graduates from STEM educations are policy objectives.

The new R&I strategy builds on previous R&I policies. It specifies and extends the ambitions for the already very high science performance and has the clear objective to make research more useful for society. The RESEARCH2025 (FORSK2025) themes are still relevant to the new strategy, and through the Innovation Fund funds are allocated to research under the following themes: New technological opportunities, Green Growth, and Better Health (three of the four themes in RESEARCH2025). The new R&I strategy will later be followed by separate strategies for digitalisation and growth in life sciences.

High public R&D investments will support the strategy. Public R&D investments dropped slightly below 1% in 2016 because of budget cuts, but expenditures are estimated to have been about 1% of GDP for 2017 following a smaller increase in the budget for 2017 (Styrelsen for Forskning og Innovation, 2017b). The Government has confirmed in the new strategy its commitment to keeping public R&D investments at 1% of GDP.

Effective policies for R&D and innovation ensure the efficient and effective working of the innovation system regarding the generation, dissemination, and use of knowledge. The new R&D and innovation strategy addresses all parts of the innovation system. Nevertheless, the discussion in the previous sections pointed to the potential for improvement in some areas. In this section, we discuss three identified challenges for improving the Danish innovation performance: (i) increase the innovativeness of SMEs, in particular the number of high growth innovative firms, (ii) increase the quality and availability of human resources, and (iii) support innovation to boost productivity. The challenges are on different levels of aggregation and have different time perspectives,

⁷ We note that at the time of writing the Government has put forward proposals for new policy initiatives, notably a tax reform and a new industrial policy. Political negotiations are currently focused on these proposals and the fiscal budget for 2018, which could therefore not be systematically taken into account in this report.

but are nevertheless strongly linked. They are not new in the Danish context and were presented in the 2016 RIO report (Knudsen, Christensen, & Christensen, 2017).

4.1 Challenge 1: Reinforcing the links between actors to improve the innovativeness of firms and the commercialization of research

Description

This challenge is related to the overall connectivity of key actors in the innovation system as well as the commercialization capabilities at firm level. The former has been a policy focus for many years, but improvements are still needed as also recognized in the new R&I Strategy. At the firm level, a challenge for Danish SME's is to improve their innovation capabilities by benefitting to a larger degree from the strong science system to enhance innovation output. This is demonstrated above by the declining innovation performance within the Innovation Scoreboard (Chapter 2).

Policy response

Several policies to enhance collaboration between actors in the system have been implemented in the past, including funding of 22 innovation networks. The Innovation Fund's InnoBooster program (established in 2014) aims to support the innovative capabilities of SME's. In 2017, an evaluation showed that the program has been successful in providing the "final push" to firms (Iris Group & The Danish Innovation Foundation, 2017). Similarly, the Market Maturation Fund supports initiatives to promote growth, employment and export, particularly for SMEs and within three focus areas: (i) market development through co-funding for private enterprises' innovative solutions, (ii) market development through innovative public procurement, and (iii) market development through industry partnerships⁸. These initiatives are directed at R&I developments, which are very close to market introduction.

A strengthening of the RTO system (including the private "Advanced Technology Group Institutes") has also been prioritised. Although at a relatively small scale, the ministry invites applications for additional funds that are simultaneously aimed at supporting new policy focus areas like drones, space, and the circular resource economy. The regulations on collaborative agreements between actors will be reviewed and possibly relaxed. Technology transfer in terms of spin-outs, licensing, and other use of IPR is a priority in recent government plans. Over the past years, the Danish universities have initiated a process of reconfiguring their technology transfer offices to improve their commercialization capabilities and attention from a traditional linear approach towards a more collaborative and interactive model. In line with this work, physical 'Innovation Hubs' and 'Science and Innovation Parks' are being built to provide shared facilities for researchers, student entrepreneurs, and businesses. Funding of such activities is also a focus of private foundations.

At the regional level, the six regional growth fora have, to a large extent, focused on innovation in the private sector. Examples are strengthened collaboration between research institutions and SMEs and counselling on growth plans and innovation audits in SMEs. The regional growth fora spent approximately DKK 800m (approximately €107m) on regional growth measures in 2016 (Uddannelses- og Forskningsministeriet, 2016).

