UK value capture from innovation

Understanding the alignment challenges between UK R&I capabilities and industrial opportunities

Cambridge Industrial Innovation Policy
Institute for Manufacturing, University of Cambridge

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This study was commissioned by the Department for Science, Innovation and Technology (DSIT) to inform the work of the National Technology Adviser, Dr Dave Smith.

Contributors

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Key findings

UK value capture from innovation

KEY FINDINGS

There is limited data readily available on technological maturity, sectoral breakdowns, and the lifecycles of industries and technologies

- In this report several disparate sources are used to reveal correlations and identify issues that require further analysis. This includes a mix of national, technological, sectoral, grant, patent, company and survey data.
- Surveys of businesses and government departments and agencies ensure detailed self-reporting, enabling this breakdown. In particular, business expenditure on R&D (BERD) is detailed and comprehensive.
- The Transparent Approach to Costing (TRAC) method does not collect disaggregated data on higher education expenditure on R&D (HERD) by type of research. The most recent HERD data for the UK, classified by type of research, dates back to 2017 and was collected using the HESA survey method, which has been discontinued.
- UKRI grant data has revealed the potential to be useful for analysing the UK's technology portfolio by sectoral impact, but stricter compliance with data submissions is needed. There is also potential to track the evolution of technology portfolios over time by collecting relevant data on technology readiness levels (TRLs).

UK government investment in technology R&D is weighted towards (TRL 1–3) scientific discovery research and applied-science proof-of-principle research

- R&D performed by the business and government sectors in the UK places less emphasis on experimentation and development and more emphasis on basic research than other OECD countries. In 2022, 14% of BERD in the UK was directed towards basic research. Although this represented the smallest share by research type, it was well above the OECD average of 8%. Similarly, between 2017 and 2022, 39% of the UK government's R&D was on basic research, above the OECD average of 28%. In contrast, 20% of the UK government's R&D was on experimental development, below the OECD average of 33%.
- Analysis of grant data confirms that a significant share of UKRI funding is allocated to research organisations and programmes typically supporting curiosity-driven research. Between 2018 and 2022, on average, almost half of total UKRI grant funding went to research councils, around one-quarter to Innovate UK, and 11% to the Industrial Strategy Challenge Fund (ISCF). By programme, 62% of UKRI grant funding went to programmes typically funding curiosity-driven and world-class research, such as research grants, training grants and fellowships.
- In the UK R&D expenditure and performance seem to be concentrated within universities, placing significant demand on them to deliver across a broad spectrum of research activities in terms of both TRLs and sectoral focus using the same set of incentives. In contrast, international counterparts distribute their efforts across a wider range of institutions, which tend to have different incentives and mandates from those of universities:

KEY FINDINGS

- Some international examples of national applied research organisations include: A*STAR (in Singapore), the New Energy and Industrial Technology Development Organisation (NEDO, in Japan), the Fraunhofer Society (in Germany) and the National Institute of Advanced Industrial Science and Technology (AIST, in Japan). Each organisation receives around two times more in core government funding than the UK Catapult Network's core funding.
- Furthermore, each of these countries also has a range of other institutions with significant budgets, such as Kosetsushi in Japan and the Helmholtz Association in Germany, among others.

- Emerging technology publications also suggest the UK's early TRL stage focus compared to international counterparts, which also tend to focus on engineering-related challenges and industrial applications. In the UK publications are also dominated by universities.

UK government investment in R&D is disproportionately clustered in areas of relevance to particular industry sectors

- UK government expenditure is clustered in high and medium/high-R&D-intensity industries, mainly the manufacture of machinery and equipment; computer, electronic and optical products; and air and spacecraft and related machinery.
- In contrast, the manufacture of food products, beverages and tobacco products, and the manufacture of motor vehicles received disproportionately less government funding than international benchmarks.
- Over the past decade the balance between direct and indirect R&D business support has shifted towards R&D tax incentives, which have nearly doubled across OECD countries. In 2021 over two-thirds of UK government support to business R&D was in the form of R&D tax relief.
- UKRI grant funding data suggests that projects predominantly led by universities that had a (self-reported) impact in 2022 were in healthcare (14%); digital and ICT; education; environment (each at 8%); agriculture, food and drink; government, democracy and justice; and manufacturing (each at 7%).
- UKRI grant funding data suggests that projects predominantly led by companies went to professional, scientific and technical activities (35%) and manufacturing (28%) in 2022.
  - The majority of professional, scientific and technical activity funding went into other research and experimental development on natural sciences and engineering; other professional, scientific and technical activities; and research and experimental development on biotechnology.
  - The majority of manufacturing funding went into the manufacture of aerospace-related machinery; motor vehicles; machining; and engines and turbines (except aircraft, vehicle and cycle engines).

Introduction

UK value capture from innovation

Introduction

The UK is one of the leading countries in the world for scientific research and innovation. The UK is ranked first in the world for research quality (as measured by citation impact) and third for research output (as measured by the share of total world publications).[1] And it is second in the world for the number of Nobel-prize-winning scientists. The UK has 3 of the top 10 universities in the world. But the UK's strengths are not just in scientific research: it is the only country in Europe with a technology sector worth over US$1 trillion. The UK is second in the world for investment in university spin-out companies (after the USA). And fourth in the world for the number of "tech unicorns" (start-up firms valued at over US$1 billion).[2]

However, UK leadership in many advanced industries has been declining. The UK's research and innovation (R&I) leadership is at odds with its industrial performance (right-hand-side of the chart). The share of the population employed in higher-value-added manufacturing is lower than competitor countries. Manufacturing value added went from 16% of gross domestic product (GDP) in 1990 to 8% in 2022.[3] Manufacturing employment has declined by 315,000 in the last 10 years.[4] A study by the Information Technology and Innovation Foundation (ITIF) found that across 10 advanced industries (including motor vehicles, pharmaceuticals, chemicals, machine equipment, electrical equipment and computers), the UK's global market share dropped by nearly half after the turn of the century, going from 4% in 2000 to just 2.1% in 2020.[5]

As a result, scientific value creation is not translating into economic value capture through industrial activity based in the UK. Some sectors in the UK, such as aerospace and automotive, are able to capture value from UK R&I activity thanks to the existing industrial capacity, including UK-based primes and supply chains. In other areas, however, the benefit of UK research investment may be captured in other countries where those industries are well established. The jobs being lost in advanced industries are high-quality, high-wage roles that are being replaced, in many UK regions, by low-value-adding services.

[1] Cambridge Industrial Innovation Policy (2023). UK Innovation Report 2023.
[2] CB Insights (2023). Global Unicorn Club.
[3] World Bank (2023). World Development Indicators.
[4] ONS (2024). Nomis - Annual population survey dataset.
[5] Information Technology and Innovation Foundation (2023). The Hamilton Index, 2023.

SECTION 1

Overview of UK expenditure on R&D

How does the UK government's support for business R&D compare with that of other OECD countries?

What is the contribution of the business sector to R&D?

How has the balance between direct and indirect R&D support in the UK changed over the past two decades?

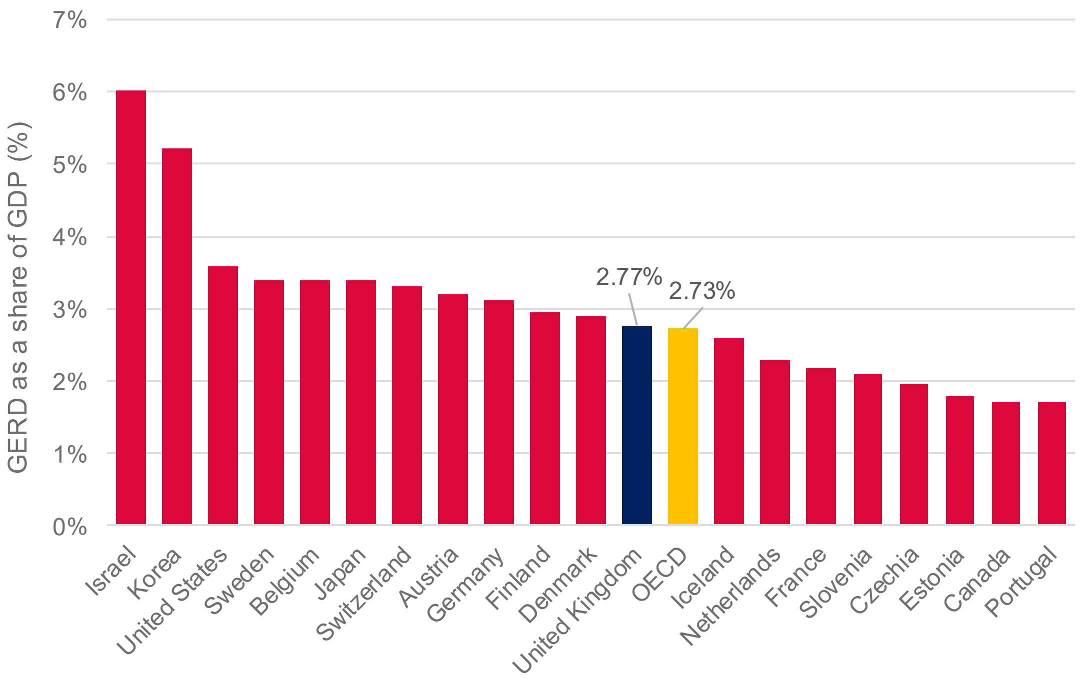
Section 1 – Key findings

KEY FINDINGS

In 2021 the UK provided the highest level of public support to business R&D as a share of GDP among OECD countries, driven primarily by R&D tax relief. UK business R&D support via this route had the largest increase across OECD countries between 2011 and 2021. However, indirect support instruments such as R&D tax relief are, by definition, less targeted towards national priorities compared to direct funding mechanisms.

- In 2022 UK R&D expenditure reached £70.7 billion, representing 2.77% of GDP, slightly above the OECD average of 2.73%.
- The business sector is the largest source of R&D funding, contributing 62% of total expenditure, while the government and UKRI contribute 14.6%. This aligns with G7 patterns, where business investment drives R&D.
- UK businesses performed 70.6% of total R&D, reflecting patterns seen across G7 countries.
- Over the past two decades, the balance between direct and indirect R&D support has increasingly shifted towards R&D tax incentives, which have nearly doubled across OECD countries. In 2021 over two-thirds of UK government support to business R&D was in the form of R&D tax relief.

1.1 R&D expenditure in the UK was 2.77% of GDP in 2022



- In 2022 **UK R&D expenditure** totalled **£70.7 billion**, equivalent to **2.77%** of GDP, slightly above the OECD average (2.73%).
- Leading OECD countries by R&D intensity (gross domestic expenditure on R&D as a share of GDP) include: Israel (6.02%), Korea (5.21%), the USA (3.59%), Sweden (3.41%) and Belgium (3.41%).
- In absolute terms, the UK ranked fifth in the OECD. The USA remains the global leader (US$726 billion), followed by Japan (US$172 billion), Germany (US$129 billion) and Korea (US$110 billion). [1]

Note: Switzerland data refers to 2021.
Source: Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025*.

[1] US dollars, PPP converted, constant prices.

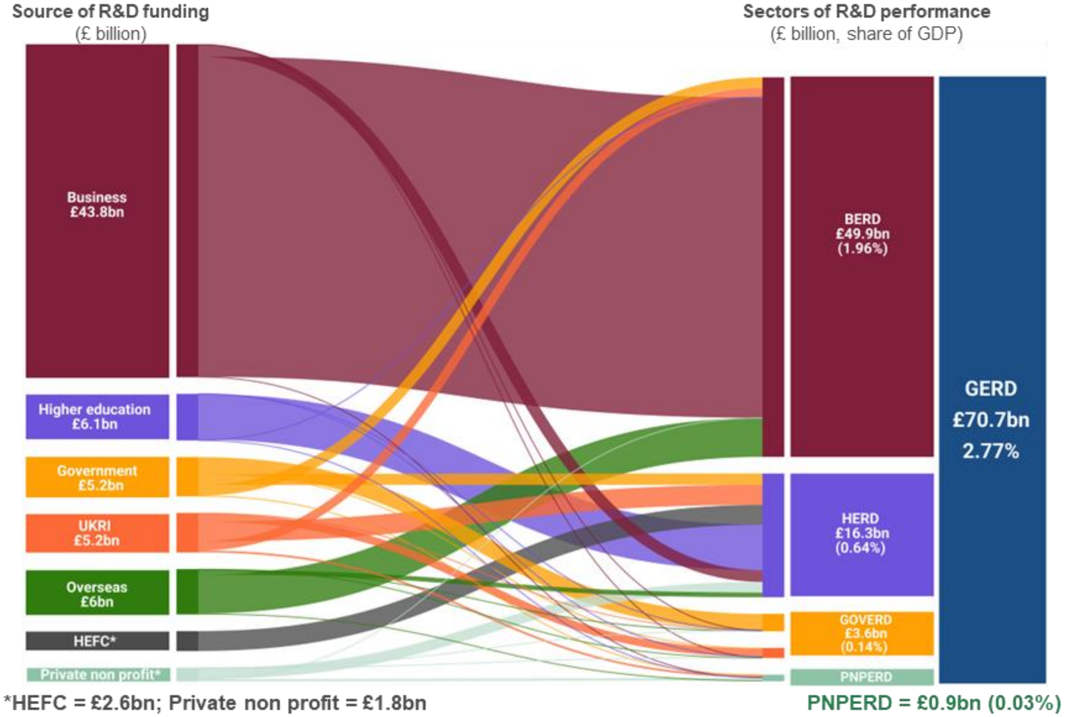
1.2 UK businesses are the primary funders and performers of R&D

Current prices, £ millions

- **By source of funding**, the UK business sector accounted for 62% of total R&D funding, while the government and UKRI contributed 14.6%.
- Among G7 countries, the main source of R&D funding is the business sector. In countries such as the USA and Japan, business R&D expenditure has higher levels (68% and 78%, respectively).[1]
- **By sector performance**, UK businesses conducted 70.6% of the total R&D, reflecting a similar pattern across G7 countries.

[1] OECD (2024). Main Science and Technology Indicators (MSTI database).

GERD Gross domestic expenditure of R&D
BERD Business enterprise expenditure on R&D
HERD Higher education expenditure on R&D
GOVERD Government expenditure on R&D
PNPERD Private non-profit expenditure on R&D

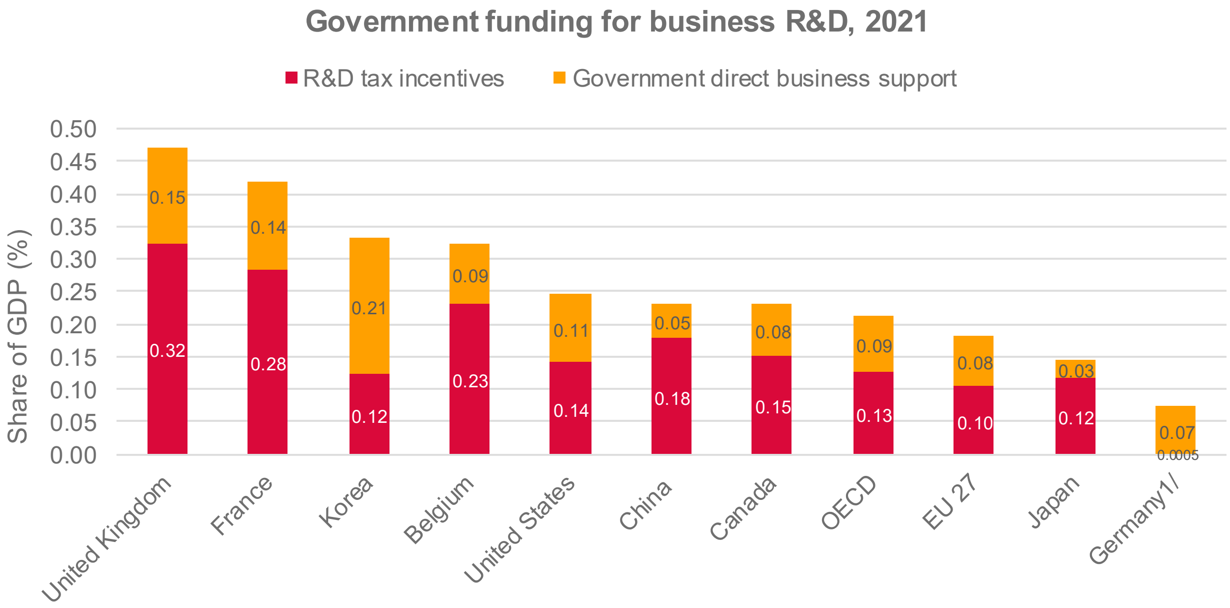


Note: UKRI = UK Research and Innovation; HEFC = higher education funding councils.
Source: Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025*.

1.3 Among OECD countries, the UK provides the largest government financial support to business R&D as a share of GDP

Direct government funding and government tax relief for business R&D expenditure, share of GDP, top 15 OECD countries, 2021 or latest available

- Among OECD countries, the UK provided the largest government financial support to business R&D as a share of GDP in 2021: 0.48% of GDP, against the OECD average of 0.21%.
- In 2021 over two-thirds of **UK** government support to business R&D was in the form of R&D tax relief (0.33% of GDP).



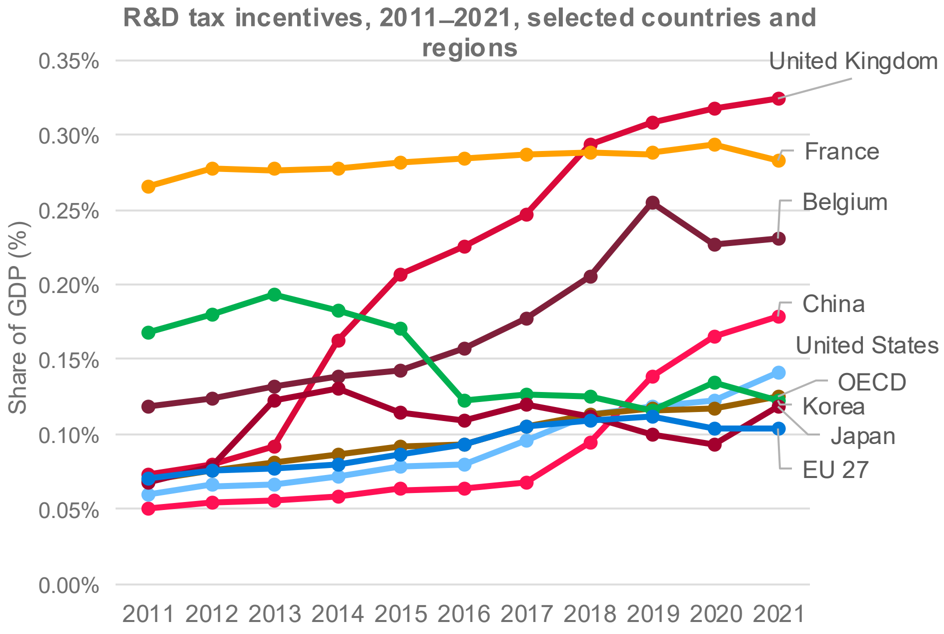
Note: 1/ Germany introduced its national R&D tax incentive only in 2020 which explains why uptake and scale remain modest.
Source: OECD (2025). R&D tax expenditure and direct government funding of BERD.

1.4 Among OECD countries, the UK has shown the largest increase in R&D tax incentives as a percentage of GDP in the past decade

Government R&D tax incentives, share of GDP, selected countries and regions

- Government financial support for business R&D relies on a mix of policy instruments, including direct funding and indirect support through tax relief. Over the past decade, **the balance has increasingly shifted towards R&D tax incentives**, which have nearly doubled across OECD countries.
- In the UK, R&D tax incentives as a percentage of GDP grew from 0.07% in 2011 to 0.33% in 2021.
- R&D tax credits were originally introduced to stimulate R&D spending by UK-based businesses and to attract increased inward investment in R&D. However, this objective appears to have **fallen short of expectations.** Research in both the USA and EU contexts has similarly found that tax incentives have minimal or no impact on the location of R&D investments.[1]

[1] Connell, D. (2021). *Is the UK's flagship industrial policy a costly failure?* Cambridge Judge Business School, University of Cambridge.



Source: OECD (2025). R&D tax expenditure and direct government funding of BERD.

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SECTION 2

Basic versus applied research

How are efforts allocated between basic research, applied research, and experimental development in the UK?

How does this distribution compare with other OECD countries?

What role do public research organisations play in the UK R&D system compared with other industrialised countries?

Section 2 – Key findings (1/3)

KEY FINDINGS

The UK excels in curiosity-driven science, placing more emphasis on basic research than OECD peers. In comparison, international peers have a wider critical mass of research, development and innovation (RDI) institutions that include well-funded applied research organisations and national labs with mandates better suited to later-stage technology development. These institutional differences contribute to a UK system that excels in early-stage scientific research, mostly driven by universities, but struggles to advance technologies through demonstration and commercial application.

Compared to leading OECD countries, R&D in the UK, across both the business and government sectors, places more emphasis on basic research and less emphasis on experimental development.

- In 2022, 14% of BERD in the UK was directed towards basic research. Although this represented the smallest share by research type, it was well above the OECD average of 8%.
- Between 2017 and 2022, 39% of the UK government's R&D was on basic research, above the OECD average of 28%. In contrast, 20% of the UK government's R&D was on experimental development, below the OECD average of 33%.
- Data by type of research relies on self-reporting by institutions, which can introduce inconsistencies and reduce its reliability for cross-country comparisons.

A significant share of UKRI funding is allocated by funding organisations and programmes typically supporting curiosity-driven and world-class science, including research councils, research grants, training grants and fellowships.

- Between 2018 and 2022, on average, almost half of total UKRI grant funding was allocated through research councils, typically funding curiosity-driven and world-class research. Around one-quarter went through Innovate UK and 11% through the Industrial Strategy Challenge Fund (ISCF), both typically funding applied R&D and company R&D.
- By programme, 62% of UKRI grant funding went to programmes typically dominated by curiosity-driven research, such as research grants, training grants and fellowships.

Section 2 – Key findings (2/3)

KEY FINDINGS

In the UK R&D expenditure and performance seem to be concentrated within universities, placing significant demand on them to deliver across a broad spectrum of research activities in terms of both TRLs and sectoral focus. In contrast, international counterparts distribute their efforts across a wider range of institutions (e.g. national applied research organisations, RTOs, national labs, competence centres). These institutions tend to have different incentives and mandates from those of universities.

- Some international examples of national applied research organisations include: A*STAR (in Singapore), the New Energy and Industrial Technology Development Organisation (NEDO, in Japan), the Fraunhofer Society (in Germany) and the National Institute of Advanced Industrial Science and Technology (AIST, in Japan). Each of these organisations receive roughly two times more in core government funding than the UK Catapult Network's core funding. Furthermore, each of these countries also has a range of other institutions with significant budgets, such as Kosetsushi in Japan and the Helmholtz Association in Germany, among others.

- Core government funding for Manufacturing USA Institutes can be used flexibly depending on needs, and it can be supplemented with other government funding, which has been particularly useful for later-stage demonstration activities, as well as skills development. There is an opportunity for the UK's Catapult Network to enable more flexible funding. In the USA, significant scale-up and late-stage technology development and demonstration follow-on funding is available through the DOD and DOE, among others.

- Emerging technology publications in quantum technologies, synthetic biology, graphene and compound semiconductors suggest the UK tends to focus on the earlier stages of TRLs, whereas international peers tend to also focus on engineering-related terms, challenges and industrial applications aligned with their industrial strengths. In the UK publications are also dominated by universities.

Section 2 – Key findings (3/3)

KEY FINDINGS

There is limited data readily available on technological maturity, sectoral breakdowns, and the lifecycles of industries and technologies.

- Surveys of businesses and government departments and agencies on R&D expenditure ensure detailed self-reporting, enabling a breakdown by type of research, including basic research, applied research and experimental development. Business expenditure on R&D (BERD) is especially comprehensive, being based on a significant number of detailed surveys sent to R&D-intensive companies.

- The Transparent Approach to Costing (TRAC) method does not collect disaggregated data on higher education expenditure on R&D (HERD) by type of research. The most recent HERD data for the UK, classified by type of research, dates back to 2017 and was collected using the HESA survey method, which has been discontinued.

- UKRI grant data has revealed the potential to be useful for analysing the UK's technology portfolio by sectoral impact, but stricter compliance with data submissions is needed. There is also potential to track the evolution of technology portfolios over time by collecting relevant data on TRLs.

