Quantum Ecosystem Mapping report

NPL | Beauhurst

Contents

Foreword

“The National Physical Laboratory (NPL), as the UK’s national metrology institute, plays a major role across the full scale and scope of the UK National Quantum Technologies Programme **(NQTP)**. In support of its objectives, the NPL Quantum Programme (NPLQP) uses our wide range of capabilities, delivered with the discipline of international metrology and coupled with our independence, to support the UK quantum economy.

In order for this to occur, NPL’s quantum programme works with the broader UK quantum ecosystem to help them develop products with confidence and prove value to customers, end users and investors. This is vital for both NPL and public R&D more broadly, given that their respective economic benefits are channelled through the private sector. To help NPL better understand the quantum ecosystem, this report was commissioned to understand its scale, shape and interests. It provides useful information such as the £282 billion of GVA that these companies account for, while breaking new ground for NPL, as it assesses our R&D ecosystem in a data-driven way. This will be something that will likely be repeated in the future for other scientific areas. This particular study will help to provide important information to help inform programme planning, decision-making and evidence submissions to the government – which is particularly notable now given that we are currently going through Spending Review.

NPL

Introduction

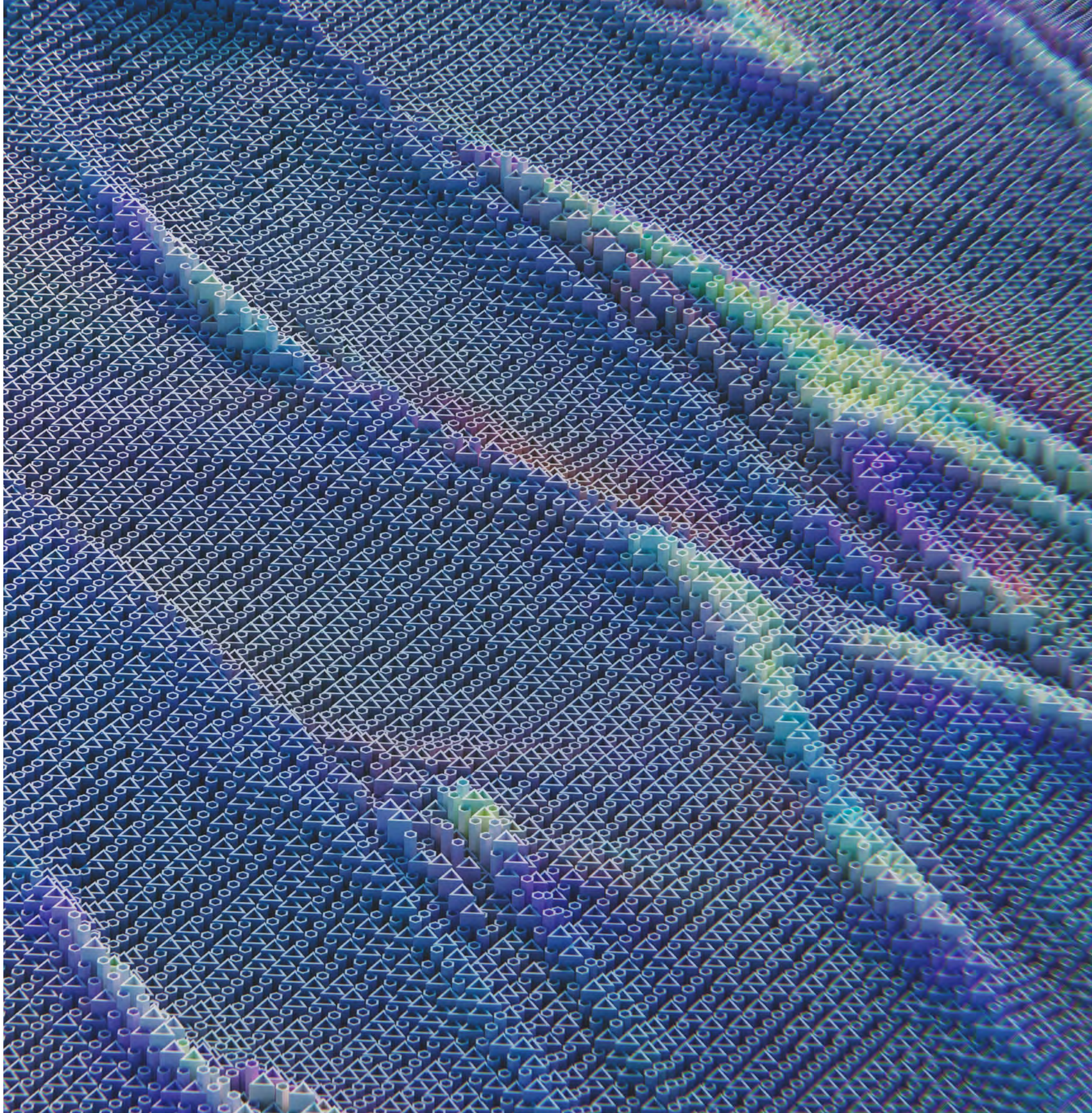
This report was commissioned by the National Physical Laboratory (NPL) to understand the size, nature, and demography of its UK-based quantum ecosystem. Using Beauhurst's extensive search capabilities, a bespoke methodology has been developed to produce a cohort of companies that make up the UK's market for quantum measurement and science services.

This cohort was produced using a specialised list of 49 'quantum-specific' keywords and phrases. These were developed using NPL's six quantum capabilities.[1] These keywords were used across three search methods: company descriptions, grant descriptions and abstracts, and patent abstracts, on the Beauhurst platform to identify matches with other companies. The data was then carefully cleaned to ensure relevance and accuracy. Inactive and recruitment companies were removed, as were companies whose names matched keywords but were not actually engaged in quantum-related activities. The total number of companies identified using this method is 771. These 771 companies are referred to as the 'identified quantum companies' throughout this report.

Full details of the methodology can be found on **page 44** of this report.

The remainder of this report outlines the sub-sectors, regional distribution, scale, turnover, patents, grants and private equity investment for the identified quantum companies.

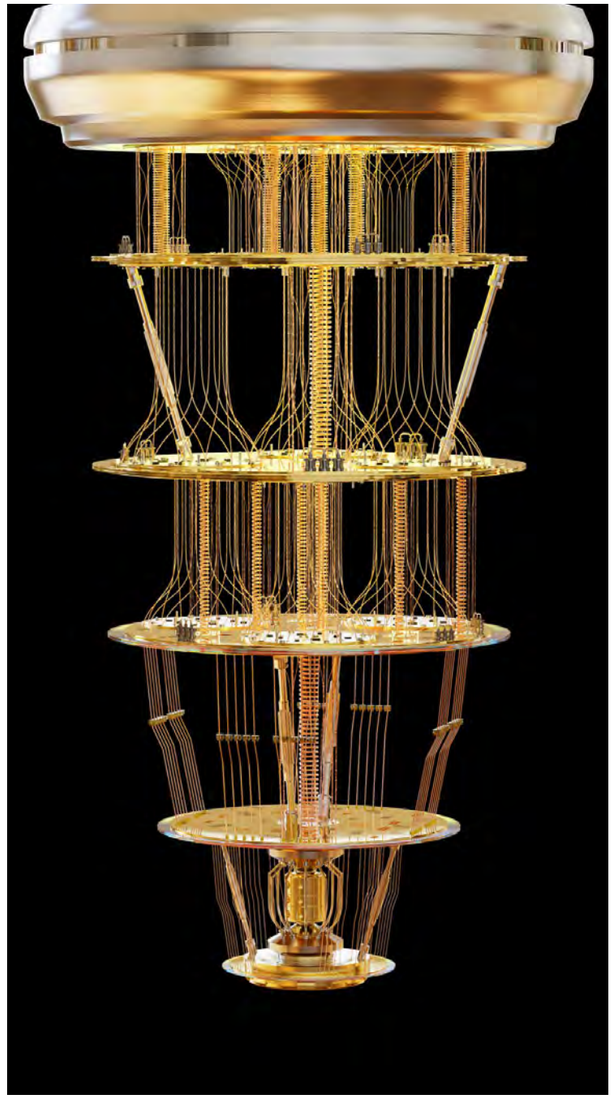
[1] NPL, Quantum technologies.
Available from: https://www.npl.co.uk/quantum-technologies



1.0

NPL quantum capabilities overview

This section contains an overview of how quantum principles have led to the development of quantum technologies. It explains NPL's main functions and how it supports businesses operating in the quantum sector.



What is Quantum technology?

Quantum technology is a transformative field based on the principles of quantum mechanics, a branch of physics that describes the behaviour of matter and energy at atomic and subatomic levels. Quantum mechanics introduces concepts such as superposition (where particles can exist in multiple states) and entanglement (where particles are interconnected regardless of distance). These concepts enable breakthroughs that can define industries and offer capabilities beyond traditional technology. The UK is a global leader in the development of quantum technologies, which have applications in computing, communication, sensing, and imaging.

What does NPL do?

The NPL is the UK's National Metrology Institute (NMI). It is responsible for maintaining the UK's primary measuring standards and collaborating with other NMIs to maintain the international system of scientific measurement. NPL works across various sectors, including aerospace, finance, quantum, and life sciences, offering services such as commercialisation, composite testing, and optical measurement.

NPL's Quantum Metrology Institute (QMI) is a branch of the NPL that focuses on providing the measurement expertise and facilities needed to underpin the development of quantum technologies. It brings together all of NPL's leading-edge quantum science and metrology research to test, validate, and commercialise new quantum technologies. The two focus areas of the QMI are quantum technologies research and quantum time and frequency.

The QMI also aims to deliver the NPL Quantum Programme. The quantum programme fits into the UK's National Quantum Technologies Programme (NQTP). The principal objectives of the NQTP are to drive significant economic growth and enhance national security and resilience through the development and application of quantum technologies. The NPL is supporting the objectives of the NQTP through the NPL Quantum Programme. Using its wide range of capabilities, delivered with the discipline of international metrology, to ensure that new products by UK-based companies are brought to market more quickly and more successfully, and new standards and regulations should help and not hinder the development of the UK economy.

"We are enabling the UK quantum industry to develop products with confidence and prove value to customers, end users and investors. In doing so, we are contributing to UK economic growth, creating high-skilled jobs and building a more secure and resilient UK.

NPL

Some examples of the NPL's quantum programme in practice include its contributions to global timekeeping, and the Measurement for Quantum (M4Q) programme. the NPL conducts research in time and frequency metrology, including developing a new generation of optical atomic clocks. These developments can potentially improve satellite navigation systems and test fundamental physical theories. The M4Q programme run by The NPL provides businesses with specialist quantum measurement expertise to help solve their measurement challenges. The programme is designed to assist companies in moving from a prototype to a new product or service that is ready for market.

