ANALYSIS OF NATIONAL INITIATIVES on DIGITISING EUROPEAN INDUSTRY[1]

DENMARK:

Towards a Digital Growth Strategy – MADE

CONTENT

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[1] This report has been produced for DG CNECT by Jan Larosse, independent adviser (Vanguard Initiatives Consult&Creation).
The analysis is limited to the information available till September 2017 and the proposed analytical framework can be a basis for a more comprehensive policy documentation.

1. Context

1.1.   In general

- Denmark ranks again 1st out of the 28 EU Member States in the Digital Economy and Society Index in 2017, and it progressed at a higher pace than the EU average. Denmark performed very well on Connectivity, thanks to the widest 4G coverage in Europe and the increase in take-up of fast connections. However, the share of ICT specialists stagnated. On the supply side, Denmark made outstanding progress in the use of digital technologies by enterprises, leading the EU and the world rankings, according the EDPR 2017. [2]

- Denmark is strong in the delivery of online public services thanks to a consistent long-term national policy. The **Digital Strategy 2016-2024**, an umbrella governmental digital plan presented in May 2016, aims at further enhancing close public sector collaboration to deliver good, efficient and coherent services to the public and businesses. A **Digital Growth Strategy** to enhance the connection with Industry 4.0 and to ensure a long-term leadership position, is announced for Autumn 2017.

- The national initiative **MADE** (Manufacturing Academy Denmark), started in 2013 as a bottom-up initiative to implement Industry 4.0 in Denmark, is one among other initiatives for industrial transformation. But it is gaining a stronger role in aligning public and private research and innovation strategies for digitising industry.

1.2.   Political changes; new policies

- On 28 November 2016 a new tripartite (minority) government has taken office. The Minister of Commerce, Business and Growth changed to another party. And a new Ministry for Public Innovation (including digital strategy) was created. In the multi-party system there is a strong consensus politics regarding business and growth policies.

- Prime minister Rasmussen announced in Summer 2016 (in this capacity also in the former government) a **new 2025 economic plan**. The objective is to increase GDP with DKK 80 billion (€ 10,75 billion) by 2025. Digitisation is expected to be an important driver for new growth.

- The Government elaborated in its '**Report on Growth and Competitiveness 2017:'Denmark-Going for Growth'** a framework for this longer-term growth strategy, based on the comparative analysis of competitive strengths and weaknesses of the Danish economy in a fast changing world, with the objective to maintain Denmark in a top position and secure its citizens a prosperous society in which all citizens benefit from grasping the opportunities of globalisation and industrial transformation. This requires a persistent focus on good growth and competition conditions, which are to be adjusted to technological and global trends on an ongoing basis.

  o One of the main challenges for growth is the **slowdown in productivity growth** (not limited to Denmark, but a structural barrier for all industrial countries). But the low business investment ratio (with 13,5% of GVA in 2015 below all other industrial countries) reveals idle production potential and uncertainty of export opportunities. Digitalisation and new technologies are drivers for new productivity growth. The study showed that the category of most digitised companies in Denmark have on average 20% higher productivity that the category of least digitised. Another main

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[2] Europe's Digital Progress Report (EDPR) 2017 Country Profile Denmark, p.2

challenge is the supply of productive workers, trained in using these new technologies.

- o The aim and objective of the Danish Government is to **boost GDP by DKK 80 billion (€10,75 bn) up to 2025** through **increased productivity** (DKK 35 billion – €4,70 bn)) and **increased labour supply** (DKK 45 billion - €6,05 bn). Danish companies' framework conditions must be among the best in the world. It is crucial among other things for companies to have access to relevant skills and high effective labour supply. Companies must find it attractive to place investments in Denmark. The framework for research and innovation must be good and there must be a strong entrepreneurial environment, effective competition and strong capital markets. The Government focuses on ensuring that growth and development will benefit all of Denmark.

- To achieve the goal, the government has taken its first steps by launching a new **business and start-up proposal**. The proposal was launched end of August 2017. It focuses on start-ups, digitization and new business, low cost for citizens and companies, and globalisation.

- The Government will also address the opportunities and challenges relating to jobs of the future in **The Disruption Council** - partnership for Denmarks future. The reason is among others that digital transition and globalisation make major demands on companies' efficiency and innovation.

- Specifically, the Government will present a **strategy for Denmark's digital growth** (expected in Autumn 2017) that emphasises Industry 4.0. The strategy is to ensure that Denmark, also in future, remains at the cutting edge in terms of exploiting technological opportunities. The strategy will be based on the recommendations from The Digital Growth Panel (published in May 2017), among others.

1.3.   Status of the general Digital Agenda

- The agenda for digitising industry is benefits from of a **variety** of strategies which are supported by different ministries (responsible for business and industry policy, innovation policy, science policy, education and labour market).
- As a starting point, Denmark has **two main strategies addressing digitisation** that evolve from two different angles: **business innovation** policy and **public innovation** policy (e-government).

- o The '**Digital Strategy 2016-2024**' is aimed foremost at public administration.
- o On the other hand a '**Digital Growth Strategy'**, with a stronger business focus has been prepared for several years and is going to be launched in October 2017.

Digital Strategy: public sector as motor

- The **Digital Strategy 2016-2020** "**A Stronger And More Secure Digital Denmark**" sets the course for Danish public sector digitisation efforts and their interaction with businesses and industry. The government Digital Strategies concern the authorities at all levels of government, from central government to regions and municipalities - i.e. both the administrative institutions such as ministries, agencies and municipal and regional

administrations, and the executive institutions such as hospitals, public schools, universities, etc.

https://www.digst.dk/Servicemenu/English/Policy-and-Strategy/Digital-Strategy-2016to2020

The strategic digital initiatives make it possible for the public sector to make joint investments in areas which are particularly complex and in which there are interdependencies across different authorities and sectors. These initiatives are structured around 9 focus area under the **three goals** for the development of a more digital public sector: security and confidence must be in the focus at all times; user-friendly and better welfare services; provide good conditions for growth.

This third goal will be pursued with a number of **concrete initiatives in three focus areas**:

1. Better framework for the business community: Public sector digitisation should contribute to realising the Government's goal to reduce the administrative burden on the business community by DKK 3 billion (€ 0,4 bn) by 2020 and to make it easier to run a business in Denmark. Initiatives are taken for automated business reporting, digital tendering procedures and procurement, cloud computing.
2. Public sector data as a growth driver: initiatives for open public sector data, smart city partnerships and infrastructure for positioning and navigation The public sector has large amounts of data which businesses can use to optimise their procedures, and which can form the basis for new business opportunities and innovation. Therefore, the public sector should make more public sector data available to businesses and support exploitation of this data by businesses.
3. An efficient utilities sector: initiatives will be taken to make common data available in a number of specific areas in which there is deemed to be a great potential for a more efficient and effective public sector and new business opportunities for Danish businesses. This includes data on topography, climate and water, on energy supply, on underground infrastructure and on waste.

Each individual authority has a responsibility to realise the digital potential within its own auspice and, thus, to ensure that digitisation leads to the desired change. In parallel with joint public sector efforts, there are sector-specific digitisation projects and strategies, for example joint municipal and regional digital strategies. This approach to public sector digitisation provides a good balance between common strategic targets and local adaptation and priorities. Furthermore, interacting with the public sector, private businesses, trade organisations and NGOs are also contributing to finding common solutions for the digital transition.

- The **Agency for Digitisation** was established in 2011 as an agency of the Ministry of Finance, building on past strategies for e-government or more specific fields, to speed up the digitisation processes required to modernise the Danish welfare society (Strategy for Digital Welfare 2013-2020). The Agency is in charge of the digitisation of Denmark and is responsible for the implementation of the government's digital ambitions in the public sector. In the new government the new Minister for Public Innovation will also be responsible for the digital strategy in the public sector.

Digital Growth Strategy : background

- Successive Danish governments have been strongly committed to the digitisation agenda from an economic growth perspective and with a partnership approach, in particular towards business, see overview figure.

