Monitoring industrial ecosystems

EU MEMBER STATES FACT SHEETS

Denmark

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Key Highlights

This country report has been developed as part of the '**European Monitor of Industrial Ecosystems'** project of the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency. It provides data insights into the twin transition and the technological performance of industrial ecosystems. The key findings of the report are summarised below:

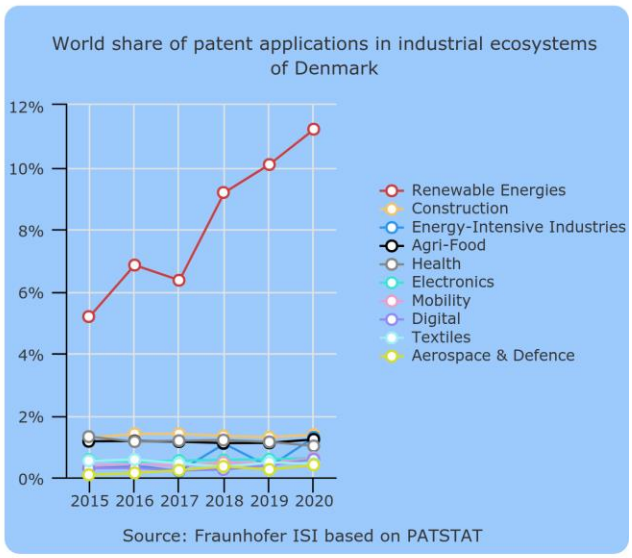
Denmark

Technological performance in industrial ecosystems:

- Denmark had by far the highest share of its patent applications in the **Renewable Energy** industrial ecosystem, where it also shows some strengths relative to its size within the EU27.

Digital and green transition technologies:

- Among the digital technologies monitored in this project, Denmark had the highest country share of patent applications in **Advanced Manufacturing and Robotics.** In the field of green transition technologies, Denmark has generated most technologies related to **Renewable Energy Technologies and Wind Power**.
- Trends over time in Denmark's share in the world patent applications show an overall increase in green transition technologies, especially in Wind Power.
- In the field of digital technologies, an oscillating trend can be observed with a surge in the world share of Denmark in **Advanced Manufacturing and Robotics** from 2017 to 2020.



Capacity to produce goods based on digital and green technologies:

- Denmark's share of production in digital technologies over global production indicates that it created the highest value by the deployment of **Micro- and Nanoelectronics and Advanced Manufacturing and Robotics** technologies across all manufactured goods in the economy in 2021.
- Over the period from 2010 to 2021 Denmark's share has increased in Digital Mobility and Big Data and since 2018 it has started to increase again in Artificial Intelligence.
- In the field of green transition technologies, Denmark created the highest value by the deployment of **Biotechnology and Advanced Materials and Nanotechnologies.**

1. Introduction

This country report has been prepared within the '**European Monitor of Industrial Ecosystems' (EMI)** project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA). The overall goal of the project is to **analyse the green and digital transformation of industrial ecosystems**.

The EU's updated industrial strategy from May 2021[1] has outlined 14 industrial ecosystems that are in the focus of the project. The 14 industrial ecosystems include *aerospace and defence, agri-food, construction, cultural and creative industries, digital, electronics, energy intensive industries, energy-renewables, health, mobility – transport – automotive, proximity, social economy and civil security, retail, textile and tourism.* The industrial strategy defined industrial ecosystems as encompassing all players operating in a value chain: from the smallest startups to the largest companies, from academia to research, service providers to suppliers[2].

The objective of this report is to **present key findings from data** collected within the framework of this project at country level notably on **patent applications, production data, trade** (available only for ten industrial ecosystems)**, private equity and venture capital** investments. Nonetheless, this report does not aim to be comprehensive; the data presented here only complement other important statistics on technology development in each country.

The monitoring framework has a technological focus. Industrial transition is driven by technological, economic, and social changes, and in particular by digital technologies and the shift to a green and circular economy. The green and digital technologies that have been taken into account are presented in the table below.