The new R&I strategy from December 2017, includes initiatives to strengthen research in technology and technology transfers from universities to business. To further incentivize private firms to carry out R&D, the Government will increase the tax benefits progressively from 100% to 110% in 2026. It will also improve coordination between the

⁸ https://markedsmodningsfonden.dk/in_english

different funding instruments, between universities and simplify the administration of R&D programmes.

Policy Assessment

Despite continued efforts over the last decades and with some notable progress, there is still a potential for improving the links between the actors in the R&I system. This assessment resonates with The Danish Council for Research and Innovation Policy (Danmarks Forsknings- og Innovationspolitiske Råd, 2016), which points to inadequate links between key actors and a fragmented innovation infrastructure. They recommend a more holistic, systemic approach to innovation policy, but it is questionable whether this will be sufficient. There is an even higher need to improve the conversion of the strong science performance into improved innovation performance of SMEs. The decreasing share of SME's that introduce new products and processes is a significant challenge since research has shown that converting non-innovative to innovative firms is hard (Suárez, 2014). The Market Maturation Fund has been successful in supporting the initiatives of SME's, but the absolute volume of funding is limited.

The Productivity Commission's (2014) proposal for larger societal partnerships including public actors as co-creators and public-private innovation efforts resonates well with the intentions of improved commercialisation. Examples of new initiatives include the MADE initiative for production aimed at improving the performance of the manufacturing sector and BloxHub focusing on city life. The first evaluations are positive. There has been a continuous policy to enhance network-based innovation. The audit of the Danish network and cluster initiatives showed that especially small firms with less than 50 employees benefit from participation in the networks in terms of improving their innovative capabilities to increase their innovation output (Styrelsen for Forskning og Innovation, 2016a; Styrelsen for Institutioner og Uddannelsesstøtte, 2017). The new R&I strategy recognises these challenges for improving links between actors as well as commercialisation of innovative efforts by firms, but the proposed policy initiatives can only be expected to have an effect in the longer run, hence there needs to be a continuous effort.

4.2 Challenge 2: Increase the quality and availability of human resources

Description

With the recovery from the economic and financial crisis, there is now a lack of skilled labour in several industries and regions. Ensuring an adequate supply of skilled and highly skilled labour is a pre-requisite for lifting Danish innovation performance and for addressing the productivity challenge. Statistics Denmark collects yearly data on vacant positions in private firms. Comparing figures for the first quarter each year indicates 18.000 vacant positions in 2013 (Q1) increasing to 31.500 in 2017 (Q1). The increase is noted in all 5 regions in Denmark. Plumbers, electricians, and IT specialists are among the type of labour most often listed by firms as being in scarce supply (Statistics Denmark, 2017a). One in four firms reports that a shortage of these types of labour has hampered their growth (Ministry for Economic Affairs and the Interior, 2017: 90-91; Statistics Denmark, 2017a).

Furthermore, while the development in the general economic situation in Denmark remains positive with an increasing GDP per capita, the overall figures hide marked and increasing differences, not only between people in or out of the labour market, but also between regions. The increasing regional inequalities are particularly problematic for companies outside the larger cities especially with respect to attracting enough skilled labour.

Policy response

A previously formulated target that at least 25% of youth cohorts should complete a master's degree by 2020 has been reached. This has led the previous government to down-scale certain educational programmes at the universities. Denmark has also strengthened the Industrial PhD and Post-Doc programmes, and efforts are made to increase the supply of skilled labour including upgrading the existing work force, and there are plans to increase innovation-related and entrepreneurial skills in courses and programmes throughout the education system. The supply and quality of labour has also been stimulated through several labour market reforms and tax policies focusing on increasing the work incentives, including postponing retirement. However, there is no robust assessment as to the responsiveness of the supply of labour to these incentives, yet.