NPL's quantum capabilities for industry

The NPL's Quantum Test and Evaluation programme (QTE) is designed to support UK industry and assist in the commercialisation of quantum technology. As part of the QTE, the NPL has created a list of six capabilities that support UK businesses in developing new products and services based on quantum technologies. Each broader category of quantum capability can be split into more specific sub-categories that can be found on NPL's **website.**

The NPL's six quantum capabilities are quantum computing, quantum communication, quantum sensors, quantum materials, quantum time and frequency, and quantum electrical measurement. Each capability is then divided into various sub-categories, which utilise the NPL's range of equipment and knowledge areas.

Quantum computing uses quantum bits, or qubits, which can exist in multiple states simultaneously. This allows for more complex calculations than traditional computers, which rely on binary logic (using 1s and 0s), limiting their ability to handle complex problems. This technology has applications across finance, materials science, and artificial intelligence industries.

Quantum communications offer security through quantum cryptography, which uses quantum entanglement to ensure that any attempt to intercept information disrupts the transmission and is immediately detectable.

Quantum sensors use quantum mechanics principles to measure physical quantities with improved accuracy. These sensors are used in atomic clocks, navigation, and medical imaging, offering enhanced sensitivity compared to classical devices.

Quantum materials are advanced materials whose properties arise from quantum phenomena like spin or charge. Quantum materials include superconductors and graphene and these materials have led to breakthroughs in fields including energy, electronics, and computing.

Quantum time and frequency technologies focus on achieving precision in timekeeping and frequency measurement. Advancements in this field have led to developments in areas such as navigation and telecommunications. Innovations include quantum clocks, which allow for extremely precise timing and underpin many important technologies, including communication systems, transport systems, and financial trading.[2]

Quantum electrical measurement harnesses quantum principles for precise electrical metrology, which can be used to measure electrical quantities such as voltage, current, and resistance. This allows for the measurement and characterisation of semiconductor devices and the evaluation of nano-scale single-electron devices.

The identified quantum companies have been grouped into NPL's six capabilities. A company can be included across multiple capabilities, see the methodology on page 44 to find out more. Nearly half (361) of the identified quantum companies conduct activities that relate to NPL quantum electrical measurement capability. Companies in this category are operating in areas that use cryogenics (very low temperatures) for electrical devices and nano-scale devices. Oxford nanoSystems falls into this group. Based in Oxfordshire, it develops nanocoatings that enhance energy transfer systems, allowing for electrolysers and heat exchangers to be made smaller, lighter and more efficient. Oxford nanoSystems has already worked with NPL.

Quantum computing is the second most common NPL capability in the identified quantum companies. Companies in this group include ORCA Computing, Oxford Ionics, and Fraunhofer UK Research, these companies are known for their activities in the quantum computing field. However, there are some larger companies, such as HSBC Bank, Standard Chartered Bank, and Ernst & Young (EY), all of which have received grants related to quantum computing. In 2023, in collaboration with ORCA Computing, EY received a grant to assess the impact of novel algorithms that use data science and quantum computing to optimise the placement of wind turbines for maximum energy output and cost efficiency.

[2] "Inside Quantum Technology's inside Scoop: Quantum and Atomic Clocks." Inside Quantum Technology. December 22, 2022 https://www.insidequantumtechnology.com/news-archive/inside-quantum-technologys-inside-scoop-quantum-and-atomic-clocks-2/.

Number of companies by NPL capability

2.0

Business demography

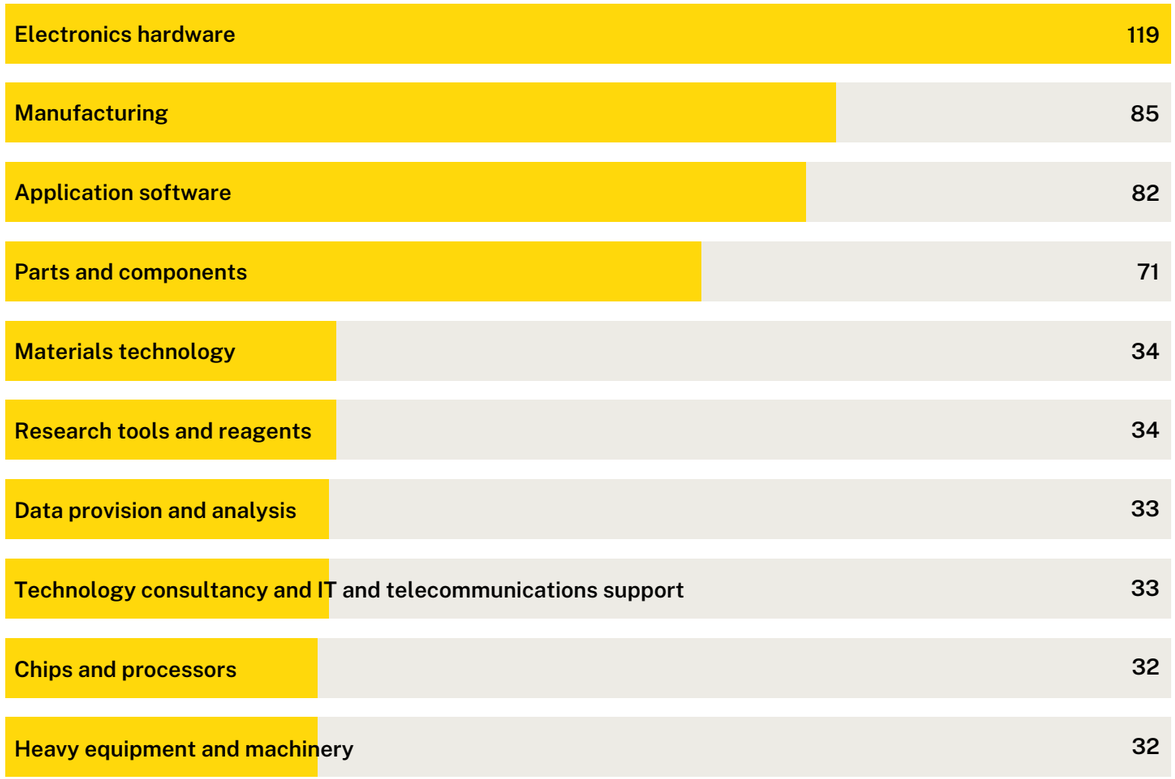
This section provides the sub-sectors, geographic distribution, and private and public investment, for the identified quantum companies.

3.0

Sub-sectors

The identified quantum companies operate in a range of sub-sectors alongside their quantum activities. These include sub-sectors such as manufacturing and electronics hardware, where companies can utilise quantum technology to advance their existing operations.

Top sub-sectors in identified quantum companies (2024)



Sub-sectors

The leading sub-sector within the identified quantum companies is electronics hardware, comprising 119 companies—15.4% of the total. This sub-sector plays a pivotal role as these companies develop critical components essential for building and operating quantum devices, including computers, sensors, and communication systems. Operating in this space is Oxford Quantum Circuits, which develops superconducting circuits for quantum computers. Based in the Thames Valley Science Park, Reading, it pioneered the delivery of the first quantum computing-as-a-service using its proprietary technology.

Out of the identified quantum companies, 85 operate in the manufacturing sub-sector. Manufacturing is considered to be closely associated with electronics hardware. These two sub-sectors are often linked, with significant overlap—27.1% of manufacturing companies in the cohort also classify as electronics hardware firms. This reflects the interdependence between cutting-edge manufacturing techniques and advancements in hardware, bringing quantum innovations from prototype to production. The application software sub-sector comprises 82 companies, representing 10.6% of the identified quantum companies. These companies bridge the gap between quantum hardware and its real-world applications, driving advancements in quantum computing algorithms, simulation tools, and user interfaces. Among the application software companies is QuantrolOx, a spinout from the University of Oxford developing machine learning algorithms for quantum computers.

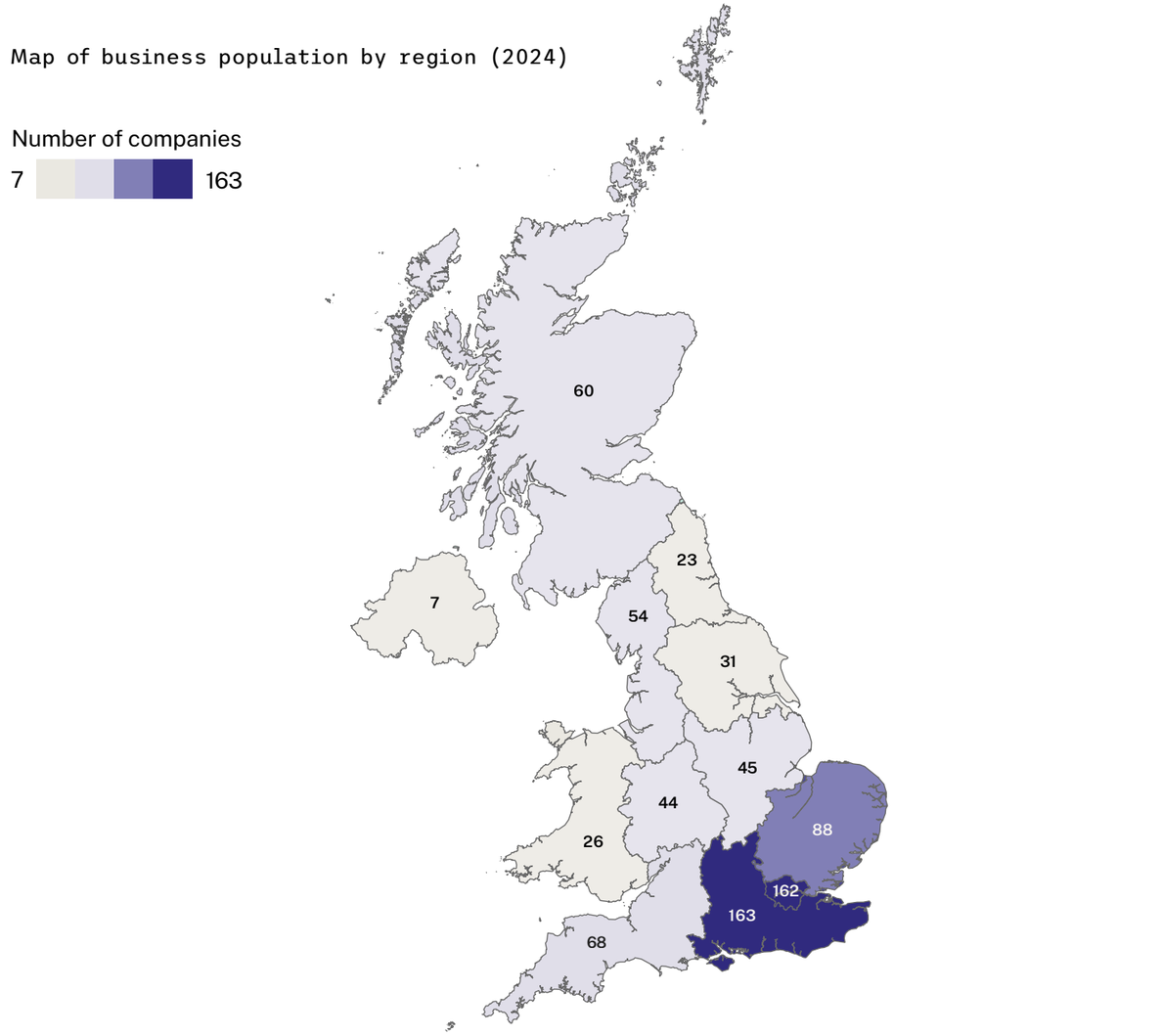
There are 34 companies representing the research tools and reagents subsector. While these companies do not always directly engage in quantum activities, they play a crucial role as enablers of innovation. By supplying essential equipment and materials to academic and industrial laboratories, they lay the groundwork for breakthroughs in quantum research and technology. One notable company in this space is Zaiku Group, based in Liverpool. The company provides research services in the fields of quantum computing, AI, and cloud computing.