Table 1: Technologies monitored in the project by patent, trade and prodcom data

Green technologies
Advanced Materials and Nanotechnology
Biotechnology (for sustainability)
Energy Saving Technologies
Renewable Energy Technologies
Solar Power
Wind Power
other (geothermal, hydropower, biomass)

Digital technologies
Advanced Manufacturing & Robotics
Advanced Manufacturing
Robotics
Artificial Intelligence
Big Data
Digital Security & Networks/ Cybersecurity
Digital Technology for Mobility
Internet of Things
Micro- and Nanoelectronics & Photonics
Micro- and Nanoelectronics
Photonics

Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

The methodological report that sets the conceptual basis and explains the technical details of each indicator is available on the EMI website. This report was prepared by Cecilia Rolla, from Technopolis Group for the European Commission. However, it does not necessarily reflect the views of the European Commission.

[1] European Commission (2021). Communication on Updating the 2020 New Industrial Strategy, COM(2021)350 final https://commission.europa.eu/system/files/2021-05/communication-industrial-strategy-update-2020_en.pdf

[2] European Commission (2020). A New Industrial Strategy for Europe, COM/2020/102 final Commission Communication: A New Industrial Strategy for Europe | European Commission (europa.eu)

2. Advanced technologies fostering the green and digital transition of industrial ecosystems

2.1. Data sources

This chapter outlines a set of indicators that capture the capacities of EU Member States to generate technologies that foster the green and digital transformation of industrial ecosystems. Industries that are underpinned by a strong technology basis and supported by vibrant entrepreneurial communities have better conditions for success. The production of technology-based products indicates that technologies are commercialised, while a positive trade balance in technologies is a sign of international competitiveness.

Patent analysis is a widely used method for tracking technological development activities. With a view to industrial ecosystems under study in this project, technology generation and hence patenting takes place in a relatively limited number of ecosystems, while others mainly profit from technologies generated elsewhere. Technology development drives industrial transformation in a general way. The patent analysis is based on transnational patents, notably those filed through the WIPO PCT procedure[3] or at the European Patent Office[4] directly. They have been localised based on the address of the applicant. The different advanced technologies have been identified based on International Patent Classification (IPC) codes and keyword searches.

Trade data, more specifically export data, is a further relevant indicator to document industrial development at higher technology readiness levels. It informs on countries' competitive advantage in specific technology-based product areas. While somewhat simplistic, export strengths in certain technological areas still mark a specific relevance of technology relevant goods for the economy and remain among the reliable indicators of performance. The analysis focuses on trade balances based on UN Comtrade[5] statistics processed specifically for the purposes of this project. The trade balance can help reveal how nations are intricately involved in supply chains with substantial imports and relevant exports. By putting exports in relation to parallel imports, it is possible to assess whether a country displays strength in production.

Prodcom data[6] allows the monitoring of technology diffusion. Prodcom provides statistics on the production of manufactured goods carried out by enterprises on the national territory of the reporting countries. It helps measuring the uptake of technology through the production of manufactured goods by focusing on the specific components and elements enabled by green and digital technologies. Production data allows to measure to what extent technology-related products are being produced in the country. The production indicators are calculated based on product-level data from the Eurostat's Prodcom database.

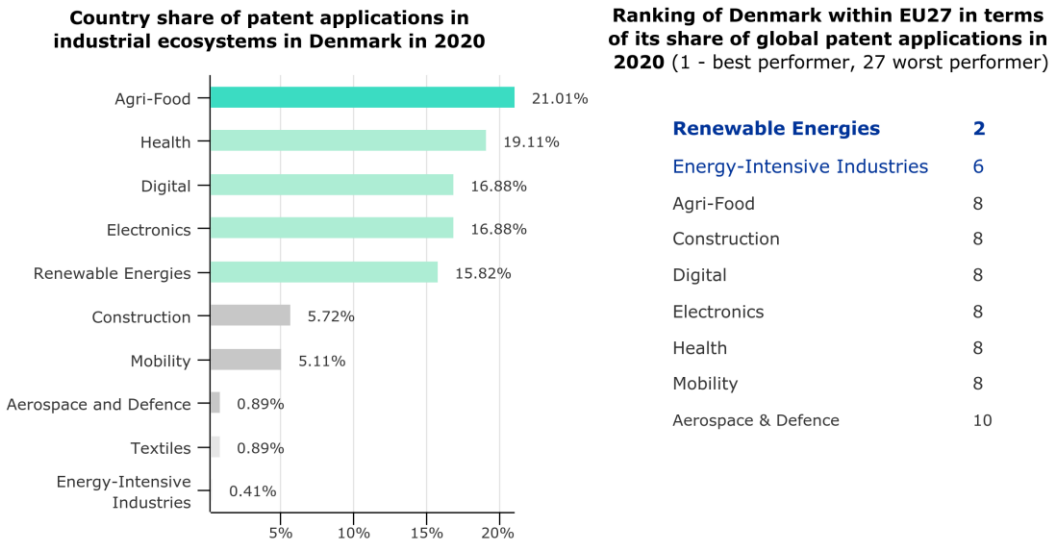
Crunchbase data[7] were used to analyse entrepreneurial dynamics and private equity and venture capital investment. Crunchbase is a widely trusted source of information on venture capital backed innovative companies. Technology startups represent key building blocks in the transition towards a more digital, green and resilient economic model. Entrepreneurial activity helps accelerate the diffusion of technologies in industrial ecosystems and startups that provide green and digital solutions are relevant indicators of how the industrial ecosystem is transforming itself to reach environmental sustainability objectives. More information about these data sources can be found in the methodological report of the project.