One of the two main objectives of the new R&I strategy from December 2017 is to increase the quality of Danish research further from its current high level. This is to be achieved through the establishment of special "Nobel" research centres in collaboration with private philanthropic funding, the introduction of a performance based research funding model, improved career possibilities for researchers, further international research cooperation, and further investments in research infrastructures. Moreover, the Government plans to establish a technology "pact" between business, universities and public authorities to stimulate STEM education.

As a response to the challenges associated with regional inequalities, the Government launched in 2015 a strategy "Growth and development in the whole of Denmark", which focused on competitive advantages and framework conditions for regional areas outside of the two largest cities (Regeringen, 2015b). As one of many parts of this strategy, the Government decided to move 3900 government jobs from Copenhagen to other regions in the following four years towards 2018. A status in September 2017 showed that 2546 jobs had been moved. 23 of the planned 44 institutions had completed their move. The Government announced on 28 November 2016, a second wave of relocation of government jobs, which is planned from 2018 onwards. These initiatives are focused on reducing the regional inequalities in job opportunities and stimulating the economy in the regions through the indirect effects from these jobs. A head count showed that 22% of the moved jobs were filled with employees that moved or commuted to the new site (Regeringen, 2017c). Another 2016 policy initiative is the introduction of a 2-year subsidy to firms in rural areas (in 2016) employing high-skilled people for innovation projects. In total, 122 policy initiatives aimed at this challenge were planned. Around half of these have been implemented (Regeringen, 2015a). The attention to regional disparities continues in recent policies, for example in the business promotion agreement of November 12th, 2017.

Policy Assessment

All projections show that there will be a shortage of people with STEM skills and skilled craftsmen. Therefore, the initiatives to create more interest in STEM educations and the efforts to improve research as well as the careers perspectives of researcher are highly needed. Still, the skills challenge can only be resolved in the medium to long term as it takes time to train people. But the challenge is also to ensure upgrading of existing labour supply, in view of future demands for skills. This is not only a matter of deep technical skills, but the future requirements of the skills profile of workers also require more 'soft' competences like collaborative capabilities to function in increasingly networked work environments (European Commission, 2016; OECD, 2017b; Vækstforum Nordjylland, 2016). The work of the new Disruption Council is aiming to provide analyses, solutions, and suggestions for bridging the current supply and the future needs of skills –considering the digitalisation and automation opportunities and the challenges that these developments pose to qualifications. It is important for the success of the work in the Disruption Council and elsewhere that a broad view of the skills challenge is

applied, implying that recommendations and initiatives go beyond a narrow focus on technical skills and STEM educations only.

The skills challenge relates not only to the education system, but also to the labour market. This is accentuated by the need to improve labour market inclusion and improving the employability of disadvantaged groups. The job-integration measures agreed in the 2016 tripartite negotiations (August 2016) aimed at improving the integration of newly arrived refugees and migrants, as well as providing incentives for companies to create 10 000 new apprentice places. The tripartite negotiations in 2017 more generally addressed the need for upgrading of the existing workforce (valid for 2018-2021)⁹. Ideally, an improved labour market inclusion would provide part of a response to the skills challenge. The extension and widening of the researcher tax credit scheme from 5 to 7 years is an example of a relevant initiative targeted at the highest education levels, whereas the initiatives for educating low-skilled for new job opportunities with higher qualifications remain limited.

The shortage of skilled labour is most felt in the outermost regions, where companies experience the largest problems of hiring the skilled labour they need. The strategy to promote growth and development in the whole country is an attempt to alleviate the problem of regional inequalities (Danske Regioner, 2016), although the exact net effect is still to be established. In addition, there are targeted labour market and tax measures in place to encourage mobility, but so far, the problem of increasing regional inequalities persists.

4.3 Challenge 3: Support innovation to boost productivity

Description

Many advanced economies including Denmark have experienced a weak development in private investment in the aftermath of the economic and financial crisis. The level of investment in non-R&D expenditures has followed OECD trends up until the financial crisis, but decreased significantly below the OECD average after 2010 (Danish Ministry of Business and Growth, 2016). Like other OECD countries, Denmark has seen a shift towards service sectors accounting for a larger proportion of GDP compared to manufacturing and agriculture. However, analysis shows that so far sectoral shifts cannot explain the drop in productivity growth¹⁰. Still, improved productivity in the services sector has been a policy focus; in particular there has been a focus on increasing competition in services.