3.1

Regional distribution

The majority of companies in this cohort are based in the Golden Triangle, a science cluster known for innovation and world-class academic institutions. Scotland also has a strong quantum base centred on photonics.

Map of business population by region (2024)



Regional distribution

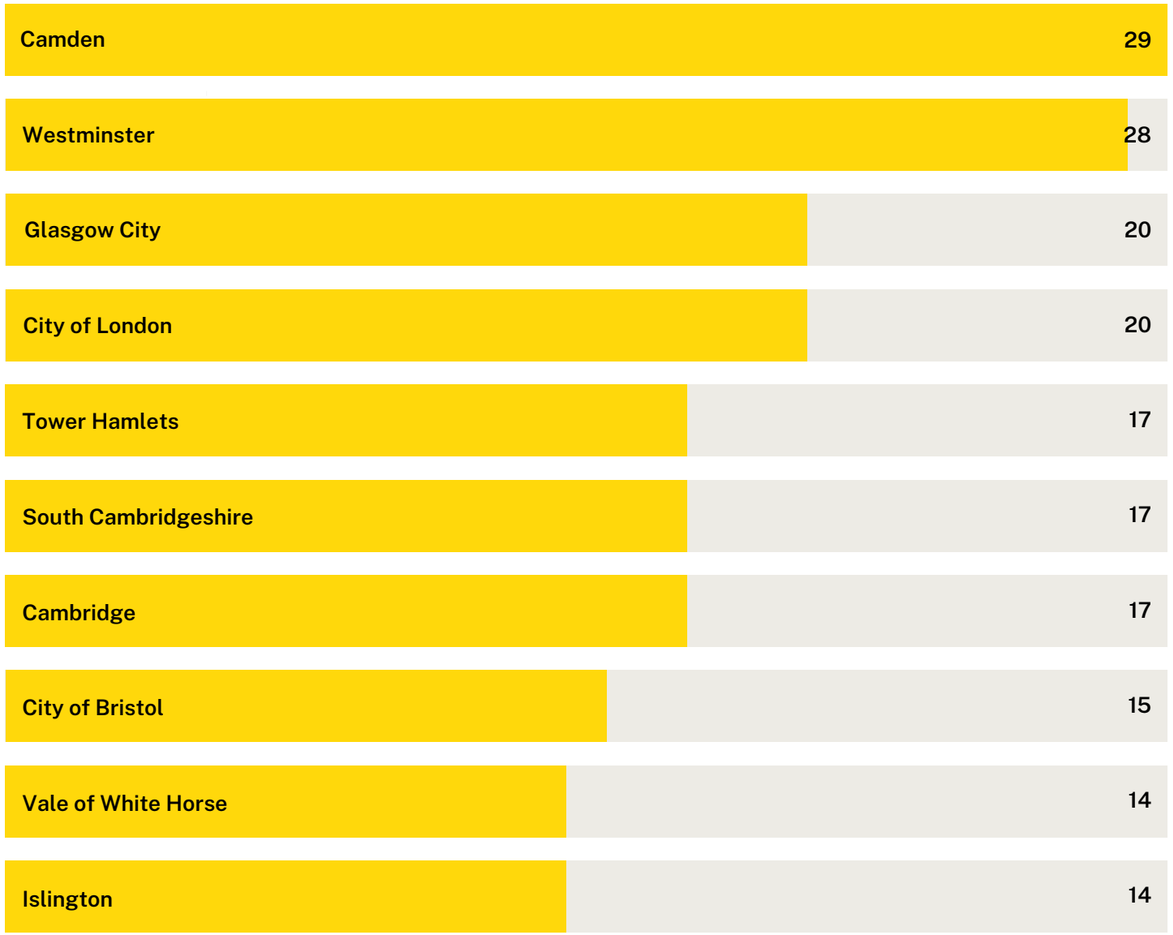
The South East and London lead the regional distribution of identified quantum companies. The South East has the largest share of companies at 21.1% (163 companies), and London follows closely with 162. The East of England also boasts a significant concentration, with 88 companies. These top three regions form part of the “Golden Triangle”, a hub for technological and scientific innovation spanning London, Oxford, and Cambridge. Known for its academic excellence and world-class institutions, the Golden Triangle is a powerhouse for developing intellectual property, fostering spinouts, and driving the UK’s global competitiveness in science and emerging technologies.

Several institutions based in the South East are actively contributing to the region’s large concentration of identified companies operating in the quantum sector. For example, the Harwell Science and Innovation Campus in Oxfordshire is home to the National Quantum Computing Centre (NQCC). The NQCC works to accelerate the development of quantum computing in the UK, tackling some of the challenges posed by the technology’s early stage of development. These include scalability, the lack of standardised hardware and algorithms, or the significant energy demands for cooling.

Scotland is home to 60 identified quantum companies, making up 7.78% of the cohort. Scotland is a key player in the advancement of quantum technology, with its strong foundation in photonics technology, leveraging its expertise in lasrers and advanced optics.

The region’s quantum cluster, aptly named “Glen-tanglement”, combines the Scottish word “glen”, meaning valley, with “entanglement”, a quantum phenomenon describing the interconnection of particles.

Business population by local authority (2024)



Assessing the regional clusters at a more granular level shows Camden is the top local authority with 29 identified quantum companies. Followed closely by Westminster and the City of London with 28 and 20 companies, respectively. Tower Hamlets (17) and Islington (14) also contribute significantly, reinforcing London's position as a central hub for quantum-related activities in the UK.

Glasgow is home to 20 companies, further highlighting Scotland's relevance as a key quantum cluster. The local authority is bolstered by world-class research institutions such as the James Watt Nanofabrication Centre at the University of Glasgow and the Li-Fi Centre at the University of Strathclyde. Of the 20 companies headquartered in Glasgow, 11 operate in photonics and have received grants for photonics-related research.

Among the Glasgow-based companies is M-Squared, which develops photonics and quantum technology. Founded in September 2020, the company designs and manufactures lasers, optical instruments, and integrated quantum systems.

Cambridge and South Cambridgeshire each host 17 of the identified quantum companies. These local authorities form part of the renowned Cambridge Cluster, also known as "Silicon Fen". This area benefits from the presence of the University of Cambridge and its prestigious Cavendish Laboratory. The Cavendish Laboratory drives innovation through spinouts and collaborations in quantum computing, communication, and materials science. In the county of Oxfordshire, the Vale of White Horse hosts 14 identified quantum companies. This local authority hosts the NQCC based at the Harwell Campus. Eight of the 14 companies based here have a quantum computing focus.

Ranking eighth is Bristol, which houses 15 of the identified companies. The city is a hub for quantum innovation, supported by institutions such as the Bristol Quantum Information Institute and the Quantum Technology Enterprise Centre, both spearheaded by the University of Bristol.

3.2

Private Investment

These identified quantum companies have seen consistent growth in the amount of equity investment they have received. Companies in the South East raised the most equity investment across the period, with several companies in the region raising more than £100m in total equity investment.