[3] World Intellectual Property Organization, WIPO Patent Cooperation Treaty (PCT) https://www.wipo.int/pct/en/
[4] European Patent Office, Supporting Innovation and Patents in Europe https://www.epo.org/en.
[5] United Nations Comtrade, UN Comtrade Plus-International Trade Data Platform https://comtradeplus.un.org/
[6] Eurostat, Eurostat PRODCOM-European Union Production and Trade Statistics https://ec.europa.eu/eurostat/web/prodcom
[7] Crunchbase, Business Information and Networking Platform https://www.crunchbase.com/

2.2 Technology development in industrial ecosystems

Regarding technology development, Denmark had the highest share of its patent applications in technologies related to the Agri-Food, Health, Digital, Electronics and Renewable Energy industrial ecosystems in 2020 as captured by patent data. In a global comparison, Denmark ranked second in Renewable Energies, and sixth in Energy-Intensive Industries within the EU27 countries. In several industrial ecosystems, it ranked on the 8th place such as Agri-Food, Construction, Digital, Electronics, Health or Mobility.

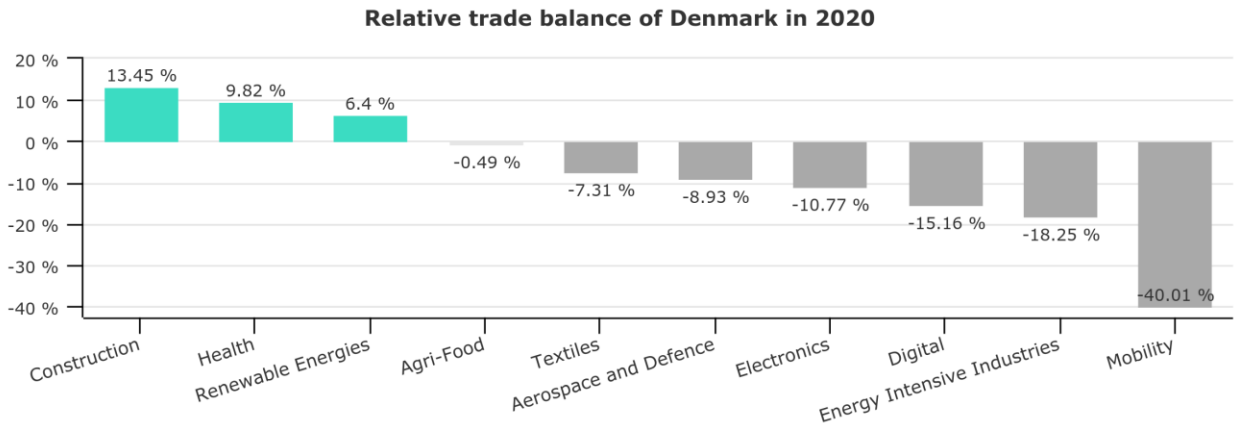
Figure 1: Denmark's country share and world share (expressed in terms of ranking) in patent applications in industrial ecosystems



Source: Fraunhofer ISI based on Patstat

Trade is a common indicator of international competitiveness because it shows how attractive a country's products are outside of its domestic market. Total exports provide evidence about a country's role as a producer, and trade balance captures its sovereignty in certain areas of production. Figure 2 displays the trade balance in relation to overall trade volume by technology development in industrial ecosystems. Denmark registered a trade surplus in technology-based products related to Construction, Health and Renewable Energies in 2020.

