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The semiconductor industry in the UK

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Summary

Semiconductors are essential ingredients of all modern electronic systems. They are used as switches and transistors and are the building blocks of computer chips.

Semiconductors are used in communications infrastructure, artificial intelligence, electric and autonomous vehicles, robotics, healthcare, military technology, quantum and cloud computing, and everyday consumer devices. They are a crucial technology that underpins the modern economy.

The UK has a comparatively small semiconductor industry by comparison with the US or countries in Asia, but our products have global reach, and we have world-leading capabilities in certain fields such as design, intellectual property and compound and advanced material semiconductors.

The UK does not, however, have an end-to-end supply chain. Supplies were seriously disrupted during the pandemic, and they remain potentially vulnerable to significant disruption from geopolitical factors, for instance if China were to invade Taiwan and disrupt the export of semiconductors.

The UK is particularly exposed to future disruption in global supplies of semiconductors and is falling behind other governments in mitigating such risks. Failure to do so could result in significant economic shocks to UK business.

The Government should therefore work more closely with allies, in particular with the EU and US, to safeguard security of supply, both of finished products and of the materials needed for production in the UK.

The National Security and Investment Act 2021 allows the Secretary of State to review certain acquisitions of control that may give rise to a risk to national security. The Secretary of State used these powers on 16 November to require Nexperia, a Dutch firm but ultimately Chinese-owned, to sell at least 86% of its 100% shareholding in Newport Wafer Fab, a semiconductor manufacturing facility in South Wales. We have a role, through our National Security and Investment Sub-Committee, in scrutiny of such decisions and the process behind them. We will consider the Nexperia case retrospectively, in line with international best practice, once the period for appeal has expired. In the meantime, the Department should work proactively to ensure a successful transfer of the Newport site to a new owner. Ministers should update the Committee on progress made.

Many Government departments have intersecting interests in the UK semiconductor industry. But the sector is uncertain about where primary responsibility within Government lies and to which part of Government they should address concerns. We believe that should rest with BEIS, because of its overarching responsibility for industrial strategy, business support, engagement with industry and policy on research funding, and because of its role in protecting UK industrial assets from undue control by overseas entities.

DCMS told us that it had been reviewing its approach to the semiconductor sector and that it planned to publish a semiconductor strategy in autumn 2022. The strategy has

already been nearly two years in the making. The industry has waited for the strategy and will base crucial decisions upon it. The Government should lose no more time and should publish its Semiconductor Strategy immediately.

We recommend that the Government's Semiconductor Strategy consider scope for development of the UK semiconductor industry in the following fields:

- Intellectual property and design;
- Supporting the design chain for leading edge node chips;
- Matching UK manufacturing capability to UK design capability;
- Developing manufacturing processes for silicon semiconductors;
- Development of existing strengths in compound and advanced material semiconductors, to meet demand in emerging markets;
- Facilitating the construction of new fabs, including consideration of an open access fab in the South Wales cluster.

In addition, we recommend that the Government produces a risk and resilience strategy for the semiconductor industry alongside its Semiconductor Strategy, as a matter of urgency.

It is not clear to us that the support or attention currently offered by Government is at anything like the scale which is needed to secure our supply of semiconductors and to deliver the future prosperity of the semiconductor industry.

The Government must not overlook the semiconductor industry any longer. Whilst we recognise the difficult fiscal picture in the UK, we call on Ministers to set up a new sector deal as the vehicle to work with industry to agree UK priorities and the best use of any public funds or support. This could be via additional funding or guarantees made available via the Compound Semiconductor Applications Catapult, Innovate UK or the British Business Bank.

The UK is missing out on inward investment at a crucial time for the semiconductor industry, and we are competing with other countries. The Government should be more proactive in seeking to secure partnerships with US and EU counterparts, and engage with Taiwanese and other major companies to secure significant inward investment in the UK.