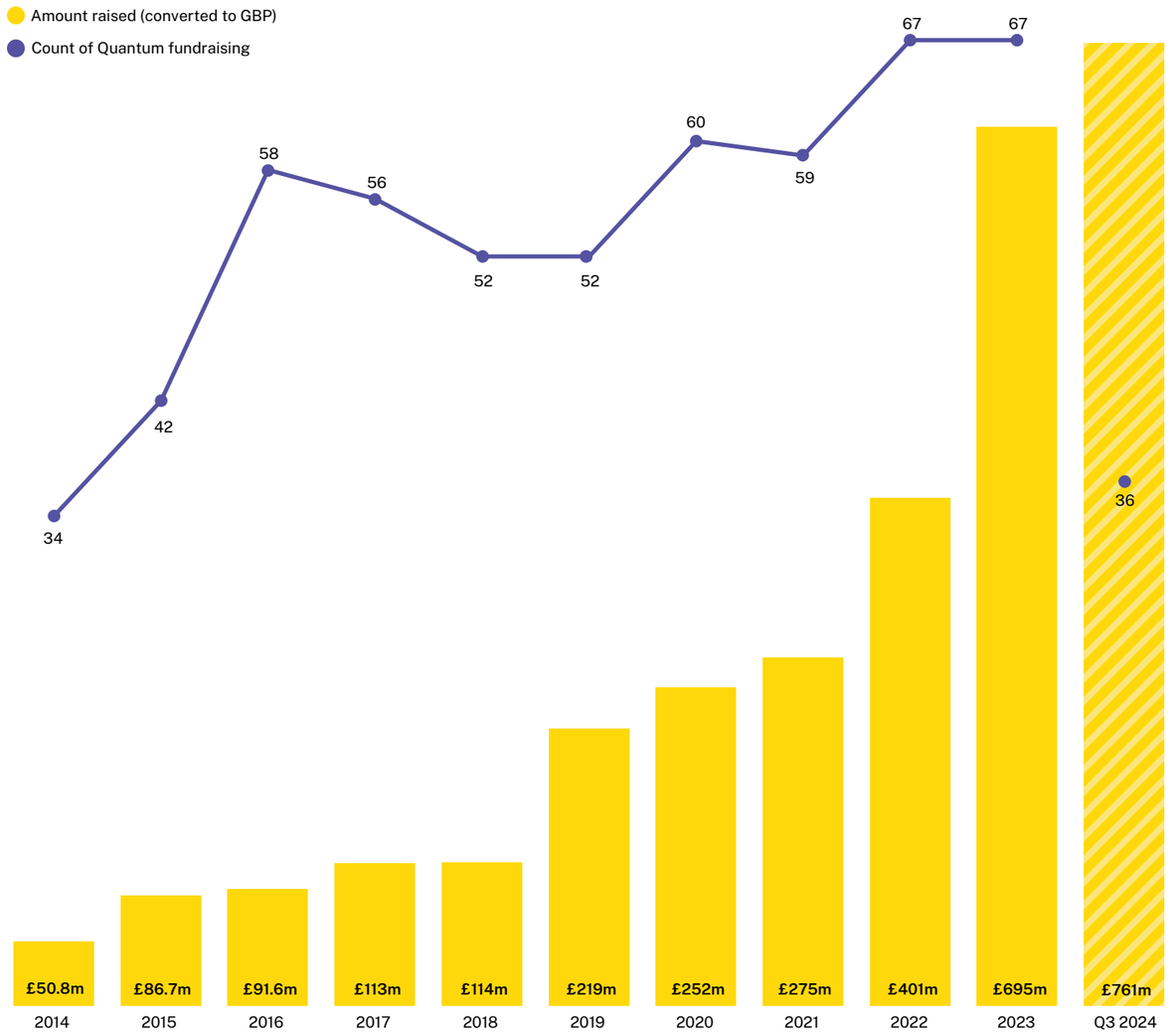
Private investment

The value of equity investment in identified quantum companies has shown consistent growth since 2014, reaching its highest level in 2024—even with data available only for the first three quarters of the year.

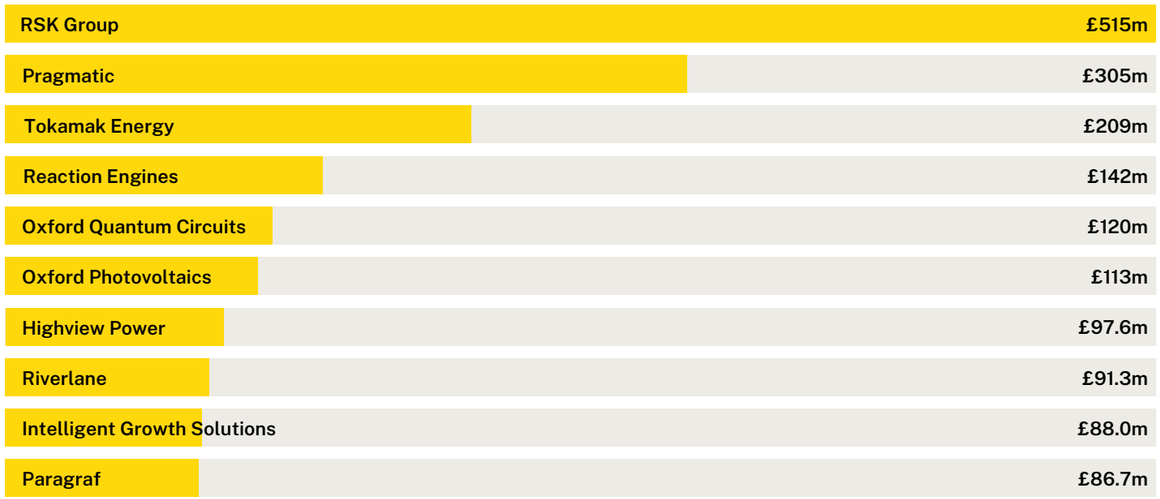
This peak in 2024 was largely driven by a single £515m deal secured by RSK Group in June, which accounted for 67.7% of all equity raised by these companies in 2024. RSK Group is identified as having quantum-related activities from receiving a £119k grant in 2015 for a collaborative project with the University of Birmingham. The project explored the potential of quantum gravity sensors for geophysical surveys, focusing on applications like locating buried objects and detecting voids. It aimed to evaluate existing technologies and set benchmarks to advance sensor development and pave the way for commercialisation.

The steady increase in deal values reflects the sector's emerging status. As companies in this industry mature, they become more likely to raise equity, contributing to the sector's record highs over the past two years.

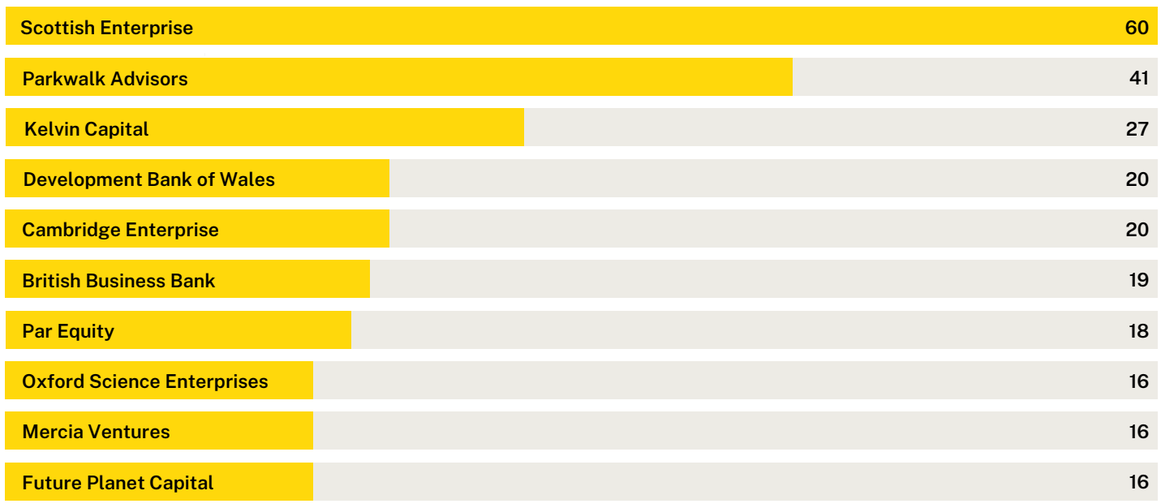
Equity investment into quantum companies (2014-Q3 2024)



Top companies by the amount of equity investment received (2014-Q3 2024)



Top investors in quantum companies by number of deals (2014-Q3 2024)



Regionally, companies headquartered in the South East raised the most equity investment between 2014 and Q3 2024, raising a total of £953m. Over this period, several companies secured a significant amount of investment, including £209m by Tokamak Energy, £142m by Reaction Engines, and £120m by Oxford Quantum Circuits.

The East of England ranks second, with £693m raised since 2014—27.3% less than the South East. The total raised by companies in the North West during this period was almost entirely attributable to RSK Group's £515m funding round in June 2024, which made up 96.6% of the region's funding. Scottish Enterprise emerged as the most active investor in identified quantum companies, participating in 60 equity deals between 2014 and Q3 2024. This economic development agency invests through its co-investment funds, providing vital support to the sector. Parkwalk Advisors also played a significant role, participating in 41 deals during the same period. Notably, 38 of the 41 deals for the identified quantum companies were for academic spinouts the identified quantum companies were for academic spinouts, underscoring Parkwalk's focus on nurturing innovation originating from universities.

3.3

Public Investment

Grant funding is vital for innovative firms. In total, these companies have received nearly 5,000 grants since 2014, with 664 grants being awarded in 2020 alone. The majority of the grants awarded are from Innovate UK, the UK's national innovation agency that helps UK businesses grow by developing and commercialising new products and services.

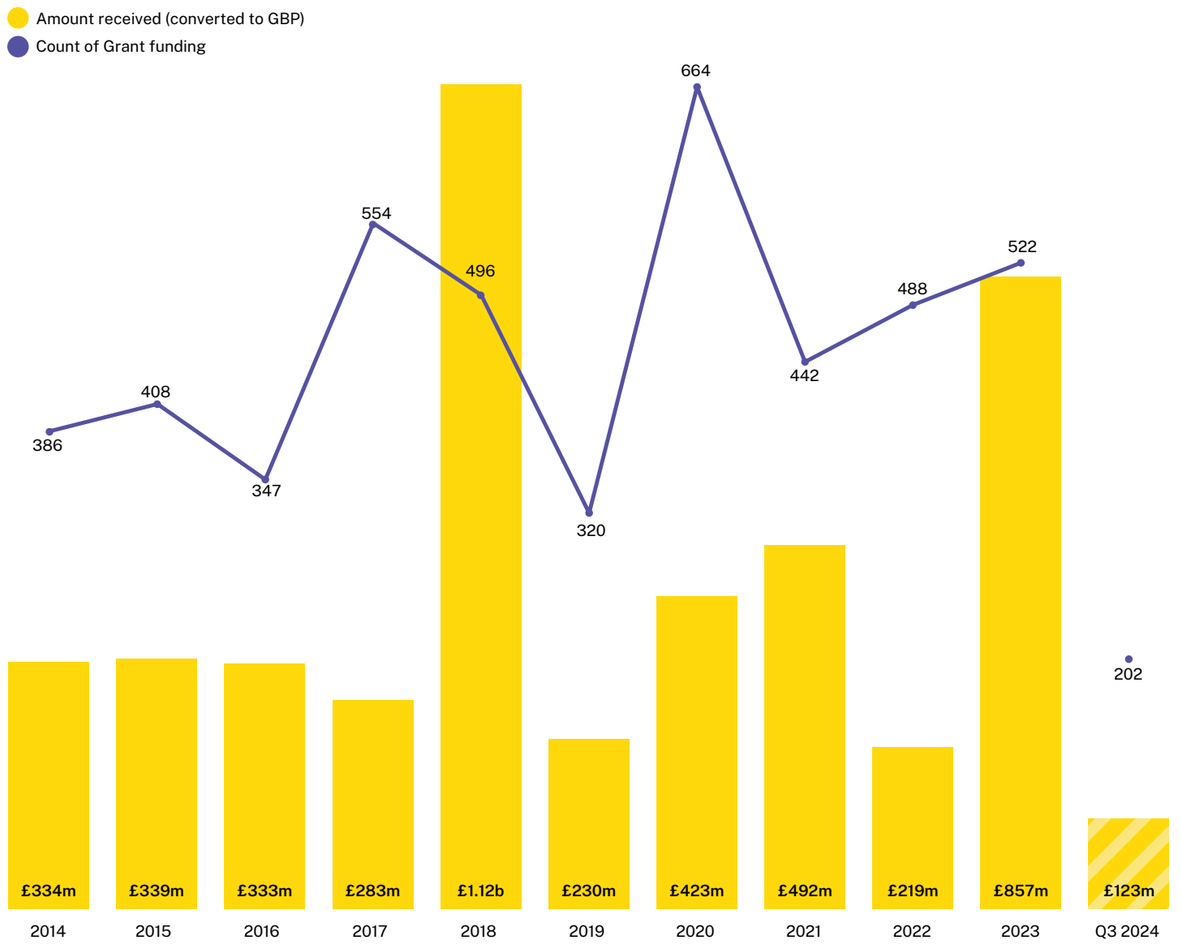
Public investment

Between 2014 and 2023 these identified quantum companies were awarded over £4.75b across 4,829 innovation grants.