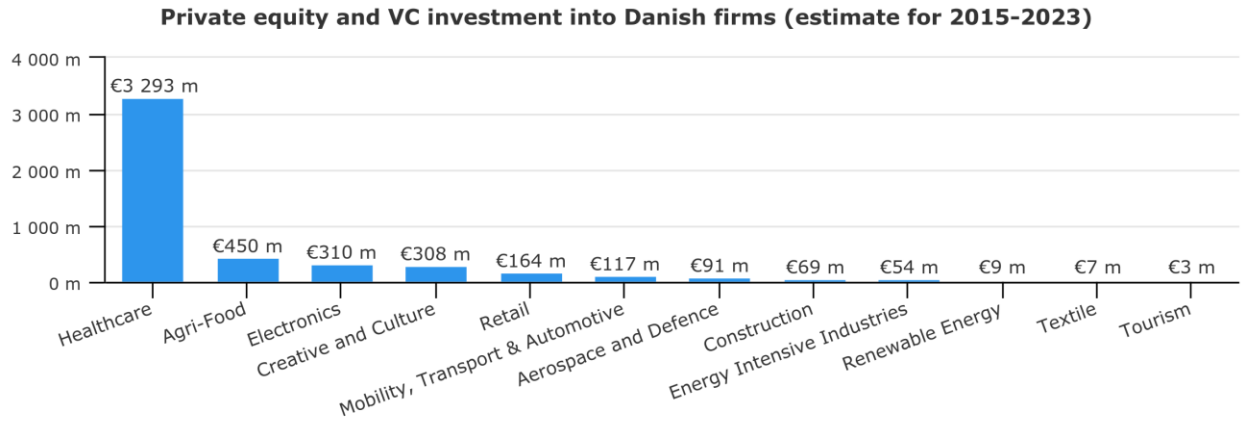
*Figure 2: Trade balance in relation to overall trade volume ((exp. - imp.-1)*100) (2020)*



Source: Fraunhofer ISI based on UNCOMTRADE

Over the period from 2015 to 2023, most private equity and venture capital investments went into innovative Swedish tech companies operating in Tourism, Aerospace and Defence, and Agri-Food.

Figure 3: Private equity and venture capital investment into tech companies related to industrial ecosystems in Denmark