A challenge such as low productivity growth can probably only be addressed through a broad range of measures. Nevertheless, there is significant scope for R&D and innovation and infrastructure investments to support improvement in the business sector especially amongst SMEs. Together with increased qualifications of human resources, improvements in the business sector have the potential to provide a significant contribution to a stronger productivity development.

Policy response

Following recommendations from the Productivity Commission (2014) and the Economic Councils, the Government has been attentive to the effects on productivity from increased competition, smooth and limited regulation, and high efficiency of the public administration. Concerning R&I, in addition to reinforcing the links between R&I actors (challenge 1) and the need to increase the quality and availability of human resources

⁹ <https://www.regeringen.dk/nyheder/trepartsaftale-2017/>

¹⁰ This phenomenon is sometimes referred to as "Baumol's disease". However, the analysis by the Danish Economic Council Danish Economic Councils ("De Økonomiske Råd"). 2017. Autumn Report: Konjunktur og offentlige finanser, Langvarigt offentligt forsørgede, Brancheforskydninger og vækstudsigt: 1-272. Copenhagen: De Økonomiske Råd.) shows that Denmark is not (yet) impacted by "Baumol's disease".

(challenge 2), Denmark has improved the funding possibilities for R&I. Support is provided by the Danish Growth Fund for on-going business development in sectors of high societal importance (see below in the section on smart specialisation).

Policy Assessment

Improved innovation performance is a key to address the productivity challenge. Therefore, the policy response to the productivity challenge should also address relevant shortcomings in the innovation system ('system failures') in order for innovation to contribute to a stronger productivity development. Importantly, the measures to improve funding complements the measures addressing the skills challenge and improving interactions between R&I actors.

5 R&I in National and Regional Smart Specialisation Strategies

Danish business support policies have applied the smart specialisation principles for a long time. In their original formulation (Foray, David, & Hall, 2009), it was emphasized that smart specialisation describes a process, which departs from the embedded strengths of a region and involves entrepreneurship and regional stakeholders. Policy processes in Denmark have to a large extent been pursued in this manner for a couple of decades. At a national level of aggregation, key actors from both public and private organisations are consulted for advice, and at a regional and local level they are also engaged in the actual implementation phase. Hence, the Local Action Groups, an European Regional Development Fund (ERDF) supported scheme, are particularly active and with a high involvement of local actors in Denmark (ibid.). Furthermore, cluster policies (see below) are likewise often organised with the involvement of regional stakeholders participating in the process. Recently, the regions have integrated innovation in their overall development strategies¹¹ and only in a few cases have they also carried out smart specialisation¹² or innovation analyses. The Danish ERDF Program for 2014-2020 (Erhvervsstyrelsen & The European Regional Fund, 2017) focuses on four objectives: enhanced innovation in SMEs, more high-growth firms, energy and resource efficiency in SMEs, as well as smart and green urban development. For example, it is stated in the guidelines for the program in support of Innovation in SMEs that 'Innovation should be within an area identified in the regional growth and development plan and in the description of the regional intelligent specialization, which typically will be integrated in the regional growth and development plan.' (pp.13, translation from Danish). Similar formulations are made when explaining support under other priorities. This illustrates that it is a pre-requisite for Regions to use S3 approaches, and that the smart specialisation approach is typically integrated in the overall, regional growth and development strategies.

5.1 Policies – levels of aggregation and coordination

The collection of strategies, which jointly make up the Danish smart specialisation strategy include the Government's growth plans; the annual growth partnership agreements between the Government and the Regional Growth Fora; and at a regional level the growth and development strategies of the Regional Growth Fora. Furthermore, the national innovation strategy and the national cluster strategy contain elements promoting smart specialisation. The Danish Growth Council coordinates and promotes cooperation and development between the national growth strategy and the regional growth and development strategies.