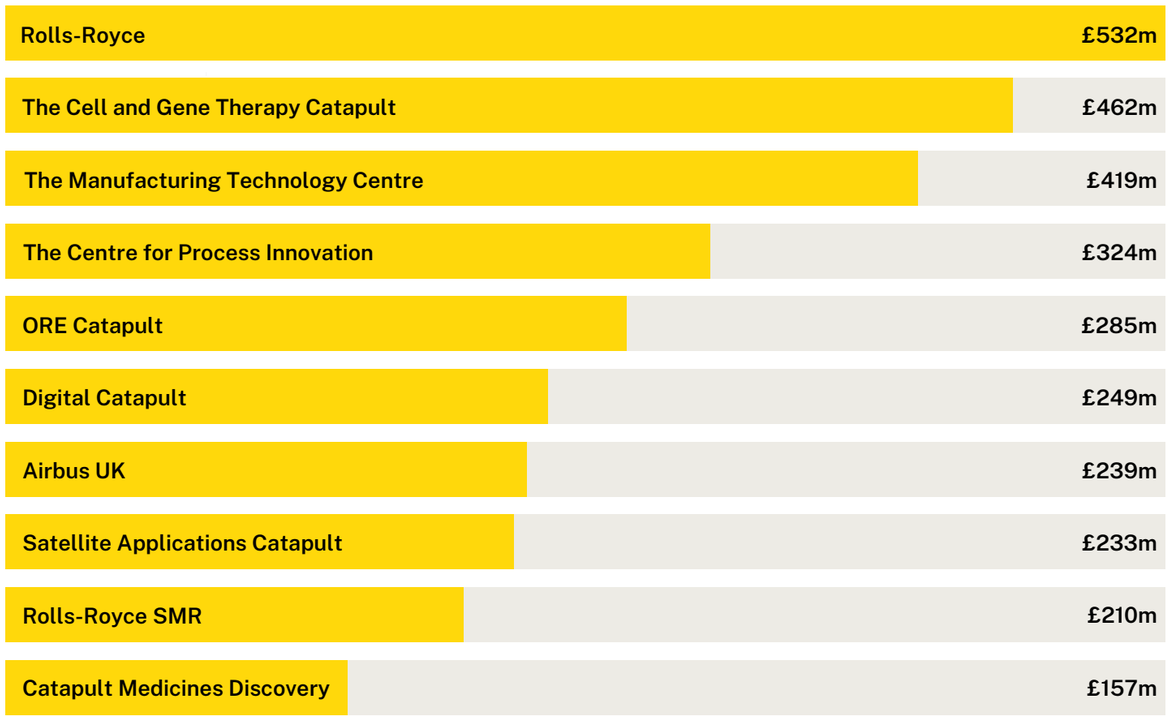
Funding between 2014 and 2017 remained relatively consistent, averaging £322m annually. However, 2018 marked a sharp inflexion point, with funding surging to £1.12b—an increase of 295% compared to the previous year. The surge in grant funding awarded to companies the in 2018 coincided with heightened government and private sector interest in quantum technologies, bolstered by initiatives like the UK National Quantum Technologies Programme that commenced in mid-2018. Among the largest recipients that year was the Manufacturing Technology Centre. It secured £236m through 17 grants, with funding allocated to projects in advanced fields such as photonics, photon science, and cryogenics.

Following this peak, grant funding levels became more variable. In 2020, the number of grants awarded rose to a record 664, likely reflecting the surge in financial support provided by the public sector for businesses during the pandemic. By 2023, the number of grants awarded declined to 552, but total funding rose to £857m. One of the top awardees was the Ore Catapult, which was awarded £92.8m in the form of 11 grants. Infleqtion (formerly known as ColdQuanta) was involved in some of the largest quantum-related projects, including a £3.50m grant to fund research into quantum superposition for its use in navigation systems.

Grant funding into quantum companies (2014-Q3 2024)



Top companies by the amount of grant funding received (2014-Q3 2024)



Among the top recipients of innovation grant funding is Rolls-Royce, a British multinational aerospace and defence company. Founded in 2011, the company designs, manufactures, and distributes advanced power systems for aviation and other industries. In the past decade, Rolls-Royce has been awarded a total of £533m via 137 innovation grants. A particularly noteworthy year for the company was 2021, during which it secured three major grants totalling £219m. Among the company's largest grants awarded since 2014 is a £17.2m grant in July 2018 for the advancement of technologies for electric and hybrid-electric propulsion systems.

In 2023, Rolls-Royce, Riverlane and Xanadu received a joint grant from Innovate UK to combine improvements in quantum software, hardware and algorithms to improve the run time and results when running quantum algorithms. The overall aim is to make quantum computers more commercially viable by reducing the time and resources required to use them. In a continuation of their collaboration, these companies are also developing computational tools to simulate large, complex materials on quantum computers. The collaboration includes working with the National Quantum Computing Centre (NQCC) to engage with other industry leaders in identifying quantum computing use cases across various sectors and business models.

Ranking second for top grant recipients is the Cell and Gene Therapy Catapult (CGT), with a total of £462m awarded via 68 grants since 2014. Founded in 2012, the CGT Catapult supports companies in the cell and gene therapy sector in projects spanning research, development, and commercialisation of technology. The company is part of the Innovate UK Catapult Network, which provides R&D facilities and technical expertise to support business innovation. While the CGT Catapult's core focus is on cell and gene therapies, it engages in various collaborative efforts that may intersect with quantum technologies.

For instance, in September 2022, the CGT Catapult financially supported the launch of the Quantum Flex Cell Expansion System, a bioreactor platform aimed at enhancing the manufacturing processes within the cell and gene therapy industry.

Since 2014, Innovate UK has awarded 4,577 (98.3%) of the total grants allocated to the identified quantum companies. As the UK's national innovation agency, IUK is the main grant funding provider among companies in the sector. Other top funders include the Ministry of Defence (38), which operates the Defence and Security Accelerator (DASA). DASA identifies and supports innovation for the defence and security sectors, working to ensure that new and disruptive technologies are effectively harnessed to address national security challenges.

In 2022, the MoD acquired the government's first quantum computer and further partnered with ORCA Computing to explore applications for quantum technology in defence.

4.0

Scale

This section explores the size distribution of the identified quantum companies in terms of turnover, headcount and GVA. The businesses are varied in size but the majority are smaller companies developing novel quantum technologies.

Turnover

This chart groups companies based on the turnover disclosed in their latest financial statements. Each bracket shows the range of company sizes, with most falling into the smallest or largest bucket. Most companies (98 companies) are either very small, with less than £10m in turnover, or very large, with turnover in excess of £500m (56 companies).

The high number of companies that fall into the low turnover brackets (£0m to £50m) speaks to the nascent nature of the quantum industry. These companies are likely to be startups or have recently been incorporated. On the other side of the spectrum, several large corporations are currently or have in the past carried out quantum-related activities or research. London is home to seven of the top 10 companies by turnover, which explains the very high average turnover in the region. Out of the 65 companies headquartered in London for which turnover data was available, 24 have a turnover of greater than £1b, two of which have a turnover in excess of £100b.

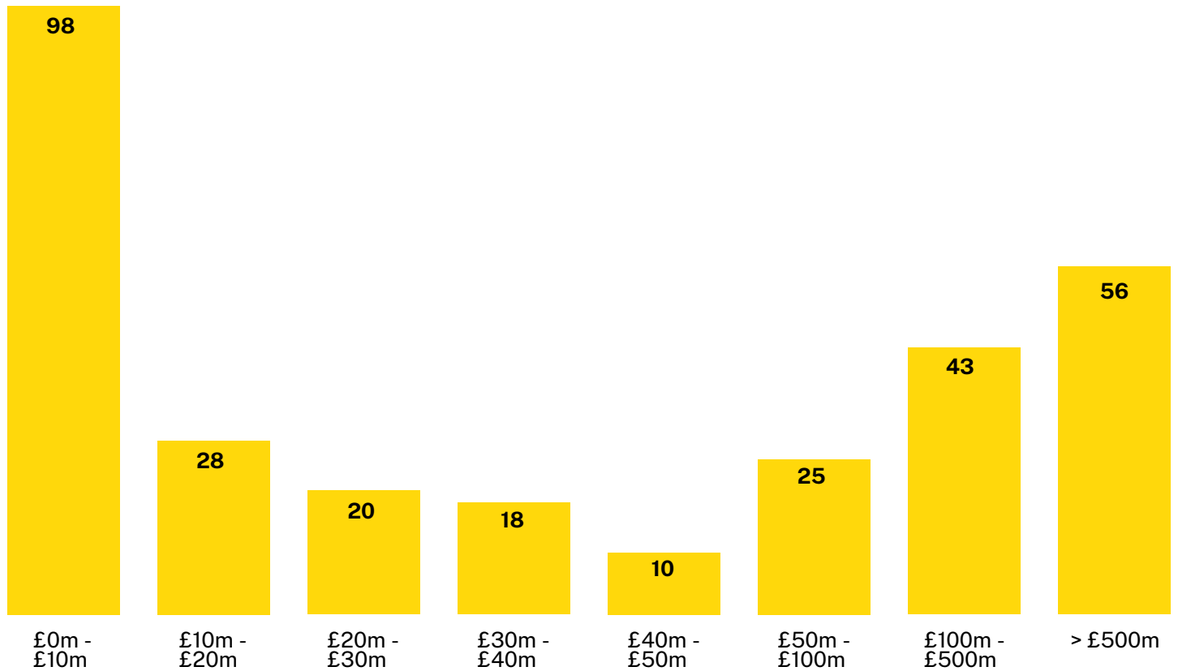
Many companies within this cohort have low turnover but are still innovating. Manchester-based Rockley Photonics latest turnover was £24.0k, but the company has applied for 576 patents on quantum materials and quantum communications capabilities.