Understanding the data

2.1 Key terms

Research and development (R&D) and types of R&D

Research and experimental development (R&D) comprise creative and systematic work undertaken to increase the stock of knowledge – including knowledge of humankind, culture and society – and devise new applications of available knowledge. A set of common features identifies R&D activities. R&D is always aimed at new findings, based on original concepts (and their interpretation) or hypotheses. It is largely uncertain about its final outcome (or about the quantity of time and resources needed to achieve it), it is planned for and budgeted (even when carried out by individuals) and the aim is to produce results that could be freely transferred or traded in a marketplace. For an activity to be R&D, it must be:

- novel
- creative
- uncertain
- systematic
- transferable and/or reproducible.

How types of R&D can be differentiated

A key criterion guides the classification of R&D activities by type: the expected use of the results.

In addition, two questions can help to identify the type of R&D project:

- How far ahead in time is the project likely to lead to results that can be applied?
- How broad is the range of potential fields of application for the results of the R&D project (the more fundamental the research, the broader the potential field of application)?

An evaluation of the type of R&D at project level is recommended, by classifying the project's expected results according to the two "indicators" described above.

Source: OECD (2015). *Frascati Manual,* pp. 44, 45, 53.

2.1 Key terms

Basic research

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

Basic research analyses properties, structures and relationships with a view to formulating and testing hypotheses, theories or laws. The reference to no "particular application in view" in the definition of basic research is crucial, as the performer may not know about potential applications when doing the research or responding to survey questionnaires. The results of basic research are not generally sold but published in scientific journals or circulated to interested colleagues.

Such research is usually performed in the higher education sector but also, to some extent, in the government sector. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications. Business enterprises in the private sector may also undertake basic research even though no specific commercial applications may be anticipated in the short term.

Source: OECD (2015). *Frascati Manual,* p. 50.

2.1 Key terms

Applied research

Applied research is original investigation undertaken to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.

Applied research is undertaken to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives. It involves considering the available knowledge and its extension in order to solve actual problems. In the business enterprise sector, the distinction between basic and applied research is often marked by the creation of a new project to explore promising results of a basic research programme (moving from a long-term to a medium/short-term perspective in the exploitation of the results of intramural R&D).

The results of applied research are intended primarily to be valid for possible applications to products, operations, methods or systems. Applied research gives operational form to ideas. The applications of the knowledge derived can be protected by intellectual property instruments, including secrecy.

Source: OECD (2015). *Frascati Manual,* p. 51.

2.1 Key terms

Experimental development

Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed at producing new products or processes or improving existing products or processes.

The concept of experimental development **should not be confused with "product development"**, which is the overall process – from formulating ideas and concepts to commercialising them – aimed at bringing a new product (good or service) to market. Experimental development is just one possible stage in the product development process: the stage when generic knowledge is tested for the specific applications needed to bring such aprocess to a successful end. During the experimental development stage, new knowledge is generated, and that stage comes to an end when the R&D criteria (novel, uncertain, creative, systematic and transferable and/or reproducible) no longer apply.

As an example, in a process aimed at developing a new car, the option to adopt some technologies could be considered and tested for use in the car being developed: this is the stage when experimental development is performed. It will lead to new results by dealing with new applications of some general knowledge; it will be uncertain, because testing could produce negative results; it will have to be creative, as the activity will focus on adapting some technology to a new use; it will be formalised, requiring the commitment of a specialised workforce; and it will involve a codification, to translate the results of the tests into technical recommendations for the further stages of the product development process. However, cases of product development wthout R&D are discussed in the economics literature, especially in the case of SMEs.

The concept of experimental development should not be confused with "pre-production development", the term used to describe non-experimental work on a defence or aerospace product or system before it goes into production. Similar cases apply in other industries. It is difficult to define the cut-off point between experimental development and pre-production development: the distinction between these two categories requires "engineering judgement" as to when the element of novelty ceases and the work changes to routine development of an integrated system.

Source: OECD (2015). *Frascati Manual,* pp. 51–52.

2.1 Key terms

Examples of R&D by type of research

In life sciences:

- Basic research: developing a new method to classify immunoglobulin sequences.
- Applied research: investigations carried out to distinguish between antibodies for various diseases.
- Experimental development: devising a method to synthesise the antibody for a particular disease on the basis of knowledge of its structure and clinical tests of the effectiveness of the synthesised antibody on patients who have agreed to an experimental advanced treatment.

In computer and information sciences:

- Basic research: searching for alternative methods of computation, such as quantum computation and quantum information theory.
- Applied research: investigating the application of information processing in new fields or in new ways (e.g. developing a new programming language, new operating systems, program generators).
- Experimental development: developing new applications software; substantial improvements to operating systems; application programmes.

In nanotechnology:

- Basic research: researchers study the electrical properties of graphene using a scanning tunnelling microscope to investigate how electrons move in the material in response to voltage changes.
- Applied research: researchers study microwaves and thermal coupling with nanoparticles to properly align and sort carbon nanotubes.
- Experimental development: researchers use research in micromanufacturing to develop a portable and modular micro-factory system with components that are each a key part of an assembly line.

Source: OECD (2015). *Frascati Manual*, pp. 54–55.

2.2 Understanding the data: What are we actually counting?

A key limitation of R&D data by type of research is that this data is self-reported, which can introduce inconsistencies and reduce its reliability for cross-country comparisons. This data is collected in three main ways:

1. Business enterprise research and development (BERD) survey. Statutory survey that collects information about employment and expenditure on R&D performed by businesses in the UK, for both civil and defence purposes. Businesses sampled for the survey receive either a short or long form, depending on the size of the business and how much R&D they perform. Companies respond to the question: *How much of the total non-capital expenditure for civil R&D relates to basic research, applied research and experimental development*.

2. Government research and development survey (GOVERD) survey. Annual census of government departments in the UK, to collect expenditure and employment figures relating to R&D conducted within its establishments.

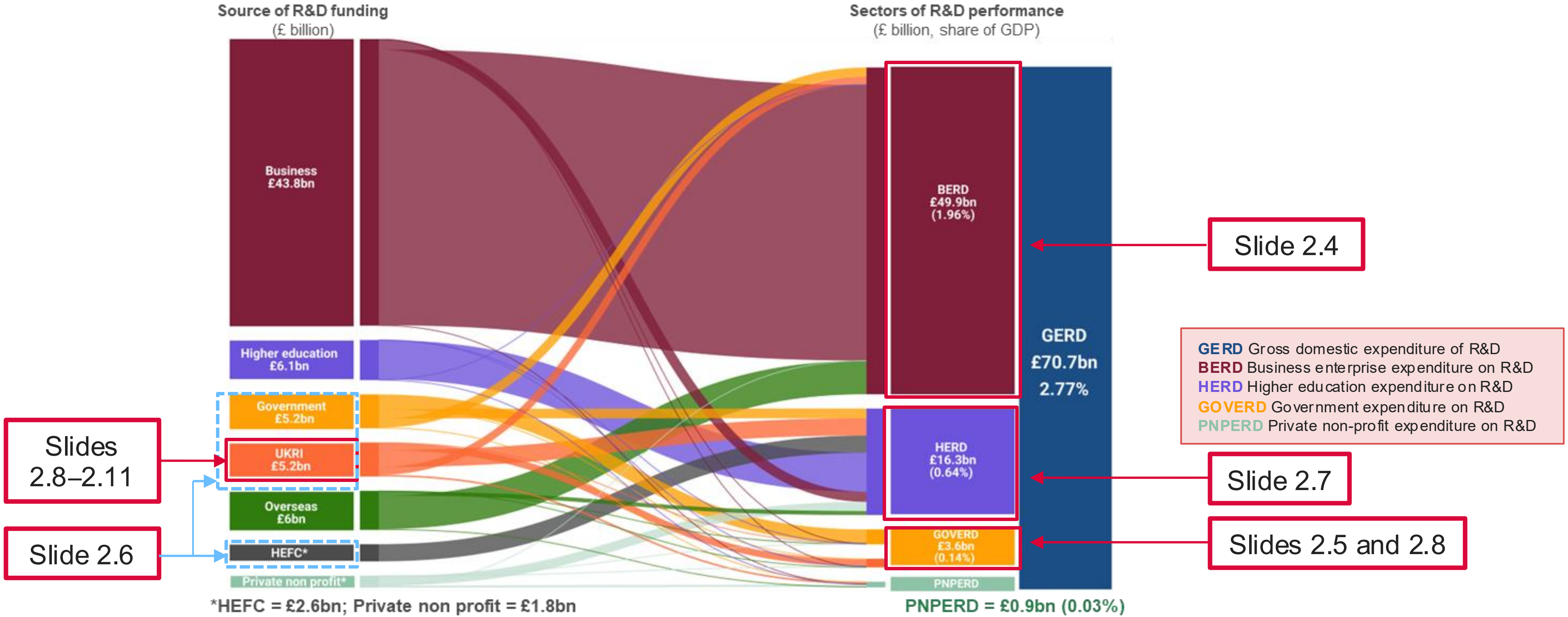
3. Transparent Approach to Costing (TRAC). Activity-based costing system, adapted for an academic culture in a way that also meets the needs of the main public funders of higher education. TRAC uses institutional expenditure information from published financial statements and "cost adjustments" to provide the "full economic cost" of activities. It encompasses both the direct and indirect costs of activities and an adjustment to the historic expenditure to reflect the full, sustainable costs of the activities. The main activities to which TRAC allocates costs are: (i) teaching (analysed between publicly and non-publicly funded activity); (ii) research (analysed between the main sponsor types: research councils, government departments, charities, European Commission bodies, etc.); (iii) other (analysed between commercial and non-commercial activities); and (iv) support activities such as preparation, proposal writing and administration, which are costed separately but attributed, as appropriate, to the three core activities. But **TRAC does not collect disaggregated data by type of research. The most recent higher education research and development (HERD) data for the UK, classified by type of research, dates back to 2017, which used to be collected using HESA surveys, which were discontinued.**

Source: Office for National Statistics, Business enterprise research and development (BERD) survey, of businesses performing research and development (R&D) in the UK; Questions for Business enterprise research and development 2023 survey; Office for Students (2025). *TRAC guidance 2024*; https://www.trac.ac.uk/about/

National data

2.3 Expenditure on R&D in the UK by performing and funding sectors, 2022

Current prices, £ millions



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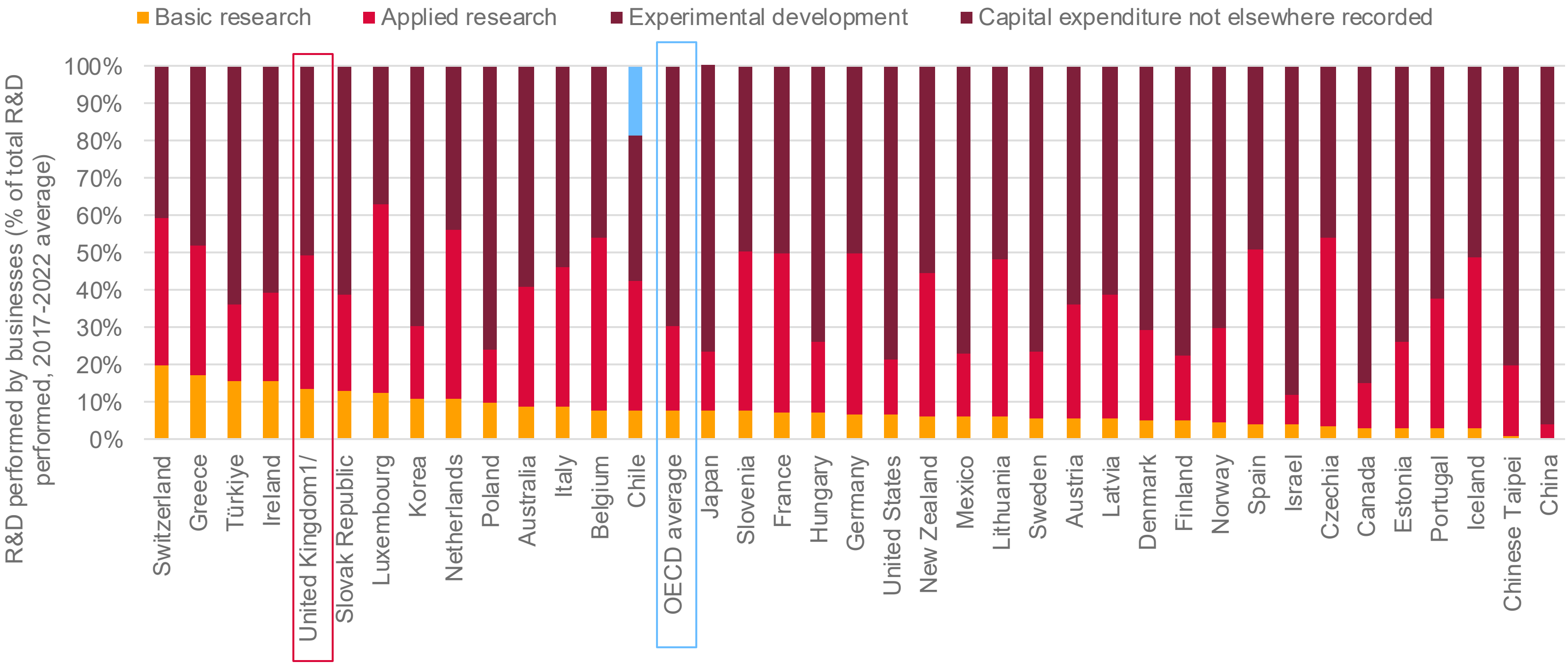
Note: UKRI = UK Research and Innovation; HEFC = higher education funding councils.
Source: Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025*.

2.4 Business R&D in the UK places more emphasis on basic research than other OECD countries (1/2)

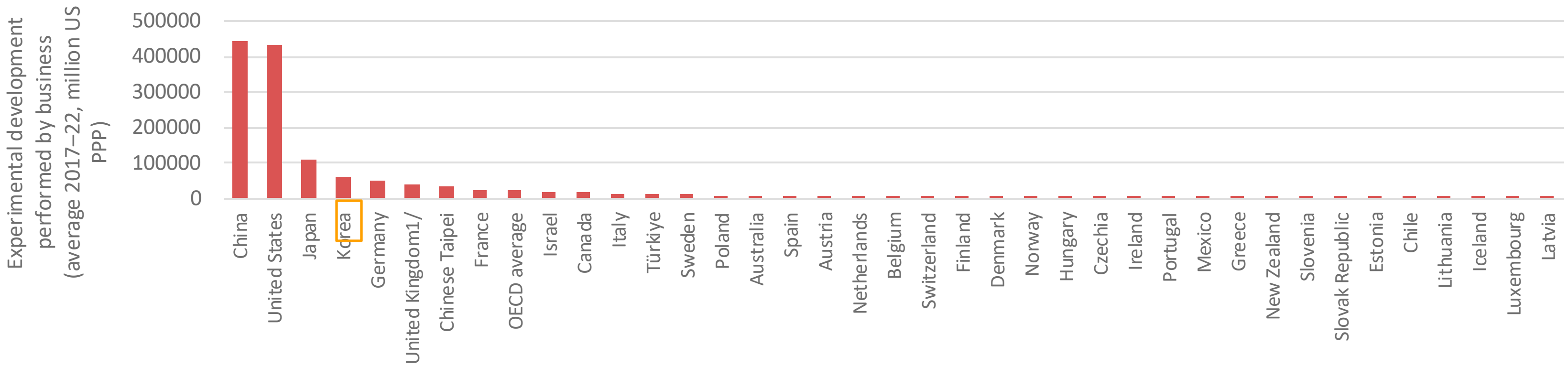
Business enterprise expenditure on R&D (BERD) by type of research, 2017–22 average, OECD countries + China and Chinese Taipei

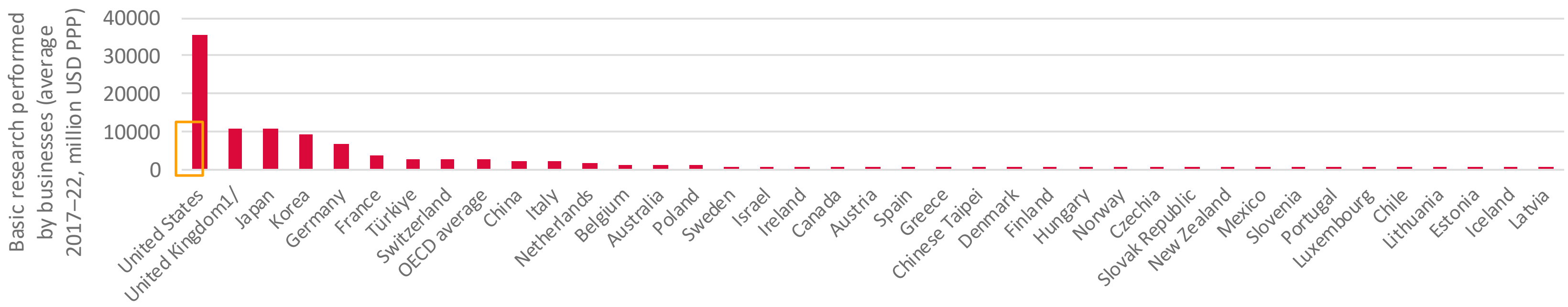


Note: 1/2022 data for the UK.
Source: OECD (2024). *Gross domestic expenditure on R&D by sector of performance and type of R&D*; ONS (2024). *Business enterprise research and development (R&D), UK: 2022.*

2.4 Business R&D in the UK places more emphasis on basic research than other OECD countries (2/2)

Business enterprise expenditure on R&D (BERD) by type of research, 2017–22 average, OECD countries + China and Chinese Taipei

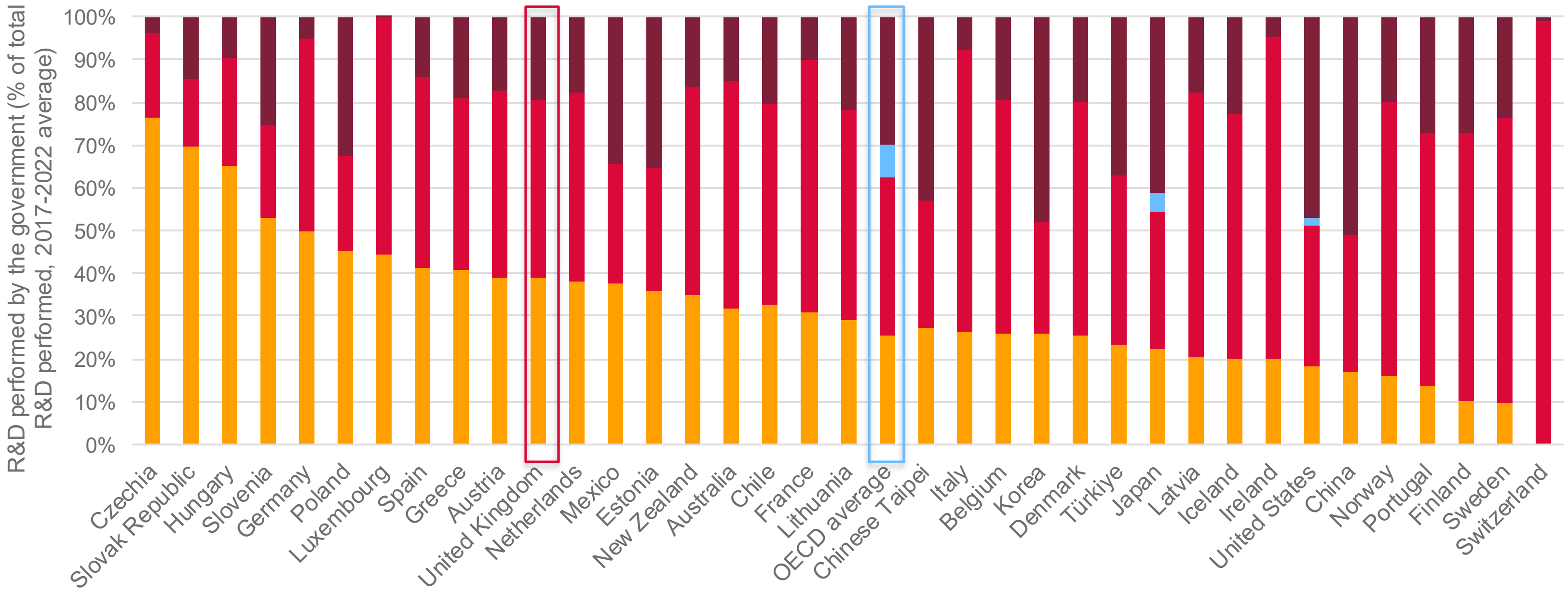




Note: 1/2022 data for the UK.
Source: OECD (2024). *Gross domestic expenditure on R&D by sector of performance and type of R&D*; ONS (2024). *Business enterprise research and development (R&D), UK: 2022.*

2.5 UK government R&D places more emphasis on basic research than the OECD average (1/2)

Government expenditure on R&D (GOVERD) by type of research, 2017–22 average, top OECD countries + China and Chinese Taipei



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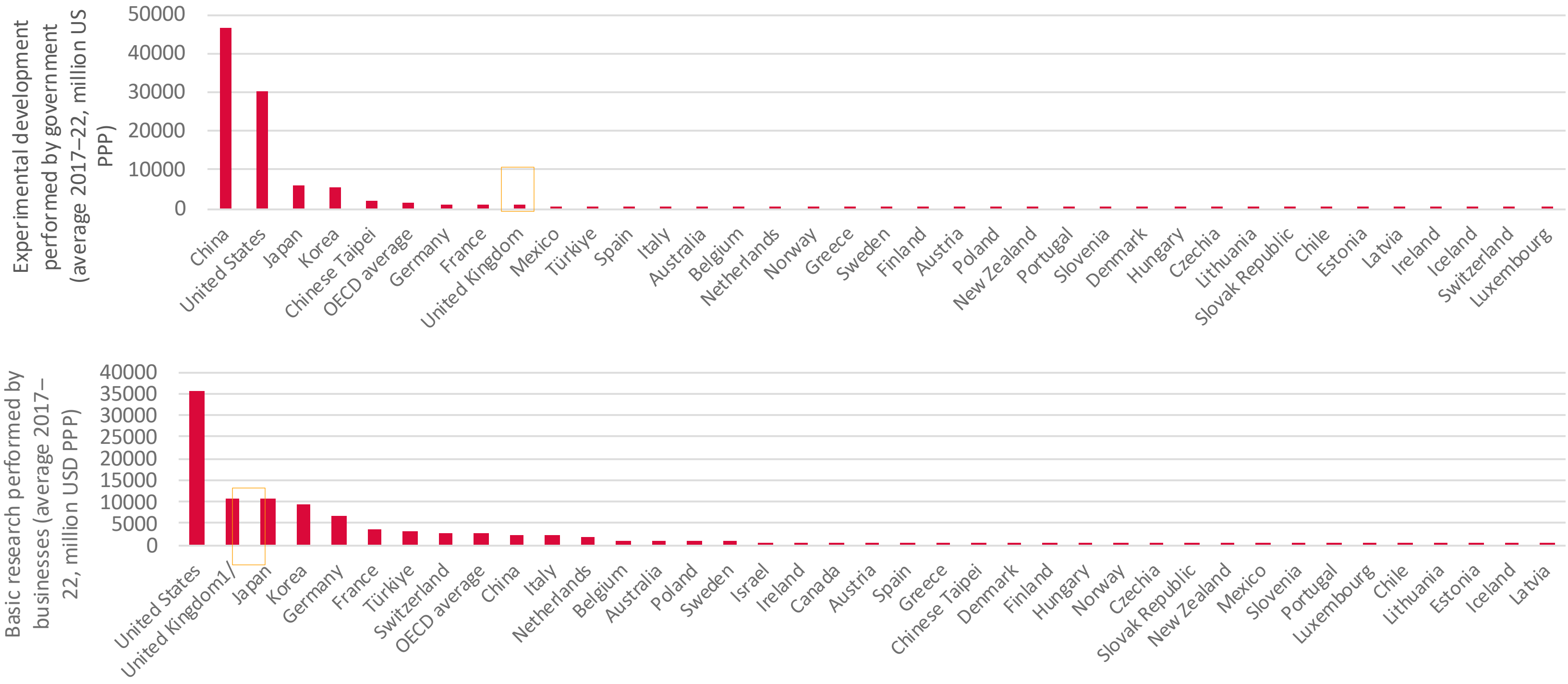
Source: OECD (2024). *Gross domestic expenditure on R&D by sector of performance and type of R&D.*

2.5 UK government R&D places less emphasis on experimental development than the OECD average (2/2)

Government expenditure on R&D (GOVERD) by type of research, 2017–22 average, top OECD countries + China and Chinese Taipei



Source: OECD (2024). *Gross domestic expenditure on R&D by sector of performance and type of R&D*.