1 Introduction

1. Semiconductors are materials which form an essential part of electronic systems, whether they are everyday consumer devices such as smartphones, household appliances and computers, or more complex and specialised products for use across a wide range of civilian and military purposes. A car will contain many thousands of semiconductors of differing types.

2. The purpose of this inquiry, which we launched in May 2022,[1] was to take stock of the state of the semiconductor industry in the UK and its place in the complex global supply chain. One of the primary reasons for launching this inquiry was a global shortage in semiconductors, beginning in 2020, and the disruption to worldwide manufacturing which resulted. Large financial commitments are being made globally to strengthen sovereign semiconductor supplies and geographically diversify the location of semiconductor facilities and companies. We therefore also consider where the UK fits internationally within this changing landscape.

3. This Report sets out our findings, and it considers what steps the Government should take to support the UK semiconductor industry and reduce vulnerability to disruption to the supply chain.

4. We received more than 70 written submissions, most of which have been published on our website, from firms in the industry, trade bodies, academics, and others. We were struck by how many responses we received to the call for evidence on a relatively narrow topic and within a tight timeframe. We take this as an indication of the significance of the sector and of the associated concerns. We took oral evidence from representatives of the semiconductor industry, including trade associations, designers and international associations and companies. We also undertook visits to South Wales on 11 July 2022 and to North East England on 8 September 2022, to learn more about the domestic manufacturing, design and use of semiconductors within the UK, and discussed the issue with counterparts in the United States. A full list of all those who gave evidence to our inquiry is included at the end of this report. We are grateful to all who assisted us in our inquiry, including our Specialist Adviser, Marcus Buechel.[2]

5. Chapter 2 of this report describes the various types of semiconductors, their purposes, and their place in both the domestic and global economy. Chapter 3 sets out the complexities of the production and supply chain, identifying the vulnerabilities and risks. Chapter 4 looks at the role of Government and policymaking, and how it can support development of the industry, boost investment, and secure the supply of skills which are essential to the prosperity of the industry.

1 Terms of reference can be found at Inquiry launched into the Semiconductor Industry in the UK - Committees - UK Parliament.
2 Parliamentary Office of Science and Technology Fellow

2 About semiconductors

6. A semiconductor is a material with a capacity to conduct electricity which lies somewhere between that of a pure metal (or conductor), such as copper, and that of an insulator, such as rubber. The distinct feature of a semiconductor is that it can be used to control how, when and where electricity flows. They are perfect for use as a switch or as a transistor. A transistor is the building block of modern computer chips.[3]

7. Many different materials act as semiconductors, but they disaggregate into broadly three types:

- Silicon
- Compound (such as silicon carbide, silicon germanium, zinc sulphide, gallium nitride, gallium arsenide and indium phosphide), and
- Other advanced semiconductor materials (such as graphene or diamond)

The materials themselves are used to form semiconductor components, such as computer chips, sensors and light emitting diodes (LEDs).

8. Silicon semiconductors are the most established type and have the most mature technology, having been used since the 1960s. At present, approximately 80% of the world's semiconductors are made of silicon.[4] Despite being an older technology, silicon semiconductors are present in over 90% of electrical devices.[5]

9. When using only a single element (such as silicon) to produce semiconductors, it is possible to scale up the manufacturing process, even though it may not be considered the "best" semiconductor material. Due to the technological maturity of the process for creating silicon semiconductors, electrical circuitry of incredibly small dimensions can now be created.

10. Compound semiconductors, by contrast, are made up of more than one element or material: for instance, silicon carbide is a combination of silicon and carbon. The combination of different materials gives compound semiconductors useful properties: they can generate and detect light, handle high power loads and enable high-speed communication, and they operate at much higher temperatures than their silicon counterparts.[6] Only twenty per cent of semiconductors used worldwide are compound semiconductors; but their value in terms of efficiency and versatility is expected to stimulate a significant increase in demand for use in consumer products and industry.

3 The more circuitry (and transistors) on a computer chip, the more powerful and computationally expensive the tasks that can be performed. When the integrated circuit was invented in 1958 there were only a few transistors on a single substrate. Intel, a computer chip manufacturer, is now aspiring to embed up to a trillion transistors per computer chip by 2030.