£850b
total turnover in latest financial statement

£31.0m
median turnover in latest financial statement

Turnover

Number of companies by turnover (latest financial statement)



Average turnover by region (latest financial statement)

London	£10.0b
North West	£2.57b
East of England	£1.74b
South East	£953m
Scotland	£393m
West Midlands	£311m
Northern Ireland	£215m
Yorkshire and The Humber	£153m
South West	£98.2m
North East	£51.7m
Wales	£48.6m
East Midlands	£42.0m

Employee count

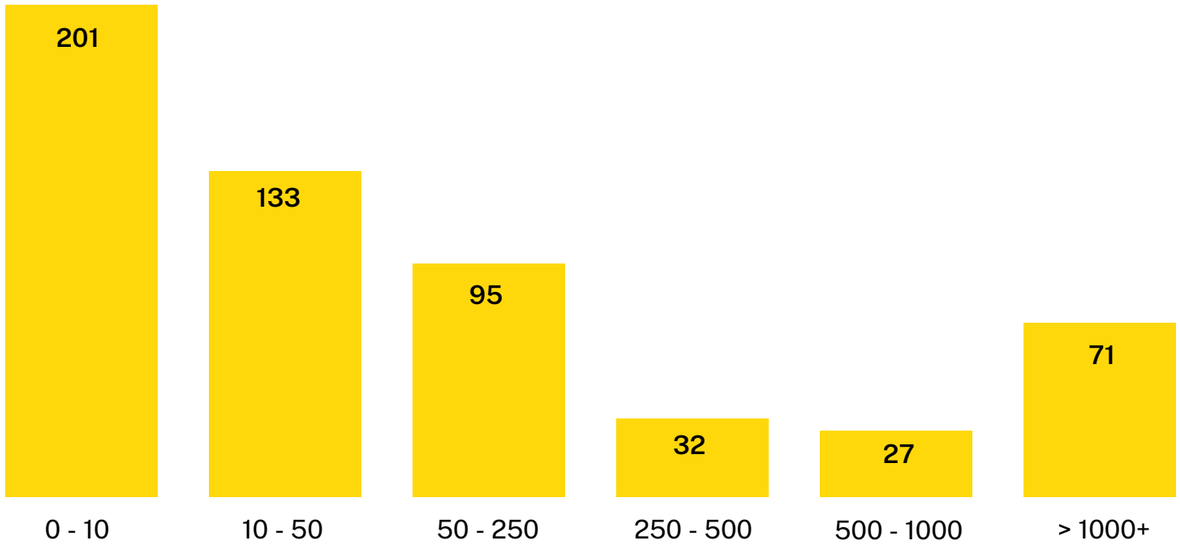
The majority of the identified quantum companies in this cohort have between 1 and 50 employees, with 28 being the median number of employees for the whole cohort. While most companies fall into the lowest employee count bracket, 71 employ more than 1000 people, including three very large companies that employ more than 100k people.

The identified quantum companies based in London have the highest overall employee count at 834k (as of the latest financial statement), with an average employee count of 8,783. The average in the North West is propped up by Unilever, which employs 128k people. Unilever has applied for patents related to NPL's quantum electrical measurement and quantum sensors capabilities and is on NPL's pathway to being a Regularly Supported Firm. Unilever filed a patent application in 2018 related to microcapsules, which involve small-scale particles with precise control needed over their size, structure, and functionality.

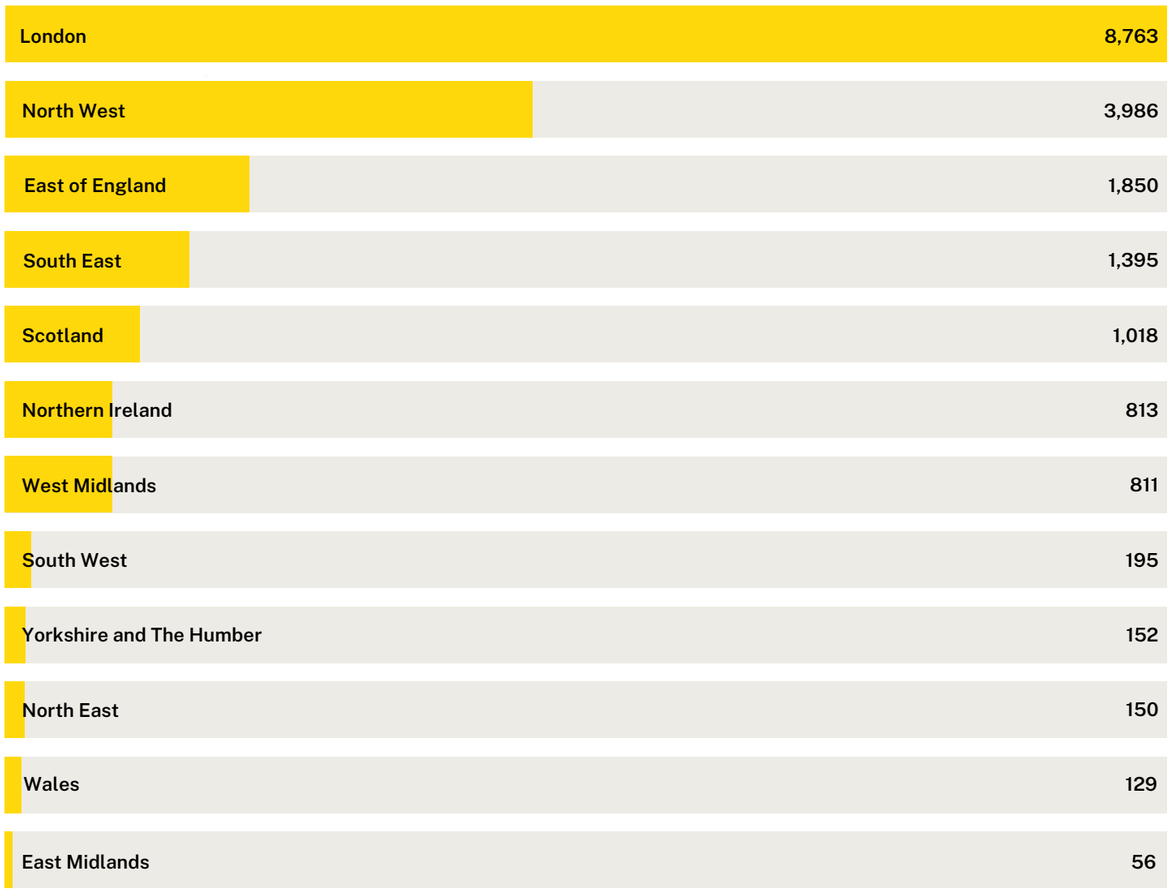
1.38m
total number of employees in latest financial statement

28
median number of employees in latest financial statement

Number of companies by employee count (latest financial statement)



Average employee count by region (latest financial statement)



GVA

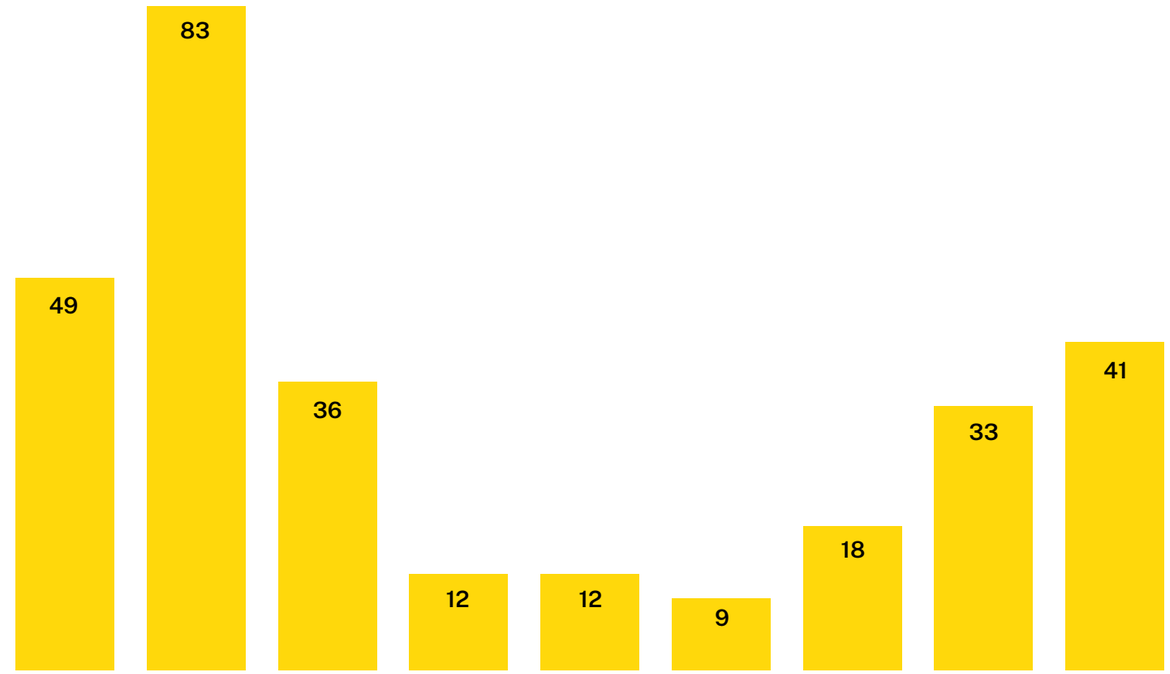
Gross Value Added (GVA) refers to the value added to the economy by a business. In total, these companies have added £282b (as of the latest financial statement) to the economy. Companies in London contribute the most GVA, adding £3.19b on average. One of the biggest contributors to GVA among the cohort is BP (£46.5b). BP received a grant in 2018 which was designed to develop “quantum-safe” communication devices that are protected from quantum computers. This was implemented using quantum-resistent algorithms and techniques from quantum cryptography.

There are 41 companies in this cohort with a GVA of greater than £500m, 31 of which have a latest GVA of over £1b. The identified quantum cohort companies most commonly contribute between £0-£10m in GVA. This is likely due to the high number of quantum startups that are yet to be profitable and employ very few people.