2.6 UKRI and higher education funding bodies account for more than half of the UK government's net expenditure

UK government net expenditure on R&D by department, 2022 current prices

UK government net expenditure on R&D in 2022: £16,063 million

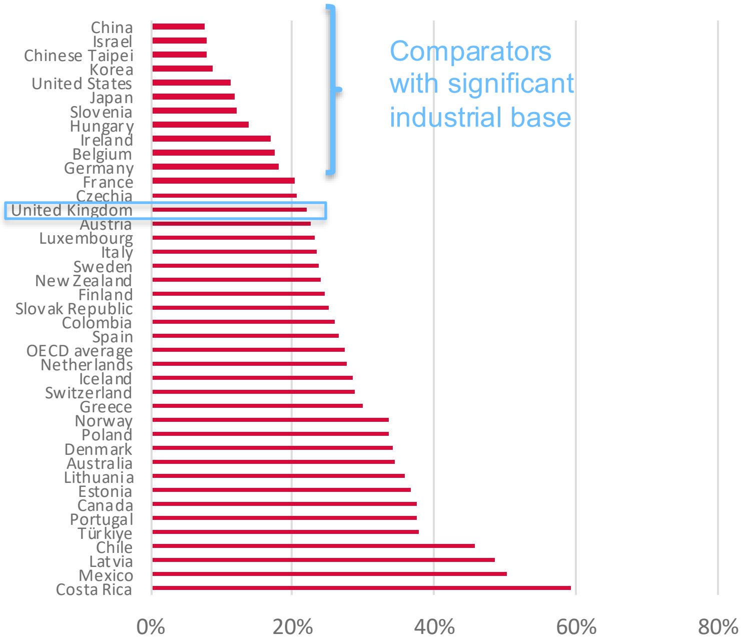
	£ millions
UK Research and Innovation (UKRI)	**5,967**
Higher education funding bodies	**3,537**
Research England (part of UKRI)	*3,028*
Scotland (SFC)	*315*
Wales (HEFCW)	*127*
Northern Ireland (DfE)	*67*
Devolved administrations	**234**
Scottish Government (SG)	*164*
Welsh Government (WG) [note 5]	*48*
Northern Ireland departments (NI)	*22*
Indicative UK contributions to EU R&D expenditure	**568**

	£ millions
Government departments	**5,757**
Ministry of Defence (MoD)	*2,051*
Dept of Health and Social Care (DHSC) (including the NHS)	*1,444*
Business, Energy and Industrial Strategy (BEIS)	*1,414*
Foreign, Commonwealth and Development Office (FCDO)	*333*
Environment, Food and Rural Affairs (Defra)	*131*
Department for Transport (DfT)	*109*
Digital, Culture, Media and Sport (DCMS)	*70*
Home Office (HO)	*40*
Other departments	*40*
Department for Education (DfE)	*36*
Department for Levelling Up, Housing and Communities (DLUHC)	*28*
Department for Work and Pensions (DWP)	*24*
Ministry of Justice (MoJ)	*20*
Health and Safety Executive (HSE)	*7*
Food Standards Agency (FSA)	*6*
Department for International Trade (DIT)	*4*

Note: Net expenditure on R&D includes in-house R&D performed, plus purchased or funding provided for R&D, less funding received for R&D.
Source: ONS (2024). *Research and Development (R&D), by the UK government, 2022 Datasets.*

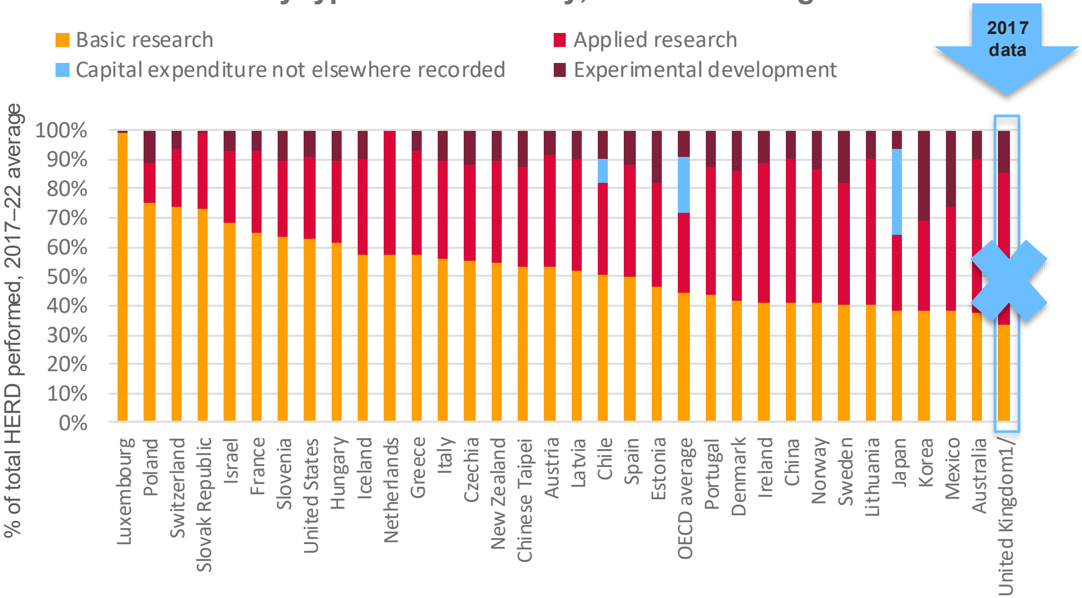
2.7 R&D expenditure (and performance) in the UK is concentrated within universities, placing significant demand on them to deliver across a broad spectrum of research activities – international counterparts distribute their efforts across a wider range of institutions that also tend to have different incentives and mandates

HERD as proportion of GERD (2017–22 average)



The UK adopted a new system to collect data from universities, including expenditure on R&D. This has resulted in discontinuing the classification of HERD by basic, applied research and experimental development.

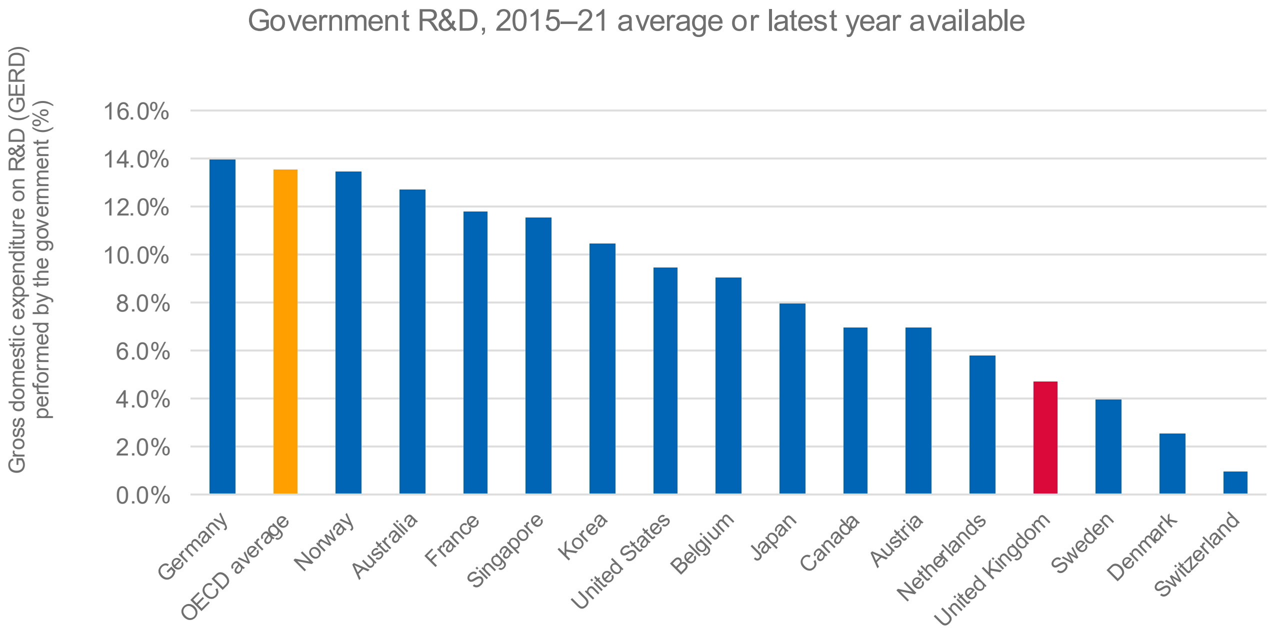
HERD by type of R&D activity, 2017–22 average



Note: [1]/2017 data for the UK.
Source: OECD (2024). Gross domestic expenditure on R&D by sector of performance and type of R&D.

2.8 Public research organisations in the UK perform a smaller share of R&D than the OECD average

In the UK, only 4.7% of R&D is conducted by government organisations, well below the OECD average (13.5%) and the levels seen in countries such as Germany (14%), Singapore (11.5%), Japan (7.9%), and Austria (7%)

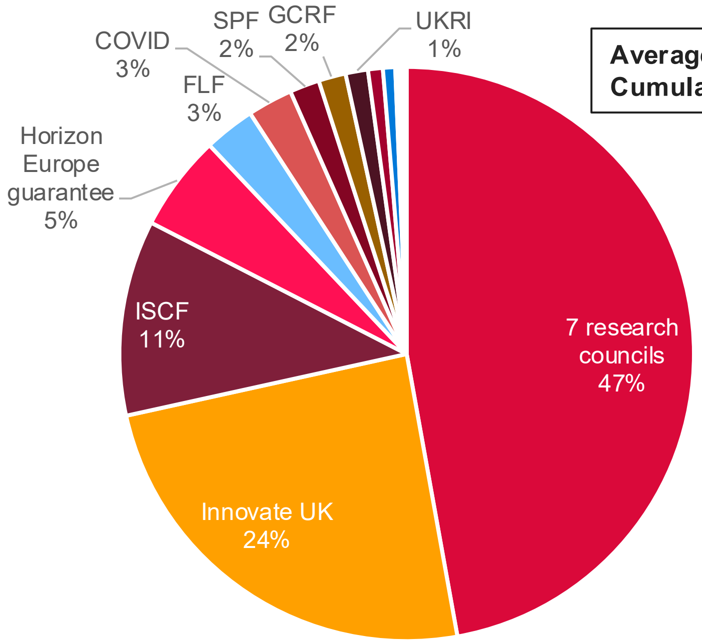


Source: OECD (2025). Gross domestic expenditure on R&D by sector of performance and type of R&D.

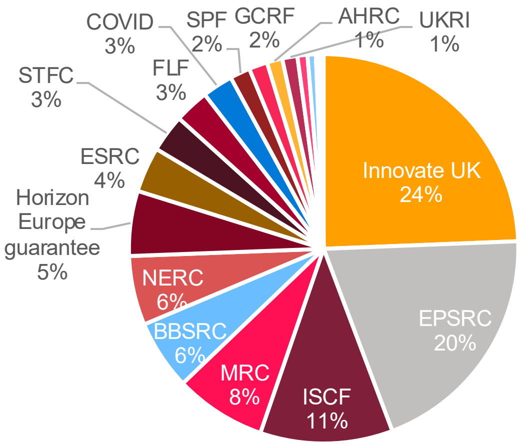
UKRI data

2.9 Almost half of UKRI funding was allocated by research councils typically supporting curiosity-driven research

Average of UKRI grant funding by funding organisation between 2018 and 2022 (grant allocation year)*



Average: £4.5bn*; ~12,000 grants
Cumulative: £22.3bn; ~ 60,300 grants



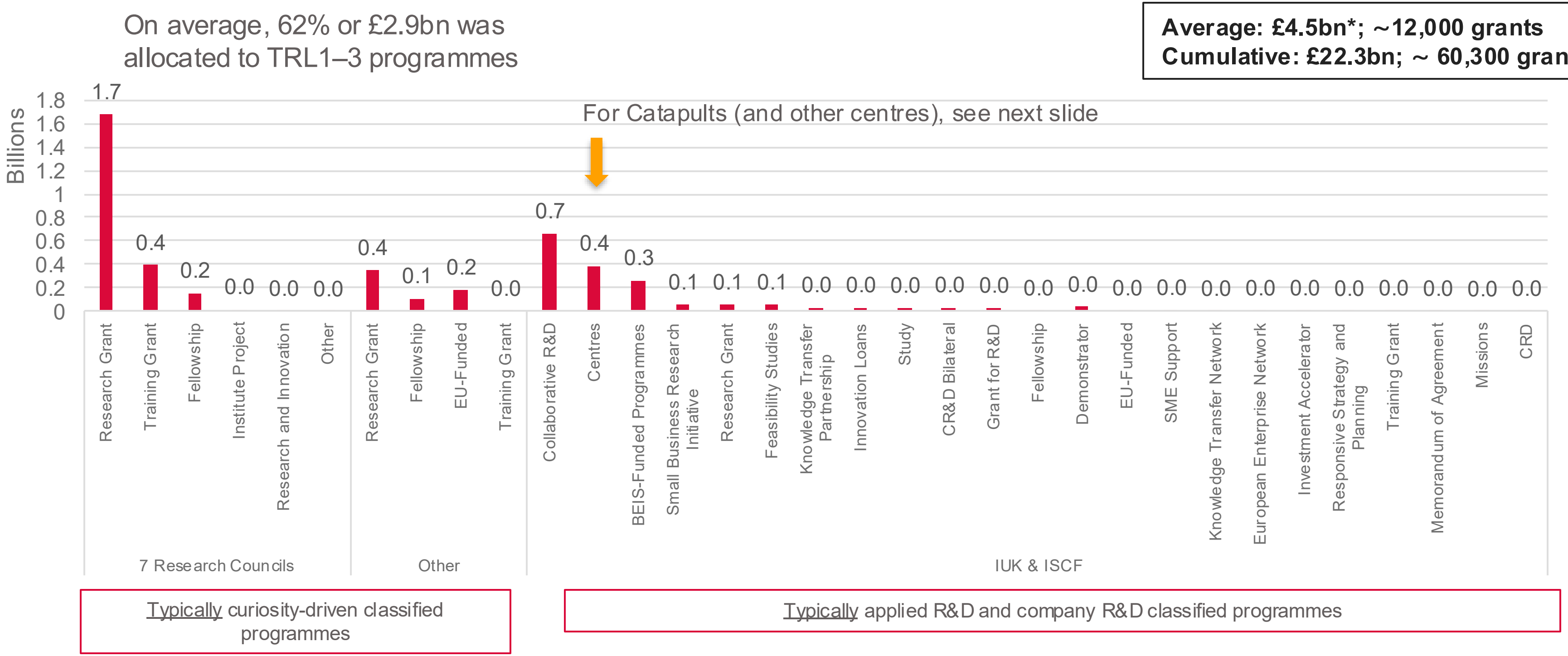
- On average, almost half of UKRI funding was allocated by research councils, which can typically be classified as funding curiosity-driven research, between 2018 and 2022.
- The Engineering and Physical Sciences Research Council (EPSRC) makes up about 20% of the total research council funding, followed by the MRC, BBSRC and NERC.
- Only about 35% of UKRI funding came from typically applied and company R&D funding organisations and programmes, including Innovate UK and the Industrial Strategy Challenge Fund (ISCF).

Note: *Allocation year of grants is used here, meaning allocation of grants of several years may not be picked up if not within the years analysed here. This explains the discrepancy between UKRI funding allocated and grants awarded (e.g. £5.2bn vs £4.8bn in 2022). Shares below 1% include: UUI, FIC, Open Access Block Grants, Infrastructure Fund, NC3Rs, Newton Fund.
Source: UKRI GtR (2024). All data: Project search.

2.10 A significant share of UKRI funding is allocated to programmes typically supporting curiosity-driven research

Average of UKRI grant funding by programme between 2018 and 2022 (grant allocation year)*

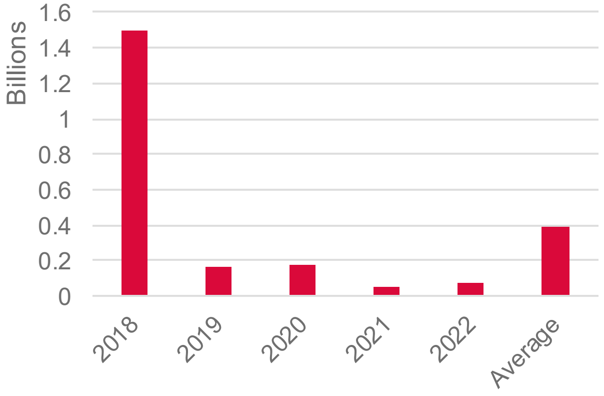
Average: £4.5bn*; ~12,000 grants
Cumulative: £22.3bn; ~ 60,300 grants



Note: *Allocation year of grants is used here, meaning allocation of grants of several years may not be picked up if not within the years analysed here. This explains the discrepancy between UKRI funding allocated and grants awarded (**e.g. £5.2bn vs £4.8bn in 2022).** Other category includes Horizon Europe guarantee, COVID, GCRF, SPF, UKRI (other), UUI, FIC, FLF, Open Access Block Grants, NC3Rs, Infrastructure Fund, Newton Fund. **Source:** UKRI GtR (2024). All data: Project search.

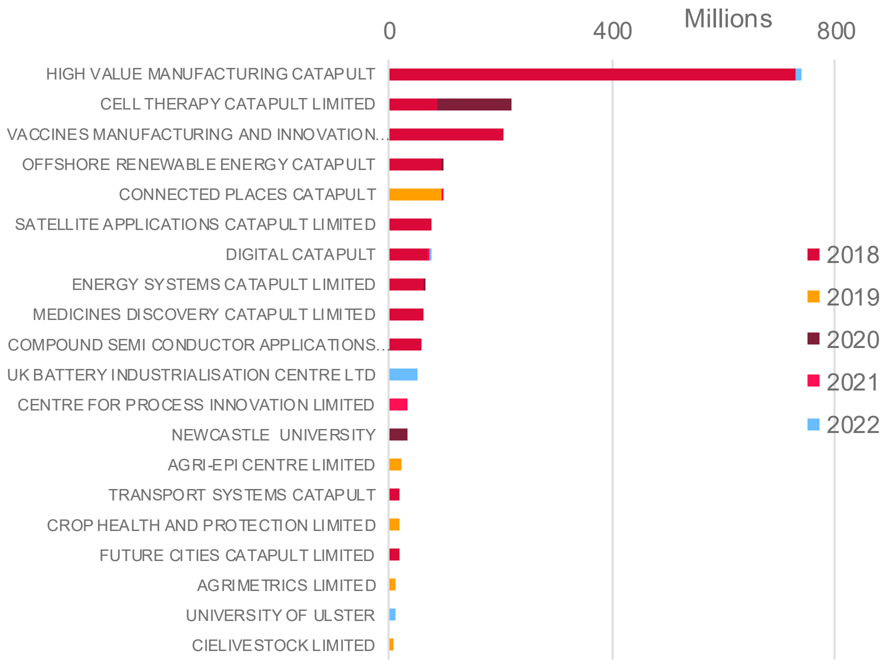
2.11 Catapults (and other centres) received, on average, around £0.4 billion in funding between 2018 and 2022 through the Centres programme

Average and annual UKRI grant funding under the Centres programme between 2018 and 2022 (grant allocation year)*



Note: The figures here represent core UKRI funding to centres. They do not reflect other UKRI funding through other programmes. *Allocation year of grants is used here, meaning allocation of grants of several years may not be picked up if not within the years analysed here. **Source:** UKRI GtR (2024). All data: Project search.

Top 20 receiving organisations of UKRI grants funded under the Centres programme for the period between 2018 and 2022 (grant allocation year)*



2.12 The top 30 UKRI grants by value include several collaborative R&D projects with large manufacturing companies

Top 30 receiving organisations of UKRI grants (excl. the Centres programme) for the period between 2018 and 2022 **(grant allocation year)***

- A number of collaborative R&D projects with manufacturing companies emerged among top projects by value, when excluding the Centres programme.
- The companies cover sectors such as power engines, manufacturing technologies, mass-capacity data storage (Seagate Technology), clean maritime technologies (Artemis), batteries, semiconductor design software, and aerospace.

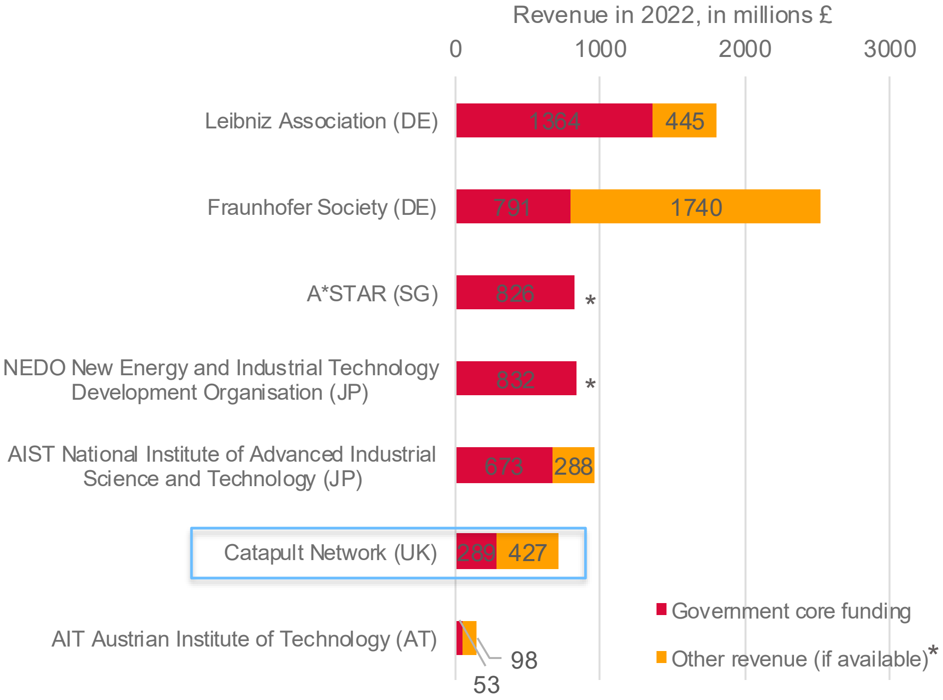
Funding organisation	Lead receiving organisation	Programme category	Grant allocation	Awarded, £
ISCF	Rolls-Royce UK SMR	Collaborative R&D	01/11/2021	210,000,000
NERC	National Oceanography Centre	Research grant	31/03/2019	153,440,000
ISCF	The Faraday Institution	Research grant	01/01/2018	133,829,729
EPSRC	University of Manchester	Research grant	31/03/2022	96,000,000
ISCF	The Manufacturing Technology Centre Ltd	Collaborative R&D	31/07/2018	81,882,276
EPSRC	CCFE/UKAEA	Research grant	31/03/2022	77,400,000
EPSRC	University of Cambridge	Research grant	30/01/2018	75,000,000
EPSRC	Rosalind Franklin Institute	Research grant	31/03/2022	66,364,013
ESRC	University of Essex	Research grant	31/07/2020	53,434,506
EPSRC	CCFE/UKAEA	Research grant	31/03/2019	43,231,602
Innovate UK	Seagate Technology Ireland	Small Business Research Initiative	01/12/2021	42,319,479
SPF	The Alan Turing Institute	Research grant	01/11/2018	38,799,999
Innovate UK	UNIVERSITY OF GLASGOW	Collaborative R&D	30/09/2020	38,123,334
ISCF	ARM Limited	CR&D Bilateral	01/11/2019	37,500,000
ISCF	Swansea University	Research grant	02/09/2018	35,947,427
ISCF	UK Battery Industrialisation Centre Ltd	Collaborative R&D	01/02/2020	33,500,000
Innovate UK	Artemis Technologies Ltd	Collaborative R&D	31/08/2020	33,114,173
Innovate UK	University of Bristol	Collaborative R&D	31/03/2021	29,908,139
EPSRC	Rosalind Franklin Institute	Research grant	30/06/2019	29,642,554
EPSRC	University of Birmingham	Research grant	01/12/2019	28,537,607
ISCF	BP Exploration Operating Company Ltd	Collaborative R&D	01/03/2021	28,043,902
Innovate UK	Airbus Operations Limited	BEIS-funded programmes	30/04/2021	27,689,779
EPSRC	University of Oxford	Training grant	30/09/2022	27,675,153
EPSRC	University of York	Research grant	01/12/2019	27,348,141
EPSRC	University of Oxford	Research grant	01/12/2019	27,338,780
Innovate UK	GKN Aerospace Services Limited	BEIS-funded programmes	01/12/2020	27,186,331
UKRI	University of Manchester	Research grant	31/08/2020	26,621,454
Innovate UK	Airbus Operations Limited	BEIS-funded programmes	01/01/2022	26,527,245
Innovate UK	Cardiff University	Collaborative R&D	01/11/2020	25,449,184
BBSRC	University College London	Training grant	30/09/2020	25,199,630

Note: *Allocation year of grants is used here, meaning allocation of grants of several years may not be picked up if not within the years analysed here. **Source:** UKRI GtR (2024). All data: Project search.