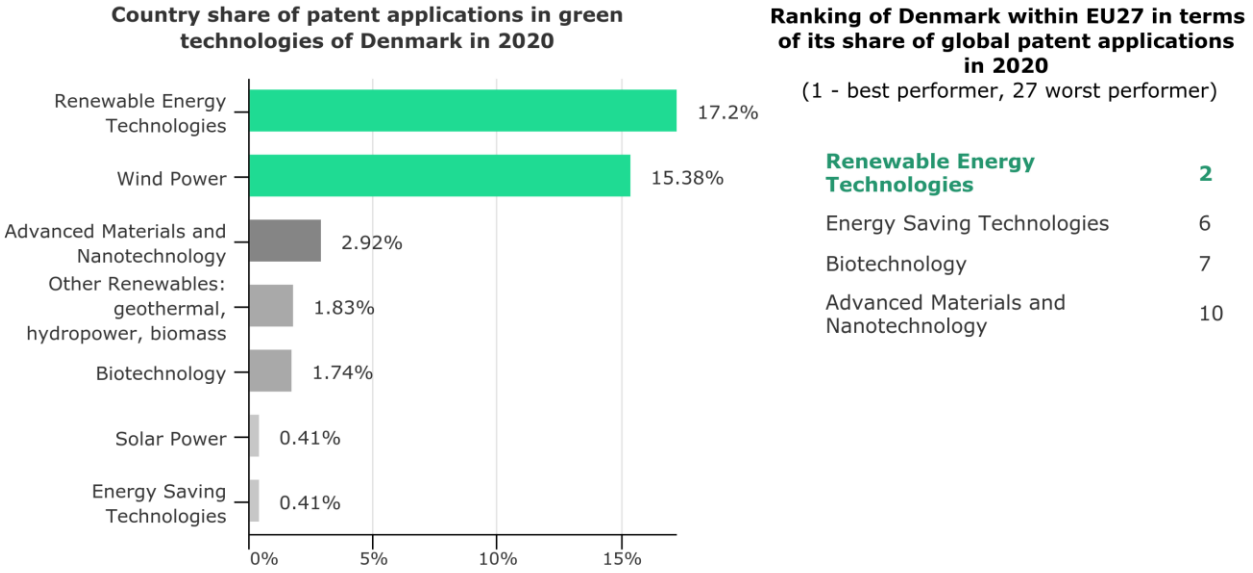


Source: Technopolis Group based on Crunchbase

2.3 Green transformation

Denmark has been the most specialised in generating technologies related to Renewable Energy Technologies, and more specifically Wind Power, within its economy, which have the potential to drive the green transformation of its industries. Similarly, Denmark ranked second among EU27 Member States in Renewable Energy Technologies, and sixth in Energy Saving Technologies regarding its world share of patent applications.

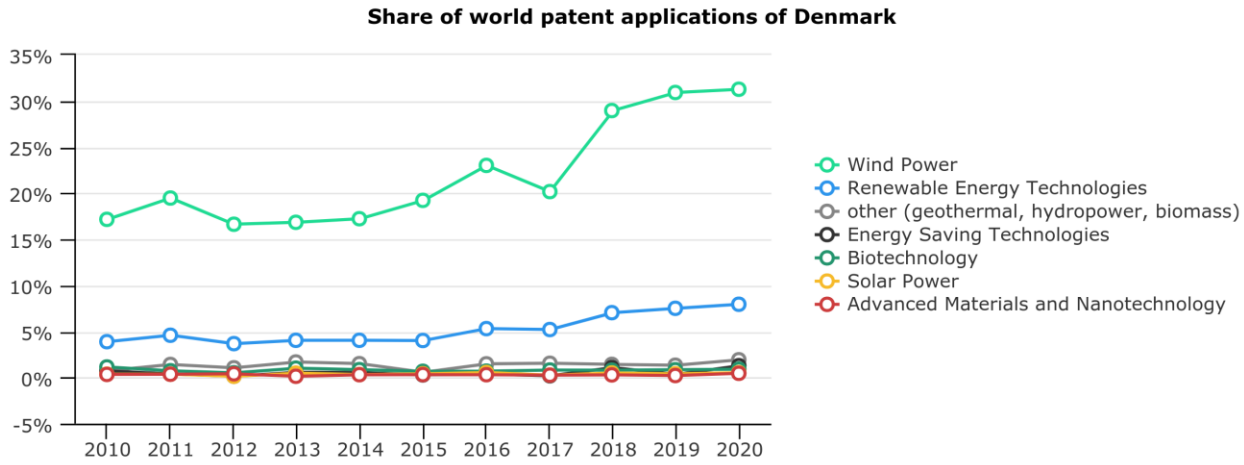
Figure 4: Country share and world share (expressed in terms of ranking) in patent applications of Denmark



Source: Fraunhofer ISI based on Patstat

Trends in patent applications across the world show that Denmark has increased its global share in various fields, including Renewable Energy Technologies and, more specifically, Wind Power and Other Renewable Energy.