- Growth team policy has contributed in the last years to structural adjustments of the economy. Already in 2011 the government commissioned 'growth teams' composed of experts to provide recommendations for specific growth plans in 8 demand-driven growth areas with a competitive potential for Denmark: Blue Denmark; Creative Industries and Design; Water, Bio and Environmental Solutions; Food Sector; Health and Care Solutions; Energy and Climate; Tourism and experience economy; **ICT and Digital Growth**.
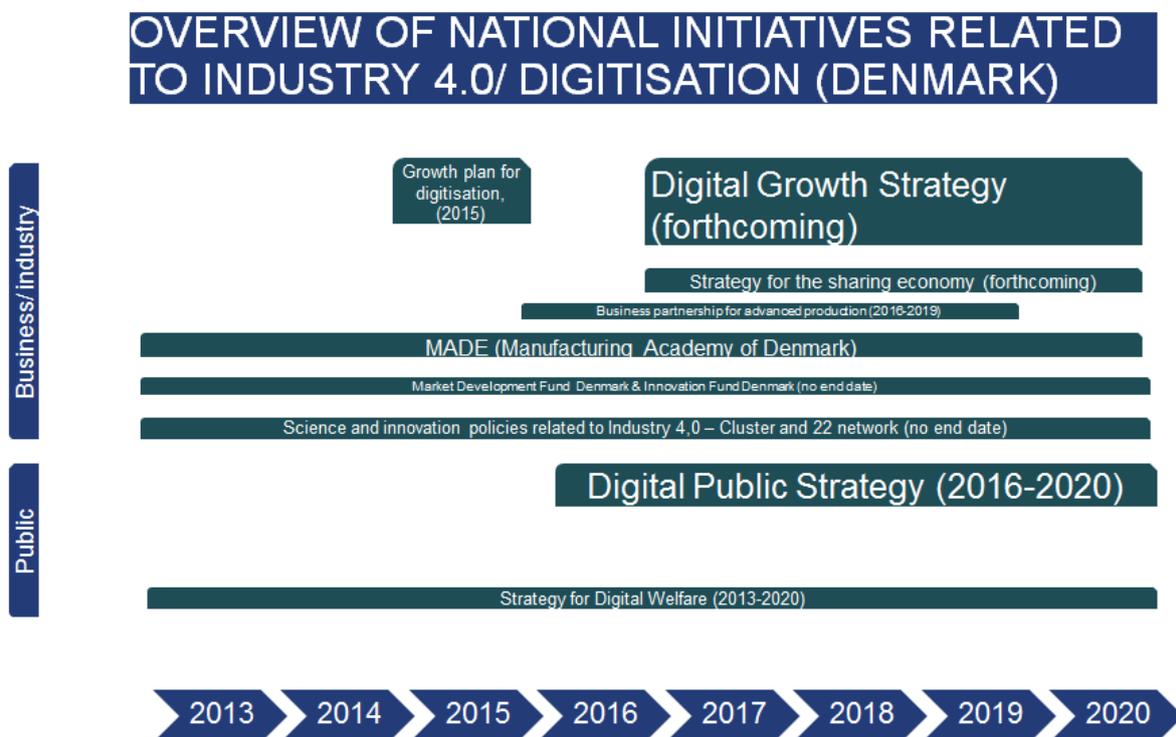
- The development of a Digital Growth Strategy is on the political agenda since in 2013 a first Government Growth Team for ICT and Digital Growth (comprised of 12 experienced business leaders, entrepreneurs and knowledgeable individuals from the Danish ICT community) was commissioned to come up with ideas to support ICT strongholds in Denmark and to strengthen the competitive power of Danish companies through the increased use of digitisation. Following this the Government would introduce a growth plan with a number of concrete initiatives to address the recommendations.
  This team handed over their recommendations to the Danish government in January 2014. The team recommended that all Danes must swiftly have access to a fast broadband infrastructure.

- The Government and political parties then agreed on the **Growth Plan for Digitisation in Denmark** in February 2015. It followed up on Growth Team for ICT that presented

recommendations to the government. The aim of the plan is that Danish companies should be among the leading countries in Europe to develop and utilities ICT-communications and data to create growth and jobs. The goal was followed up by four main focus areas:

1. Good mobile and broadband coverage in the whole country. 8 initiatives were launched that should support the government set goal of 100 Mbit/s download or 30 Mbit/s upload by 2020.
2. Strengthened use of IT and data in Danish business. 4 initiatives were launched that should create a digitalization boost in Danish business through initiatives that support even more companies exploiting their digital potential, eg. through increased e-commerce and the use of Big Data.
3. Digital security. 3 initiatives were launched that aimed at supporting business in developing a comprehensive it-security report.
4. Promotion of digital skills and learning resources. 2 initiatives aimed at supporting digital skills.

- The Government has issued further initiatives, including a broadband fund, to promote coverage in the action plan '**Growth and development in all of Denmark**'. It also included the Enterprise Partnership for Advanced Production.

The preparation of a Digital Growth Strategy with a focus on business took a longer preparation. A first '**Growth Plan for Digitisation in Denmark**' from 2014 was mainly focussed on broadband deployment. The new strategy of 2017 will focus on industry access to digital skills, new and competitive business models, proactive regulation and IT-security. The preparation of this Digital Growth Strategy will be set-out in the dedicated chapter on national initiatives.

1.4.   Role of ICT and of digitalisation of industry in R&I policy and in industrial policy of the country

Digitisation is among the core subjects of the national industry policy. Looking ahead, the role of ICT in contributing to increased productivity is vital. Among the future growth motors manufacturing is considered to be one of the key sectors.

Several initiatives to promote ICT and manufacturing are supported in the business and industry policies , in science and innovation policy, in cluster policy and in other related policies for regional growth and smart specialisation.

Initiatives related to business promotion

In the listed initiatives (see box) some are of a more generic nature and some are targeted in specific to support industrial and digital transformation. The government can use its management agreements with the public agencies and other allocation arrangements to indicate its priorities. For instance according to the agreement on the distribution of the research reserve for 2017, the **Market Development Fund** must promote automation and digitisation in small and medium-sized manufacturing enterprises. In other instruments the role of stakeholders is activated. For instance the former government has established the **Business Partnership for Advanced Production**, which consists of the major business federations, the Association of Approved Technological Institutions and the Danish Commerce and Industry Agency, to support in the period 2016-2019 small and medium-sized production companies to overcome market barriers for increased automation and digitization through specific business processes and information activities.

The initiatives are rather scattered at this moment. Therefore the announced Digital Growth Strategy will offer a consistent and coherent long-term framework.

The Danish Growth Fund

Purpose: The Growth Fund is the State Finance Fund, with an independent act and board. The Growth Fund Act states that the Fund is to promote growth and renewal in small and medium-sized enterprises in order to achieve greater socio-economic returns.

Description: In cooperation with private investors, the fund has co-financed growth in over 6,000 companies since 1992 for a total commitment of more than DKK 17 billion (€2,3 bn). The Growth Fund provides a number of funding schemes that cover both the start-ups and growth of companies, including arrangements for "Come-in Loans" and "Growth Provisions".

Financing: Funding funds come from several sources. The basic capital of the founding in 1992 was DKK 2 billion (€0,270 bn). At the end of 2014, the equity was 3.6 billion DKK (€ 0,484 bn), and cash equivalents including securities amounted to 701 million DKK (€0,363 bn). The equity is generally affected by transferred surplus and deficit and by capital injection from the Ministry of Business, Industry and Financial Affairs.

The Market Development Fund:

Purpose: The Market Demand Fund aims to promote growth, employment and export, especially in small and medium-sized enterprises in areas where Denmark has special strengths and potentials.

Description: The Market Demand Fund can provide companies with grants for testing and adapting innovative products to potential customers and end users in the final phase of market launch, where the product is fully developed with customers. The fund will thus help Danish companies to overcome the market barriers they experience during the market maturation phase, eg through the co-financing of tests and adapting the innovative prototypes of companies to potential customers.

A midterm evaluation of effects shows that DKK 1 million (€ 0,134 mio) in funding from the Market Development Fund generates 8.5 jobs in Danish companies. The evaluation estimates that enterprises that have received co-financing from the Fund collectively will increase turnover by DKK 3.5 billion (€ 0,47 bn), exports by DKK 2.7 billion (€ 0,363 bn) and create 2,000-2,300 jobs by 2018.

Financing: Approx. DKK 60 million (€8 mio) per year.