4 CSA Catapult, What are Compound Semiconductors?, 5 June 2020

5 Semefab (SEM0046)

6 Compound semiconductors point the way ahead for life after silicon, *Engineering and Technology,* 13 September 2018

11. Other materials that are used for semiconductors include diamond and graphene, for use in printing electronics onto substrates, or in emerging technologies such as transition metal dichalcogenides (a form of semiconductor suited to optoelectronics and photonics). This sector, while currently tiny in value, is expected to undergo exponential growth over the next decade.

What are semiconductors used for?

12. Over one hundred billion semiconductors are being used daily.[7] They have driven the integration of electronic systems for the last 30 to 40 years: one witness told us that they had "probably been the main technology for miniaturisation and for everything that we have got used to in our electronic world".[8] They are essential components of electronic devices[9] and are also used in electronic systems that enable infrastructure to function. They underpin major industries and—by extension—much of the economy.

13. An electronic product will most likely have more than one type of semiconductor in it. In a smartphone, for example, different types of semiconductors are used for the processing, display, facial recognition and communication (e.g. 5G) capabilities.

14. Demand for semiconductors is set to increase significantly, driven by use and development of communications infrastructure (such as 5G, 6G and space communication), artificial intelligence, smart devices (such as heart monitor implants) which communicate data over a network (sometimes known as "the Internet of Things"), quantum and cloud computing, electric and autonomous vehicles, computer processing units,[10] decarbonisation of the power sector and moving towards renewable energy (energy production and transmission), virtual and augmented reality, robotics and automation, healthcare,[11] military technology (space and defence),[12] power electronics (storage and generation such as batteries and solar panels), data storage, and consumer devices.

15. In vehicles, for example, semiconductor content has doubled between 2017 and 2021 and is expected to increase exponentially.[13] One witness told us that most automotive manufacturers were looking to incorporate silicon carbide semiconductors into their power electronics,[14] and another told us that "by the end of this decade a premium vehicle will have five times as much semiconductor content as today".[15] The CEO of Intel has predicted that by 2025, chips will make up 12% of premium vehicle material costs, and by 2030, 20%.[16]

7 Semiconductor Industry Association, Semiconductors are the Brains of Modern Electronics, 5 February 2014
8 Martin McHugh, Q1
9 See Mr Banks Q25 and Q43
10 These include Central Processing Units (CPUs), which enable programmes to run on computers, and Graphical Processing Units (GPUs), which are specialised to produce the display image.
11 See Dr Rickman, unnumbered question before Q99
12 Unnumbered question before Q99
13 Advanced Propulsion Centre (SEM0066)
14 Mr McGibbon Q9
15 Ms Blomfield Q123
16 Intel CEO Predicts Chips Will Be More than 20% of Premium Vehicle BOM by 2030, 7 September 2021

16. Compound semiconductors, in particular, are playing an ever larger part in key products. Americo Lemos, Chief Executive Officer of IQE,[17] told us that:

> Most of what we call the megatrends in innovation will require compound semiconductors, more so in volume than the traditional semiconductor products that we see… There is no net zero without compound … There is no autonomous driving without compound electronics. There is no telecom 5G without compound electronics.[18]

Importance to the global economy

17. The global semiconductor industry is the fourth largest in the world behind oil production, automotive and oil refining and distribution,[19] and revenue from semiconductors accounted for 0.5% of global GDP in 2020.[20] Over 1.1 trillion semiconductors were sold in 2021,[21] and the sector is thought to generate between 500 and 600 billion US dollars annually in revenues.[22] It was suggested to us that revenues would reach US $1 trillion dollars by the end of this decade.[23] DCMS offered an estimate of a real term annual growth rate in demand in the semiconductor sector of around 7% between 2021 and 2031.[24] The global compound semiconductor market alone was estimated to be worth US $91 billion in 2020 and has been forecast to reach $136 billion by 2024 (of which the UK's share would be 8%).[25]