¹¹ See e.g. The North Jutland regional development strategy <http://www.rn.dk/Regional-Udvikling/Strategier-og-planer/REVUS>.

¹² See e.g. the North Denmark expert assessment of the Smart specialisation implementation Asheim, B. 2014. North Denmark Region RIS3 Expert Assessment 1-36. Brussels: DG Regional and Urban Policy .

Regional growth fora try to ensure coordination and synergy between the Danish Government's growth strategy and the specific regional key strengths. The aim is to convert the Government's growth plans in selected business areas into specific actions with consideration for the strengths existing within the region. Ideally, an efficient smart specialization strategy would have a large degree of overlap between the prioritized areas at the regional level and priorities at the national level. Regional strongholds and national priorities do not necessarily overlap. Therefore, the partnership agreements between the Government of Denmark and the regional Growth Fora are important instruments in ensuring coordination.

At a lower level of geographical aggregation other, local initiatives seek to stimulate growth. For instance, on the Island of Funen, a part of the Region of Southern Denmark, five municipalities out of 10 (including the largest, Odense) have joined forces to stimulate growth on the island through collaboration with local industry and relevant research environments. The initiative "UdviklingFyn" ("Development Funen") was established in its current form in 2012, but was preceded by other smaller initiatives centred around the City of Odense. Priorities include robotics, drones, tourism, and the maritime area, which are all based on existing or emerging industrial strengths. The initiatives are primarily focused on clusters. In part, the initiatives of Udvikling Fyn are parallel to the initiatives taken by the Regional Growth Forum, but no explicit coordination of the efforts seems to take place.

5.2 S3 priorities

Over the past few years, Denmark has improved the funding possibilities for R&I in certain areas and has pursued analyses and policies in line with the 3S approach. Although not directly related to development of 3S, the Danish Government commissioned in 2012 eight growth teams with members from industry in areas where Danish businesses are, or can be, internationally competitive. Based on their recommendations, the Government published during 2013 specific growth plans for each of the following areas: Blue Denmark; Creative Industries and Design; Water, Bio and Environmental Solutions; Health and Care solutions; Energy and Climate; Food Sector; Tourism and Experience Economy ICT and Digital Growth. The plans addressed specific barriers to investment and focus on areas in which new markets can be developed.

Based on these plans, the current Smart specialisation priority areas of Denmark for the 2014-2020 period are (European Commission, 2017c):

1. Manufacturing & industry
2. Energy production & distribution
3. Sustainable innovation
4. Human health & social work activities
5. Agriculture, forestry & fishing

The degree of alignment with national priorities varies across regions. For example, the regional priorities of the Central Denmark Region are: Energy and Environment, Foodstuffs, and Welfare Technology. The Region of Southern Denmark has a focus on: Health and Social Innovation, Sustainable Energy, Experience Economy. The Growth Forum of the North Denmark Region (Growth and Balance', 2010¹³) listed the priorities of the North Denmark Region as: Tourism and Experience Economies, Construction Industry, Energy, Food, Health and Life Science, ICT, Intelligent Transport (including Logistics), and Maritime Sector (European Commission, 2017d). The regions are not obliged to coordinate their actions and plans across or with other regions, which may lead to some duplication.

¹³ In September 2017, a new partnership agreement with the government was signed. Priorities are focused on three areas; Technology and digitalisation, the Maritime sector, green growth and circular economy.

5.3 Related policies and prioritizations

An important Danish policy initiative complementary to the smart specialization priorities is the INNO+ catalogue (Ministry of Science, 2013), which in a 3-5 year perspective, presents areas for strategic investments in innovation, channeled through, among others, the Danish Innovation Fund. The current efforts in INNO+ are linked to the Research2020 efforts and priorities (Ministry of Science, 2013). The INNO+ catalogue was created through the involvement of stakeholders from the Danish society with their input on promising technologies and business areas of the future. The INNO+ catalogue entails prioritized areas for innovation policy:

- Innovative transport, environment and urban development
- Innovative food production and bio economy
- Innovative health solutions
- Innovative production
- Innovative digital solutions
- Innovative energy solutions

There seems to be a potential for further regional coordination with the national INNO+ priorities to support the implementation of smart specialization strategies. The smart specialization priorities are broad enough to cover the sub-priorities under the areas listed in the national priorities.