Enterprise Partnership for Advanced Production

Purpose: The Enterprise Partnership for Advanced Production aims to overcome market barriers for increased automation and digitization in small and medium-sized manufacturing companies in Denmark through specific business processes and information activities.

Description: Specifically, the partnership contribute to that manufacturing companies are exposed to the economic potential of implementing automation and digitization technology. The business partnership consists of DI Industrial Cooperation / DI Digital, Land Use & Food, Danish Business / IT Branch, Dansk Metal, IDA Inger Association, Association of Approved Technology Institutions, and the Danish Commerce and Industry Agency (Chairman).

Financing: The agreement on Growth and Development in all of Denmark has allocated DKK 42 million (€5,64 mio) in 2016-2019 to the "Enterprise Partnership for Advanced Productions"

Robot Technology Transfer Network - ROBOTT-NET

Purpose: ROBOTT-NET is PPP-partnership that will transfer new technology from robot companies to manufacturing companies.

Description: The network is a collaboration between GTS-like institutions in DK, DE, UK and ES. 64 companies (either technology or manufacturing companies) receive consultancy services to briefly complete their innovation / automation needs as well as a business case for product maturation or robot automation. The eight most prospective projects then receive consultancy assistance for 1500-hour development and demonstration projects, where they are also linked to real case companies to conduct pilot appointments. In addition, the network will host open-lab events, featuring state-of-the-art technology, and networking between technology companies, investors and end users.

ROBOTT-NET has a narrower technology focus (robotic technology only) than the Enterprise Partnership, but a broader target group focus (both manufacturing and technology companies).

Financing: The network has € 7.5 million from the EU's Research and Innovation Framework Program Horizon2020 in the period 2016-2019

RoboTekSyd – regional business promotion of robots

Purpose: New effort for increased productivity and job retention through automation in small and medium-sized enterprises.

Description: Syddansk Growth Forum has allocated DKK 25 million (€3,36 mio) to develop new automation solutions in collaboration between universities, GTSs and SMEs providing automation technology. In addition, it is possible to collaborate with production companies that constitute test users and thus represent customer requirements and needs.

Financing: Growth Forum has allocated a frame of DKK 25 million (€3,36 mio) for the effort: DKK 7,5 million (€1 mio) from the Regional Fund and DKK 17,5 million (€2,35 mio) from the regional business development funds.

Initiatives related to Science and Innovation

There is a big focus in **science and innovation** on policies related to Industry 4.0. Public strategic investment in research must help solve societal challenges and create growth and prosperity. A **new Science and Innovation Strategy** is announced (forthcoming in 2017).

A paradigm shift has been operated in innovation policy since 2011, from a supply-push towards a demand-driven approach that is more solution oriented. This involves a rearticulation of research and development for ICT as enabling technology towards the provision of concrete solutions for societal needs and development of business opportunities.

Innovation policy has thus contributed in the last years to structural adjustments of the economy. Already in 2011 the government commissioned 'growth teams' composed of experts to provide recommendations for specific **growth plans** in 8 demand-driven growth areas with a competitive potential for Denmark (see above). While seven others growth plan were finished by the

Government, the **Growth Plan on ICT and Digital Growth** took more time to be developed (see below).

The Danish government manages the public support via executive bodies through development contracts which transmit the political priorities. The Innovation Fund is the most important funding channel for R&I in digital transformation, but also other bodies such as Approved Technological Service institutes (GTS) are instruments relevant for digitizing industry.

The government has launched recently a number of **targeted strategies**:

- National Strategy for Space,
- Development and Use of Drones,
- Arctic Research.
- Danish center for artificial intelligence (DCKAI)

Also MADE (the Manufacturing Academy of Denmark, enhancing Industry4.0 in Denmark) can be considered to be part of this trend to a more targeted sectoral approach. The MADE initiative will be presented under de heading 'National initiative'.

Innovation Fund Denmark

Purpose: The Innovation Fund invests in the development of new knowledge and better market positions for the country's companies. The Fund allocates funding for activities in strategic research, technology development and innovation.

Description: Innovation Fund was established per April 1, 2014 and allocates funding for activities in strategic research, technology development and innovation. The Innovation Fund has three main inputs of Grand Solutions, InnoBooster and Talents. The Innovation Fund is a collection of support instruments previously used by the Strategic Research Council, Technology and Innovation Council and the High Technology Foundation.

Below are examples of the fund's achievements:

Grand Solutions:

Provides significant investments and long-term projects / partnerships focusing on research, development and / or commercialization. In 2015, 67 Grand Solutions projects were committed and allocated a total of 1,344.90 million. Below are three examples of Grand Solutions projects:

• The Center for Quantum Innovation (Qubiz): The Qubiz Center will act as an incubator for the development of new products and ensure that Danish companies are created with knowledge in quantum computers and quantum technology in the future. Qubiz has a grant of 80 million. The center is located at the Niels Bohr Institute, KU, and is a collaboration between KU, AU, DTU and 18 business partners.

• Danish Center for Big Data Analytics-Driven Innovation (DABAI): DABAI is a partnership that brings together data-based research forces with companies and public authorities to find solutions to exploit the potential for innovation and growth related to Big Data in Denmark . DABAI has an appropriation of DKK 45 million (€6,05 mio) from the Innovation Fund and a total grant of DKK 117 million (€15,72 mio). The key partners in the project are computer science institutes at the University of Copenhagen, AU, DTU, and the project manager is Alexandra Institute.

• FlexDraper: The research project is to teach robots to handle composite materials an intelligent robot vision system for the benefit of, among other things, aerospace industry. The project has received a grant of DKK 12.8 million (€1,82 mio). The project manager is SDU and partners in projects include AAU, DTU, Terma and Robotool.

InnoBooster:

The scheme is for smaller companies, entrepreneurs and researchers with good development plans. Support for R & D projects. In 2015, 295 InnoBooster projects were committed and allocated a total of DKK 112,5 million (€15,11 mio).

Talents:

For students, graduates or researchers who wish to become entrepreneurs or to establish a research career in private. This entry includes Business Phd and Business Postdoctoral Projects, as well as the in-business pilot scheme. In 2015, commitments were made to 18 research projects and 40 entrepreneurial pilot projects and a grant of a total of DKK 35.0 million (€4,70 mio).

• Dragonfly Eye: Development and commercialization of a three-dimensional (3D) camera system for virtual reality devices produced in Scandinavia. The project is an entrepreneurial pilot with two newly graduated candidates from CBS and SDU.

• Brain - Computer Interface (BCI): BCI is a new software technology that can digitize and analyze electrical activity in the human brain relative to wireless programming of robots and other devices. The project is an entrepreneurial pilot.

Financing: In 2015, the Innovation Fund had a total funding of almost DKK 1.6 billion (€ 0,215 bn). In 2015 DKK 1,344 billion (€ 0,181 bn) went to Grand Solutions, DKK 112,5 million (€ 15,11 mio) for InnoBooster projects and DKK 35 million (€4,70 mio) to the talent schemes.

Approved Technological institutes

The GTS network consists of eight institutes that develop and sell technological services to Danish companies. Digitization and production technology are, to a greater or lesser extent, an element in many of the developed services. Below are highlighted examples of ongoing development activities at the institutions that have the highest activity in industry 4.0, digitization and advanced production. However, the performance-contracted activities are very wide and include, for example, digitization of processes within as diverse areas as fire protection, veterinary diagnostics and offshore operations, which for the sake of clarity are not included here.

The GTS are non-profit companies that are approved every three years and can then apply for an exclusive pool of funds from the Danish Agency for Science, Technology and Innovation (Ministry of Higher Education and Science). The Danish Ministry of Higher Education and Science has concluded development contracts with the GTS institutes for 2016-2018, i.a. with three binding targets of increased regional knowledge dissemination, strengthened synergies across the innovation system and strengthened internationalisation of Danish companies. Companies can buy services from the GTS-institutes or participate in collaboration projects that are co-funded.

Out of the 8 institutes, 3 are specifically relevant:

- Danish Technological Institute (TI)

- Force Technology and DELTA

- The Alexandra Institute – Center for artificial intelligence

Danish Technological Institute - TI

Purpose: TI aims to disseminate, adapt and develop new technologies for the benefit of Danish business, including SMEs in particular. TI has special skills within construction, industry and energy, business development, materials as well as productivity and logistics.