18. Several semiconductor markets were cited in evidence as offering significant potential for growth:

- the silicon carbide device market, which could grow to US $6.1 billion by 2027, with a compound annual growth rate (CAGR) of 34% between 2021 and 2027;[26]
- the global market for high performance solar cells for space, which is predicted to be worth more than £30 billion over the next eight years;[27]
- the market for devices in the "Internet of Things",[28] which could reach up to US $12.6 trillion in global economic value by 2030 and US $13.2 trillion in global economic activity by 2035, driven by the expansion of 5G networks;[29]

17 A firm which designs and manufactures complex compound semiconductor wafers
18 Q67
19 CSConnected (SEM0023)
20 DCMS (SEM0080)
21 Make UK (SEM0012)
22 See Mr Banks Q18, Imperial College London (SEM 0016) and CSConnected (SEM0023)
23 Mr Beresford-Wylie Q102 and Imperial College London (SEM 0016)
24 DCMS (SEM 0080)
25 CSA Catapult (SEM 0029). The CSA Catapult is a non-profit research and technology organisation helping companies to develop advanced electronic systems using compound semiconductors, developing sovereign supply chains where possible. See also Mr Lemos Q72.
26 Clas-SiC Wafer Fab (SEM0050)
27 MicroLink Devices UK Ltd (SEM0045)
28 See paragraph 14
29 Qualcomm Technologies Ltd (SEM0077)

- military and telecommunications infrastructure, which uses gallium nitride in the radio frequency market, and which is expected to grow to over US $2 billion in value by 2025. The gallium nitride microLED display market (used in virtual reality) could grow to over US $7 billion by 2025;[30]
- 'vertical cavity laser' markets, based upon gallium arsenide semiconductors, which could grow to over US $2.7 billion in value by 2025 through expansion of smartphone facial recognition, LiDAR (Light Detection and Ranging) and optical telecommunications applications;[31]
- optical communications and sensing applications (using indium phosphide semiconductors), which could grow to US $5.1 billion by 2025;[32] and
- photonics applications, where demand is expected to grow by 15% CAGR in the period 2021–26, for radio frequency applications (estimated to grow by up to 17% CAGR over the same period) and for power applications (estimated growth by between 35% and 65% CAGR over the same period).[33]

19. CSConnected told us that "for each direct semiconductor job, almost 6 additional jobs are induced in the associated industrial supply chains and wider economy".[34]

20. The growth in the semiconductor industry has been driven by the ability to constantly reduce transistor size, cost and energy consumption whilst simultaneously improving semiconductor performance. Whether that trend can be maintained is debatable: the scope for reducing transistor size at least may now be quite limited. We also note that the market is itself cyclical in nature, with periods of overdemand and overcapacity.[35]

30 CSConnected (SEM0023)
31 CSConnected (SEM0023)
32 CSConnected (SEM0023)
33 IQE plc (SEM0075)
34 CSConnected (SEM0023)
35 Nexperia UK (SEM0054), Dr Ron Black (SEM0049), CSConnected (SEM0023). See also The silicon squeeze, The Economist, 22 October 2022

How are semiconductors and semiconductor components made?

21. The basic steps for manufacture of semiconductors and then semiconductor components are procurement of raw materials, component design, fabrication (actual manufacture), and assembly, testing and packaging.[36] The various types of company involved in the process are shown below (although this list should not be seen as exhaustive or definitive).

