



Monitoring industrial ecosystems

EU MEMBER STATES FACT SHEETS

Germany

EUROPEAN COMMISSION

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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:

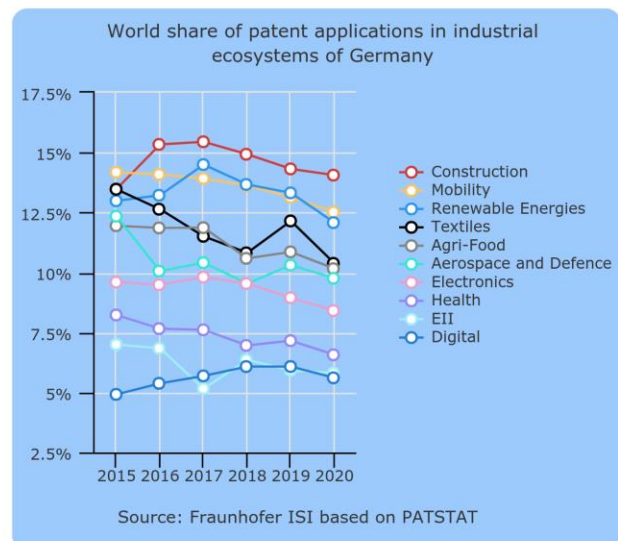


Technological performance in industrial ecosystems:

- In a global comparison, Germany had the highest share of world patent applications in **Construction, Mobility, and Renewable Energies** and it ranked first among the EU27 in all ecosystems in 2020.

Digital and green transition technologies:

- Within the EU27, Germany ranked among the top countries in generating digital and green technologies in **Advanced Manufacturing and Robotics, Digital Mobility/ in Renewable Energies and Advanced Materials** as indicated by patent data.
- It has dynamically increased its world share of patent applications in **Renewable Energy Technologies** and more specifically in **Geothermal, Hydropower and Biomass energies** from 2010 to 2020 and it defended its position in other green transition technologies such as Energy Saving Technologies and Advanced Materials as well over time.
- In the field of the digital transition, Germany decreased its global position in various digital technology fields over the period from 2010 to 2020, except for Digital Security. Its world share of patent applications decreased between 2010 and 2015 in the field of Artificial Intelligence but has been increasing since then.



Capacity to produce goods based on digital and green technologies:

- Germany's high production share in digital technologies globally shows that it has generated the most value through the use of **Advanced Manufacturing and Robotics technologies** in 2021. Trends over time show a dynamic increase in its global production share in Advanced Manufacturing and Robotics, however, a decrease or stagnation in all other digital technology related goods.
- In the field of green transition technologies, Germany created the highest value by the deployment of **Advanced Materials**. The share of production in green technologies indicates a decrease overall from 2010 to 2021, as indicated by Prodcom data.

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 2021¹ 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 suppliers².

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	Digital technologies
Advanced Materials and Nanotechnology	Advanced Manufacturing & Robotics
Biotechnology (for sustainability)	Advanced Manufacturing
Energy Saving Technologies	Robotics
Renewable Energy Technologies	Artificial Intelligence
Solar Power	Big Data
Wind Power	Digital Security & Networks/ Cybersecurity
other (geothermal, hydropower, biomass)	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 Henning Kroll, from Fraunhofer ISI 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 procedure³ or at the European Patent Office⁴ 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 Comtrade⁵ 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 data⁶ 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 Eurostat's Prodcom database.

Crunchbase data⁷ 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, Germany had the highest share of its patent applications within the country in the Electronics, Agri-Food, and Digital industrial ecosystems in 2020 as captured by patent data. In a global comparison, it ranked at the 1st place across all ecosystems within the EU27 countries (with the highest world share in Construction, Mobility and Renewable Energies).