Figure 5: Trends over time in Denmark's share in world patent applications

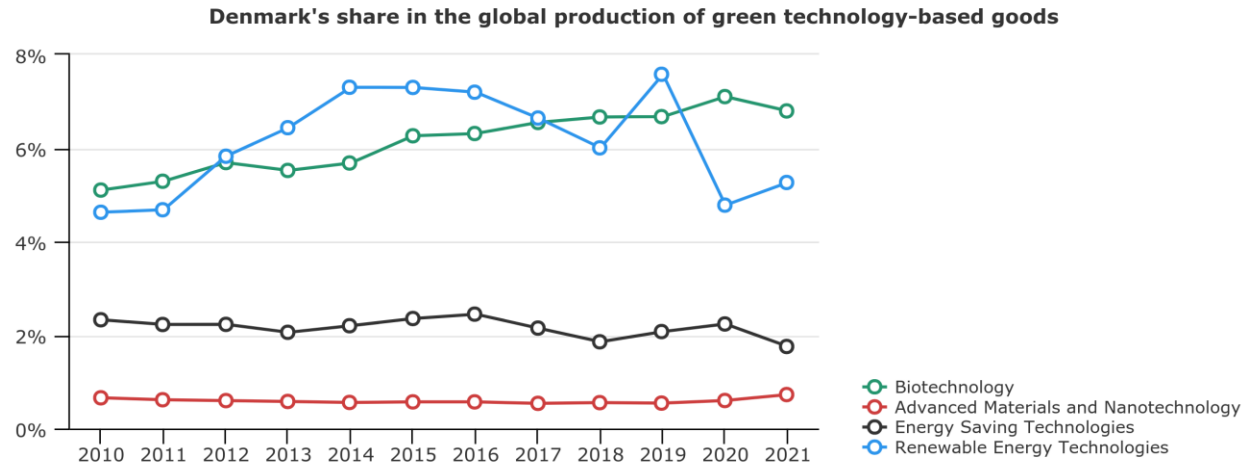


Source: Fraunhofer ISI based on Patstat

The indicators based on Prodcom data measure the evolution of advanced technology-related production in Denmark for a given year and capture the countries' share in the global production of manufacturing goods (as presented in the Figure below).

Denmark's share of production in green technologies over the global production indicates a positive trend in Biotechnology and Renewable Energy related technology-based products with fluctuations since 2018. Its share decreased in Energy Saving Technology-based products.

Figure 6: Production of advanced technology-based products in Denmark

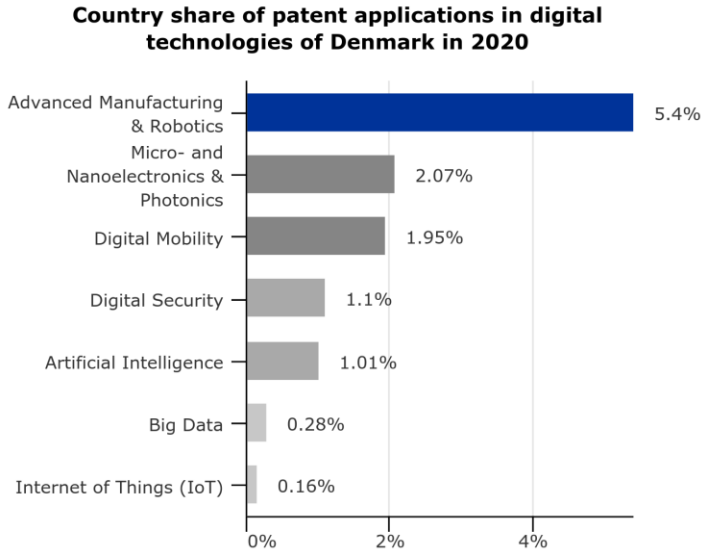


Source: IDEA Consult based on Prodcom data

2.4 Digital transformation

Among the digital technologies monitored in this project, Denmark had the highest share of its patent applications in Advanced Manufacturing and Robotics and Micro- and Nanoelectronics. It ranked at 8th place both in Advanced Manufacturing and Robotics and in Digital Mobility in terms of its world share of patent applications among the EU27 Member States. It has been also performing well in Micro-and Nanoelectronics, Internet of Things and Digital Security.

Figure 7: Country share and world share (expressed in terms of ranking) in digital technology related patent applications of Denmark



Ranking of Denmark within EU27 in terms of its share of global patent applications in 2020