Case study 1: International comparison of budgets of national applied research organisations

2.13 The Catapult Network receives around two times less core government funding than comparable national applied research organisations

National applied research organisations by funding in 2022, in millions £

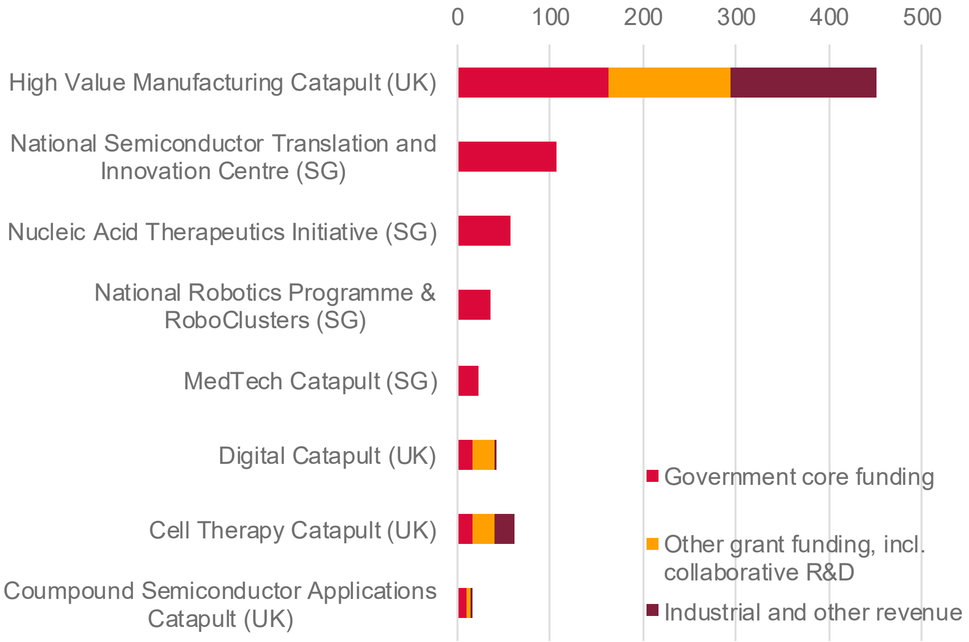


- The UK Catapult Network's core government funding of £289 million was around **two times lower** than that received by internationally comparable applied research organisations in FY2022. While Catapult's core funding has increased to around £320 million per year for the period between 2023 and 2028, this remains low by international comparison.
- **Furthermore, each of these countries have other organisation structures with significant budgets,** such as Kosetsushi in Japan and the Helmholtz Association in Germany, among others.
- Across all organisations, a significant portion of other revenue is represented by industrial contract R&D, publicly funded contract R&D and collaborative R&D. Other streams include IP revenue and technical consulting, among others.

Note: *No values for "other revenue" indicate missing data. Conversion rates used on 25 Feb 2024: 1EUR = 0.83GBP; 1JPY = 0.0053GBP; 1SGD = 0.59GBP. **Sources:** Leibniz Association (2024); Fraunhofer (2022); AIST (2023); Austrian Institute of Technology (2022); ASTAR (2023) ; NEDO (2023).

2.14 Comparing selected UK Catapults with Singapore's A*STAR plans on funding-applied research institutes suggests differences in scale of funding

Selected national applied research institutes by funding in 2024*, in millions £



- In 2024 Singapore's Economic Development Board announced the opening of four applied research institutes in four areas with an emphasis on commercialisation and related infrastructure: semiconductors, nucleic acid therapeutics, robotics and medtech.
- Comparing the initial investment of Singapore with the core funding of UK Catapults suggests a significant difference in terms of the scale of funding, except for the High Value Manufacturing Catapult, despite the large difference in country size. Small countries may be targeting niches.
- For example, the initial investment allocated to the National Semiconductor Translation and Innovation Centre (SG) in 2024 was 10 times larger than the core annual funding allocated to the Compound Semiconductor Applications Catapult in the UK in 2023/24.

Note: *Most recent years are used for each institute: 2022/23 for HVMC, 2023/24 for all other UK Catapults, and planned allocation for 2024 for the Singapore institutes. Conversion rate used on 25 Feb 2024: 1SGD = 0.59GBP.
Sources: HVMC (2023); EDB Singapore (2024); Digital Catapult (2024); CGT Catapult (2024); CSA (2024).

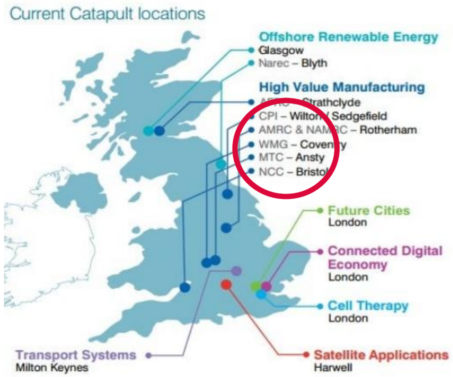
2.15 UK funding of Catapults is less flexible than the funding of Manufacturing USA Institutes

Comparative case study of applied research organisations in digital technologies in the UK and USA, 20 interviews

- The tech-development activities of applied research organisations have been shifting to higher TRLs, especially towards demonstration activities (in response to demand from companies and new engineering-based technologies).
- In the USA, late-stage MxD more quickly adapts to company requests in terms of infrastructure and funding when it comes to demonstration needs, whereas the HVMC in the UK is not well equipped to help with demonstration needs.
- Likewise, the HVMC cannot deliver workforce activities, despite this being one of the key recent activities demanded from companies.
- **Core government funding for Manufacturing USA Institutes can be used more flexibly, depending on needs, and it can be supplemented with other government funding. However, this is not the case for the Catapult funding in the UK.**
- The US government is also designing incentives for applied research organisations to serve as orchestrators and work with the wider innovation ecosystem, enabling a more efficient division of labour, which is not the case for the UK. In the USA there is also significant scale-up and late-stage tech-development and demonstration follow-on funding available through the DOD and DOE, among others.

Digital Manufacturing and Cybersecurity Institute (MxD), Manufacturing USA Institutes (USA)

High Value Manufacturing Catapult (HVMC), The Catapult Network (UK)



Source: Anzolin, G. and O'Sullivan, E. (2025). Innovation intermediaries in the digital transformation process.

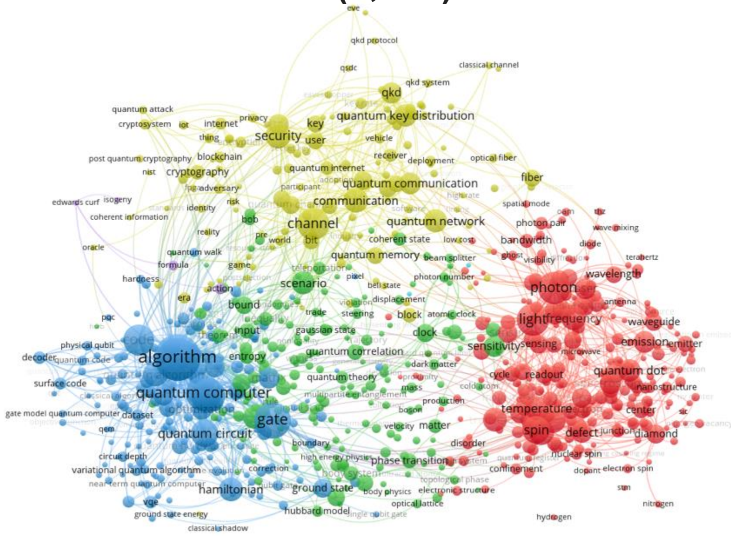
Case study 2: International comparison across emerging technologies

2.16 UK quantum publications tend to cluster words related to basic and applied research (earlier TRLs) compared to Germany's publications, which also mention terms related to applied physics and engineering

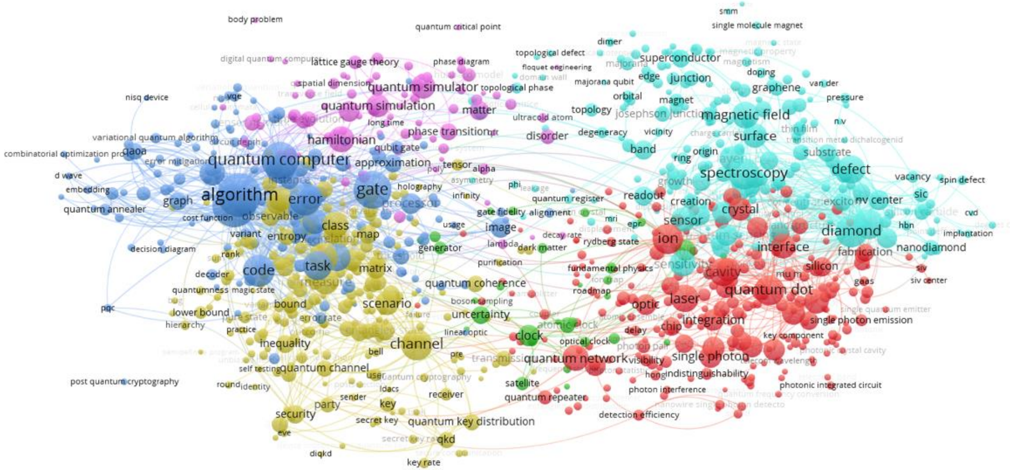
Term co-occurrence map of quantum academic publications between 2019 and 2023: UK vs Germany

UK quantum technology publications tend to cluster words related to mathematics and experimental physics, whereas Germany's publications also mention terms related to applied physics and engineering (e.g. spectroscopy, integration, fabrication, implantation, purification, component, telecom wavelength), as well as engineering challenges (e.g. interference and efficiency).

UK (2,782)



Germany (3,394)

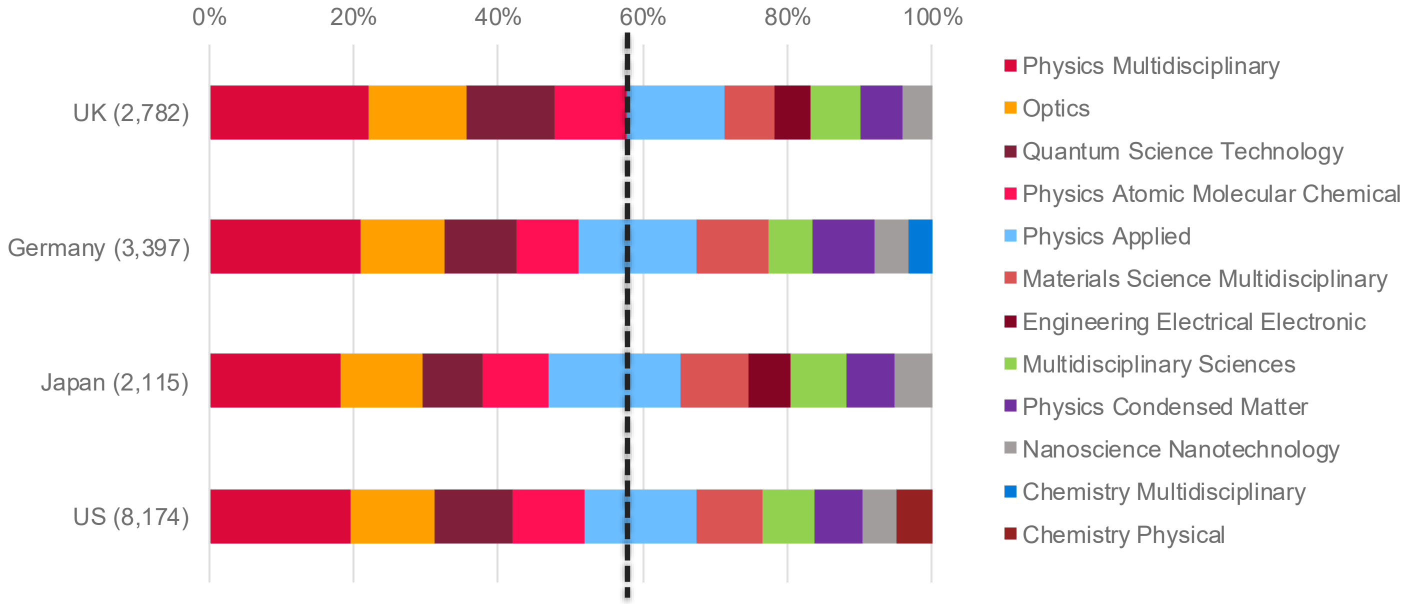


Note: Only journal articles were included. Quantum technology keywords filtered for quantum 2.0 technologies based on Bornmann et al. (2019). Publications filtered based on titles, abstracts, keywords (using Web of Science). Co-occurrence maps based on titles and abstracts and full counting of words.

Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

2.17 By research category, UK quantum publications are most significant in optics, quantum science and technology, and atomic, molecular and chemical physics; and less prominent in applied physics and materials science

Quantum academic publications by Web of Science category between 2019 and 2023



Note: Only journal articles were included. Quantum technology keywords filtered for quantum 2.0 technologies based on Bornmann et al. (2019). Publications filtered based on titles, abstracts, keywords (using Web of Science).
Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

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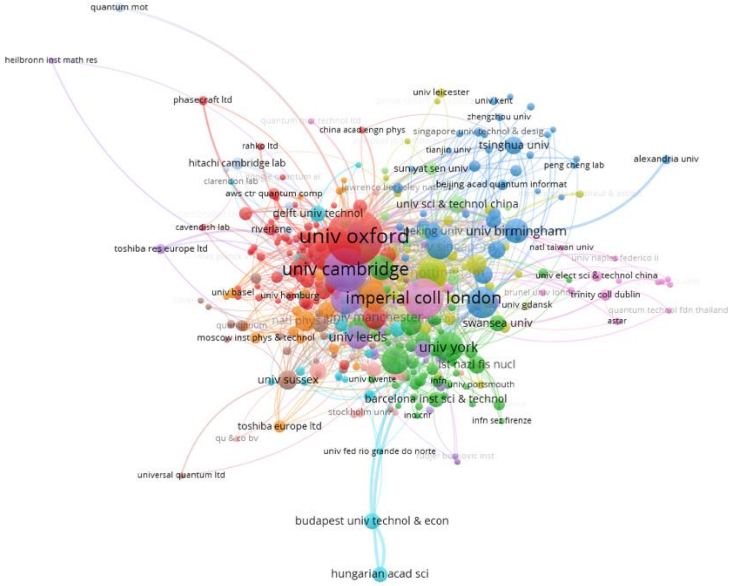
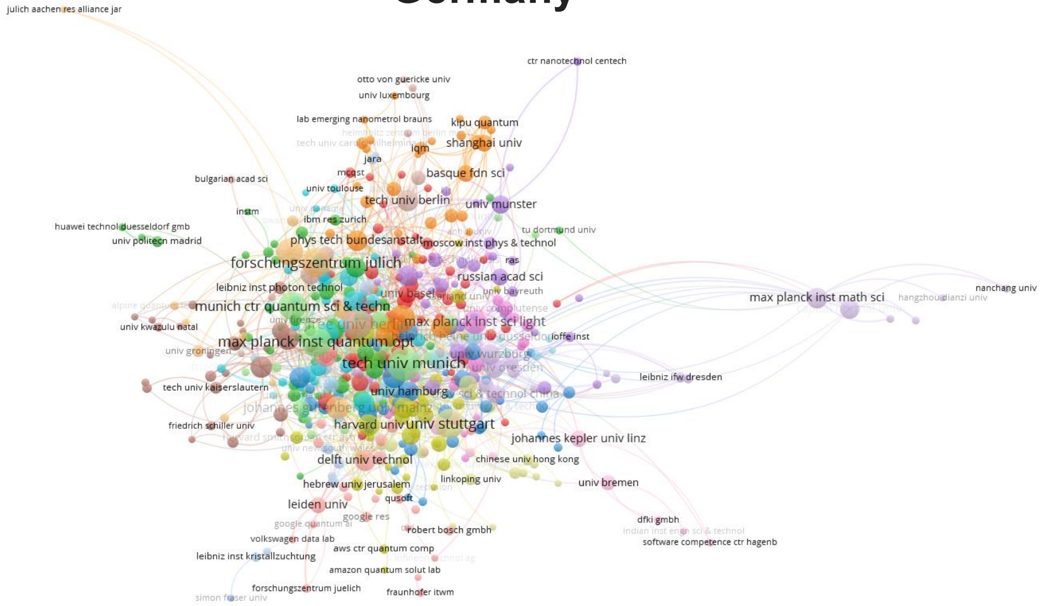
2.18 A few universities tend to dominate the UK's quantum publications compared to Germany, which has much more dispersed publication patterns

Co-authorship map of quantum academic publications between 2019 and 2023: UK vs Germany

UK



Germany



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Note: Bubble size represents number of documents. Only journal articles were included. Quantum technology keywords filtered for quantum 2.0 technologies based on Bornmann et al. (2019). Publications filtered based on titles, abstracts, keywords (using Web of Science). Co-authorship maps based on titles and abstracts and fractional counting of authors.

Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

2.19 Compound semiconductor publications reveal that all top five affiliations include universities in the UK – in comparator countries, national applied research organisations, RTOs, national labs and other types of organisation also emerge among top affiliations

Top five affiliations of compound semiconductor academic publications between 2019 and 2023

Top five affiliations	UK (1,758)	Japan (2,747)	Germany (2,024)	South Korea (2,095)	France (1,523)
1	University of Cambridge	Nagoya University	Leibniz Association	Korea University	Centre National De La Recherche Scientifique (CNRS)
2	University of London	University of Tokyo	Helmholtz Association	Seoul National University	Communaute Universite Grenoble Alpes
3	University of Sheffield	Osaka University	Fraunhofer Society	Hanyang University	Universite Grenoble Alpes UGA
4	University College London	National Institute for Materials Science	Paul Drude Institute for Solid State Electronics	Yonsei University	CEA
5	Cardiff University	National Institute of Advanced Industrial Science & Technology (AIST)	Technical University of Berlin	Sungkyunkwan University	Université Paris-Saclay

Note: Only journal articles were included. The keywords "compound semiconductor*" OR GaAs OR InP OR GaN OR GaSb were searched for in publications, filtered based on titles, abstracts, keywords (using Web of Science).
Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

2.20 Advanced composite materials publications reveal that all top five affiliations include universities in the UK – in comparator countries, national applied research organisations, RTOs, national labs, government departments, technical universities and other types of organisation also emerge among top affiliations

Top five affiliations of advanced composite materials academic publications between 2019 and 2023

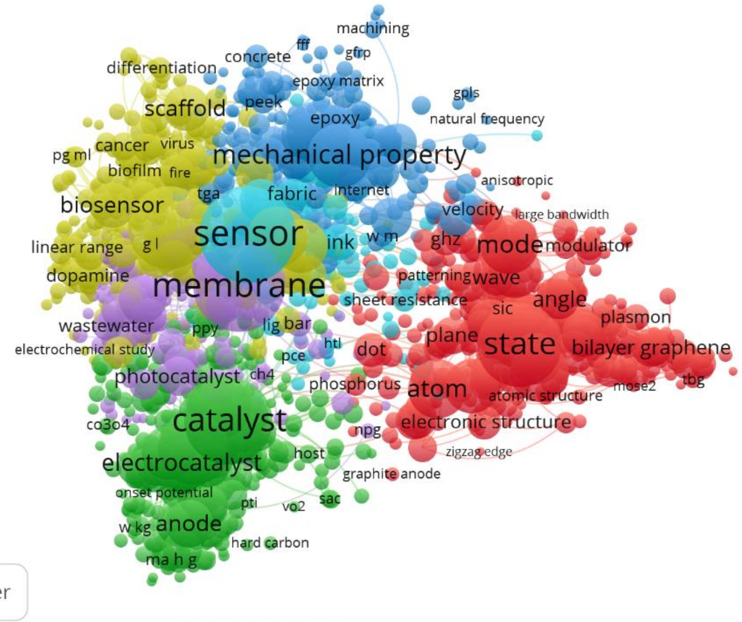
Top five affiliations	UK (1,198)	USA (2,255)	Germany (1,095)	South Korea (1,230)	France (1,026)
1	Imperial College London	Department of Energy (DOE)	Helmholtz Association	Hanyang University	Centre National De La Recherche Scientifique (CNRS)
2	University of London	University of California System	Karlsruhe Institute of Technology	Seoul National University	CNRS Institute for Engineering Systems Sciences INSIS
3	University of Bristol	University System of Ohio	Technische Universitat Dresden	Yeungnam University	CNRS Institute of Chemistry Inc.
4	University of Manchester	University System of Georgia	Fraunhofer Society	Yonsei University	University de Toulouse
5	University of Nottingham	University of Texas System	Max Planck Society	Jeonbuk National University	Université Paris-Saclay

Note: Only journal articles were included. The keywords “advanced composite” OR “advanced composite” OR “adv composite” OR “composite material” OR “composite materials” were searched for in publications, filtered based on titles, abstracts, keywords (using Web of Science).
Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

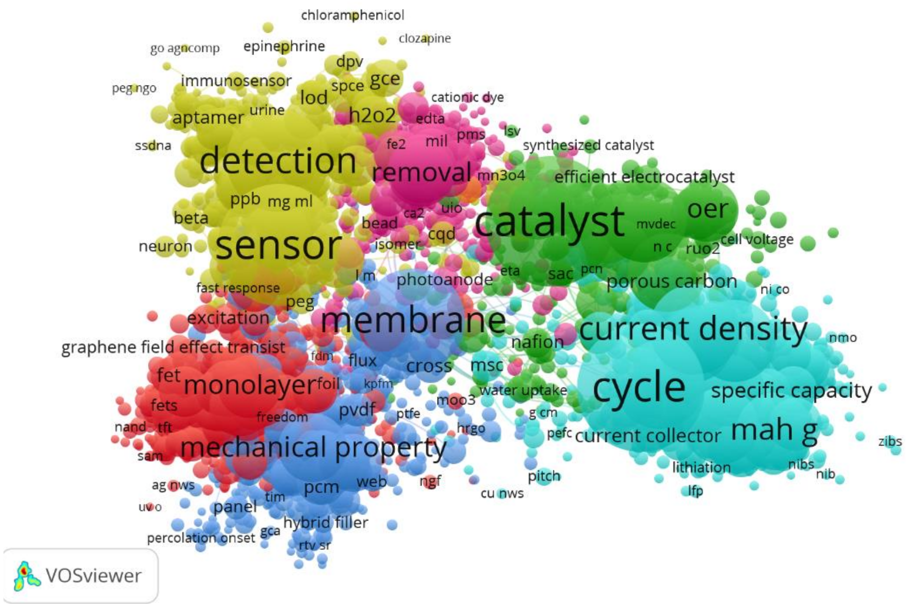
2.21 With the exception of human-health-related biosensors, UK graphene publications tend to focus less on applications with word clusters such as theory and physics, while South Korea focuses more on applications, including semiconductors (e.g. graphene FET) and battery research, that reflect its industrial base

Term co-occurrence map of graphene academic publications between 2019 and 2023: UK vs South Korea

UK (5,015)



South Korea (10,127)