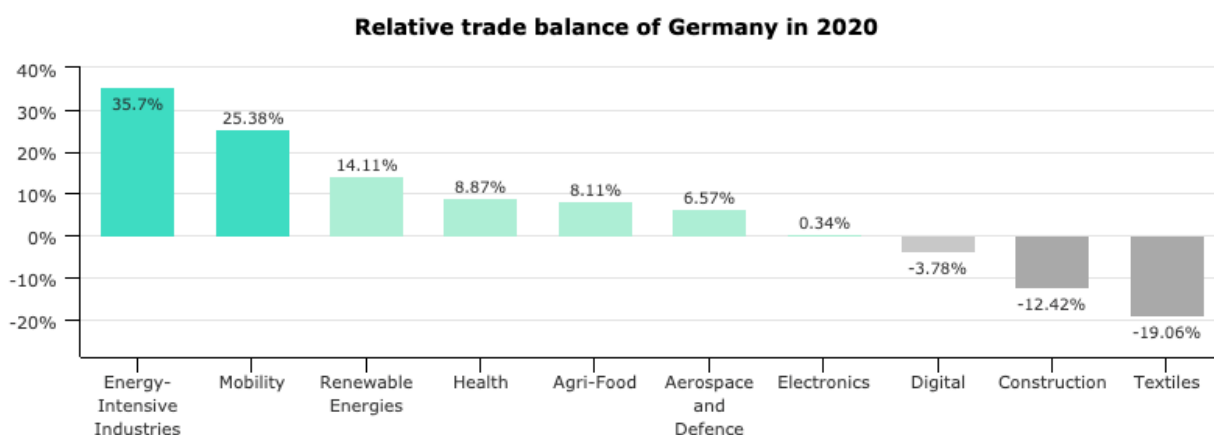
Figure 1: Germany's country specialisation and world share (expressed in terms of ranking) in patent applications in industrial ecosystems



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. Germany registered a trade surplus in technology-based products related to Energy-Intensive Industries, Mobility, Renewables, Health, Agri-Food, Aerospace and Defence, and Electronics industrial ecosystems in 2020.

Figure 2: Trade balance in relation to overall trade volume $((exp - imp)/(exp + imp))$ (2020)



Source: Fraunhofer ISI based on UNCOMTRADE

Most private equity and venture capital investment went into innovative German tech companies operating in the field of Aerospace and Defence and Tourism (including airlines) over the period from 2015 to 2023.

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

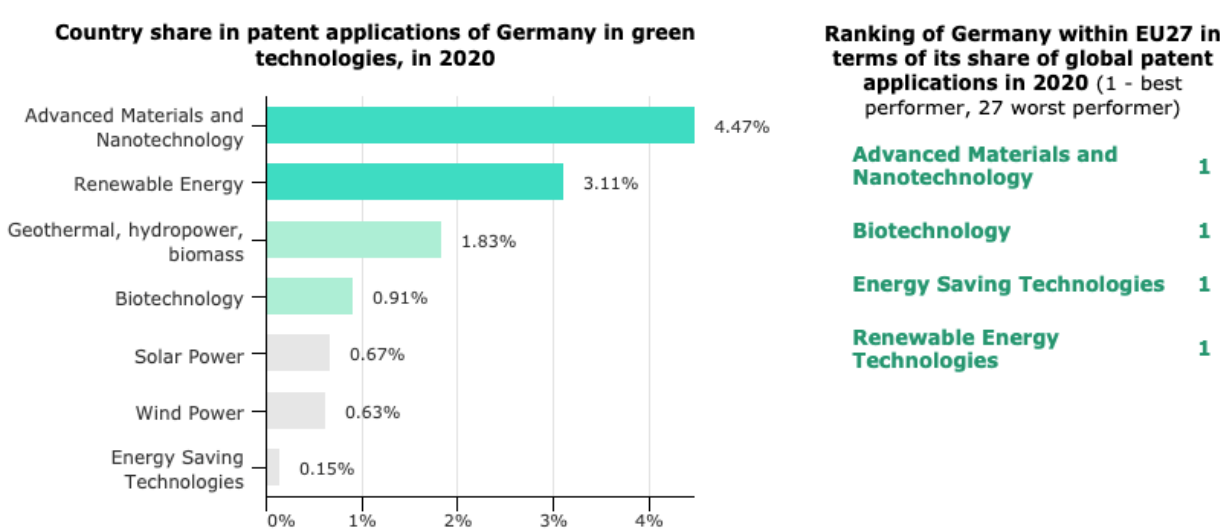


Source: Technopolis Group based on Crunchbase

2.3 Green transformation

Among the green technologies monitored in this project, Germany had the highest share of patent application within its country related to Advanced Materials and Nanotechnology, which have the potential to drive the green transformation of its industries. Germany ranked at the 1st place among the EU27 Member States in all green technologies monitored in this project.