At the national policy level, the RESEARCH2025 catalogue (Styrelsen for Forskning og Innovation, 2017a) also provides sectoral priorities in line with the smart specialization priorities and is an important new policy development for 2017. Similar to the creation of the INNO+ catalogue, the RESEARCH2025 Catalogue was created in a process involving a variety of stakeholders including businesses, organizations, ministries, and Danish knowledge institutions. The RESEARCH2025-catalogue will function as a source of inspiration and a basis for prioritizing future research investments. 19 areas are prioritised and presented under four main themes: 1) Technology, production, new materials, and digitisation; 2) Health; 3) Food, environment, energy, transport and climate; 4) Education, Public sector and globalisation¹⁴.

Regional investments in cluster development are covered by the ERDF programme, when the industrial focus areas of the clusters belong to the overall regional smart specialisation priorities. Cluster policies and cluster investments are therefore closely related to the smart specialisation policies. The Danish cluster strategy 2.0 (Styrelsen for Forskning og Innovation, 2016b) (2016-2018) is an update of the first cluster strategy from 2013 and aims at enhancing value creation from the cluster efforts (Styrelsen for Forskning og Innovation, 2016b). A recent evaluation of cluster performance finds that there are positive effects from clusters (Styrelsen for Institutioner og Uddannelsesstøtte, 2017). Cluster policy is a well-established, highly valued and popular type of policy at both national, regional, and municipal level.

5.4 Assessment

Denmark has a long tradition for S3-like policies from before the S3 concept was developed. For example, Denmark was one of the first countries to implement active cluster policies, especially from the mid-1990s onwards. In line with the S3 approach, a mapping was done and subsequent extensive policy initiatives were implemented in 1993-94 on eight 'Resource Areas'. These analyses laid out the links between and within sectors defined not by the statistical production activities of firms, but rather by

¹⁴ Published June 2017 Styrelsen for Forskning og Innovation. 2017a. FORSK2025 – fremtidens løfterige forskningsområder: 1-224. Copenhagen: Ministry for Science and Education.

commonalities of market and assets amongst a wider range of actors¹⁵. The debate on regional competitive advantages in the years following the Resource Area mapping was focused on specialisation/diversification and regional strongholds, which provided a basis for national and regional priority setting. The formulation and implementation of the initiatives following the Resource Area analyses engaged key actors from private industry and organisations outside the usual policy making spheres.

It is clear from the above that a number of policy areas run parallel with smart specialisation policies. It is also clear that regions differ in how they pursue 3S and which areas they prioritize. Moreover, the smart specialisation efforts are often integrated in the general pursuit of industrial policy. In this perspective, the coordination and alignment of smart specialisation strategies in Denmark is complicated. Likewise, it is difficult to assess the stage of implementation of 3S in Denmark¹⁶ because of the highly integrated nature of the initiatives. Generally, the way smart specialisation was originally formulated, i.e. as a policy process involving experimentation, recognising and utilising locally embedded resources and existing strongholds, and involvement of key stakeholders in an entrepreneurial discovery process (Foray et al., 2009), fits well with how policy processes have been implemented in Denmark. Nevertheless, as also discussed there seems to be room for further coordination and alignment across different policy levels in Denmark. Such coordination efforts are not easily defined as they would potentially include coordination across the regions (the industrial differences are not that large and the geography not that challenging) as well as the local municipal levels (as the example of "UdviklingFyn" demonstrates).

¹⁵ In fact, even a few years prior to this, Michael Porter published his influential book on National Competitive Advantages (Porter, M. E. 1990. *The Competitive Advantage of Nations*. New York: Free Press) in which Danish cases played a key role and was designed in a somewhat similar way as the resource area mapping.