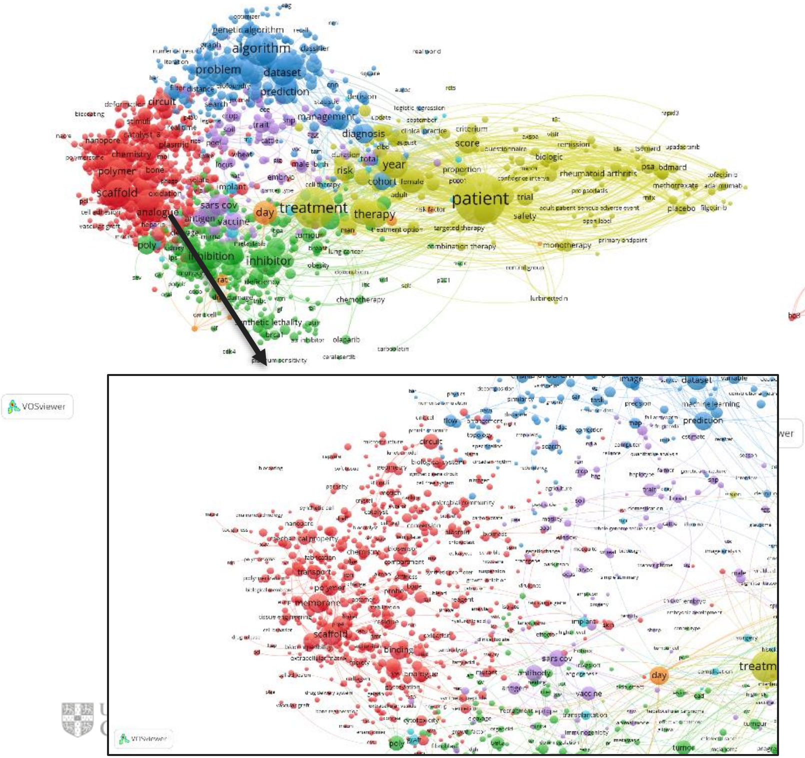


Note: Only journal articles were included. The keyword graphene was searched for in publications, filtered based on titles, abstracts, keywords (using Web of Science). Co-occurrence maps based on titles and abstracts and full counting of words.
Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

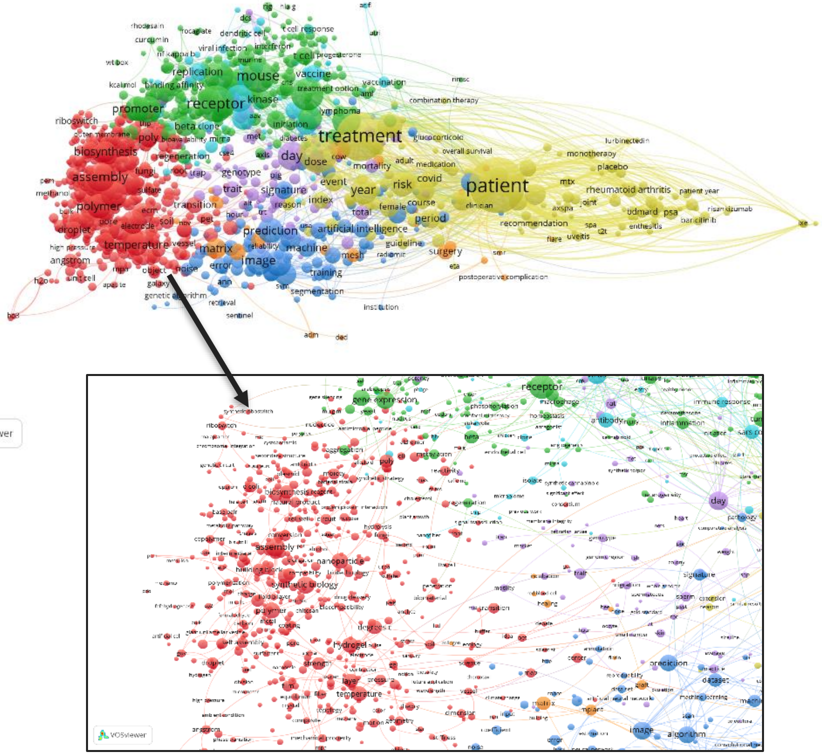
2.22 Clustering results of synthetic biology publications in the UK and Germany show similarities at the highest level, but Germany seems to cluster more engineering-related keywords, including assembly, self-assembly, biosynthesis, chemical synthesis (as shown by the red cluster)

Term co-occurrence map of synthetic biology academic publications between 2019 and 2023: UK vs Germany

UK (4,219)



Germany (4,550)



Note: Only journal articles were included. Synthetic biology keywords retrieved from Shapira et al. (2016). Publications filtered based on titles, abstracts, keywords (using Web of Science). Co-occurrence maps based on titles and abstracts and full counting of words. **Source:** CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

SECTION 3

Sectoral orientation of UK expenditure on R&D

How is the UK government's R&D funding distributed across economic activities?

To what extent does the distribution of funding reflect sectoral R&D intensity and broader economic impact?

How does it compare with patterns observed in other OECD countries?

Section 3 – Key findings

KEY FINDINGS

The distribution of UK government R&D funding reflects a concentration in traditionally high and medium/high-R&D-intensity industries, such as machinery and equipment and aerospace. However, sectors with strong R&D potential and economic importance—such as food and drink manufacturing and motor vehicles—receive comparatively less public investment relative to international peers.

Six sectors account for three-quarters of business R&D funded by the UK government

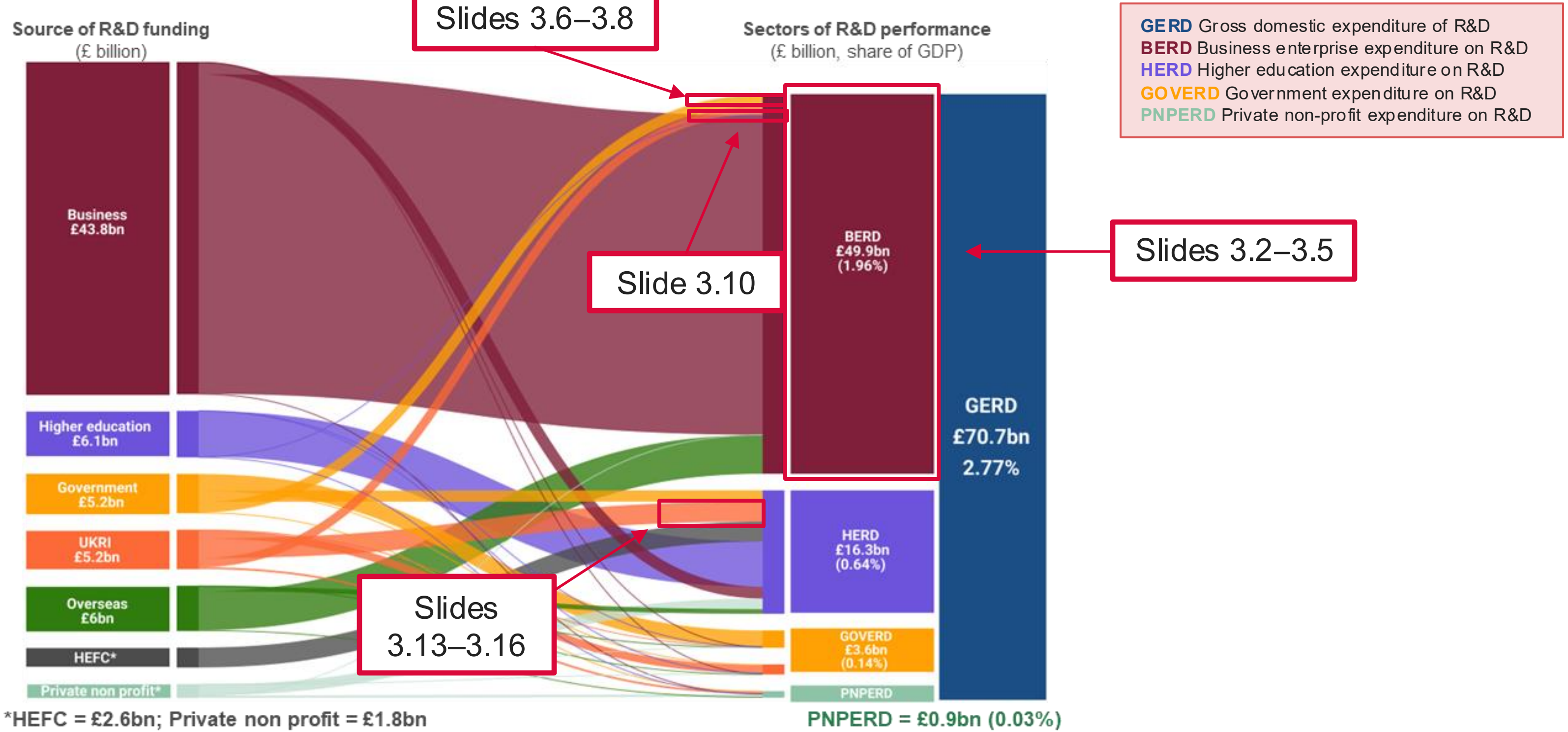
UK government expenditure is clustered in high and medium/high-R&D-intensity industries, mainly the manufacture of machinery and equipment; computer, electronic and optical products; and air and spacecraft and related machinery.

- In contrast, the manufacture of food and drinks and the manufacture of motor vehicles received disproportionately less government funding than international benchmarks.
- Nonetheless, the manufacture of food and drinks ranks among the UK industries with the highest R&D intensity compared to other OECD countries.
- UKRI grant funding data suggests that projects with recorded impact in 2022 were in healthcare (14%); digital and ICT; education; environment (each at 8%); agriculture, food and drink; government, democracy and justice; and manufacturing (each at 7%). The grants can be roughly classified as curiosity-driven and applied R&D grants, as they were predominantly led by universities.
- UKRI grant funding data suggests that most funding to companies went to professional, scientific and technical activities (35%) and manufacturing (28%) in 2022. These grants can be roughly classified as company R&D, as they were predominantly led by companies.
  - The majority of professional, scientific and technical activity funding went into other research and experimental development on natural sciences and engineering; other professional, scientific and technical activities; and research and experimental development on biotechnology.
  - The majority of manufacturing funding went into the manufacture of aerospace-related machinery; motor vehicles; machining; and engines and turbines (except aircraft, vehicle and cycle engines).

National data

3.1 Expenditure on R&D in the UK by performing and funding sectors, 2022

Current prices, £ millions

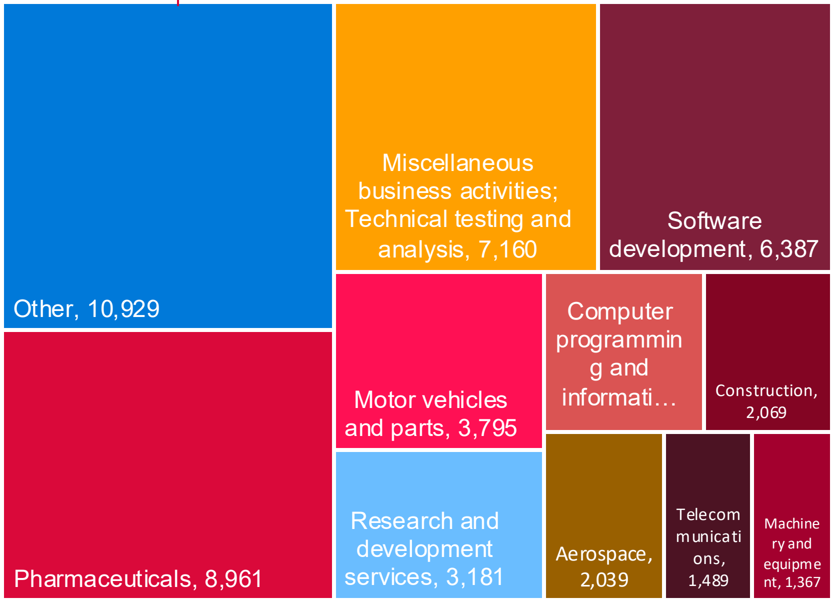


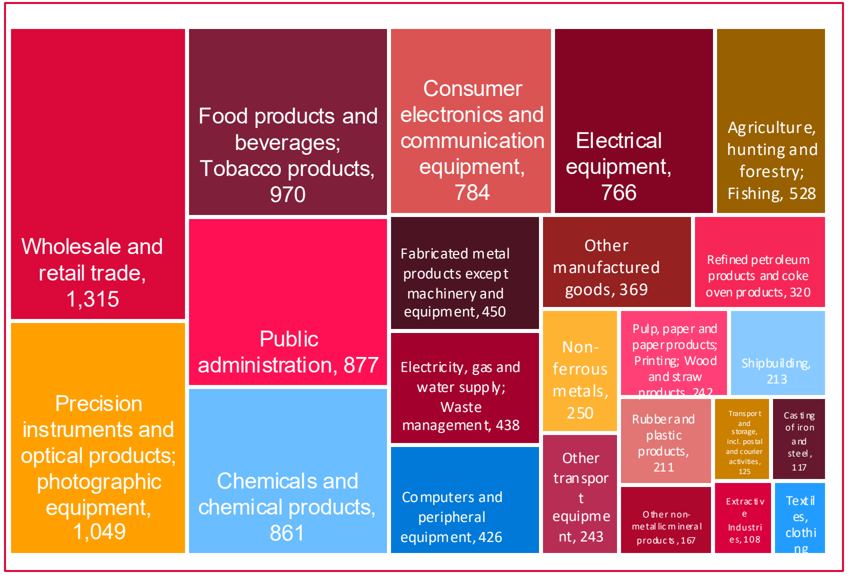
Note: UKRI = UK Research and Innovation; HEFC = higher education funding councils.
Source: Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025*.

3.2 Pharmaceuticals and automotive lead R&D investment across business sectors

Total expenditure performed by business in 2022, £ million

Business enterprise expenditure on R&D (BERD) in 2022: £49.9 billion
Top 10 product groups: £39 billion





Source: ONS (2024). Business enterprise research and development (R&D), UK: 2022.

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3.3 Pharmaceutical industry R&D is mainly funded by business and overseas organisations

Current prices, £ million

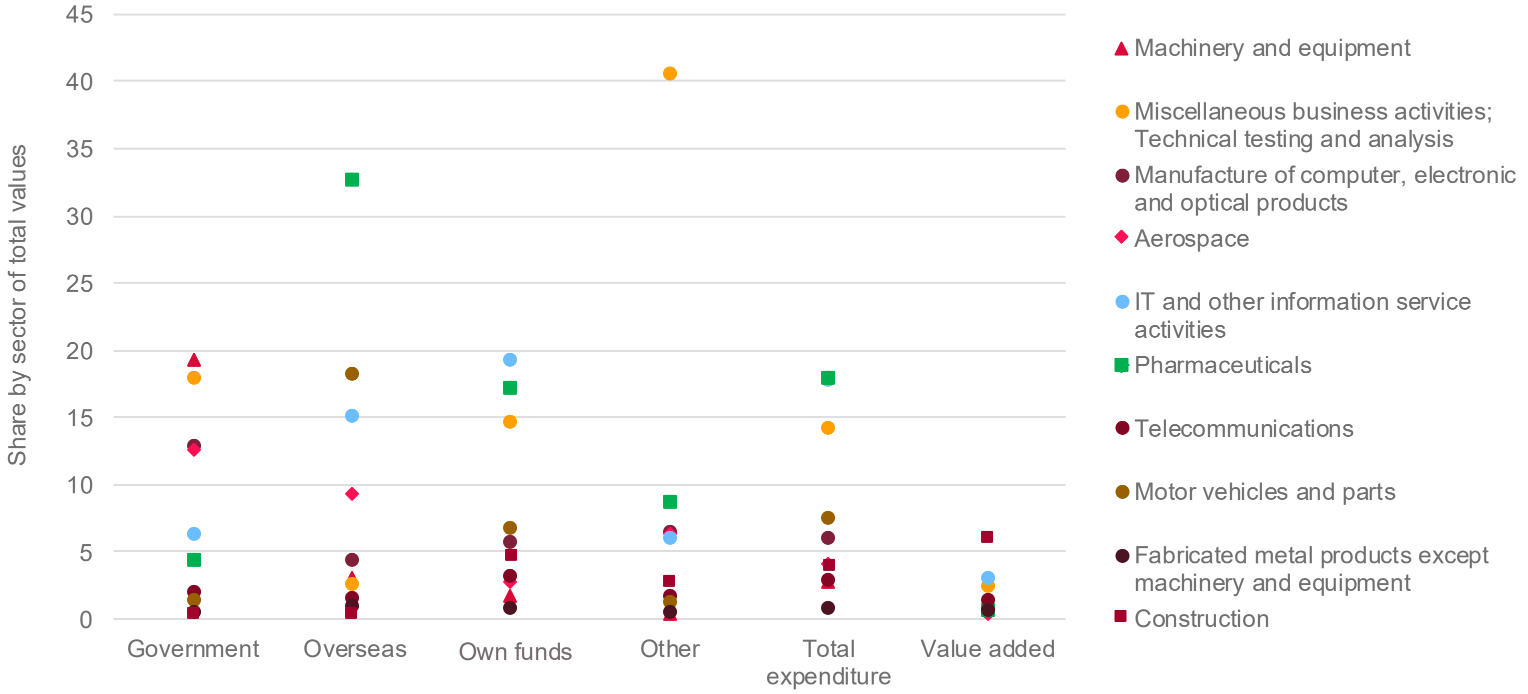
Detailed product groups	UK government	Overseas	Own funds	Other	Total expenditure	Value added	Value-added share
Agriculture, hunting and forestry; fishing	5	10	485	30	528	16,683	0.7%
Extractive industries	[c]	[c]	107	[c]	108	40,632	1.8%
Food products and beverages; tobacco products	3	8	916	42	970	33,358	1.5%
Textiles, clothing and leather products	[c]	[c]	99	[c]	100	6,060	0.3%
Pulp, paper and paper products; printing; wood and straw products	[c]	[c]	240	[x]	242	12,895	0.6%
Refined petroleum products and coke oven products	[c]	[c]	295	[c]	320	3,102	0.1%
Chemicals and chemical products	3	21	836	[x]	861	12,247	0.5%
Pharmaceuticals	114	1,659	7,075	112	8,961	16,781	0.7%
Rubber and plastic products	[x]	[c]	207	[c]	211	8,262	0.4%
Other non-metallic mineral products	8	[x]	159	[x]	167	6,959	0.3%
Casting of iron and steel	7	[x]	110	[x]	117	2,721	0.1%
Fabricated metal products, except machinery and equipment	14	51	378	7	450	17,433	0.8%
Machinery and equipment	494	160	708	5	1,367	16,223	0.7%
Manufacture of computer, electronic and optical products	333	224	2,383	84	3,025	14,041	0.6%
Motor vehicles and parts	38	930	2,811	16	3,795	15,524	0.7%
Other transport equipment	[c]	[c]	126	6	243	12,466	0.6%
Shipbuilding	[c]	8	96	[c]	213	2,069	0.1%
Aerospace	322	476	1,157	83	2,039	9,737	0.4%
Other manufactured goods	[c]	[c]	319	3	369	18,530	0.8%
Electricity, gas and water supply; waste management	[c]	26	293	[c]	438	24,871	1.1%
Construction	12	23	1,996	38	2,069	138,259	6.1%
Wholesale and retail trade	[x]	[x]	1,314	[x]	1,315	229,915	10.1%
Transport and storage, including postal and courier activities	[c]	[c]	120	[c]	125	81,689	3.6%
IT and other information services	214	856	9,270	101	10,441	104,704	4.6%
Miscellaneous business activities; technical testing and analysis	461	136	6,040	523	7,160	58,508	2.6%
Research and development services	[c]	331	2,539	[c]	3,181	20,421	0.9%
Public administration	[c]	[c]	851	2	877	114,416	5.0%
Total[1/]	**2,560**	**5,071**	**41,024**	**1,287**	**49,942**	**2,266,082**	100.0%

Note: [c] = confidential, [x] = nil, figures unavailable or too small to display. "Other" includes funds from UK private non-profit organisations and higher education establishments and international organisations; 1/ the sum of product groups may not match the total values because of excluding confidential data and product groups that do not correspond to an SIC code.

Source: ONS (2024). Gross domestic expenditure on research and development, UK: 2022; GDP output approach, low level aggregates, UK, Quarter 2 (Apr to Jun) 2024.

3.4 Government R&D spending tends to focus on machinery and equipment; computer and electronics and aerospace

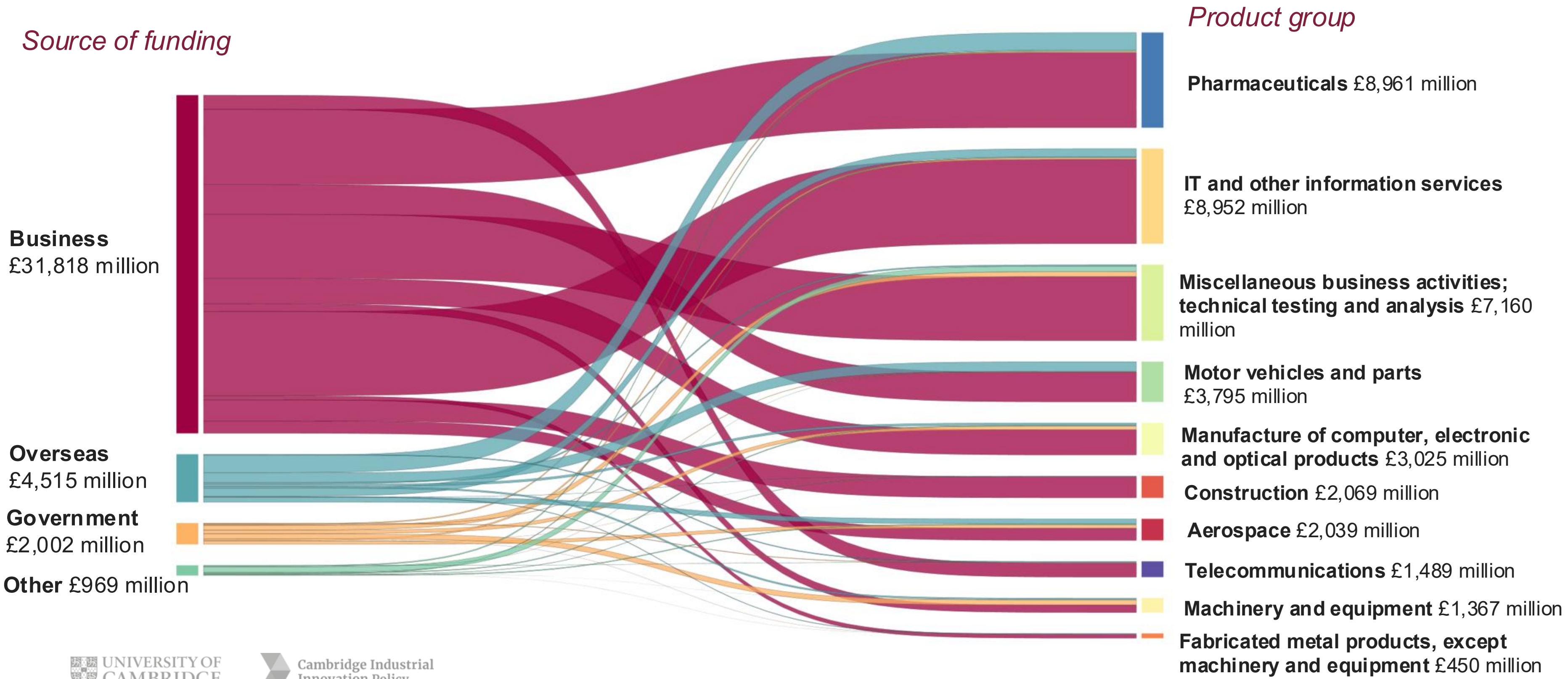
Top 10 product groups by government funding, 2022



Note: "Other" includes funds from UK private non-profit organisations and higher education establishments and international organisations.
Source: ONS (2024). Gross domestic expenditure on research and development, UK: 2022; ONS (2024). GDP output approach, low level aggregates, UK, Quarter 2 (Apr to Jun) 2024.

3.5 Sources of funds for R&D performed in UK businesses

Top 10 product groups by government funding, 2022



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Note: "Other" includes funds from UK private non-profit organisations and higher education establishments and international organisations.
Source: ONS (2024). Business enterprise research and development (R&D), UK: 2022.