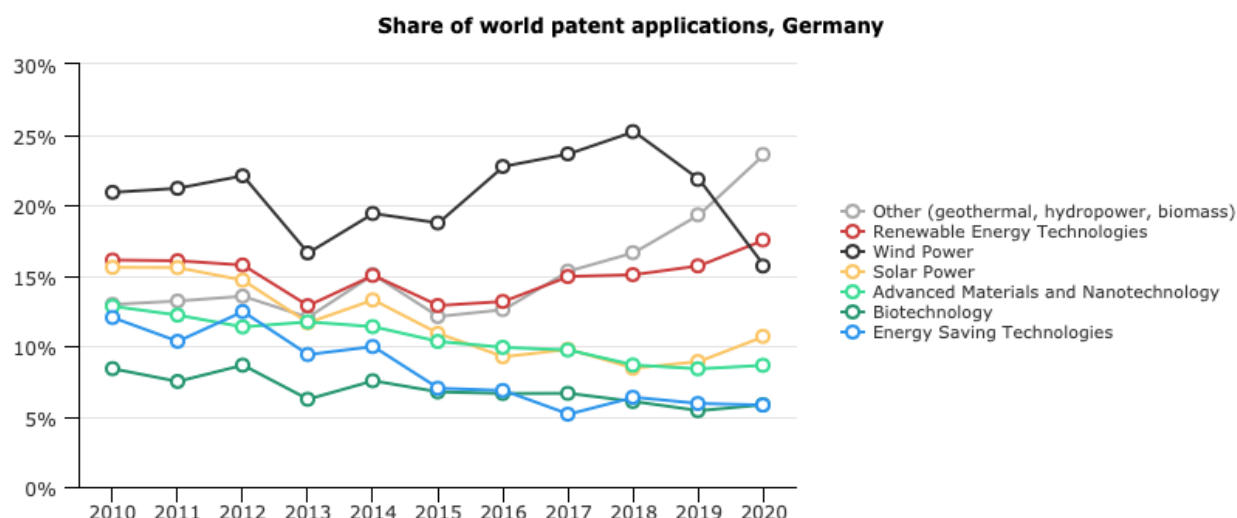
Figure 4: Country specialisation and world share (expressed in terms of ranking) in patent applications of Germany



Source: Fraunhofer ISI based on Patstat

Trends in the world's patent applications show that Germany increased its global share in various fields such as in Renewable Energies driven by Other Renewable Energies that include Geothermal, Hydropower and Biomass, and secondly by Solar Power. Its world share in Wind Power fell sharply since 2018. The data show a decreasing trend in Germany's global position in Advanced Materials and Energy Saving Technologies and Biotechnology.

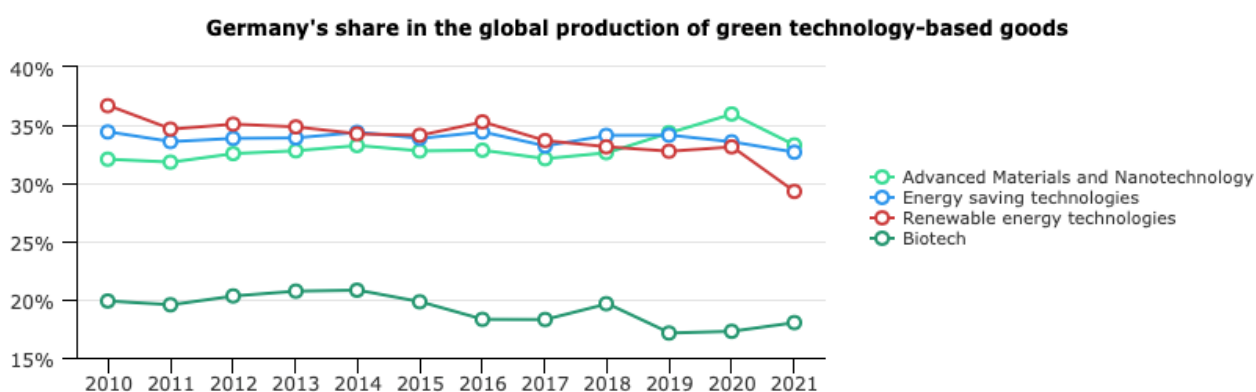
Figure 5: Trends over time in Germany's share in world patent applications