Description: TI is one of the 8 Approved Technical Service Institutions (GTS). TI has entered into a number of performance contracts related to Industrial 4.0, digitization and production for the period 2016-2018:

- *3D Printed Construction*: Builds a technological service area within robot-based 3D printing of construction parts for construction, such as columns, walls and beams (granting DKK 6,27 million - €0,84 mio).

- *Factory in a day*: "Factory in a day" aims to develop a platform that transfers and adjusts the visions found in the Industry 4.0 vision to Danish conditions and demonstrates its effect through rapid conversion of customized automated production (Granting DKK 13,37 million – €1,80 mio).

- *Pilot production as a high-tech innovation engine for Danish industry (PP-TECH)*: PP-TECH develops high-tech manufacturing and innovation processes for pilot production under industrial conditions (granting DKK 14.80 million - €1,99 mio).

- *Robotic technology innovation - The Danish robot industry of the future*: This performance contract focuses on industrial robotics and the newer service robotic area, as well as the innovation opportunities that arise in the cross-domain through technology and domain side-stepping (DKK 13.68 million -).

- *Innovation Center for eBusiness IV (IBIZ Center):* TI is the project manager for IBIZ Center. The Center is working to break down barriers that restrict the use of IT by SMEs with the aim of strengthening corporate operations and competitiveness (granting DKK 10.0 million - €1,34 mio).

TI has its head office in Høje Taastrup and larger departments in Aarhus and Odense. By 2015, TI had a turnover of DKK 1,018 billion (€137 mio). R & D investments for DKK 229.0 million (€30,8 mio) and 1004 employees.

Financing: TI has a main appropriation of DKK 406.0 million (€54,5mio) for (2016-2018). The allocation for performance contract activities related to Industrial 4.0, digitization and production is approx. DKK 63.0 million (€8,5 mio).

FORCE Technology and DELTA

Purpose: FORCE and DELTA aim to redistribute, adapt and develop new technologies for the benefit of Danish business, including SMEs in particular. FORCE has special skills in offshore, maritime, development and infrastructure. DELTA has special skills in electronics, ICT, sensor systems, acoustics, light and optics.

Description: FORCE and DELTA have entered into a number of performance contracts with UFM, which concern Industry 4.0, digitization and production for the period 2016-2018:

- *Design of Smart Things (DELTA):* The activity establishes serial services that collect and disseminate knowledge about technologies and methods for designing the future "Smart Things", which can be upgraded using, inter alia, app's and software updates. The activity has more focus on knowledge

gathering and knowledge dissemination than actual technology development (grant of DKK 8.39 million – €1,13 mio).

- *Design Psychological Test Center (FORCE):* The activity aims at raising the level of existing methods of usability testing and user experience analysis, thereby qualifying especially SMEs' work with user-friendliness, user experience and user safety in their design of smart products and services (grant DKK 9.56 million - €1,28 mio).

- *Consumer Preferences in Multimedia (DELTA):* The activity focuses on breaking down technical and market barriers with focus on Danish companies that across the industry and sector develops or uses multimedia and AV technology, such as AV conference - communications and surveillance equipment, telecommunications sector, hearing aids and parts thereof, screens and video, television and broadcast, producers of film, vi-deo and digital content as well as the gaming sector (grant of DKK 8.39 million – €1,13 mio) .

- *Battery-free and self-sufficient electronics (DELTA):* The activity focuses on lowering barriers for the use of battery-free and self-sufficient electronics. Technological service is being developed regarding state-of-the-art technologies for the harvest of energy from the environment, tools and modules for rapid feasibility and early realization of prototypes and improved microelectronics for controlling energy for the realization of new reliable self-sufficient products (granting DKK 10,5 million - €1,41 mio).

- *Internet of things test center (DELTA):* Building technology-based services to ensure that as many Danish companies as possible get the opportunity to bring new IoT products and solutions to the market through the necessary technical test, development and advisory . Unlike the series of IoT research projects, the Center will focus on implementation (granting DKK 16 million- €2,15 mio).

FORCE and DELTA have their head office in respectively. Brøndby and Hørsholm. By 2015, FORCE had a turnover of DKK 1,288 billion (€1,65 bn), R&D investments for DKK 144 million (€19,34 mio) and 1316 employees. DELTA had a turnover of DKK 1,312 billion (€1,76 bn), R&D investment for DKK 65 million (€8,73 mio) and 236 employees.

Financing: FORCE has a government grant of 123.4 million DKK and DELTA a main grant of DKK 94 million (€ 12,63 mio) for a three-year period (2016-2018). The interest for performance contract activities related to Industry 4.0, digitization and production is approx. DKK 52,8 million (€7,04 mio).

Alexandra Institute

Purpose: Alexandra aims to disseminate, adapt and develop new technologies for the benefit of Danish business, including especially SMEs. Alexandra has special skills in ICT, cyber security and privacy, Big Data, Internet of Things (IoT), IT-based infrastructure, positioning systems.

Description: Alexandra has entered into a number of performance contracts with UFM, which relate to Industry 4.0, digitization and production for the period 2016-2018:

- *Interactive Augmentet Reality and Virtual Reality for Industrial Training and Instructions*: The activity is designed to help Danish manufacturing companies utilize the great potential of Augmented Reality (AR) and Virtual Reality (VR) for digital training and instruction (grant DKK 5.76 million – €0,77 mio).

- *Big Data Data Technologies and Tools*: In this activity, gaps in the market and barriers, eg lack of competencies and business processes, address the importance of Danish companies in the value of Big Data (granting DKK 8.82 million – €1,18 mio).

- *Security and privacy tools*: The activity focuses on developing new knowledge services and tools that enable Danish companies to drive and strengthen their business using ICT, despite the major challenges they face in IT security and privacy. DBI and DELTA are partners in the project (grant DKK 10.40 million – €1,4 mio)).

- *Design and development of smart products and servitization*: The activity develops new technology services (advice on IoT, cyber-physical systems, network protocols, positioning, etc.), which stimulates product and service innovation in Danish manufacturing companies. The activity shall include help lower entry barriers to companies to introduce their products online (granting DKK 8.82 million - €1,18 mio).

Alexandra has its head office at Katrinebjerg, AU Computer Science Institute. By 2015, Alexandra had a turnover of DKK 54 million (€7,25 mio), R&D investments for DKK 29.0 million (€3,9 mio) and 78 employees.

<u>Financing</u>: Alexandra has a main grant of DKK 46 million (€6,8 mio) for a three-year period (2016-2018). The grant for performance contract activities related to Industry 4.0, digitization and production in the same period totaled approx. DKK 33,8 million (€4,54 mio).

Cluster and Network initiatives

Another source of support is the 'Cluster and network strategy 2016-2018'. The **Danish Cluster Forum**, consisting of six ministries and the five Danish Regions and Local Government, has launched an updated cluster and network strategy for the period 2016-2018, which aims at supporting Danish strong areas, new growth areas, and renewal in existing industries.

The Cluster Forum was established in 2013 with the aim of supporting cluster development in Denmark and create   cohesion between local, regional, national and international cluster and network efforts. The strategy is focusing i.a. on strengthening the knowledge bridge between Danish companies and institutions of education and research through business clusters and through innovation networks.

- The **business clusters** at regional level are professional venues for almost 12,000 small and medium-sized enterprises where they can spar with Danish knowledge institutions and each other. Among them: a strong ICT Cluster in North Denmark 'BrainBusiness' and the Odense Robotics cluster.
- At the national level the 'Innovation Network Denmark' programme managed by the Ministry of Higher-Education and Science has approved for the period 2016-2018 22 national **innovation networks**, these are clusters of a wider nature (see box).

Innovation Networks[3]

The network operators are chosen for 4 years through a tender process. The current networks were chosen in 2014. For the 22 innovation networks all together: 7522 companies are part of it – 5348 with less than 50 employees. On average 23 knowledge (universities, RTOs, business colleges, etc.) institutions in each network. 25 public authorities also take part. The Ministry of Higher Education and Science finances up to half of the Innovation Network activities for the professional operation of

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[3] See strategy: http://ufm.dk/en/research-and-innovation/cooperation-between-research-and-innovation/collaboration-between-research-and-industry/innovation-networks-denmark

a network secretariat, facilitating matchmaking activities as well as running specific collaboration projects within e.g. research, education, knowledge dissemination. The networks have to obtain the other half of the funding from private companies, regional funds, etc.