Semiconductor production chain: company types

- **Equipment design and manufacture companies** build the equipment and machinery that processes the raw materials required to produce semiconductors and associated components
- **Research and design companies** develop future designs for semiconductors and new manufacturing and material techniques. This is an area of significant strength in the UK, where it is normally undertaken by universities and associated spinouts. In other countries research and design may form a large part of a company's investment
- **Electronic Design Automation (EDA)** companies create the computer tools used to design and validate semiconductor design and manufacturing
- **Fabrication companies** operate the "fabs" or foundries where semiconductor components are physically created in "wafers"
- **Packaging (assembly and testing) companies** remove chips from the wafers produced by the fab and add the electrical contacts required to enable integration with printed circuit boards and electrical systems. China and Taiwan collectively account for 65% of the final packaging stage of semiconductor production. The UK has approximately 20 packaging companies, although these are not high-volume companies when compared internationally
- **Original Equipment Manufacturers (OEM) and Contracted Electronics Manufacturing Service (EMS) companies** integrate packaged chips into electrical systems such as electric vehicles, smartphones and military equipment. This is another area of strength for the UK, which has around 5,000 such companies
- **Integrated Device Manufacturers (IDMs)** are companies which bridge many processes and which design, manufacture and sell the produced semiconductor components. Approximately 71% of computer chip sales come from IDMs such as Intel

36 For a summary of the stages of the process, see written submission from Compound Semiconductor Applications Catapult (SEM0029)

"Fabs" and what they do

22. A "fab" is an umbrella term: fabs vary in what they can produce and in the number and types of processes involved. In essence, raw materials (such as silicon) are used to produce a base "wafer". These circular crystalline discs typically vary between 75 and 300 millimetres in diameter. The larger the diameter, the more chips that can be produced per wafer and so the greater the output capacity of a fab. In a process known as epitaxial growth, atomic layers of semiconductor material are deposited on the base wafer. This can either be the same material as the base wafer (e.g. silicon on silicon) or a different material. Epitaxy is the process by which crystals are grown in a particular orientation and configuration above another crystal structure. Depositing this layer upon the wafer provides a suitable foundation from which to develop the semiconductor component.

23. In cleanroom conditions, where there are very low amounts of airborne particulates, the "wafer" is processed and individual chips are implanted. This stage is commonly referred to as "fabrication". The manufacturing capability of a fab is related to how advanced the design and capability of semiconductor lithography equipment are. Lithography is the process by which light is used to produce circuitry on the wafers. The more advanced the lithographic equipment, the smaller and more complex circuitry you can produce on your semiconductors. "Node size" is a term commonly used to categorise the manufacturing capability of a fab and roughly equates to the size of the circuitry that can be produced at the facility. Smaller node sizes can produce more complex and sophisticated circuitry on wafers (at present the most advanced widely produced node size of silicon semiconductors is five nanometres (nm)). Dies, or the individual chips on the wafers, are then tested to remove any faulty ones and the rest are then cut out of the wafers. These chips are then packaged to be integrated within electrical systems.

24. Fab construction costs vary. We heard that the cost of building and running a fab "of a reasonable scale" in non-silicon or older silicon technologies in the UK was "typically £50 million to £100 million".[37] But for advanced silicon technology semiconductors (with node sizes less than 28 nm), the investment needed for fab construction is of a quite different order. Alistair McGibbon, representing the Compound Semiconductor Applications Catapult, told us that the cost of constructing a fab using leading edge silicon technology capable of producing the most complex integrated circuits was such that "you would not get much change out of US $20 billion".[38] And costs are increasing in line with each advance in node technology: Trish Blomfield, UK Country Manager for Intel, told us that a fab which would have cost $3 billion ten years ago now cost "between $10 billion and $15 billion".[39] Because of the sheer size of investment required, fabs often continue to produce for decades the semiconductor components which they were originally designed for.

25. Some fabs are "open access fabs": facilities which open their services to customers to load the fab with their own semiconductor component designs. Designers of integrated circuits mostly operate a "fabless" business model, typically outsourcing manufacturing to fabs to offset the costs of advanced fabrication. Open access fabs generally need to operate at or near full capacity if they are to be financially viable.