Source: Fraunhofer ISI based on Patstat

The Prodcom-based indicator (as presented in the Figure below) measures the evolution of advanced technology related production in Germany for a given year. The share of production in a certain technology over Germany's total production indicates an overall decrease in Renewable Energy Technologies and in Energy Saving Technologies over the period from 2010 to 2021. The share of Advanced Materials related products increased until 2020 but had a drop from 2020 to 2021.

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

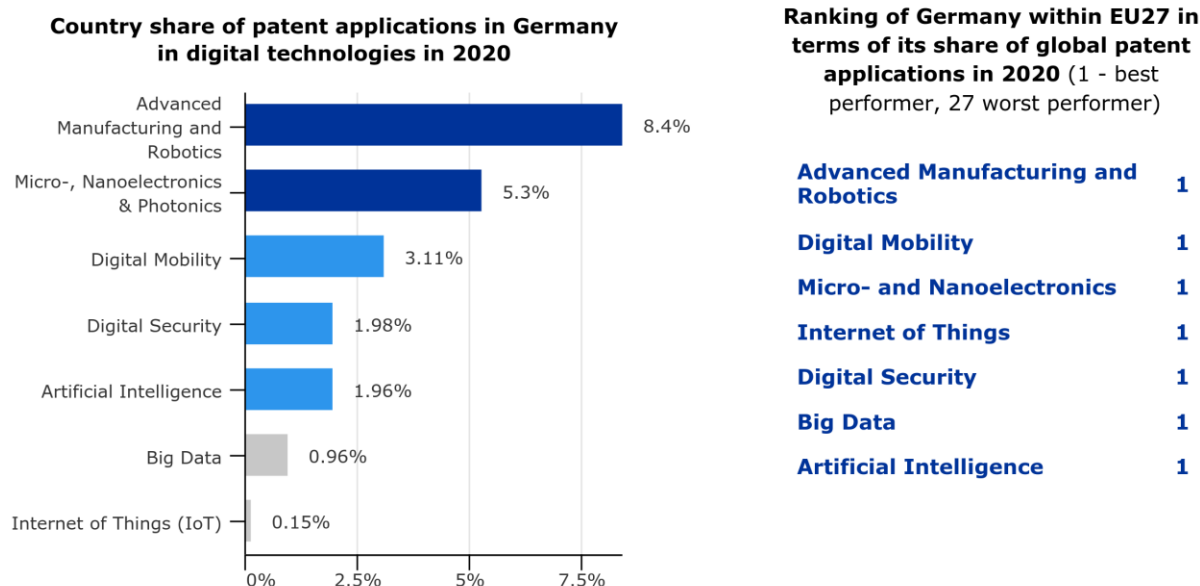


Source: IDEA Consult based on Prodcom data

2.4 Digital transformation

Among the digital technologies monitored in this project, Germany had the highest share of patent application within the country in Advanced Manufacturing and Robotics, and Micro-and Nanoelectronics. Germany ranked at the 1st place in all digital technologies in terms of its world share of patent applications among the EU27 Member States.