£282b
total GVA in latest financial statement

£12.8m
median GVA in latest financial account

Average GVA by region (latest financial statement)



Average GVA by region (latest financial statement)

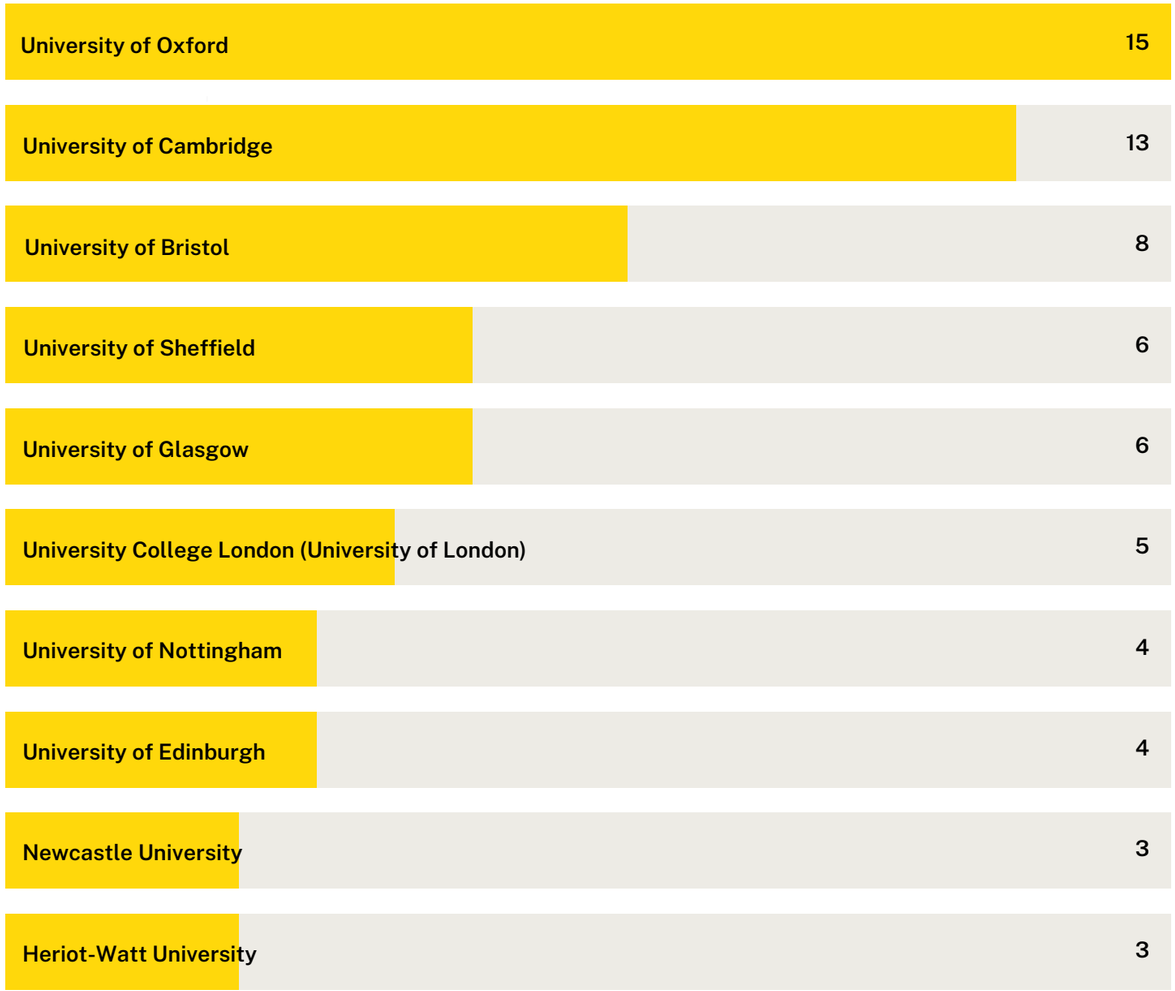
London	£3.19b
North West	£818m
East of England	£722m
South East	£404m
Scotland	£209m
West Midlands	£139m
South West	£49.6m
Yorkshire and The Humber	£31.5m
Wales	£16.9m
Northern Ireland	£15.9m
North East	£15.2m
East Midlands	£2.98m

5.0

Spinouts and innovation

Universities play a vital role in innovative industries, such as quantum. Spinout companies commercialise the intellectual property developed by their respective universities. Patents are also important, allowing companies to protect their intellectual property and are a good proxy to demonstrate which companies are innovating in this field.

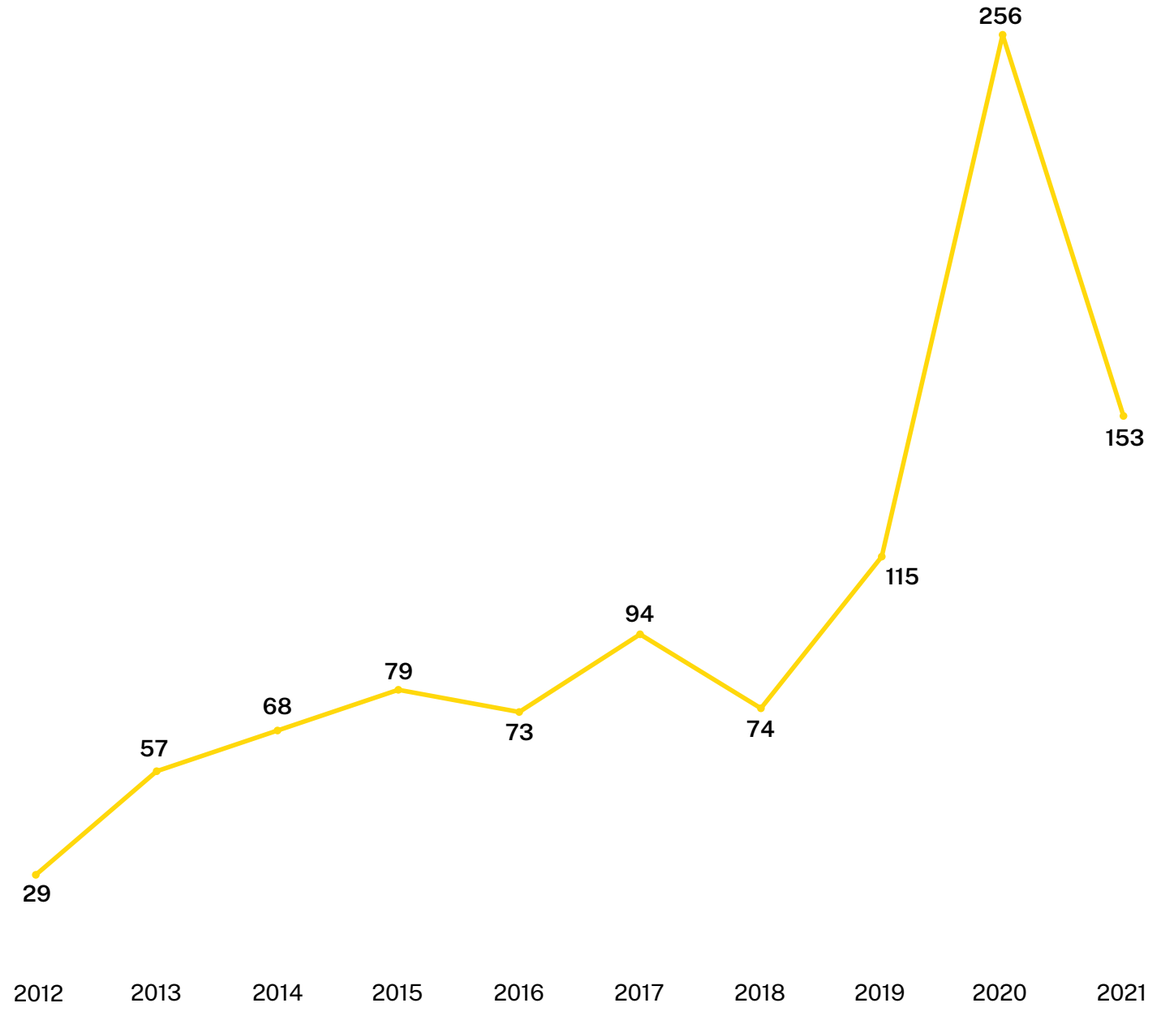
Top origin universities of quantum companies



Spinouts

This cohort includes 86 academic spinout companies. An academic spinout is a company set up to commercialise intellectual property developed by a university. In some instances, a company can be a spinout of multiple universities or academic institutions. Academic spinouts are common for companies operating in emerging technology areas such as quantum. This is due to the specialised facilities and the knowledge required to carry out research can be found within academic institutions.

The University of Oxford and the University of Cambridge are the origin institutions for 28 of the spinouts in this cohort of companies. These two institutions contribute to nearly a third of all academic spinouts in the cohort. Both of these institutions are known for their excellent quantum research, with Oxford also housing the NQCC, solidifying its position in the quantum field. Spinout companies from these institutions include Oxford Quantum Circuits, Oxford Lasers and Nu Quantum. Cambridge-based Nu Quantum received a grant from Innovate UK in 2022, which saw it partner with the University of Cambridge, the University of Oxford, and Cisco Systems to develop quantum photonic technology to allow the networking of quantum computing clusters. The motivation of the project was to scale Trapped Ion Quantum Computers (TIQC). Another prominent institution in the quantum space is the University of Bristol, which is responsible for spinning out eight companies in this cohort. The Bristol Quantum Information Institute plays a key role in the University's high number of spinouts. The Institute helps to combine the University's research, from its work on quantum theory to the development of quantum technology.



Patents

The identified quantum companies have filed a significant number of patent applications, with the majority attributed to several large corporations. Notably, just over half of these applications originate from five companies, each of which has over 10k patent filings. Collectively, these companies have filed more than 191k patents, with a peak of 6,369 applications recorded in 2016— the highest number in any single year.

Since 2016, the number of patent applications by these companies has declined, with a total of 4,253 filings in 2021. This trend may reflect a shift in focus among larger companies from creating patentable intellectual property to optimising and refining existing technologies as they mature. Additionally, the COVID-19 pandemic likely played a role in this decline. Social distancing measures and restrictions on non-essential facilities disrupted physical experimentation and innovation in many sectors, contributing to a reduction in patent activity between 2019 and 2021.

Despite the decrease in filings, the high rate of 57.1% for granted patents underscores the strategic importance of protecting innovations in the quantum domain. Companies like Toshiba Research Europe have been active in this space, filing patents related to quantum computing and quantum well technologies.

191,865
Total number of patent applications by this cohort of companies (all time)

109,556
Total granted patents (all time) - (57.1% of all applications)

6.0

Case Studies

The two companies spotlighted operate in various capacities across the NPL's quantum capability areas. These companies continue to innovate in their respective areas, which include quantum computing and quantum communication.

Infleqtion

Infleqtion, formerly known as ColdQuanta, is a quantum computing information company. Originating as a subsidiary of its American parent company, the firm provides research and development facilities in quantum technology. Among Infleqtion's clients is NASA, which uses its quantum technology at space stations.

One of Infleqtion's standout products is Tiqker, an ultra-precise quantum clock. The device uses advanced rubidium-based technology to measure time with incredible accuracy, offering stability far beyond traditional clocks commonly used in critical applications. Tiqker was recently purchased by the University of Strathclyde. Its high-accuracy frequency standard may be useful in navigation systems where GPS signals are unavailable by providing exact time and frequency references.