Three Innovation Networks is of particular relevance to the Industry 4.0 agenda:

- Innovation Network for Robot Technology – RoboCluster

- Innovation Network for Production - Inno-Pro

- Innovations Network for IT – InfinIT

Innovation Network for Robot Technology - RoboCluster

Purpose: RoboCluster aims to create innovation partnerships between residential institutions and private companies that work with the development and innovative use of robotics and automation, to further expand the robotics sector in Denmark as well as set robotics into action in fields as hospitals, farming, industry, leisure, and education, RoboCluster, the Danish **Innovation Network for Robotics and Automation**, working.

Description: RoboCluster bring together researchers, companies and public authorities to create innovation and growth in various technology areas by initiating technological projects between suppliers, producers, users, universities, and knowledge institutions in the field of robotics and automation The networks facilitate knowledge dissemination seminars, matchmaking events and limited development projects.

An example of network development activities is the mobile robot development project, which is a collaboration between TI, DTU, AAU and Fraunhofer, as well as three private providers of mobile robot units: NeoBotix, MIR and Adept. The project's goal is to enable Danish technology and integrator companies to develop, adapt and implement new flexible and affordable mobile service robotic solutions across industries, thereby strengthening the competitiveness of Danish manufacturing companies.

The RoboCluster secretariat is located at SDU. The core partners in the network include: TI, Kolding Design School, Force Technology, DTU, AAU, Danish Automation Company (DAU), Danish Robot Network (DIRA), and Dansk Industri (DI-ITEK). RoboCluster currently has approx. 200 dedicated members.

Financing: The network has a main grant of DKK 14 million (€1,88 mio) for a four-year period (2014-2018). In addition, innovation networks have the opportunity to search for earmarked pools for thematic offers.

Innovation Network for Production - Inno-Pro

Purpose**:** Inno-Pro aims to create a bridge between Danish knowledge institutions and private companies working in areas such as advanced materials, mechatronics, specialized metals and materials processing, engineering and testing services, IT, software and communication solutions, as well as other high-tech businesses that work with advanced high-value production.Inno-Pro, the Danish **Innovation Cluster for Production**,.

Description**:**. Inno-Pro has initiated a series of initiatives focusing on digital solutions in the industry, among other things. UPGRADIA project. The project is aimed at the development of new digital

business models that focus on upgrading physical products with new data sharing and app features, to create added value and new business opportunities over existing physical products. InnoPro is also an active part of the MADE partnership circle. The network has also helped establish a Danish network for drones and drones, which also includes the dronecenter in HCA Airport

The Inno-Pro Secretariat is located in Karup and is part of the Cluster for the Response and Space Industry, Center for the Security Industry in Denmark (CenSec). The core partners in the network include: DTU, AAU, TI, FORCE and Alexandra Institute. Inno-Pro currently has approx. 120 dedicated members.

Financing: The network has a main grant of DKK 14 million (€1,88 mio) for a four year period (2014-2018). In addition, innovation networks have the opportunity to search for earmarked pools for thematic offers.

Innovation Network for IT - InfinIT

Purpose: InfinIT's purpose is to create synergy, knowledge exchange and collaboration between companies and knowledge institutions focusing on corporate challenges with product and service innovation through the use of state-of-the-art information technology (ICT).

Description: InfinIT has been set up to bring together researchers, businesses and public authorities to create innovation and growth in state-of-the-art ICT and smart products.

The network operates within seven main areas, including big data and business intelligence, processes and IT, cyber security, future technologies in smart society, embedded systems engineering, tracking and posting services, usability and interaction design.

The InfinIT secretariat is located at AAU. The core partners in the network include: KU, DTU Compute, AU, SDU, Growth House Capital Region, BrainsBusiness, CISS, AAU, ITU, DELTA and Alexandra Institute. InfinIT currently has approx. 120 members.

Financing: The network has a main grant of DKK 14 million (€1,88 mio) for a four year period (2014-2018). In addition, innovation networks have the opportunity to search for earmarked pools for thematic offers.

Internationale innovation Centers - ICDK

Purpose: The Innovation Centers have the task of assisting Danish companies and research institutions with access to foreign knowledge, networks, technology, capital and markets, including locally in Munich, New Delhi, Sao Paulo, Seoul, Shanghai and Silicon Valley.

Description: The innovation centers are located near world-leading and dynamic research and development environments around the world. The ICDK program is established in cooperation between the Ministry of Education and Research, the Export Council and the Ministry of Foreign Affairs.

The innovation centers Munich (ICDK-MUC), Shanghai (ICDK-SHI) and Seoul (ICDK-Seoul) are all part of a joint innovation project for 'Industry 4.0'. During the project period, it is intended that more common technology conferences be held on 'Industry 4.0'. Among other things, an international conference in November 2016 at the Department of Engineering, AU (NAVITAS) with approx. 300 participants. The conference deals with both digital design, automation and production technologies, such as collaborative robots, IoT and connectivity. The partners in the project are fx IDA, MADE, Danish Design Center, Aarhus University and Region Midt.

ICDK-MUC also organizes study tours, cluster-to-cluster collaborations and fairs in Germany with the participation of Danish industrial companies in close cooperation with MADE. In addition, ICDK-MUC is in close dialogue with the German Bundes 'Enterprise 4.0 Platform' initiative in Berlin, which exchanges experiences and coordinates Danish-German initiatives in this area.

ICDK-SHI organizes an innovation camp in China in the use of flexible collaborative robots involving robotics in and around Odense, including Robocluster.

Financing: ICDK programs have a main appropriation of DKK 30 million (€4,03 mio) annually.

Danish Smart Specialisation Strategy

The Danish **smart specialisation strategy** of 2014 has consistently chosen the following 5 priority areas:
1. Manufacturing & industry
2. Energy production & distribution
3. Sustainable innovation
4. Human health & social work activities
5. Agriculture, forestry & fishing

The Regional Growth Fora will seek 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 under consideration of the strengths existing within the regions.

2. Status of the National Initiative

2.1. Political commitment with specific relevance to Industry 4.0

Digital Growth Strategy: emergence

- The successive Danish governments have been strongly committed to the digitisation agenda from an economic growth perspective and with a partnership approach, in particular towards business. The development of a Digital Growth Strategy is on the political agenda since in 2013

- A first Growth Plan for Digitisation (February 2015), based on recommendations of a first Government **Growth Team for ICT and Digital Growth,** focussed on full fixed and mobile broadband coverage throughout the country. The Industry 4.0 agenda was introduced by the Danish Production Panel when it launched a report with recommendations on how to increase productivity and preparation for Industry 4.0. The Rasmussen government commissioned a new **Digital Growth Panel,** featuring union and business leaders (formerly Production Panel 4.0) to deliver recommendations for the government to present an overall strategy for Denmark's digital growth. How to help Danish business to exploit the potential of digitization and new technology for growth and prosperity in Denmark, including good frameworks for the digital boost of businesses, business needs for digital competencies and the role of the public in supporting new digital business models. Additionally, recommendations should be used in connection with the Government's forthcoming 2025 growth plan and the work of the Partnership for the Future Labour Market.

- In May 2017, the Digital Growth Panel has delivered its report 'Denmark as digital frontrunner', with recommendations for accelerating digitalisation. The Government will draw up a strategy for Denmark's digital growth based on these recommendations of the Digital   Growth   Panel,   among   others. Access to the right digital skills is one of the most important factors in the digital transition and it is a focal area for the Government. Therefore, there is a need in establishing a **Technology Pact** where educational institutions, private actors and companies join forces in making an effort to ensure that more people choose technical and digital education programmes in order to match the private sector's demand for these competencies. This more comprehensive digital growth strategy is part of the implementation of the new 2025 economic plan.

- The Government has already set up for the period 2017-2019 a **Disruption Council** - **partnership for Denmarks future** with the prime minister, to help ensuring that all Danes are well prepared for the job market of the future. The partnership is to include the social partners, companies, experts and relevant Government Ministers. In the next two years the **disruption council** will come with recommendations on how to tackle the influence of new technologies on the Danish labour market.