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37 Q10

38 Q8

39 Q125

The UK semiconductor industry

26. The UK accounts for only 0.5% of sales of semiconductors across the world,[40] but its products have global reach. For example, over 90% of silicon semiconductors created in the UK are exported;[41] and a representative of Arm, a British firm which licences intellectual property for its semiconductor designs, told us that Arm's UK revenues were less than 1% of its total.[42] The Compound Semiconductor Applications Catapult estimated that the UK compound semiconductor market alone was worth around $8bn in 2020 and would rise to $11bn in 2024.[43]

27. Crucially, the UK has world-leading capabilities in certain fields, notably in core intellectual property,[44] research and development, fabrication of compound and advanced material semiconductors, and packaging design and development. One witness said that the UK's capability in compound semiconductors placed it in "a leadership position" globally.[45] Another witness summed up the UK's overall position neatly: in terms of "where we sit on the global stage, it is very high in terms of our capability. In terms of our footprint, it is very low at the moment".[46]

Fabrication in the UK

28. The UK has approximately 25 "fabs" across the country, including a number of university-based fabs in development at Leeds, Cardiff, Swansea and Cambridge;[47] but fabs in the UK do not represent the full range of manufacturing capability. In comparison to other countries, that might be considered quite a small number of fabs and a relatively small volume of wafer production when compared to demand. Alan Banks, the CEO of TechWorks,[48] told us that the UK has ideal environmental and political conditions to allow for semiconductor fabs to be built, but there needed to be the right momentum and inward investment to make them a viable proposition.[49]

29. Fabrication processes in the UK tend to date from the 1990s or early 2000s.[50] Most of the equipment used in UK fabs is relatively old "legacy node", greater than 180 nm, producing for niche applications and specialised end uses. We were told that they were profitable, primarily in automotive markets.[51] No fabs in the UK can produce the most advanced silicon semiconductors, with a node of below 28 nm; and there is little immediate prospect of such facilities being constructed in the UK, given the very high costs involved.

30. The lack of investment into building semiconductor facilities over the last 20 to 30 years has led to a distinct semiconductor ecosystem in the UK, with specialised "clusters" forming around fabs providing jobs, spin-offs, and links with academia.[52] Each fab may

40 Mr Banks Q40
41 Q10
42 Mr Williamson unnumbered question before Q99
43 Compound Semiconductor Applications Catapult (SEM0029)
44 Q102 and Q103
45 Mr Lemos Q68
46 Mr Banks Q40
47 Centre for Integrative Semiconductor Materials, Swansea University (SEM0044)
48 An industry association designed to promote deep tech capability in the UK. TechWorks defines "deep tech" as technology that is based on tangible engineering innovation or scientific advances and discoveries.
49 Mr Banks Q40
50 Dr Sellars Q11
51 Mr McGibbon Q8
52 Mr Versluijs Q80

have its own end product and method of manufacture, which means that it is difficult to diversify by applying the manufacturing equipment to other purposes. The scale of investment required for the creation of fabs, in terms of both capital funding and time, and the complexity of the process, makes it uneconomic to move facilities. So the knowledge and skills linked to a fab are likely to stay in one area: a fab becomes a "centre of gravity", and expertise and capability becomes, in the words of one witness, "very sticky".[53] That has advantages: the concentration of expertise attracts firms which support the production process or have an interest in the product. The result is that "clusters" of firms have formed in certain areas of the UK, all with an interest in, or a dependency on, semiconductor manufacture.

Semiconductor clusters

31. The main "clusters" in the UK are located in:

- Northeast England, where there is capacity to use gallium nitride and gallium arsenide technologies to produce RF (radio frequency) chips;
- Scotland, where there is a focus on heavy power and satellite applications;
- South Wales, where a cluster of firms linked to compound semiconductor manufacture is located;
- Cambridge and its environs, where "Silicon Fen" became a centre for electronics firms from the 1990s onwards; and
- Southwest England, where there is a cluster of photonics and electronics companies.[54]

32. According to CSConnected,[55] the compound semiconductor cluster in South Wales generates annual sales of £500 million and employs 2,390 staff in research, engineering and high value added manufacturing. It told us that each direct job in the South Wales semiconductor cluster supported an additional 0.51 jobs elsewhere in the Welsh economy and over £121,000 of gross value added per employee.[56] Scottish semiconductor photonics is a £1 billion industry that employs 4,000 highly skilled engineers.[57] According to one estimate, the photonics and electronics cluster in southwest England comprises some 174 companies generating over £500m in annual sales and employing over 3,000 highly skilled staff.[58]

33. The UK's well-developed clusters put the country in a good position to capitalise on growth. We were told that there was both ambition and potential to expand these sites, both in their current location and beyond, but that this could only be achieved with large-scale investment, as seen in the US.