3.6 BERD by source of funding, 2022

Total expenditure performed by business in 2022, £ million

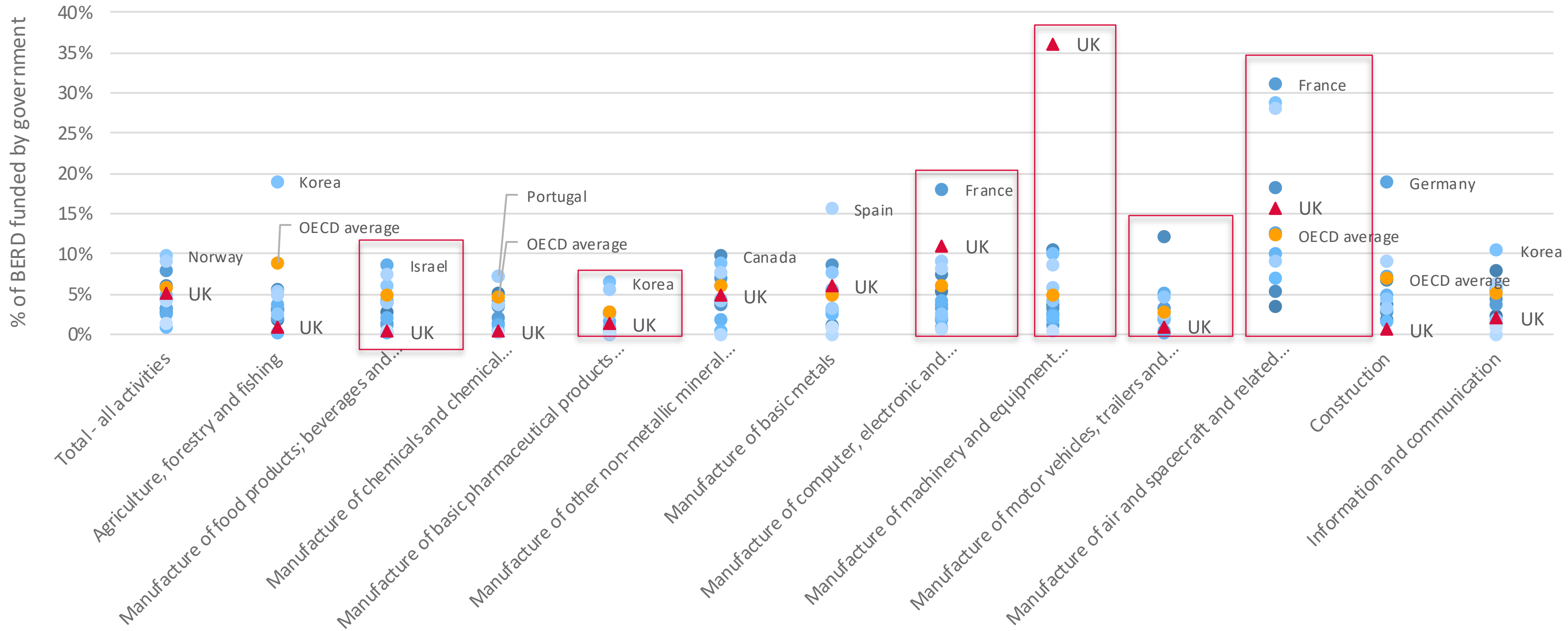
Business enterprise expenditure on R&D (BERD) in 2022: £49.9 billion

Note: "Other" includes agriculture, hunting and forestry; fishing, casting of iron and steel, chemicals and chemical products, computer programming and information service activities, computers and peripheral equipment, construction, electricity, gas and water supply; waste management, extractive industries, fabricated metal products, except machinery and equipment, food products and beverages; tobacco products, motor vehicles and parts, other manufactured goods, other non-metallic mineral products, other transport equipment, public administration, pulp, paper and paper products; printing; wood and straw products, refined petroleum products and coke oven products, research and development services, shipbuilding, textiles, clothing and leather products, transport and storage, including postal and courier activities.

Source: ONS (2024). Business enterprise research and development (R&D), UK: 2022.

3.7 The manufacture of food and drinks and motor vehicles received disproportionately less government funding than the OECD average

2015–21 average and 2022 for the UK

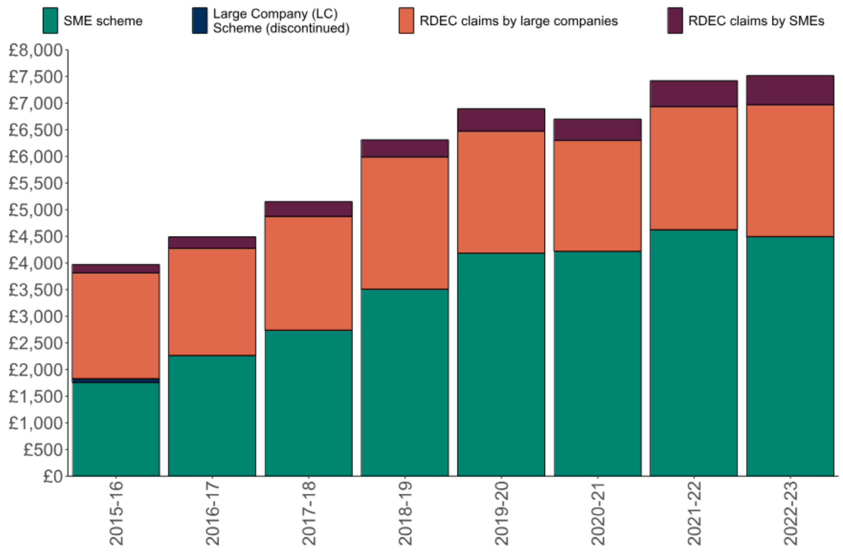


Note: 2022 data for the UK, by product group. OECD average includes: Australia, Austria, Canada, Chile, Czechia, Estonia, Finland, France, Germany, Greece, Israel, Italy, Japan, Korea, Latvia, Lithuania, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland and Türkiye. **Source:** OECD (2024). Business enterprise R&D expenditure by main activity (focused) and source of funds; ONS (2024). Business enterprise research and development (R&D), UK: 2022.

3.8 R&D tax relief is concentrated in the information and communication, manufacturing, and professional, scientific and technical sectors

- The provisional total cost of R&D tax relief claims for the tax year 2022–23 was £7.5 billion, corresponding to £46.7 billion of R&D expenditure.
- Of this, £4.5 billion was claimed under the Small or Medium-sized Enterprise (SME) scheme, and £3 billion under the Research and Development Expenditure Credit (RDEC) scheme. Within the RDEC scheme, £2.5 billion was claimed by large companies, while £545 million was claimed by small and medium-sized companies.
- Although the volume of claims under the SME scheme is significantly higher than under the RDEC scheme, the average claim size is generally much larger for RDEC than for SME.
- Sectors benefiting the most from R&D tax relief include: **information and communication (24%), professional, scientific and technical activities (24%)** and **manufacturing (22%).** However, this distribution is not proportional to their contributions to value added and overall R&D investment, where manufacturing outperforms the other two sectors.

Total support claimed through R&D tax credits by scheme, 2015 to 2016 tax year to 2022 to 2023 tax year (£ million)



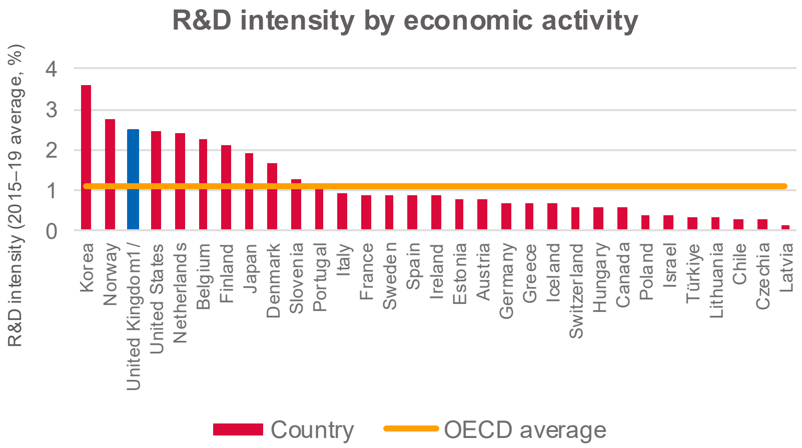
Source: HMRC (2024). *Research and Development Tax Credits Statistics: September 2024*

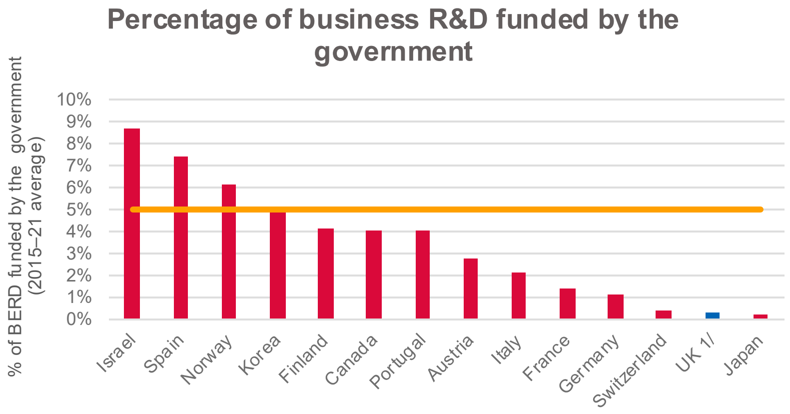
Sectoral case studies

3.9 Food and drink manufacturing

- The food and drink industry is the **UK's largest manufacturing sector**. Within manufacturing, food and drink accounted for 17% of value added, 18.4% of employment, 12% of capital investment and 3.3% of BERD in 2023.[1]
- While less R&D-intensive than other manufacturing industries, the UK's food and drink manufacturing sector has a **higher R&D intensity** (BERD as a share of value added) **than most OECD countries**. By economic activity, it had an R&D intensity of 2.5% in 2022.
- Innovation is a key focus for the UK food and drink industry. In 2021 over 11,600 new food and drink products were introduced in the UK. Key innovation areas include: healthier and more nutritious products, sustainable ingredient sourcing, low-emission production, food safety, supply chain resilience and CO_2 traceability.[2]
- However, the sector receives only 0.1% of the **UK government's R&D funding for businesses**, accounting for only 0.3% of the R&D expenditure performed by businesses. This is well **below the OECD average** of 5% seen between 2015 and 2021.

[1] Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025.*
[2] Cambridge Industrial Innovation Policy (2023). *UK Innovation Report 2023.*



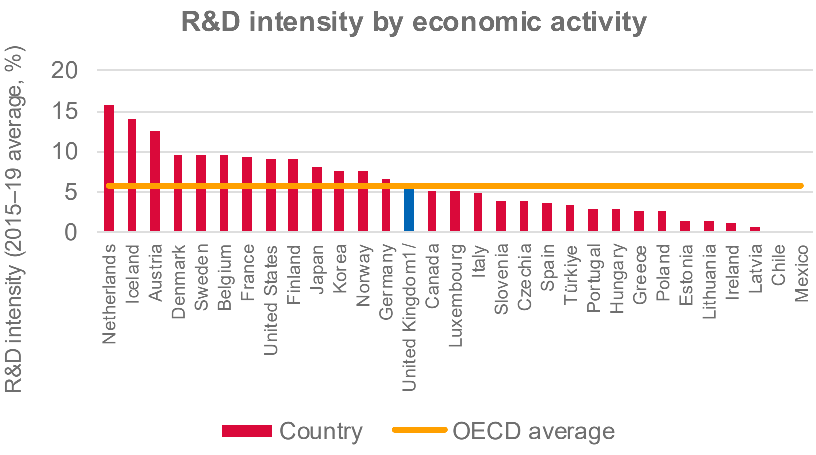


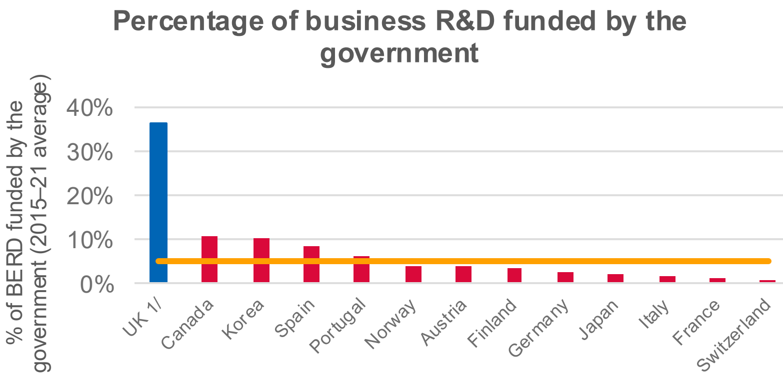
Note: 1/ 2022 data for the UK, ONS data for value added. Manufacture of food products; beverages and tobacco products.
Source: OECD (2024). Analytical Business Enterprise R&D by ISIC Rev.4 industry (ANBERD database); OECD (2024). Structural Analysis Database; OECD (2024). Business enterprise R&D expenditure by main activity (focused) and source of funds; ONS (2024). Business enterprise research and development (R&D), UK: 2022; ONS (2024). GDP output approach, low level aggregates, UK, Quarter 2 (Apr to Jun) 2024.

3.10 Machinery and equipment

- Within manufacturing, the machinery and equipment (M&E) industry accounted for 7.9% of value added, 7% of employment and 5.8% of BERD in 2023.[1]
- This is an **R&D-intensive industry**, with investment reaching 6% of the sector value added in 2022, aligning with the OECD average. **Government funding plays a crucial role**, accounting for 36% of total R&D expenditure in 2022 – significantly higher than the OECD average of 4.8% recorded between 2015 and 2021, and well above comparator countries.
- There is a dominant presence of foreign-owned original equipment manufacturers (OEMs) and distributors across UK M&E sub-sectors. There is a **perception that UK M&E companies tend to be less R&D-intensive than foreign ones**, except for some large internationally competitive firms.[2]
- Sustainability, digitalisation and materials research trends have shaped the direction of innovation efforts in recent years in this industry.[2]

[1] Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025.*
[2] Cambridge Industrial Innovation Policy (2024). *UK Innovation Report 2024.*



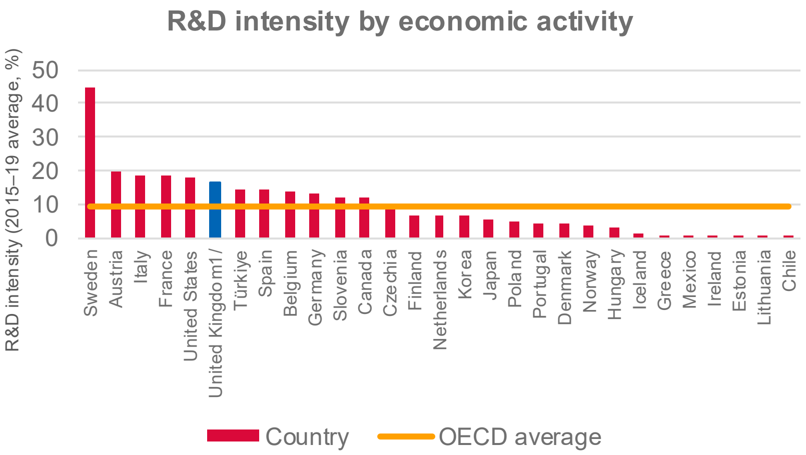


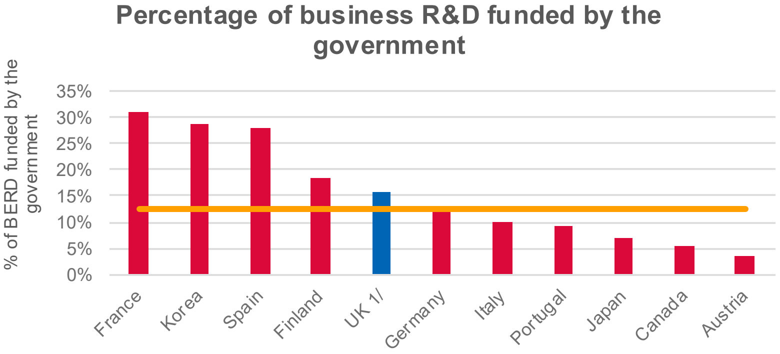
Note: 1/ 2022 data for the UK, ONS data for value added.
Source: OECD (2024). Analytical Business Enterprise R&D by ISIC Rev.4 industry (ANBERD database); OECD (2024). Structural Analysis Database; OECD (2024). Business enterprise R&D expenditure by main activity (focused) and source of funds; ONS (2024). Business enterprise research and development (R&D), UK: 2022; ONS (2024). GDP output approach, low level aggregates, UK, Quarter 2 (Apr to Jun) 2024.

3.11 Aerospace

- Within manufacturing, the aerospace industry (other transport equipment) accounted for 6.4% of manufacturing value added, 5.3% of its employment and 9.6% of BERD in 2023.[1]
- This is an **R&D-intensive industry**, with investment reaching 16.6% of the sector value added in 2022, above the OECD average. **Government funding plays a crucial role**, accounting for 15.8% of total R&D expenditure in 2022 – higher than the OECD average of 12.3% seen between 2015 and 2021. But countries such as France and Korea show a higher participation of government funding in business-performed R&D.
- Industry actors consider government support programmes to be critical to increasing their competitiveness and capturing the opportunities related to emerging technologies and net-zero targets. **Opportunities** identified include funding for **late-stage product development and commercialisation**.[2]
- Key market and technology trends that have shaped the direction of innovation efforts in recent years include: the transition from fossil fuels to zero-carbon aircraft, the emergence of new aircraft segments, digitalisation, and space tourism. [2]

[1] Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025*.
[2] Cambridge Industrial Innovation Policy (2023). *UK Innovation Report 2023*.





Note: 1/2022 data for the UK, ONS data for value added. Manufacture of air and spacecraft and related machinery.
Source: OECD (2024). Analytical Business Enterprise R&D by ISIC Rev.4 industry (ANBERD database); OECD (2024). Structural Analysis Database; OECD (2024). Business enterprise R&D expenditure by main activity (focused) and source of funds; ONS (2024). Business enterprise research and development (R&D), UK: 2022; ONS (2024). GDP output approach, low level aggregates, UK, Quarter 2 (Apr to Jun) 2024.

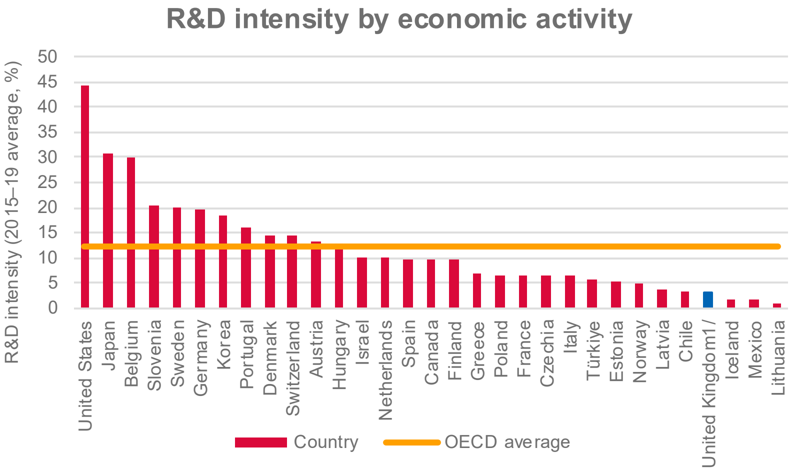
3.12 Pharmaceuticals

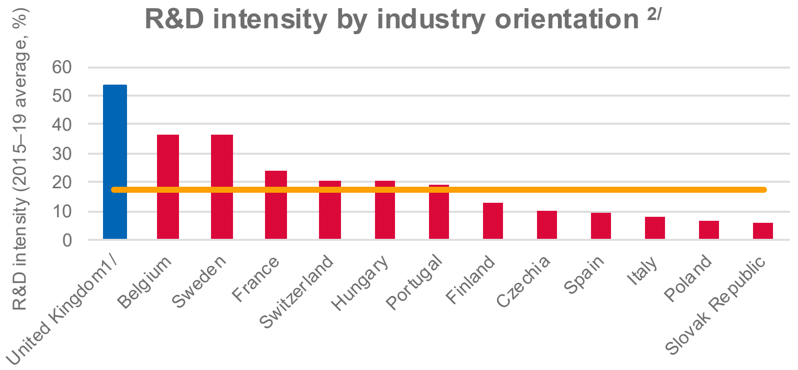
- The pharmaceutical industry is the **largest contributor to BERD** in the UK, accounting for 18.3% of total BERD in 2022. Within manufacturing, pharmaceuticals (basic pharmaceutical products) accounted for 9.3% of manufacturing value added, 2.0% of employment, 14.6% of capital investment and 36.2% of BERD in 2023. In 2022 pharmaceuticals was also the largest manufacturing contributor to service exports, primarily through intellectual property.[1]

- This is an **R&D-intensive industry**, with investment reaching 53% of the sector value added in 2022 (by industry orientation), above the OECD average. The substantial differences in R&D intensity by economic activity and orientation are explained by the fact that much of the research takes place outside manufacturing firms.

- Unlike other R&D-intensive sectors, **the pharmaceutical industry relies primarily on private-sector investment**, with government funding accounting for just 1% of total business-performed R&D in 2022. This figure fell slightly below the OECD average of 3% recorded between 2015 and 2021.

- Despite being the UK's most innovative industry, pharmaceutical R&D investment has stagnated over the past decade. Key factors contributing to this trend include limited scale-up funding, a shift from high-risk in-house R&D to acquiring smaller firms, and outsourcing of research, including to overseas organisations.[2]





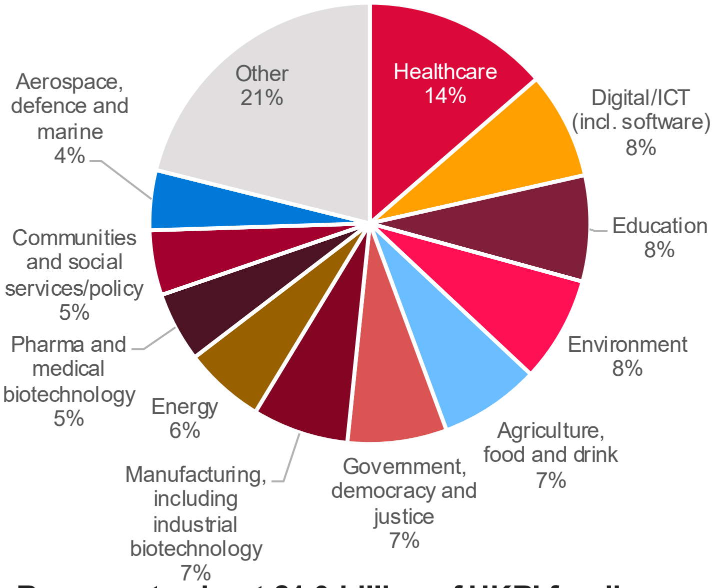
[1] Cambridge Industrial Innovation Policy (2025). *UK Innovation Report 2025.*
[2] Cambridge Industrial Innovation Policy (2022). *UK Innovation Report 2022.*

Note: 1/ 2022 data for the UK, ONS data for value added. 2/ Industry orientation refers to the industries where R&D outputs are applied rather than the primary economic activity. Manufacture of basic pharmaceutical products and pharmaceutical preparations.
Source: OECD (2024). Analytical Business Enterprise R&D by ISIC Rev.4 industry (ANBERD database); OECD (2024). Structural Analysis Database; OECD (2024). Business enterprise R&D expenditure by main activity (focused) and source of funds; ONS (2024). Business enterprise research and development (R&D), UK: 2022; ONS (2024). GDP output approach, low level aggregates, UK, Quarter 2 (Apr to Jun) 2024.

UKRI data

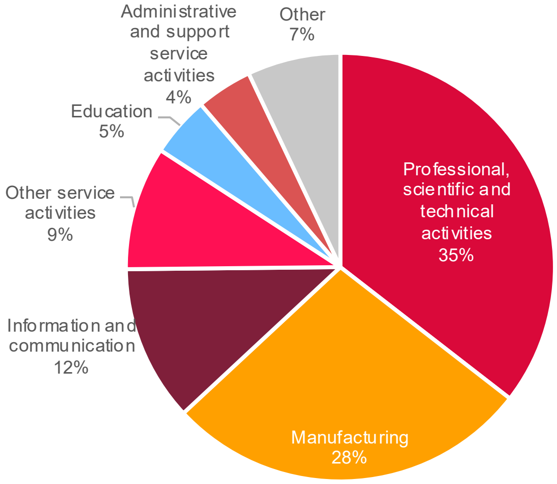
3.13 Sectoral allocation of UKRI funding: curiosity-driven and applied R&D with reported impact* vs company R&D

UKRI funding with self-reported impact in 2022 by sector and awarded value (~predominantly research-council-funded, see 3.14, and university-led)



Represents about £1.0 billion of UKRI funding allocated to projects with self-reported impact in 2022

UKRI funding matched with SIC codes by sector and awarded value in 2022 (~predominantly Innovate UK and ISCF-funded, see 3.14, and company-led)



Represents about 27% of total UKRI funding in 2022 (£1.3 billion of £4.8 billion in 2022)

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Note: *While the figure on the left predominantly represents university-led projects that resulted in impact (e.g. publication, patent, software, product) and the right predominantly represents company-led projects, **neither is exclusive.** Fractional counting was used; in other words, project funding is divided by equal shares across sectors/SIC codes. Impact year was used for left and grant start date was used for right.