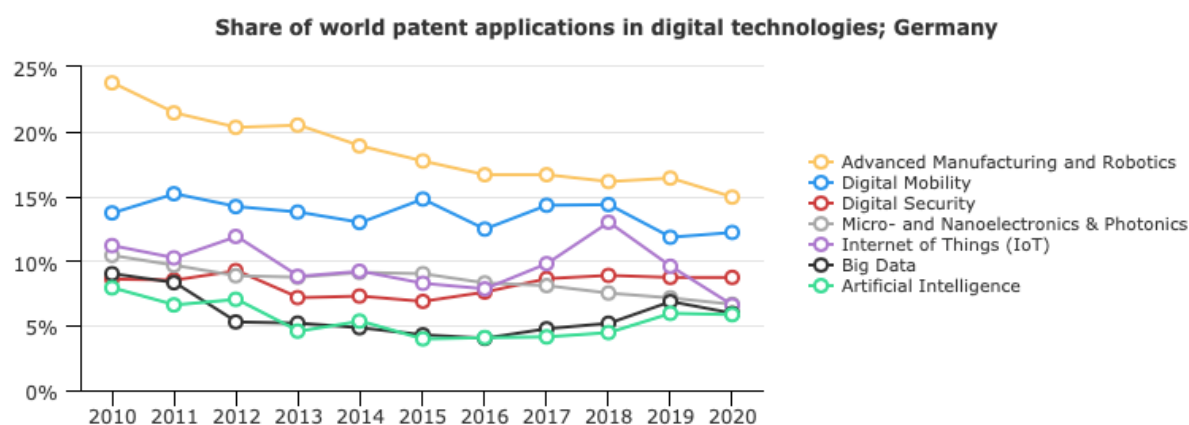
Figure 7: Country specialisation and world share (expressed in terms of ranking) in digital technology related patent applications of Germany



Source: Fraunhofer ISI based on Patstat

Trends over time indicate that Germany decreased its global position in various digital technology fields over the period from 2010 to 2020, except for Digital Security. Its world share in Artificial Intelligence technologies decreased between 2010 and 2015 but has been increasing since then.

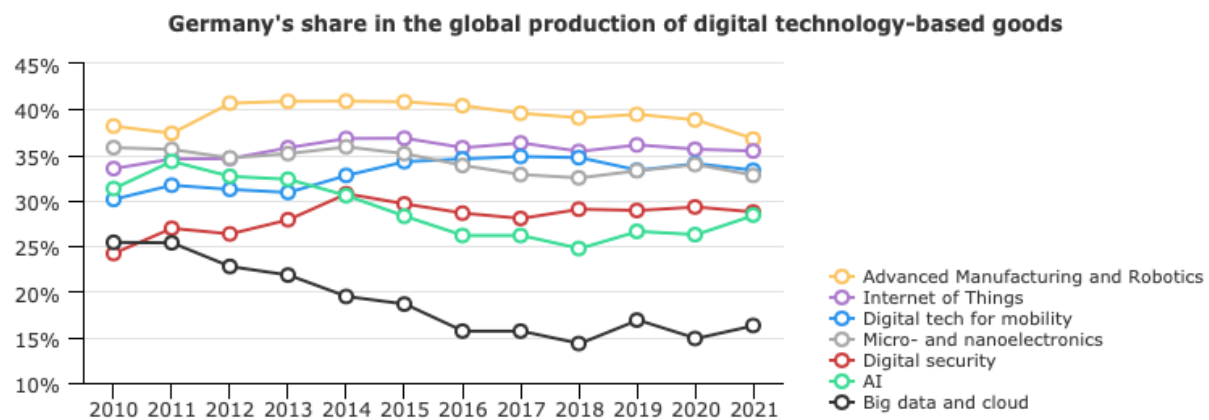
Figure 8: Trends over time in Germany's share of world patent applications



Source: Fraunhofer ISI based on Patstat

The Prodcom-based indicator measures the share of Germany in advanced technology-related production for a given year. The share of production in a particular technology over Germany's total production indicates that it has the largest share in the field of Advanced Manufacturing and Internet of Things technology-based products. Germany has been maintaining its share of production over time related to all digital technologies except for Big Data.

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



Source: IDEA Consult based on Prodcorn data