The company became the first to deploy hardware at the NQCC as part of its quantum computing testbed programme. Infleqtion's quantum computing team successfully installed a neutral atom quantum computer, marking a significant milestone in advancing quantum infrastructure. Beyond the hardware deployment, Infleqtion is actively collaborating with researchers at the NQCC to explore near-term applications of quantum computing.

Since its launch in 2014, Infleqtion has been awarded £13.8m across 21 Innovate UK grants. These grants cover areas such as atomic clocks, frequency combs, and compact lasers. The company won its latest grant in April 2024 for a total of £1.07m. Infleqtion has seen significant growth in its headcount over the past three years, growing from 10 in 2021 to 27 in 2023. Among its global team, it employs more than 90 people with PhDs in the field.

Infleqtion's latest grant was issued to advance quantum technologies, with a specific emphasis on developing infrastructure for quantum networks. The grant will fund the development of a manufacturing capacity for quantum components, which includes a vacuum processing station to fabricate compact ion-trap systems that will be used for future quantum networks. This will allow Infleqtion to establish a domestic supply chain for quantum networks. Infleqtion would benefit from the NPL's quantum communication capabilities, which include maximising efficiency in quantum networks, "metrology for photonics and quantum-secured technologies, and securing communications with single photons.

Infleqtion

> **We can work with Infleqtion to test, validate, verify and benchmark their system. We can also develop quantum computing algorithms for their system.**

Ivan Rungger
Principal Scientist
NPL

Hitachi Data Systems

Hitachi Data Systems (HDS) was founded in 1989 as a subsidiary of the Japanese conglomerate firm Hitachi. It provides computer data storage systems, management software, and services to help companies manage their data. In 2017, HDS merged into Hitachi Vantara, alongside Pentaho and Hitachi Insight Group.

Its journey into quantum computing began in 1989 with the Hitachi Cambridge Laboratory, created in collaboration with the University of Cambridge. The laboratory has since driven research on quantum phenomena and device development for over 30 years.

The company's research and development efforts in quantum computing have led to the filing of numerous patents in technologies like quantum wells and superconducting. In 2020, Hitachi developed a quantum computing system using a novel algorithm to tackle optimisation problems, leveraging superconducting circuits for efficiency. That same year, it launched a quantum computing cloud service, enabling businesses and researchers to access its quantum systems online. Hitachi has also applied for patents in the quantum material space, engineering materials at the nanoscale for use with quantum electronics.

Hitachi Data System could leverage the NPL's quantum computing capabilities. Hitachi could benefit from updating the technology or receiving additional consultation in this area. Hitachi may, therefore, benefit from NPL's "characterisation and imaging of materials from the nano to atomic scale" capability.

Hitachi Vantara

> **Quantum Materials team at NPL can support HDS by providing advanced (electrical, magnetic, optoelectronic and thermal) characterisation and nanoscale imaging of their materials and devices, incl. superconducting and semiconducting systems. These studies could be conducted in the operational conditions such as low temperature, high magnetic fields, electrical and optical gating, etc. Through understanding and minimisation of material-related issues, these studies could lead to reduction of noise and losses and improve the overall performance and efficiency of quantum device and circuits.**

Olga Kazakova
Fellow
NPL

Methodology

This outlines how the identified quantum companies for the quantum mapping report is found. While this report is based on quantum companies, not every company included in the cohort would be classified as a typical “quantum” company. In some instances, companies were included because they are/have carried out a quantum-related activity that aligns with the NPL’s quantum capabilities.

Initially, 49 keywords were identified from the list of the NPL’s quantum capabilities, which can be found **here.** Each keyword was then matched to the quantum area it is most likely to operate in (e.g., quantum computing, quantum communication, etc.).

The NPL provided a list of 276 companies made up of companies it currently works with. Given that this included several large UK companies, this cohort was expanded to include all the entities in a corporate structure to ensure that if a child company was carrying out a quantum-related activity, it could be identified. This expanded the initial cohort to 2,186 companies. This extended cohort was then used to identify which quantum-specific keywords and phrases should be used to identify similar companies using the Beauhurst platform.

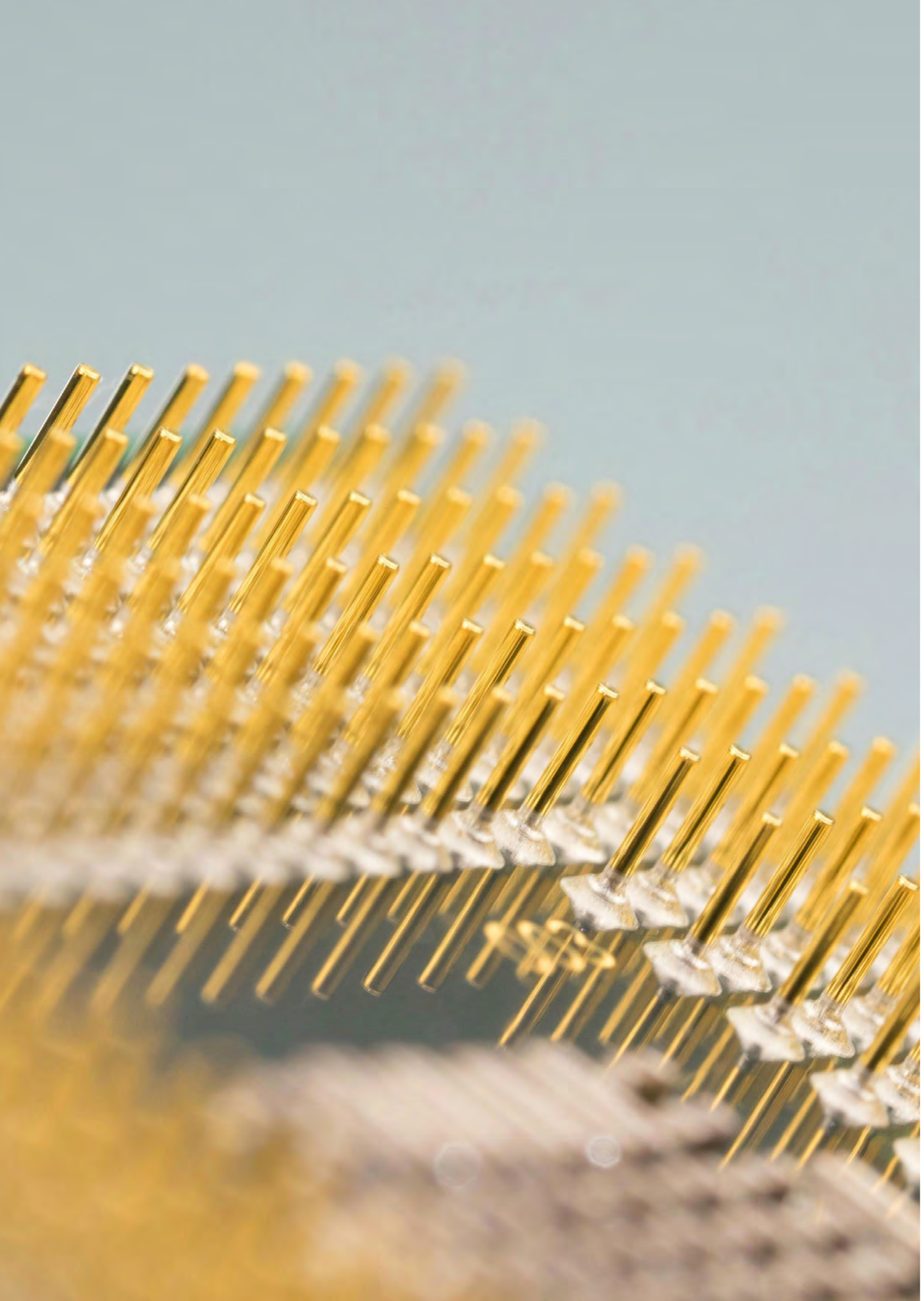
These keywords were then used across the NPL’s current client companies to identify how accurate they were for describing what these companies do, and if they could be used to find similar companies across the UK.

The keywords were used across company descriptions, grant titles and abstracts, and patent abstracts to see if they surfaced companies in the NPL’s original client list. The number of matches for each keyword was noted, and those that most accurately depicted the cohort were selected to identify the wider cohort of similar UK quantum-related companies.

The keywords and corresponding search methods were then used to create a cohort of similar UK quantum-related companies, with 1,408 possible companies being identified. This cohort was then refined, with inactive companies and recruitment firms being removed. Manual checks were performed to remove companies unrelated to the NPL’s capabilities. Several companies within the cohort are in the same corporate structure as another. Duplicate companies were removed where appropriate, but in most cases, a large company could be carrying out a quantum-related activity, and have multiple child companies also carrying out a quantum-capability-related activity, meaning all companies should therefore be included. After cleaning, the final cohort of identified quantum companies is 771 active UK companies. These are companies that have or are carrying out quantum-related activities that might require the NPL’s quantum capabilities.

In this report, GVA has been calculated as employee wage total + operating profit + depreciation + amortisation.

Keyword	Capability
Quantum computing	Quantum computing
Optoelectronics	Quantum materials
Photonics	Quantum communication
Quantum randomness	Quantum communicaton
Superconducting	Quantum computing
Quantum network	Quantum communication
Quantum technologies	Quantum computing
Quantum secure	Quantum communication
Quantum hardware	Quantum computing
Atomic clock	Quantum time & frequency
Quantum clock	Quantum time & frequency
Cryogenic	Quantum electrical measurement
Linewidth	Quantum time & frequency
Frequency combs	Quantum time & frequency
Superconductor	Quantum computing
Atomic sensors	Quantum sensors
Quantum well	Quantum materials
Compact lasers	Quantum time & frequency
Single photon	Quantum communication
Cryogenic temperatures	Quantum computing
Quantum-secure	Quantum communication



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Beauhurst is a searchable database of the UK's high-growth companies. Our platform is trusted by thousands of business professionals to help them find, research and monitor the most ambitious businesses in the UK.

We collect data on every company that meets our unique criteria of high-growth; from equity-backed startups to accelerator attendees, academic spinouts and fast-growing scaleups.

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For more information and a free demonstration, visit **beauhurst.com.**

NPL

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The National Physical Laboratory (NPL) is the UK's National Metrology Institute (NMI), developing and maintaining the national primary measurement standards, as well as collaborating with other NMIs to maintain the international system of measurement.

As a public sector research establishment, we deliver extraordinary impact by providing the measurement capability that underpins the UK's prosperity and quality of life.

We develop the metrology required to ensure the timely and successful deployment of new technologies and work with organisations as they develop and test new products and processes.

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