Source: UKRI GtR (2024); Companies House (2024). Free Company Data Product.

3.14 Sectoral allocation of UKRI funding: curiosity-driven and applied R&D with reported impact* vs company R&D

UKRI funding with self-reported impact in 2022 by sector and awarded value (~predominantly research-council-funded and university-led)

Funding org.	Sum awarded	# of projects	Share of sum awarded
EPSRC	386,329,338	361	38.66%
GCRF	131,016,619	110	13.11%
BBSRC	84,384,418	170	8.45%
ESRC	65,553,388	204	6.56%
NERC	61,544,883	132	6.16%
FLF	54,330,226	53	5.44%
AHRC	46,994,801	226	4.70%
SPF	46,910,334	50	4.69%
COVID	35,917,226	97	3.59%
UKRI	29,999,824	6	3.00%
MRC	25,913,679	30	2.59%
ISCF	14,241,801	23	1.43%
UUI	5,959,513	3	0.60%
NEWTON FUND	4,632,724	13	0.46%
FIC	3,044,542	25	0.30%
STFC	2,438,465	20	0.24%
Grand total	**999,211,781**	**1,523**	**100.00%**

UKRI funding matched with SIC codes by sector and awarded value in 2022 (~predominantly Innovate UK and ISCF-funded, and company-led)

Funding org.	Sum awarded	# of projects	Share of sum awarded
Innovate UK	713,224,575	1,937	55.64%
ISCF	332,236,861	313	25.92%
Horizon Europe guarantee	133,939,017	395	10.45%
EPSRC	28,949,461	8	2.26%
NERC	25,644,129	52	2.00%
BBSRC	16,134,799	52	1.26%
MRC	10,895,171	15	0.85%
FLF	6,192,546	6	0.48%
UKRI	5,822,114	12	0.45%
ESRC	4,210,731	50	0.33%
AHRC	3,018,934	42	0.24%
Open Access Block Grant	1,138,243	13	0.09%
NC3Rs	401,610	1	0.03%
FIC	98,879	2	0.01%
STFC	17,975	1	0.00%
Grand total	**1,281,925,045**	**2,899**	**100.00%**

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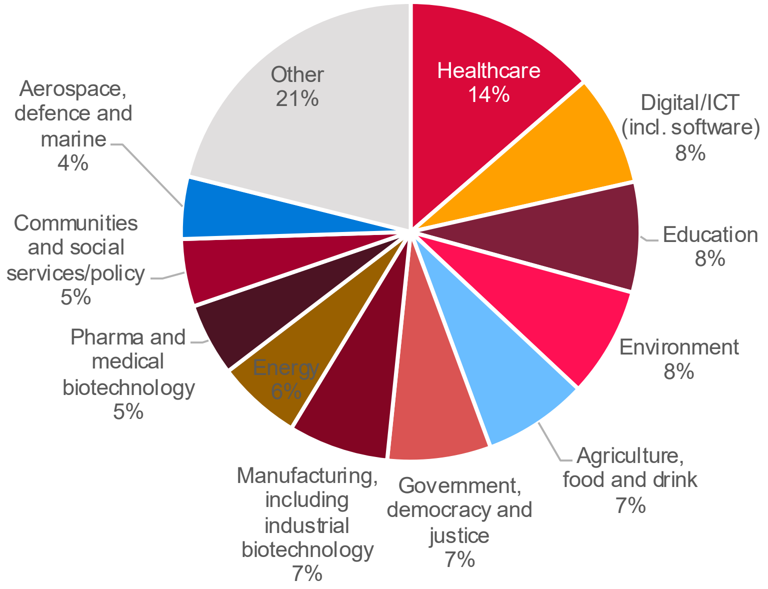
Note: *While the figure on the left predominantly represents university-led projects that resulted in impact (e.g. publication, patent, software, product, etc.) and the right predominantly represents company-led projects, **neither is exclusive.** Fractional counting was used; in other words, project funding is divided by equal shares across sectors/SIC codes. Impact year was used for left and grant start date was used for right. **Source:** UKRI GtR (2024).; Companies House (2024). Free Company Data Product.

3.15 UKRI funding with reported impact* in 2022 by sector and awarded value (~predominantly research-council-funded and university-led)



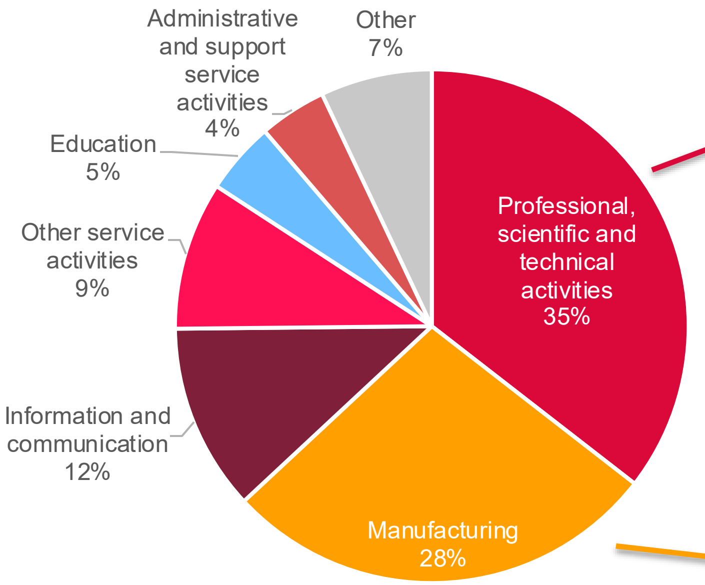
Impact sector	Sum awarded in £	Share of total
Healthcare	136,291,393	13.42%
Digital/ICT (incl. software)	78,399,696	7.72%
Education	77,592,952	7.64%
Environment	77,274,323	7.61%
Agriculture, food and drink	73,574,850	7.25%
Government, democracy and justice	72,840,257	7.17%
Manufacturing, including industrial biotechnology	70,437,470	6.94%
Energy	59,312,554	5.84%
Pharma and medical biotechnology	51,146,200	5.04%
Communities and social Services/policy	47,511,251	4.68%
Aerospace, defence and marine	43,921,666	4.33%
Other	35,218,025	3.47%
Culture, heritage, museums and collections	30,038,200	2.96%
Electronics	27,414,214	2.70%
Construction	25,073,562	2.47%
Chemicals	22,423,081	2.21%
Transport	18,837,807	1.86%
Financial services and management consultancy	17,070,800	1.68%
Creative economy	14,041,357	1.38%
Leisure activities, including sports, recreation and tourism	11,212,171	1.10%
Security and diplomacy	7,599,189	0.75%
Retail	1,980,763	0.20%
Total	999,211,781	100.00%

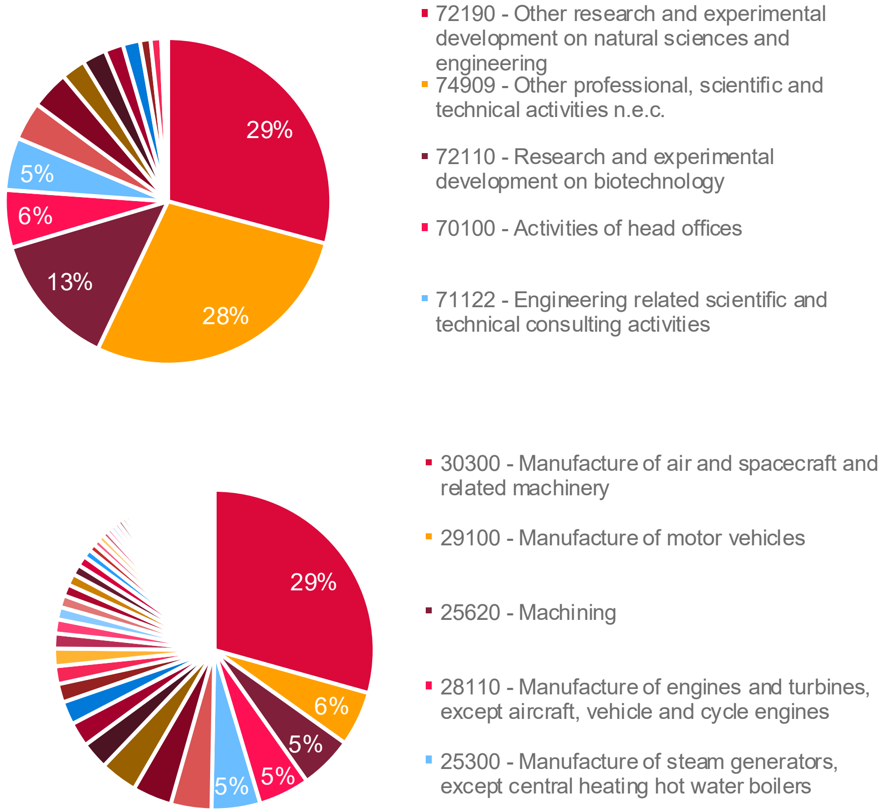
Other

Note: *Numbers predominantly represent university-led projects that resulted in impact (e.g. publication, patent, software, product, evidence to policy, conference) but are not exclusive to university-led projects. Fractional counting was used; in other words, project funding is divided by equal shares across sectors. Impact year was used for calculation. **Source:** UKRI GtR (2024).

3.16 UKRI funding matched with SIC codes by sector and awarded value in 2022 (~predominantly Innovate UK and ISCF-funded, and company-led)

Represents about 27% of total UKRI funding in 2022 (£1.3 billion of £4.8 billion in 2022).





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Note: See Appendix B.1 for methodology. If an organisation has several SIC codes, the grant amount awarded is divided by equal shares. Grant start date was used. The data also includes universities, where these have been assigned an SIC code. **Source:** UKRI GtR (2024). All data: Project search.; Companies House (2024). Free Company Data Product.

Annex A

Basic versus applied research

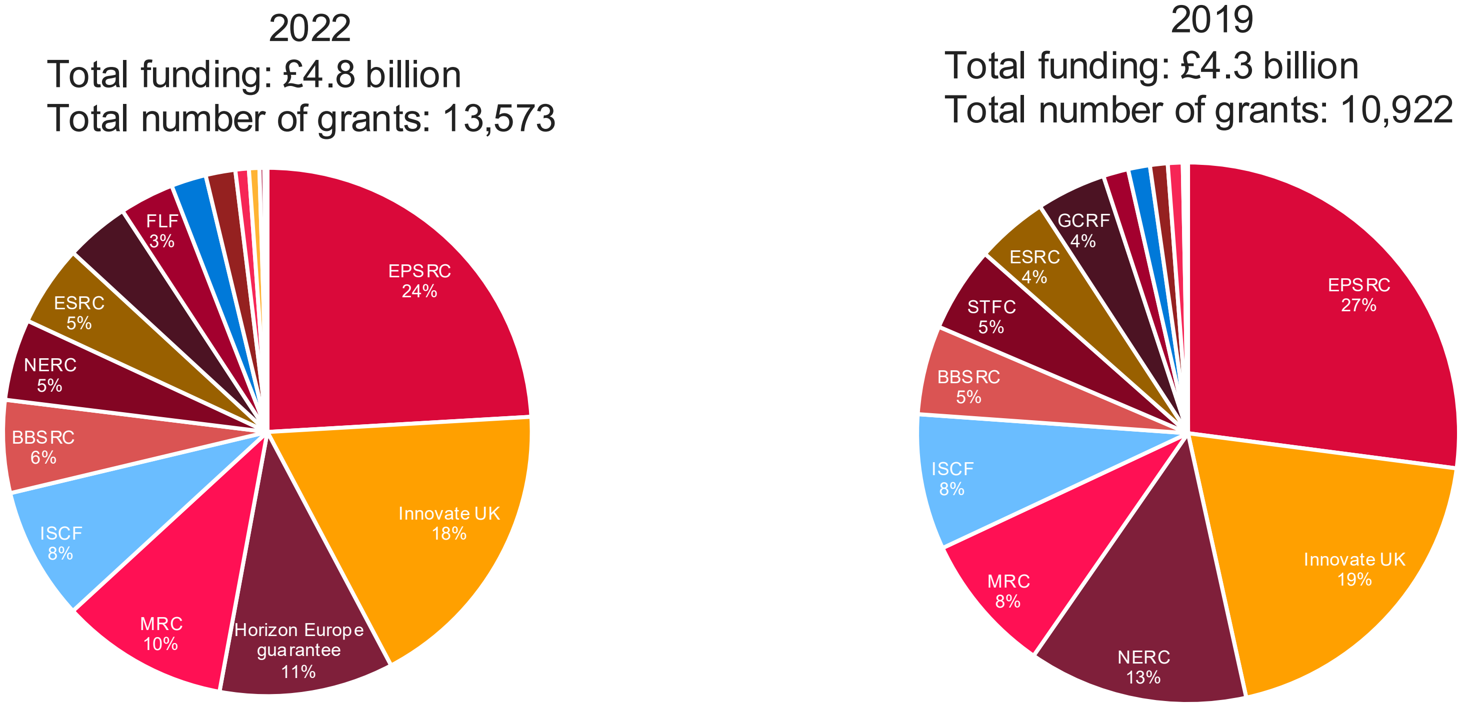
A.1 UKRI grants overview

UKRI grant summary data by awarded amount and number of projects for the years 2018–22 **(grant allocation year)***

	Amount awarded, in million £	No. of projects
2018	5,124	10,103
2019	4,302	11,007
2020	4,343	13,942
2021	3,730	11,658
2022	4,815	13,573
Grand total	22,314	60,283
average	4,463	12,057

Note: *Allocation year of grants is used here, meaning allocation of grants of several years may not be picked up if not within the years analysed here. This explains the discrepancy between UKRI funding allocated and grants awarded (e.g. £5.2 billion vs £4.8 billion in 2022). **Source:** UKRI GtR (2024). All data: Project search.

A.2 UKRI grants by funding organisation, 2022 and 2019



Source: UKRI GtR (2024). All data: Project search.

A.3 UKRI grants by programme category

UKRI grant summary data by awarded amount and number of projects in 2022

Programme category	Awarded amount in £	Number of projects
Research grant	2,362,203,886	3,481
Collaborative R&D	688,626,095	1,482
Training grant	472,639,821	271
EU-funded	372,848,693	1,054
Fellowship	347,380,198	622
BEIS-funded programmes	241,374,191	101
Small Business Research Initiative	84,711,603	105
Centres	78,741,945	8
Grant for R&D	52,658,060	684
Demonstrator	39,845,297	21
Knowledge Transfer Partnership	34,657,925	277
Innovation loans	14,439,724	15
Investment Accelerator	10,904,979	27
Feasibility studies	4,609,321	67
Research and innovation	4,003,048	7
Knowledge Transfer Network	2,036,471	5
Responsive strategy and planning	1,785,421	10
CR&D Bilateral	9,087,69	11
Study	712,901	3
Other grant	0	7
Studentship	0	5,227
Intramural	0	88
Grand total	**4,815,088,348**	**13,573**

Source: UKRI GtR (2024). All data: Project search.

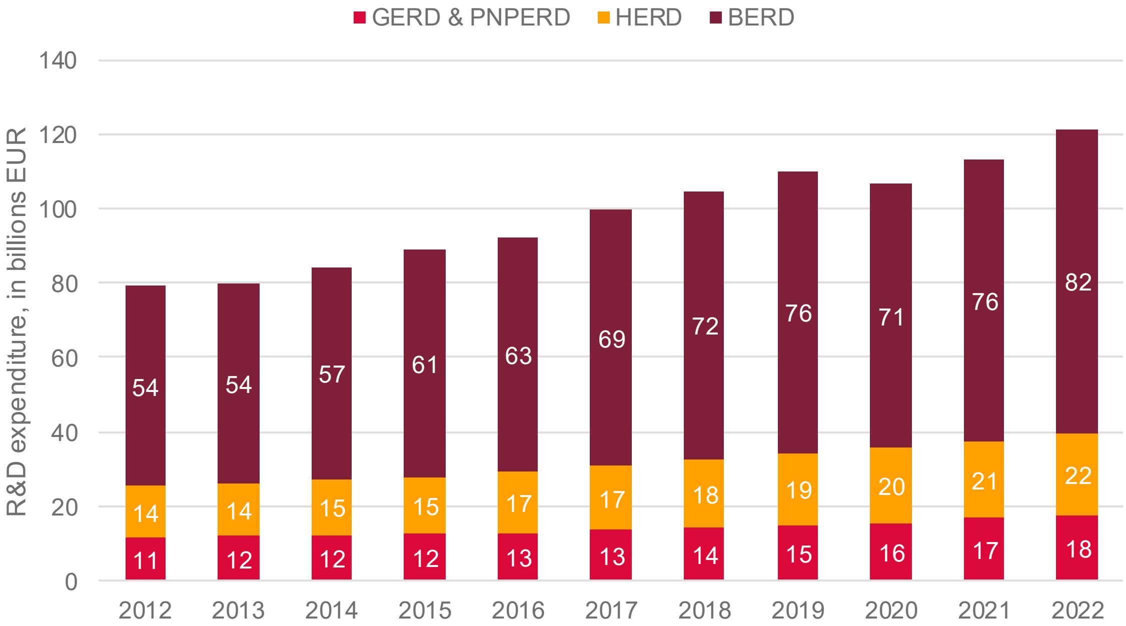
A.4 UKRI grants to the Centres programme (e.g. Catapults)

UKRI grant summary data by awarded amount in £ between 2018 and 2022

Row labels	2018	2019	2020	2021	2022	Grand total
HIGH VALUE MANUFACTURING CATAPULT	729,128,155				12,243,846	741,372,001
CELL THERAPY CATAPULT LIMITED	87,639,000		132,200,000			219,839,000
VACCINES MANUFACTURING AND INNOVATION CENTRE UK LTD	205,700,000					205,700,000
OFFSHORE RENEWABLE ENERGY CATAPULT	96,361,000		2,400,000			98,761,000
CONNECTED PLACES CATAPULT	20,000	93,707,000	22,542	59,865		93,809,407
SATELLITE APPLICATIONS CATAPULT LIMITED	78,121,016					78,121,016
DIGITAL CATAPULT	69,034,027			5,703,199	459,638	75,196,864
ENERGY SYSTEMS CATAPULT LIMITED	61,087,000		1,987,785			63,074,785
MEDICINES DISCOVERY CATAPULT LIMITED	62,466,655					62,466,655
COMPOUND SEMI CONDUCTOR APPLICATIONS CATAPULT	57,467,468					57,467,468
UK BATTERY INDUSTRIALISATION CENTRE LTD					51,610,000	51,610,000
CENTRE FOR PROCESS INNOVATION LIMITED		120,165	740,262	32,375,000		33,235,427
NEWCASTLE UNIVERSITY			33,000,000			33,000,000
AGRI-EPI CENTRE LIMITED	769,000	23,269,439				24,038,439
TRANSPORT SYSTEMS CATAPULT	19,335,600					19,335,600
CROP HEALTH AND PROTECTION LIMITED		19,130,385				19,130,385
FUTURE CITIES CATAPULT LIMITED	18,360,000					18,360,000
AGRIMETRICS LIMITED		13,364,465				13,364,465
UNIVERSITY OF ULSTER					12,650,927	12,650,927
CIELIVESTOCK LIMITED		8,956,619				8,956,619
HEALTH DATA RESEARCH UK	3,748,000					3,748,000
CELL THERAPY CATAPULT LTD	3,206,173					3,206,173
RTC NORTH LIMITED				2,362,515		2,362,515
EXEMPLAS LIMITED				2,362,515		2,362,515
THE CHRISTIE NHS FOUNDATION TRUST				2,222,862		2,222,862
THE NEWCASTLE UPON TYNE HOSPITALS NHS FOUNDATION TRUST				2,080,814		2,080,814
OPEN DATA INSTITUTE			2,000,000			2,000,000
COMPOUND SEMICONDUCTOR APPLICATIONS CATAPULT LIMITED				47,321	1,777,534	1,824,855
UNIVERSITY HOSPITALS BIRMINGHAM NHS FOUNDATION TRUST				1,458,124		1,458,124
CENTRE FOR INNOVATION EXCELLENCE IN LIVESTOCK	154,014					154,014
NCC OPERATIONS LIMITED	125,000					125,000
FUTURE CITIES CATAPULT	45,000					45,000
Grand total	**1,492,767,108**	**158,548,073**	**172,350,589**	**48,672,215**	**78,741,945**	**1,951,079,930**

Source: UKRI GtR (2024). All data: Project search.

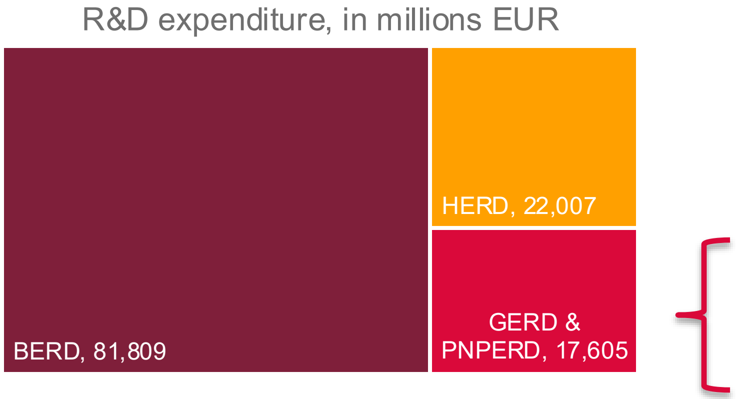
A.5 International comparison: Germany's R&D expenditure by funding sector over time



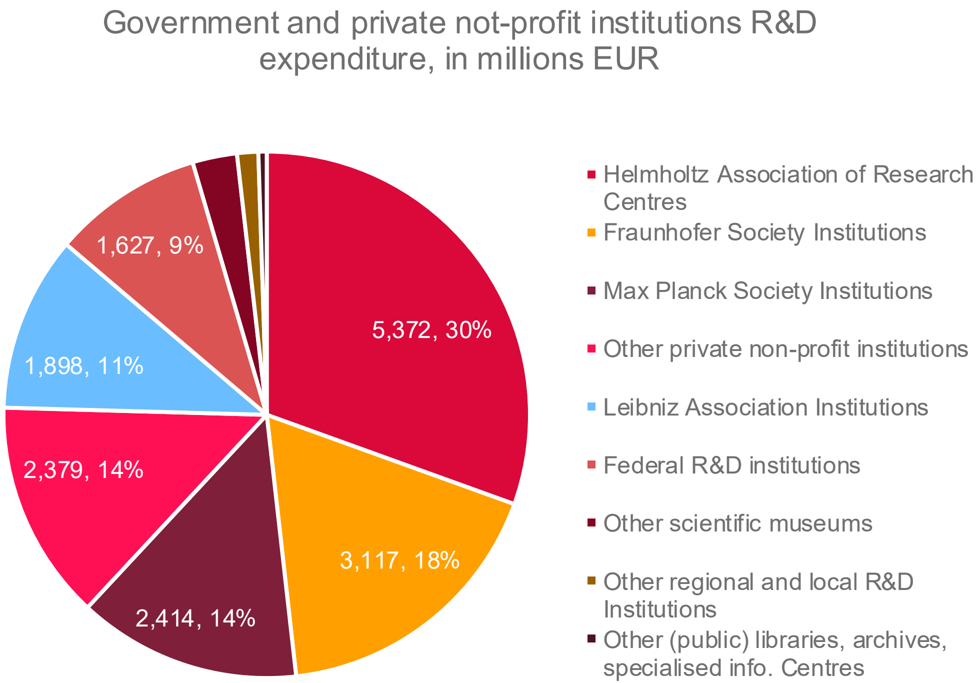
- Germany's R&D expenditure shows a steady increase over the past 10 years, from a total of €79.1 billion in 2012 to €121.3 billion in 2022 (approx. £65.7 billion to £100.8 billion, respectively).
- The largest share of this comes from BERD across all years.

Source: Statistisches Bundesamt (2024).

A.6 Germany's expenditure on R&D by funding sector in 2022



In 2022 expenditure on R&D performed in Germany was €121,421 million (approx. £100,779 million).



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Source: Statistisches Bundesamt (2024). ; Statistisches Bundesamt (2024).