- The Government also has have set up an **Entrepreneurship Panel** which is to present recommendations to the Government on how Denmark can strengthen the growth conditions for entrepreneurs with a focus on talent, capital and growth. The panel is composed of entrepreneurs, experts and other representatives of the private sector.

MADE: emergence

- MADE emerged as a **bottom-up** initiative. FME, the Association of Enterprises in the Technological Industrial Sector assembled the 5 universities around the diagnosis that the Danish manufacturing sector (reduced after the crisis to a number of niche positions, with no big leaders) should reinforce its competitive position with stronger R&I collaboration (avoiding unnecessary competition and fragmentation among the university research groups). The attribution of a major dedicated collaborative research programme (SPIR) by the Innovation Fund catalysed the formalisation of the **strategic partnership**.

- In 2013 **MADE** (Manufacturing Academy of Denmark) was established as an independent association that has now more than 100 members (companies, universities, GTS-institutes, private funds and associations). The purpose is to strengthen manufacturing companies by implementing new knowledge in domains such as 3D printing, hyper-flexible robots, in- and outsourcing, fast production development.
The initiative is characterised by a strong bottom-up governance. The nine members Board of MADE has a majority of fixed industry representatives (including the Confederation of Danish Industry); three representative from universities and one from technical institutes which rotate.; and no government members. In this sense it is not a full PPP. The industry-science partnership started with applying for a five-year SPIR-project with the Innovation Fund and was formalised after the subsidy was granted in 2013.

- In December 2016 **MADE Digital** was launched as a collaboration project to enable scientists and practitioners from companies to work together closely to develop and implement digital solutions, tailor-made to the specific needs of Danish manufacturing companies. The project

is headed by MADE, with the purpose of strengthening Danish manufacturing with new knowledge and digital technology. Denmark will invest DKK 196 million (€26,33 mio) coming from Innovation Fund, 49 companies, 6 universities, three GTS-Institutes and the Confederation of Danish Industry.

This investment creates more or less a Danish national team of digitalisation. It enables a strong and coordinated Danish digital development where particularly SMEs can gain knowledge of the latest technological possibilities and develop their business from A to Z.
MADE Digital is based on a Danish version of the German 'Industry 4.0', tailor-made for Danish conditions. Many companies in Denmark are amongst the best in the world in their niche. MADE Digital builds on these strengths and combines precisely this diversity because these companies are not competitors, enabling them to share knowledge when collaborating with the best research teams in the country and machine builders to develop new robotic solutions.
(http://en.made.dk/news-press/made-digital-uk/)

- **Innovation Fund Denmark** (the unique research and innovation funding agency of the Danish government) supports this initiative by investing DKK 79 million (€10,61 mio). This is an investment in its 'Grands Solutions' programme that has objective to find solutions through strategic research and innovation, to the big challenges in the corporate sector and society in general. MADE Digital as one of the projects to invest among nearly 500 applications. MADE Digital is the **largest financial collaboration in the history of the Innovation Fund Denmark**.

- **The Confederation of Danish Industry** (DI) is an influential partner in co-shaping business policies and policies for digitisation. DI contributes to the development of the 2025 growth strategy (https://di.dk/English/2025/Pages/2025_plan.aspx)
  DI's membership is comprised of 10,000 private enterprises within manufacturing and services covering virtually all sub-sectors. **DI Digital** is the Danish ICT and Electronics Federation in this Confederation, representing companies in the IT, electronics, communications and telco industries, from SMEs to leading global companies. The DI Digital's network for digital start-ups addresses issues like funding, growth strategies, globalization and staffing and nurture exchange of knowledge, ideas and experiences between the members.

2.2.   Strategic roadmap / action plan: Digital Growth Strategy

- The Government will draw up a strategy for Denmark's digital growth based on the recommendations of The Digital Growth Panel, among others, to the Government (published in May 2017). Analysis and recommendations of the Panel in their report 'Denmark as digital frontrunner' will most likely be important elements of the strategic roadmap.
- The Panel recommends that in order to remain at the forefront and reap the benefits of the digital transition, Denmark should gear-up efforts to build needed competences, including a digital mindset to understand the opportunities of digitisation to convert these into solutions that create value throughout society.

The **vision** is that Denmark is to be a **digital frontrunner**, the fastest and best at creating and exploiting the benefits of digitisation to the advantage of the individual business, the individual person and society as a whole. The Digital Growth Panel therefore has identified **three general objectives** to realise the vision of Denmark on digital transition:

1. **All citizens have a share in the benefits of digitisation**: Digitisation can improve the welfare of each individual through less arduous jobs, improved healthcare and increased wealth. However, this will not happen automatically. One vital prerequisite is strong focus on increasing digital skills through education and retraining in order to ensure that each individual can reap the full benefits of digitisation.

2. **Businesses unlock the growth and SMEs need at digital upgrade**: Growth in the business community will ensure that we as individuals have more welfare and a wealthier society in the future if the Danish business community can succeed with the digital transition; this is especially important for small and medium-sized enterprises, because it is harder for SMEs to get started on digitisation than it is for larger enterprises.

3. **Good digital framework conditions** will promote the digital transition: In order to take advantage of new opportunities and to manage new risks, legislation must quickly and responsibly be adjusted to support the development of new digital technologies as well as new and innovative business models. Denmark will be an international frontrunner and work towards ensuring that the digital single European market promotes innovation and new business models across different policy areas and is not overregulated and protectionist.

- To achieve this vision it is important to create good **general framework conditions,** as the foundation on which to build specific digitisation initiatives, such as favourable tax conditions, access to venture capital, the property market, free-trade agreements, the single European market and many more elements are therefore vital for Danish companies to succeed in creating growth and innovation, even during a digital transition.

- But in order to provide Danish society with the best possible framework to exploit the opportunities in the new digital reality, the Digital Growth Panel recommends **ambitious initiatives** within **four areas**:

1. **Digital competences for everyone**
   A Technology Pact focussing on digital and technical competences; informatics as compulsory subject in education; upgrade the digital skills of the workforce

2. **Attractive digital growth environment**
   Become a leading international digital hub for IoT, AI and Big Data; improved strategic research; access to demonstration and test environments; attract international digital talent; promotion of digital investment (including favourable tax depreciation and deductions on investment costs); access to capital and financing

3. **Proactive framework for digitisation**
   Agile and innovation promoting regulation and standards in ambitious European digital market; 5G infrastructure; infrastructure for driverless vehicles; open public data, IT security and ecommerce

4. **Digital responsibility and engagement**
   Political focus and roadmap for Denmark's digital development; increased awareness of digital opportunities; proactive approach in ethical questions

- The Digital Growth plan will be a key contribution to the 2025 growth plan that set an objective of DKK 80 billion (€10,75 bn) extra GDP. **Five focus sectors** are identified that can contribute up to DKK 87 billion (€11,42 bn) (based on a study by World Economic Forum and Accenture): Manufacturing; E-Commerce; Connected Mobility Services; Healthcare and the Electricity Smart Grid. **Manufacturing** would contribute DKK 17 billion (€2,28 bn) (through cost reductions and new markets), but increased competition will also result in DKK 2 billion (€0,27 bn) in lower consumption prices. (http://em.dk/digipanel)

2.3.   Implementation (focus on MADE)

- The budgets for the overall Digital Growth Strategy will be known after negotiations in Autumn. The Digital Growth Strategy will be implemented in the coming years.

- At this moment the role of MADE as Danish flagship platform is mainly confined to a research and innovation (interface with European Manufuture PPP). The role as 'national initiative' , is not clearly defined. While the political role is mostly managed through Danish Industry the platform itself is focussed on the execution of the programmes. These are followed-up intensively by the Danish Innovation Fund.

- MADE started as a bottom-up initiative for industry-science cooperation (not a full PPP)[4]. MADE is is implementing collaborative actions under the second area of the proposed Digital Growth agenda (Attractive digital growth environment), to promote production in Denmark through applied industrial research, innovation and education, enabling increase in productivity and growth.

    MADE has two main programs where industry and academic partners are working together: 1. **MADE SPIR** (Strategic Platform for Innovation and Research) which aims to develop Advanced Manufacturing technologies and strengthen the Danish manufacturing ecosystem (suppliers, end user companies, research and education). This programme is financed by mixed public-private funds, amounting to DKK 183,5 million (€24,65 million) between 2014 and 2019.