¹⁶ The Danish Business Authority (ErhvervsStyrelsen) maintains a database that keeps track of current European Regional Development Fund projects
<https://regionalt.erhvervsstyrelsen.dk/projektliste?Fond=R&Indsatsomraade=Innovation+og+videndeling>

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Table 3: Abbreviations

BERD	Business Expenditures on Research and Development
DESI	Digital Economy and Society Index
EC	European Commission
ERA	European Research Area
EU	European Union
EU-15	The 15 Member States of the European Union from 1995 until 30.4.2004 (BE, DK, DE, EL, ES, FR, IE, IT, LU, NL, AT, PT, FI, SE, UK)
EU-28	The European Union of the current 28 Member States
FDI	Foreign Direct Investment
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditures on R&D
GOV	Government
HES	Higher Education Sector
PPI	Public Procurement for Innovation
PRO	Public Research Organisation
R&D	Research and development
R&I	Research and innovation
S3	Smart Specialisation Strategies
SME	Small and Medium-sized Enterprise

Table 4: Factsheet

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GDP per capita (euro per capita)	41900	43800	44500	45500	46100	47100	47800	48400		
Value added of services as share of the total value added (% of total)	57.24	56.29	55.6	55.24	55.16	54.98	55.58	55.74		
Value added of manufacturing as share of the total value added (%)	12.88	12.67	12.8	13.24	13.62	13.67	14.3	15.32		
Employment in manufacturing as share of total employment (%)	11.11	10.37	10.37	10.23	10.05	10.02	10.04	10.05		
Employment in services as share of total employment (%)	54.13	55.31	54.86	54.9	55.21	55.15	54.97	54.78		
Share of Foreign controlled enterprises in the total nb of enterprises (%)	1.6	1.63	1.75	1.71	1.79	1.71				
Labour productivity (Index, 2010=100)	96.2	100	100.3	102.3	103.1	104.5	105	105.6		
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	1.14	1.41	1.52	1.47	2.04	2.25	2.26	2.23		
Summary Innovation Index (rank)	3	2	2	2	1	1	2	2		
Innovative enterprises as a share of total number of enterprises (CIS data) (%)				51.1		49.5				
Innovation output indicator (Rank, Intra-EU Comparison)			5	5	5	5				
Turnover from innovation as % of total turnover (Eurostat)		15		13.9						
Country position in Doing Business (Ease of doing business index WB)(1=most business-friendly regulations)						3	3	3	3	3
Ease of getting credit (WB GII) (Rank)						22	27	29		
Venture capital investment as % of GDP (seed, start-up and later stage)	0.051	0.059	0.067	0.07	0.078	0.075	0.109			
EC Digital Economy & Society Index (DESI) (Rank)						1	1	1	1	
E-Government Development Index Rank		7		4		16		9		
Online availability of public services – Percentage of individuals having interactions with public authorities via Internet (last 12 months)	73	78	81	83	85	84	88	88	89	
GERD (as % of GDP)	3.06	2.92	2.94	2.98	2.97	2.91	2.96	2.87		
GBAORD (as % of GDP)	0.98	0.99	1	1	1.02	1	1.01	0.92		
R&D funded by GOV (% of GDP)	0.8	0.82	0.83	0.87	0.89		0.87			
BERD (% of GDP)	2.13	1.96	1.96	1.95	1.88	1.86	1.89	1.89		
Research excellence composite indicator (Rank)	4	4	5	5	5	5				
Percentage of scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country		13.69	13.38	13.38	12.88	13.19				
Public-private co-publications per million population	136.99	167.49	172.64	159.13	156	165.27	131.99			
World Share of PCT applications	0.84	0.71	0.63	0.65	0.58	0.57	0.61			
Global Innovation Index				9	8	10	8	6		

List of figures

Figure 1: The Danish R&I system 8

Figure 2: GERD by Source of Funds for Denmark.....11

List of tables

Table 1: The largest R&D performers in Denmark12

Table 2: Supply of human resources13

Table 3: Abbreviations26

Table 4: Factsheet27

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