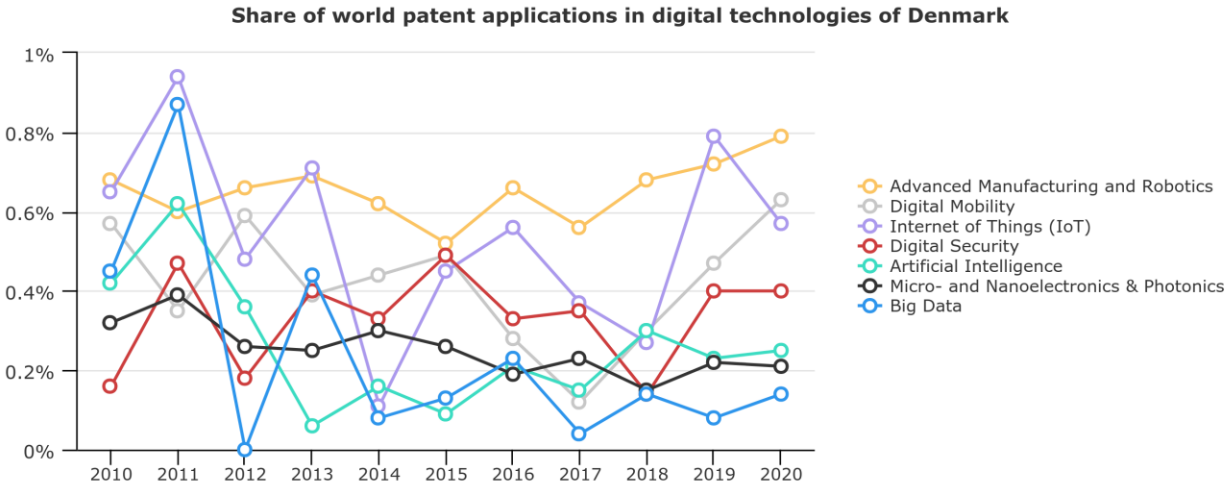
(1 - best performer, 27 worst performer)

Advanced Manufacturing and Robotics	**8**
Digital Mobility	**8**
Micro- and Nanoelectronics & Photonics	10
Internet of Things (IoT)	10
Digital Security	10
Artificial Intelligence	11
Big Data	14

Source: Fraunhofer ISI based on Patstat

Trends over time indicate that Denmark increased its global position in the field of Advanced Manufacturing and Robotics from 2015 to 2020 and also in Digital Technologies for Mobility since 2017. Nevertheless, it has decreased its world share in the field of Big Data.

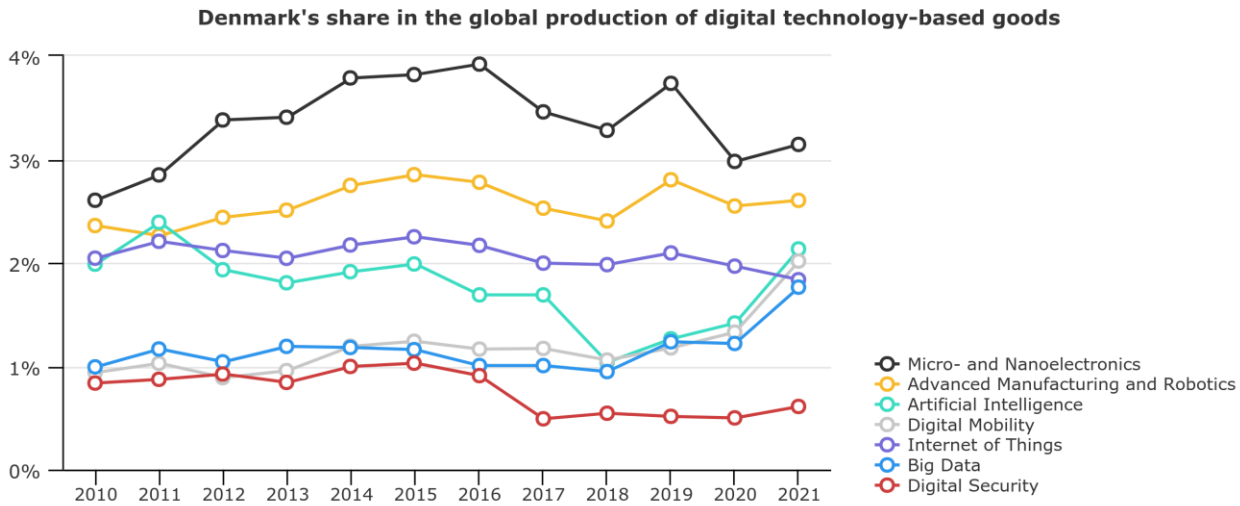
Figure 8: Trends over time in Denmark's share of world patent applications



Source: Fraunhofer ISI based on Patstat

Denmark's share of production in a particular technology over Denmark's total production indicates that it has the largest share in the field of Micro-and Nanoelectronics and Advance Manufacturing and Robotics related products. In these technologies, Denmark has been also a technology developer, which suggests that it has managed to turn these into commercialised products. Denmark has the lowest share of production in Digital Security related products.

Figure 9: Production of advanced technology-based products in Denmark



Source: IDEA Consult based on Prodcom data

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