    The research programme is organised in nine research themes (with separate steering committees, each headed by an academic partner): High-speed product development; Modular production platforms for high-speed ramp-up; 3D print and new production processes; Model-based supply-chain development; Digitalisation of supply-chains; Lifelong product customisation; The 'new' manufacturing paradigm; Hyper-flexible automation; Sensors and quality control.

    2. **MADE Digital** which is a research and innovation platform aimed at developing a Danish approach to Industry 4.0, where there is focus on the many Danish SMEs. This programme has scaled-up the MADE actions with a total budget of DKK 196 million (€26,33 million) from 2017 to 2019. MADE Digital will launch **30 digital research projects** in areas in need of new solutions.
    The research themes are again distributed along 9 work packages: Smart industrial products; Digital assistance tools; Sensor technologies and production data; Digital manufacturing process; Smart factories; Intelligent supply chains; Organising digital production; Automation with collaborative robots; Digital design.
    The aim of the **project** is to provide new knowledge through research and help large-scale companies and SMEs to implement the digital solutions. Particularly SMEs will be helped to assess which part of the factory will gain most from digitalisation.

    The MADE experience is quite unique for the Danish situation in which there are not many direct competitors in export industry because of the niche strategies of the remaining big

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[4] See also: Digital Transformation Monitor - Denmark: Manufacturing Academy of Denmark (MADE)), June 2017.

companies (such as Lego, Danfoss). This allows to come close to the market with applied research that can find diverse application domains, involving small technology suppliers to develop solutions. MADE is building quickly an innovation eco-system in the manufacturing sector that incentivises these companies to invest more in R&D, e.g. by showing results through joint demonstration projects.

An important consequence of the MADE initiative is also a much improved coordination and alignment in research agendas at the five universities that cooperate in this programmes (giving each of them a leading role in the domains in which they are the strongest).

MADE is also establishing partnership agreements with other innovation actors to structure cooperation (including with regional councils). This way MADE is organically evolving to a national hub for the manufacturing ecosystem.

2.4.   Evaluations/studies

Public digital strategy 2016-2020. (in Danish only - on period 2011-2015): *http://www.digst.dk/Strategier/Digitaliseringsstrategi-2011-15*

Summary   of   Danish   economic   policies   here   - http://em.dk/english/publications/2017/denmark-going-for-growth

Digital growth panel report on digitalisation.

3. Other policy support to digitising industry (according the EC Communication)

3.1.   Boosting innovation

- Innovation will be a focus area in the new Digital Growth Strategy (forthcoming).
- Other relevant strategies for innovation related to the digital growth strategy that will be presented in 2017 are: the strategy for the **sharing economy** (which may be a driver for new business models, innovation and growth as well as contribute to improving resource efficiency); the new **science and innovation** strategy 2017 (forthcoming); the **growth 2025** strategy (forthcoming)
- **FORSK2025** (RESEARCH2025) is a **catalogue**, published in June 2017, that provides a consolidated overview of the most promising **research areas** in the future seen from the perspective of private companies, organisations, ministries, knowledge institutions etc. as a basis of prioritisation for the strategic research. FORSK2025 must form the reference for future investments in research to be based on sound knowledge about the research needs of society and the new opportunities that research can lead to. In FORSK2025, a total of **19** prominent research topics are identified within four main areas: New Technological Options; Green Growth; Better Health; People and Society. Two most relevant research themes are: 'Denmark as a digital pioneer country' and 'Future production'. This catalogue provides an

academic basis for policy decisions and prioritisations concerning the distribution of the research reserve[5].

Research and Innovation - FORSK2025 catalogue

Purpose: The FORSK2025 catalog will provide a consolidated overview of the world's most promising research themes for Denmark, as seen from the ministries, ministries, knowledge institutions, interest groups etc. A wide range of stakeholders have suggested themes for FORSK2025, which differ in particular to industry 4.0, production and digitization.

Description: FORSK2025 must be used as a technical basis for political priorities of strategic research funds - last year, the parliament voted for more than 500 million (€ 67,2 mio). The FORSK2025 catalog is prepared on the basis of recordings from - and in close dialogue with - a wide range of stakeholders, including EVM, DI, DE, IDA, FTF, LO, TI and Danish research institutes.

The following research areas relating to industry 4.0, production and digitalization will be included in FORSK2025:

• ICT: Big Data (analysis methods, machine learning, visualization) and digitization (IoT, cyber security, blockchain)

• Growth technologies: materials (new materials, intelligent materials, nanotechnology, research towards the ESS) and future digital technologies (quantum technology, supercomputers, 3-D print, wearables eg AR glasses and implants, drills and robots), life science (biotech, drugstore)

• Conversion to Industry 4.0: production (implementation of digital technology in production, imaging eg 3-D modeling and design) and competencies (STEM in education, digital learning and management, ad-hoc and interaction).

Financing: FORSK2025 is not directly financed by the Finance Act, but is a guideline for future policy priorities regarding research priorities and earmarking of pools.

- The Danish government manages the public support via executive bodies through development contracts which transmit the political priorities. Besides the Innovation Fund, other bodies such as Approved Technological Service institutes (GTS) are instruments relevant for digitizing industry through boosting innovation. There is a big focus in science and innovation on policies related to Industry 4.0.

- The **Innovation Fund Denmark** (created in 2013 from the merger of three specific innovation agencies) is the unique agency responsible for translating ideas, knowledge and technology to the benefit of growth and employment and solutions to societal challenges. Innovation Fund Denmark invests in 2017 DKK 1,2 billion (€0,161 bn) in the innovation value chain covering: applied research, experimental development and demonstration and market development.
  Therefore three main instruments are used: **Large Scale Projects** (excess 5 million, targeted to partnerships) for integrated projects from basic research to the market; **Growth Projects**

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[5] See http://ufm.dk/publikationer/2017/forsk2025-fremtidens-lofterige-forskningsomrader

(less than 5 million, targeted to SMEs) for experimental development and demonstration; funding for **talent** development (PhDs, Post-Docs and Entrepreneurship Pilots).

The IFD covers six research areas (Bioresources, Food and Lifestyle; Trade, Service and Society; Energy, Climate and Environment; Biotech, Medico and Health ; Infrastructure, Transport and Construction; **Production, Materials, Digitalisation and ICT**), for which investment strategies are developed.

The Large Scale Projects are selected through thematic calls (based on IDK strategy and political earmarked funds); open calls and specific calls for societal innovation partnerships). Of particular importance is the creation of data analysis capacity with large-scale projects: Center for Quantum Innovation (Qubiz); Danish Center for Big Data Analytics driven Innovation (DA-BAI); Danish center for artificial intelligence (DCKAI)

In July 2017 IFD published a new international strategy that wants to increase international collaborations that match Denmark's needs and strengths.

- The **Approved Technological institutes** (GTS) are non-profit companies that are approved every three years and can then apply for an exclusive pool of funds from the Danish Agency for Science, Technology and Innovation (<u>Ministry of Higher Education and Science</u>). The Danish Ministry of Higher Education and Science has concluded development contracts with the GTS institutes for 2016-2018, i.a. with three binding targets: increased regional knowledge dissemination, strengthened synergies across the innovation system and strengthened internationalisation of Danish companies. Companies can buy services from the GTS-institutes or participate in collaboration projects that are co-funded.

  Out of the 8 institutes, 3 are specifically relevant.
  o   The Alexandra Institute – Center for artificial intelligence.
  o   DELTA (part of FORCE Technology from 1. Jan 2017)
  o   Danish Technological Institute (Ibiz-center)

- The **Innovation Networks** (supported by the Ministry of Higher Education and Science/ Danish Agency for Science, Technology and Innovation) offer companies access to the latest research and innovation trends within their respective fields of expertise, also assist in finding new partners for collaboration on both small and large scale research and innovation projects among private companies, Researchers, the public sector, technological service providers and other partners – both in Denmark and abroad.). It is an instrument to reinforce the innovation ecosystem by clustering small technology companies in domains of strength (such as robotics) around user companies.