A.7 Detail of national applied research organisations by funding in 2022

Applied research organisation	Year	Government core funding, in millions £	Other revenue, in millions £	Total revenue, in millions £	Employees	Institutes	Source	Note
Leibniz-Gemeinschaft (DE)	2022	1,364	445	1,809	21,166	97	Leibniz Association (2024). Reporting.	
A*STAR (SG)	2022/23	826	-	-	5,800	-	ASTAR (2023). Annual report April 2022-March 2023.	
NEDO New Energy and Industrial Technology Development Organisation (JP)	2022	832	-	-	1,412	-	NEDO (2023). NEDO Activity Report FY 2022.	
Fraunhofer-Gesellschaft (DE)	2022	791	1,740	2,531	30,350	76	Fraunhofer (2022). 2022 Annual Report.	Government core funding includes base funding and additional research funding (new). Other revenue includes industrial contract research, publicly funded contract research, other.
AIST National Institute of Advanced Industrial Science and Technology (JP)	2022	673	288	961	11,429	-	AIST (2023). AIST Report 2023.	Government core includes subsidy and facility maintenance grants. Other includes commissioned research, joint research revenue, IP revenue, technology consulting, and other.
Catapults (UK)	2022/23	289	427	716	6,000	9	Catapults.	Other revenue includes commercial income, collaborative R&D income, and other income.
AIT Austrian Institute of Technology (AT)	2022	53	98	152	missing	7	Austrian Institute of Technology (2022). 2022 annual financial statement.	The Republic of Austria is a shareholder of AIT (here shown under core government funding). Other funding includes contract R&D, co-financed revenues, and other.

Note: No values indicate missing data. Conversion rates used on 25 Feb 2024: 1EUR = 0.83GBP; 1JPY = 0.0053GBP; 1SGD = 0.59GBP.

A.8 Quantum keywords used to filter articles

ts=("quantum theory" SAME (qubit* OR "quantum bit*")) OR ts=("quantum hardware" OR "quantum device*" OR "quantum circuit" OR "quantum processor*" OR "quantum register*") OR ts=("quantum software" OR "quantum cod*" OR "quantum program*") OR ts=("quantum control*" OR "control* of quantum" OR "control over quantum" OR "quantum optimal control" OR "quantum state control" OR "control* quantum" OR "control* the quantum" OR "quantum coherent control") OR ts=(("quantum imag*") OR "ghost imag*") OR ts=((quantum NEAR/1 sensing) OR (quantum NEAR/1 sensor*)) OR ts=((quantum NEAR/10 metrology) OR (quantum NEAR/1 tomograph*) OR "atomic clock*" OR "ion clock*" OR "quantum clock*" OR "quantum gravimeter*") OR ts=("quantum simulat*" AND (qubit* OR "quantum bit*" OR "quantum comput*") OR "quantum simulator*") OR (ts="quantum simulat*" AND wc=("quantum science technology" OR "computer science theory methods")) OR ts=("quantum information*" OR "von Neumann mutual information" OR "quantum mutual information" OR "quantum Fisher information") OR ts=("quantum crypto*" OR pqcrypto* OR "quantum key distribution" OR "quantum encrypt*" OR (("quantum secur*" OR "quantum secre*") NOT ("quantum secreted" OR "quantum secretion"))) OR ts=("quantum communication*" OR "quantum network*" OR "quantum optical communication" OR "quantum state transmission*" OR (("quantum memor*" OR "quantum storage*") NEAR/5 photon*) OR "quantum repeater*" OR "quantum internet" OR ("quantum teleport*" AND ("qubit*" OR "quantum bit*" OR "entangle*"))) OR ts="quantum algorithm*" OR ts=("quantum comput*" OR "quantum supremacy" OR "quantum error correction" OR "quantum annealer" OR (quantum NEAR/2 (automata OR automaton)) OR "quantum clon* machine*") OR ts=(quantum NEAR/2 technolog*)

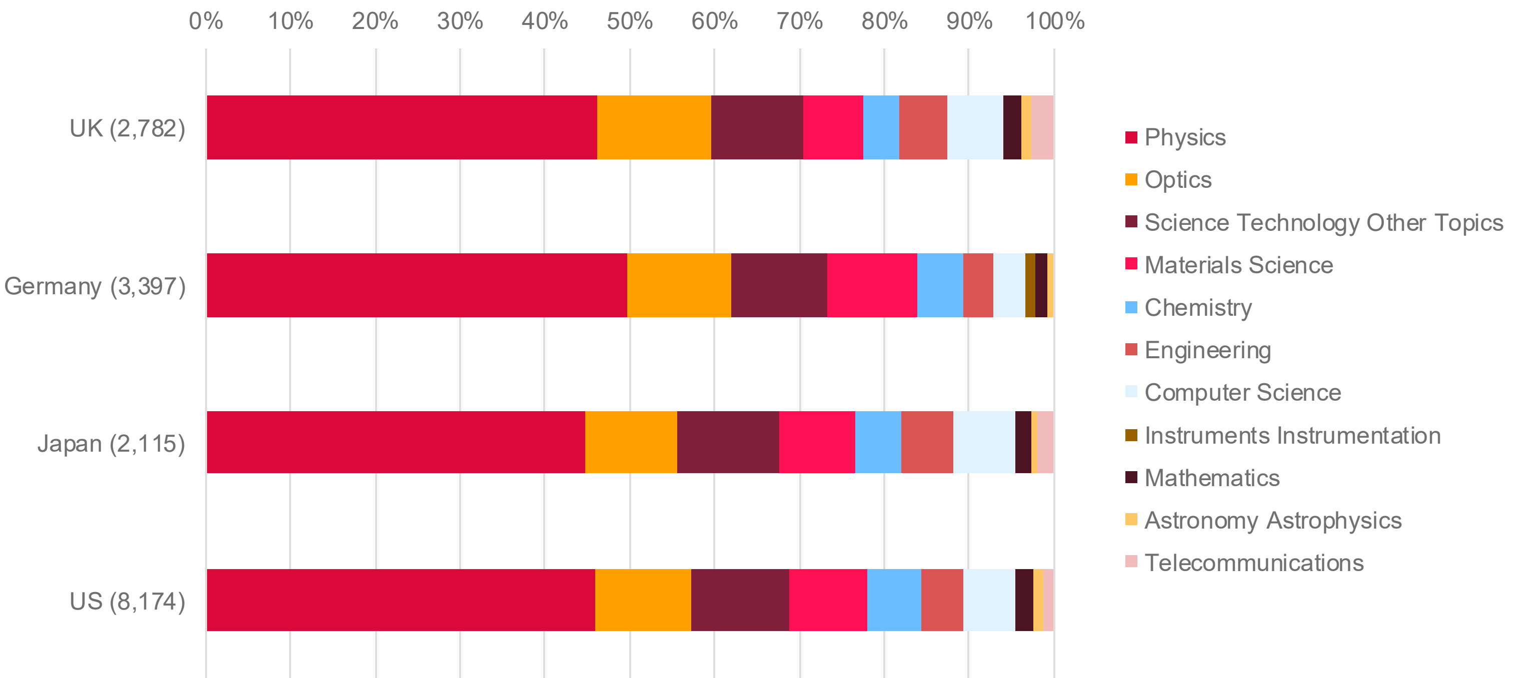
Source: Bornmann et al. (2019). Quantum technology – a bibliometric analysis of a maturing research field. Max Planck Society.

Note: Only journal articles were included. Quantum technology keywords filtered for quantum 2.0 technologies based on Bornmann et al. (2019). Publications filtered based on titles, abstracts, keywords (using Web of Science). Co-occurrence maps based on titles and abstracts and full counting of words.

Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

A.9 UK quantum publications are most significant in optics, computer science and telecommunications; and less prominent in chemistry and materials science

Academic quantum journal articles by research area between 2019 and 2023



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Note: Only journal articles were included. Quantum technology keywords filtered for quantum 2.0 technologies based on Bornmann et al. (2019). Publications filtered based on titles, abstracts, keywords (using Web of Science).
Source: CSTI (forthcoming). Policy brief: Emerging technology case studies: UK in an international comparative context.

Annex B

Sectoral orientation of UK expenditure on R&D

B.1 Methodology: Merging UKRI grants with SIC codes

1. UKRI GtR grant/project data downloaded for all available years. UKRI GtR (2024). All data: Project search.
2. Companies House data downloaded for SIC code classifications. Companies House (2024). Free Company Data Product.
3. Project lead research organisation (in 1.) and company name (in 2.) normalised – spaces, punctuations and capitalisations all normalised to increase the number of matches.
4. Data 1. and 2. merged based on the normalised value.
5. Data checked for duplicates, cleaned and compared to original for the selected year of 2022.

   For 2022, 7,493 projects matched with SIC codes (out of 13,573). But 4,193 of these had the SIC code "none supplied", and 401 were "dormant companies", leaving 2,899 projects with SIC codes for analysis.

Total	4,815,088,348	13,573
None supplied SIC (matched with SIC classification "none supplied")	1,283,662,824	4,193
NA (no SIC or not matched)	2,022,566,663	6,080
With SIC = total - [none supplied] - [NA]	1,508,858,861	3,300
With SIC, excl. dormant company = total - [none supplied] - [NA] - [dormant company]	1,281,925,045	2,899
Dormant company	226,933,816	401

B.2 Share of the amount of UKRI grant funding awarded, matched with SIC codes (one digit), 2022

Grants matched with SIC: £1.3 billion

Share of total funding: 27%

Row labels	Sum of award pounds_1
PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	455,083,849
MANUFACTURING	353,267,086
INFORMATION AND COMMUNICATION	150,998,107
OTHER SERVICE ACTIVITIES	119,664,279
EDUCATION	58,243,588
ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	54,394,424
WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	17,314,983
TRANSPORTATION AND STORAGE	13,887,776
HUMAN HEALTH AND SOCIAL WORK ACTIVITIES	13,380,334
FINANCIAL AND INSURANCE ACTIVITIES	9,151,002
WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	8,779,020
AGRICULTURE, FORESTRY AND FISHING	8,081,107
CONSTRUCTION	6,095,871
ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	5,765,287
ARTS, ENTERTAINMENT AND RECREATION	2,785,714
REAL ESTATE ACTIVITIES	1,784,669
MINING AND QUARRYING	1,728,893
PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY	953,299
ACCOMMODATION AND FOOD SERVICE ACTIVITIES	425,716
Grand total	**1,281,785,002**

Note: If an organisation has several SIC codes, the grant amount awarded is divided by equal shares. Grant start date was used. The data also includes universities, where these have been assigned an SIC code. **Source:** UKRI GtR (2024). All data: Project search.; Companies House (2024). Free Company Data Product.

B.3 Share of the amount of UKRI grant funding, matched with SIC codes under Section M: PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES, five digit, 2022

SIC codes at lowest disaggregation	Sum of amount of UK grants awarded
72190 – Other research and experimental development on natural sciences and engineering	132,758,806
74909 – Other professional, scientific and technical activities n.e.c.	126,979,780
72110 – Research and experimental development on biotechnology	60,711,200
70100 – Activities of head offices	25,990,647
71122 – Engineering-related scientific and technical consulting activities	23,710,487
71121 – Engineering design activities for industrial process and production	17,265,155
70229 – Management consultancy activities other than financial management	17,186,451
72200 – Research and experimental development on social sciences and humanities	10,956,502
71129 – Other engineering activities	10,771,994
74100 – Specialised design activities	8,366,598
75000 – Veterinary activities	7,775,332
71200 – Technical testing and analysis	4,783,190
74901 – Environmental consulting activities	4,747,693
71111 – Architectural activities	1,731,802
69102 – Solicitors	348,140
70210 – Public relations and communications activities	335,078
73200 – Market research and public opinion polling	270,096
73110 – Advertising agencies	146,688
74300 – Translation and interpretation activities	67,858
74209 – Photographic activities not elsewhere classified	61,793
69203 – Tax consultancy	40,770
69109 – Activities of patent and copyright agents; other legal activities n.e.c.	36,325
69201 – Accounting and auditing activities	16,615
71112 – Urban planning and landscape architectural activities	12,476
69202 – Bookkeeping activities	12,376
Grand total	**455,083,849**

Note: If an organisation has several SIC codes, the grant amount awarded is divided by equal shares. Grant start date was used. The data also includes universities, where these have been assigned an SIC code. **Source:** UKRI GtR (2024). All data: Project search.; Companies House (2024). Free Company Data Product.

B.4 Share of the amount of UKRI grant funding, matched with SIC codes under Section C: MANUFACTURING, five digit, top 50 codes, 2022

Note: If an organisation has several SIC code classifications, each accounts for an equal share of the grant awarded.
Source: UKRI GtR (2024). All data: Project search.; Companies House (2024). Free Company Data Product.

Row labels	Sum of award pounds 1
30300 – Manufacture of air and spacecraft and related machinery	103,635,722
29100 – Manufacture of motor vehicles	19,484,088
25620 – Machining	18,956,148
28110 – Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	18,205,995
25300 – Manufacture of steam generators, except central heating hot water boilers	17,361,124
26110 – Manufacture of electronic components	14,525,408
32990 – Other manufacturing n.e.c.	13,994,890
27900 – Manufacture of other electrical equipment	13,333,458
32500 – Manufacture of medical and dental instruments and supplies	9,794,955
20590 – Manufacture of other chemical products n.e.c.	8,699,694
26511 – Manufacture of electronic measuring, testing etc. equipment, not for industrial process control	8,272,602
23130 – Manufacture of hollow glass	6,605,000
29320 – Manufacture of other parts and accessories for motor vehicles	6,345,893
29310 – Manufacture of electrical and electronic equipment for motor vehicles and their engines	6,271,998
28960 – Manufacture of plastics and rubber machinery	5,368,509
28990 – Manufacture of other special-purpose machinery n.e.c.	5,005,455
20160 – Manufacture of plastics in primary forms	4,423,542
30910 – Manufacture of motorcycles	4,262,804
22290 – Manufacture of other plastic products	4,096,024
25990 – Manufacture of other fabricated metal products n.e.c.	4,068,596
26200 – Manufacture of computers and peripheral equipment	3,683,861
27200 – Manufacture of batteries and accumulators	3,650,442
25110 – Manufacture of metal structures and parts of structures	2,900,869
27110 – Manufacture of electric motors, generators and transformers	2,537,721
28921 – Manufacture of machinery for mining	2,249,881
28150 – Manufacture of bearings, gears, gearing and driving elements	2,162,089
33140 – Repair of electrical equipment	1,990,097
26309 – Manufacture of communication equipment other than telegraph, and telephone apparatus and equipment	1,674,571
20130 – Manufacture of other inorganic basic chemicals	1,644,877
26400 – Manufacture of consumer electronics	1,636,462
28302 – Manufacture of agricultural and forestry machinery other than tractors	1,627,795
10310 – Processing and preserving of potatoes	1,516,826
10890 – Manufacture of other food products n.e.c.	1,468,683
21200 – Manufacture of pharmaceutical preparations	1,408,302
21100 – Manufacture of basic pharmaceutical products	1,367,033
30990 – Manufacture of other transport equipment n.e.c.	1,353,139
23690 – Manufacture of other articles of concrete, plaster and cement	1,352,283
26512 – Manufacture of electronic industrial process control equipment	1,313,485
26600 – Manufacture of irradiation, electromedical and electrotherapeutic equipment	1,177,121
26701 – Manufacture of optical precision instruments	1,168,273
33200 – Installation of industrial machinery and equipment	1,147,699
22220 – Manufacture of plastic packing goods	1,067,015
20110 – Manufacture of industrial gases	987,042
31030 – Manufacture of mattresses	882,626
28910 – Manufacture of machinery for metallurgy	862,277
30110 – Building of ships and floating structures	713,946
14190 – Manufacture of other wearing apparel and accessories n.e.c.	687,807
23990 – Manufacture of other non-metallic mineral products n.e.c.	679,507
20140 – Manufacture of other organic basic chemicals	649,736
33130 – Repair of electronic and optical equipment	**630,546**

Annex C

Mechanisms aligning basic and applied research

C.1 Mechanisms aligning basic and applied research (1/5)

The USA

- **National Science Foundation grant funding for projects that align with the technical focus areas of the Manufacturing USA Institutes.** The goal is to "facilitate the transition of promising research results and educational programs to them, leverage the programs, facilities, infrastructure, expertise, and member companies of one or more Institutes, and/or provide experiential learning opportunities for students"

Germany

- **DFG Transfer projects.** Transfer projects in collaborative research centres test the findings of basic research under real-life conditions or to develop them, in collaboration with an application partner, into a prototype or an exemplary application. Their goal is to transfer knowledge between research and application, to the benefit of both sides.
- **DFG Transfer projects with the Fraunhofer Society.** By issuing joint calls for proposals for trilateral transfer projects, the DFG and the Fraunhofer Society are seeking to close the gap that often exists between basic research and application, supporting the use of fundamental scientific findings in all areas. Funding is provided for projects pursued by consortia consisting of scientists at universities, universities of applied sciences (HAW or FH) and Fraunhofer Institutes in cooperation with application partners, with no limitations on topics.

C.1 Mechanisms aligning research with industrial needs (2/5)

Germany

- **Fraunhofer model of performance-based basic funding.** The Fraunhofer model of performance-based basic funding creates a steering mechanism to align research to application, reward successful transfer, and strengthen strategic focus on application possibilities and future needs in all organisational units.
    - A large proportion of the base funding is allocated directly to the Fraunhofer Institutes on the basis of a distribution key that is fed by **performance-related indicators**. The most important indicator is the institute's economic return, namely **the direct contracts awarded by companies**. This mechanism promotes a constant orientation of the institutes to the needs of (potential) clients, who then use the research results – mostly technologies or technology-related knowhow – outside the sphere of science.
    - Even the development of new competencies within the Fraunhofer Institutes – which is financed from the basic funding distributed to them and continued through acquiring public projects – always keeps future application scenarios in mind, so the institute can again successfully acquire contract projects.
- **German Agency for Transfer and Innovation (DATI).** The core tasks of DATI are:
    - Networking and activating transfer partners (for example, matching science and business)
    - Information, advice and coaching (for example, disseminating tried-and-tested standards for knowledge and technology transfer)
    - Creating innovative, needs-based funding offers: in particular, further development of the funding formats “Innovation Sprints” and “Innovation Communities” from DATI pilot, as well as prospectively needs-based development of new funding formats
    - Also, DATI aims to provide an impetus to develop the German system of promoting transfer and innovation. The impetus can be, for example, best-practice examples, identified funding needs or findings from the use of new funding approaches.
- **Federal government research funding through the German Federation of Industrial Research Associations (AiF).** Each year, €535 million in public funding is channelled via the AiF into industrial research and the transfer of research findings into commercial use. It is the biggest source of research funding for the SME sector.
- **Central Innovation Program for SMEs (ZIM) – Cooperation projects.** Funding of cooperative R&D projects between SMEs or between SMEs and public and private non-profit research and technology organisations (RTOs). There are several ways to set up a ZIM cooperation project:
    - R&D cooperation projects between at least two companies
    - R&D cooperation projects between at least one company and at least one RTO.

    These include the possibility for companies within their sub-project to award an R&D contract to a research partner (min. 30% and max. 70% of the eligible person-months) and for companies and RTOs to involve a subcontractor for external services (max. 25% of the eligible personnel costs).

C.1 Mechanisms aligning research with industrial needs (3/5)

Switzerland

- **Knowledge and technology transfer (KTT) services.** KTT is one of the tasks of the Federal Institutes of Technology (ETH Domain), cantonal universities and universities of applied sciences. Since these institutions traditionally focus on teaching and research, KTT takes place primarily via graduates who work in companies ("transfer via heads"). There are three main institutional forms for KTT services:
    - KTT service totally integrated into the university or institute of technology
    - KTT service integrated into the university or institute of technology, but management is decentralised across faculties and departments
    - KTT carried out by a company owned by several universities. The universities of Zurich, Berne and Bâle adopted this solution with its company Unitectra AG.
- **Centres de Competénce Technologique.** These are centres that have the mandate to cooperate with universities and private companies. Examples are:
    - Centre Suisse d'Electronique et de Microtechnique (CSEM)
    - Inspire SA society, in Zurich and Saint-Gall
    - Institut Suisse pour la médecine translationnelle et l'entrepreneuriat, Berne (Sitem-Insel SA)
    - Swiss m4m Center et ANAXAM – supported by the AM-TTC (Advanced Manufacturing Technology Transfer Centers) initiative.
- **Swiss Innovation Park**, which links science and business, is a key location for KTT. Under the umbrella brand of "Switzerland Innovation", the park currently comprises six main sites, situated near Switzerland's two federal institutes of technology (ETH Zurich and EPFL in Lausanne), in Aargau, Northwestern Switzerland, Biel and Eastern Switzerland. Other regional sites are connected to these main sites.
    - Technology transfer or KTT offices have been established to encourage and support KTT. These offices vary in terms of institutional structure and content. In addition, Innosuisse instruments are also designed to intensify KTT between researchers and businesses.

C.1 Mechanisms aligning research with industrial needs (4/5)

Japan

- **Innovation Japan: University Technology Exhibition.** This programme provides opportunities for industry–academia collaboration and technology transfer by **bringing together technology seeds from universities across Japan and showcasing them for business enterprises.** This exhibition, particularly the new technology exhibition, is the largest event in Japan **helping to match research seeds with industrial needs**, especially in new technologies (part of the Technology Transfer Support Center Program). Responsible entity: JST/NEDO.

- **Program for Collaborative Research Based on Industrial Demand.** This programme supports universities engaged in **basic research that can help to solve technological problems shared by industries**. The programme accelerates solutions to technological issues by establishing a platform for "**collaborative creation" (dialogue between the industrial and academic sectors)** to transfer knowledge and ideas from market to research. Responsible entity: JST.

- **Leading Industrial Technology Development Project Grant Funds (Grants for Young Researchers):** With the aim of identifying industrial technology seeds that can address the needs of industry and society and developing human resources for industrial technology research, **this programme provides financial support so that young researchers at universities and incorporated administrative agencies can carry out research and development for industrial applications** (renamed from the Industrial Technology Research Grant Program, launched in 2000). Responsible entity: METI .

- **Public-Private Innovation Program: closed in 2012.** The national government invests in universities and other things to **promote public–private partnership** research and development projects **to transform research and development outcomes into businesses and products**. Responsible entity: MEXT.

- **Support Program for Strengthening the Creation of Seeds and Needs of Universities.** With the aim of supporting activities to create innovation from universities and other things, and efforts to **identify subjects for collaborative studies** in accordance with the visions of the COI STREAM, this programme explores new seeds, needs, ideas and other things. Responsible entity: MEXT.

- **Cross-ministerial Strategic Innovation Promotion Program (SIP).** The CSTI allocates budget across ministries and sectors to promote measures, including regulatory and institutional reforms, to **create a seamless process from basic research to applications (commercialisation and business development)**. Programme directors are appointed on an issue-by-issue basis. Responsible entity: CSTI.

C.1 Mechanisms aligning research with industrial needs (5/5)

Singapore

- **Industry Alignment Fund – Industry Collaboration Project (IAF-ICP).** Supports public research performers in strategic R&D collaborations with industry. The aim is to foster industry-relevant public-sector R&D efforts, and public research performers to collaborate with industry, with a line of sight to potential economic outcomes. This grant is different from typical academic grants, as proposals are assessed primarily on their potential economic impact and relevance to building up Singapore's R&D ecosystem:
    - Potential to generate product or process innovations to the industry player(s) involved (i.e. improved processes or products)
    - Potential to generate higher economic or R&D activity for industry player(s) involved (e.g. through creation of R&D jobs, increased market share, reduced costs and improved productivity)
    - Potential to deepen tech-or-people capabilities in local companies (e.g. through upskilling, enhanced training and development of new IPs)
    - Ability to uplift the ecosystem (e.g. by fostering collaboration with other local enterprises such as suppliers)
    - Level of the industry partner's commitment to research and innovation in Singapore
    - Other relevant factors.
- **Industry Alignment Fund – Pre-Positioning Programme (IAF-PP).** The aim of this grant is to develop industry-ready capabilities to deepen the alignment of public sector research, as well as multidisciplinary and integrated programmes with early industry involvement. Programmes are expected to lead to industry participation within 3–5 years. This encompasses new programmes, as well as existing programmes that have demonstrated a strong track record of success and industry potential. **Key criteria: potential for industry development and economic impact.**

About us

Cambridge Industrial Innovation Policy

Cambridge Industrial Innovation Policy (CIIP) is a global, not-for-profit policy group based at the Institute for Manufacturing (IfM), University of Cambridge. CIIP works with governments and global organisations to promote industrial competitiveness and technological innovation. We offer new evidence, insights and tools based on the latest academic thinking and international best practices.

This report was delivered through IfM Engage, the knowledge-transfer arm of the IfM.

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