3.2.   Skill development
- ICT skill development is high on the policy agenda, in particular for education. E.g. Increased use of ICT in primary schools was part of the eGovernment strategy for 2011-2015, which was allocated 500 million dkr. A new computational thinking subject (Informatik) is on test level in upper secondary school.
- Access to the right digital skills will be a key focus area in the coming digital growth strategy. Among the focus areas recommended by the Digital Growth Panel is a **technology pact** (possibly still in 2017)where educational institutions, private actors and companies join forces in making an effort to ensure that more people choose technical and digital education programmes in order to match the private sector's demand for these competencies.

- In addition the Government has set up for the period 2017-2019 a **Disruption Council - partnership for Denmarks future** with the prime minister, to help ensuring that all Danes are well prepared for the job market of the future. The partnership includes the social partners, companies, experts and relevant Government Ministers. In the next two years the **disruption council** will come with recommendations on how to tackle the influence of new technologies on the Danish labour market. Additionally, recommendations should be used in connection with the Government's forthcoming growth plan.

Looking to the past the Danish government has a focus on skill development particularly related both to education and further training.

Education
ICT in primary schools
Objective: Increased use of ICT in primary schools.
Description: Increased use of ICT in primary schools was part of the eGovernment strategy for 2011-2015, which was allocated 500 million dkr.**Dimensioning of higher education**
Objective: The aim of the dimensioning of higher education is to move from education with systematic discouragement among the graduates to higher education programs.
Description: The government wants a better connection between study options and the labor market. The government has therefore chosen to continue the ceiling introduced in autumn 2014 on admission to a number of higher education programs at universities, university colleges and vocational academies, which have had systematic discontinuity compared to other graduates from higher education.

High School reform to strengthens students' digital skills Objective: The college reform from June 2016 put a stronger focus on pupils' digital skills, enabling students to work for the future of the future, where technological development is a basic condition. Implemented from the school year 2017/18.

Description:
- *New IT subjects - Informatics*: A new IT subject is introduced. At stx, informatics C must replace either biology C or natural geography C. In htx, informatics C should be able to replace the subject communication and IT C, and the subject is also included as a Bachelor's degree at B level. In hhx, Informatics C is introduced as a compulsory course and as a Bachelor's degree in B-level. The subject may also be offered as electives at both C and B levels.
- *The subject of b-level programming* is introduced as a field of study in htx, as well as programming is introduced into the compulsory subject technology B in htx.
- *Enhanced skill - Digital competencies*: The students' digital competencies must be strengthened so that they learn to make a critical view of digital media. They must learn to seek information and to execute source criticism, as well as make self-esteem, digital productions and learn to enter into digital communities, as well as learn to reflect on the selection and selection of digital tools in different contexts. The objectives must be reflected in the core material of the subjects and in working and trial forms. Development of IT skills should be prioritized in pedagogy education.
- *Enhanced digitalization in teaching*: The strategy for digitization in the teaching, which will put students 'digital skills and competencies, teachers' digital competencies and digital didactics, as well as the use of data to support learning and development on the agenda.

- *Competence development course*: Experiences from schools that today use IT and digital learning resources innovatively and successfully, are collected and disseminated to other schools. The experience is part of the competence development process for teachers and managers.

National science strategy

Purpose: A national science strategy aimed at strengthening the natural sciences, knowledge and interest of all children and young people from day care and higher education, and to strengthen recruitment to technical and science education.

Description: Danish companies need more qualified natural science employees to follow the global knowledge and growth cycle. The strategy can be linked with the technology pact to ensure a common direction and coherence nationally. The strategy is anchored Agreement on Enhanced Higher Education (Gymnasial Reform) from June 2016. A strategy group will be set up at the beginning of September 2016, which will submit a comprehensive presentation to a national science strategy to the government at the end of 2017.

Further training

Improved Postgraduate .dk (EfterUddannelse.dk)

Objective: The initiatives have initiatives to facilitate corporate administrative burdens in the field of training of their employees.

Description: Improvement of EfterUddannelse.dk (nationwide registration and application portal for vocational adult and continuing education), so it becomes easier - especially for the smaller companies who do not have a routine to apply EtterUddannelse.dk - to register employees for a course and apply for WEEE allowance. (Launched in the autumn of 2016).

Optimization of registration and WEU application flow, currently is being designed in close cooperation with the users. This version is expected to be completed in spring 2017.

Better adult and continuing education (WEU)

Purpose: More and better adult and continuing education

Description: In 2013, the then government presented "Growth Plan DK" to ensure growth and jobs in the future of Denmark. One of the focus areas was to strengthen adult and continuing education efforts. A $ 1 billion pool was therefore allocated for more and better adult and continuing education by 2020. It is estimated that the initiatives at the upper secondary level will contribute to lifting the activity by more than 3,000 students, equivalent to more than 20,000 students during the period.

Funding: 1 billion have been allocated. for the efforts in the Finance Act 2014-2020. Of these, good is DKK 355 million (€47,69 mio) allocated to strengthened opportunities and increased activity in adult and postgraduate education at upper secondary level.

3.3.   Standardisation

Use standardisation to increase the uptake of digital technologies. For more information it is possible to contact Danish Standard. https://www.ds.dk/en/about-dansk-standard

3.4.   Regulation Framework

Denmark has a long time focus on ensuring good conditions for business development. As a result Denmark is among the top countries on the scoreboard of ease of doing business. This is among other things due to a focus on business friendly environment across all ministries and across all sectors.

Among the examples of were regulation conditions has been a focus area is the Growth Plan for Digitisation in Denmark from 2014 and the Digital strategy 2016-2020. These strategies are described in the top section.

Proactive regulation will also be a key principle in the coming Digital growth strategy.

4. Investments (to be completed)

- At the time of this report no details on investments in the new Digital Growth Plan were available. In the vision of Digital Growth Panel the new government strategy can have unlocked DKK 90 bn (€12 bn) by 2025 within the five selected sectors with the most potential in connection with the digital transition[6]. These recommendations don't not include estimates on the investments needed to achieve the value impacts. But the recommendations anticipate measures for favourable climate for digital investments and access to capital and financing, by promoting investment by SMEs in digital transition and a review of tax depreciation rules for digital investments and deductible development costs. Other instruments for promoting investments of SMEs) are the Danish Growth Fund and the Market Development Fund (see above).
- It was decided that budgets for publicly funded R&D will be cut by 2% each of the next four years. However, public R&D is still projected to be close to 1%. The Innovation Fund Denmark is the major public lever for new innovation driven investment (annual budget of DKK 1,6 billion or €210 million), with specific actions on digitising (such as the MADE Digital, with DKK 79 million or €10,61 million).

5. Good practices:

Denmark has used PPPs in a number of areas in order to promote a digital agenda. To name a few with specific relevance to Industry 4.0.:

- MADE (see description – further up)
- Enterprise Partnership for Advanced Production
- Robot Technology Transfer Network - ROBOTT-NET
- Digitalization Partnership for Retail, Wholesale and E-Commerce

    Purpose: The Digitalization Partnership aimed to promote the understanding and exploitation of digital opportunities in retail, wholesale and e-commerce in Denmark.

    Description: As part of the government's Growth Plan for Digitization in Denmark, a partnership was established for digitizing retail, wholesale and e-commerce. More specifically, the partnership aims to promote the understanding and exploitation of digital

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[6] Based on a study by World Economic Forum and Accenture: Unlocking Value to Society of Denmark, http://em.dk/digipanel

opportunities in e-commerce, sales channels, Big Data and e-commerce. The members of the Digitalization Partnership are DI Handel, DI Digital, Danish Business, IT Branch and FDIH.

6. Contribution to European priorities

a) Investments in key-technologies:

RoboCluster
Data analytics
MADE

b) Development and networking of Digital Innovation Hubs

Development contracts with Approved Technological Service Institutes (GTS institutes):
The Danish Ministry of Higher Education and Science has concluded new development contracts with the GTS institutes for 2016-2018, i.a. with three binding targets of increased regional knowledge dissemination, strengthened synergies across the innovation system and strengthened internationalisation of Danish companies

The Danish universities are currently reconfiguring their technology transfer offices aiming to improve their commercialization capabilities from a traditional linear approach towards a more collaborative and interactive model. Moreover, physical 'Innovation Hubs' are being built to provide shared facilities for researchers and businesses. Collaboration with industry and the broader society is also part of the mandatory parameters in performance contracts between the Ministry of Higher Education and Science and the universities.

c) Participation in industrial platforms

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