53 Mr McGibbon Q8
54 Mr McHugh Q16. See also EPIC-Torbay-Hi-Tech-Cluster-2022.pdf (epic-centre.co.uk)
55 A body representing organisations that "are directly associated with research, development, innovation and manufacturing of compound semiconductor related technologies" and organisations "along the supply chains whose products and services are enabled by compound semiconductors"
56 CSConnected (SEM0023)
57 Photonics Scotland, Photonics in Scotland: A Vision for 2030, 10 April 2019
58 Harlin Ltd, Microelectronics and Photonics in the Heart of the South West Region, 23 May 2017

3 Supply and demand

Why has there been a supply shortage?

34. The dependence of certain sectors of the global economy on the supply of semiconductor components became all too evident in 2020, when a shortage caused widespread disruption to the manufacture of many items, ranging from consumer goods to more complex devices. Goldman Sachs, a multinational investment bank, estimated that at least 169 industries had been affected.[59] Analysis by Deloitte, a consultancy, suggests that the chip shortage has resulted in the loss of more than US $500 billion in revenue amongst the semiconductor and its customer industries.[60] The CEO of Intel has warned that the current shortage could last for two more years, because of the limited availability of key manufacturing tools,[61] and the Department for Digital, Culture, Media and Sport's written submission drew our attention to a forecast that global chip demand might outstrip capacity for the next decade.[62]

35. Analysis by KPMG, which specialises in accountancy and audit services, suggests that the automotive sector has been particularly badly hit, accounting for 80% of the US $125 billion in sales estimated to have been lost because of the shortage.[63] A car cannot ship with any components missing, regardless of cost, and so production lines can come to a halt as a result.[64] One witness suggested that the automotive sector had been hit particularly hard because the semiconductors used in vehicles had to operate in a wide range of environments and climates, and it was not always viable to substitute an alternative type of semiconductor.[65]

36. Supply shortages led to an increase in prices: the British Electrotechnical and Allied Manufacturers Association (BEAMA), a trade association for manufacturers of electrical and energy-related products, told us that doubling of "normal" prices had been commonplace, and for certain semiconductors in exceptionally short supply, price increases of up to 200 times the standard price had been reported.[66] The rise in integrated circuit prices for the automotive industry was especially pronounced, increasing by 34% in 2022 on the 2021 base.[67]

37. The main cause of the shortages in supply to the automotive industry was the COVID-19 pandemic. The pandemic, and resulting lockdowns, led to a reduction in demand for vehicles and interruptions to vehicle manufacturing (as they did in some areas of semiconductor manufacture). As automotive manufacturers reduced their orders for semiconductor components, production was switched to production for consumer devices, where demand was increasing due to a shift to working from home and remote

59 Yahoo! Finance, These 169 industries are being hit by the global chip shortage, 25 April 2021
60 Deloitte, 2022 semiconductor industry outlook: Analyzing key trends and strategic opportunities, 2022
61 CNBC, Intel CEO now expects chip shortage to last into 2024, 29 April 2022
62 DCMS (SEM0080)
63 Surviving the silicon storm, KPMG, 2021
64 Professor Young Q49. Data from the Society of Motor Manufactures and Traders shows that UK car output in 2021 fell to the lowest total since 1956 to only 859,575 units: see SMMT (SEM0035).
65 Mr Banks Q25
66 BEAMA (SEM0055)
67 Make UK (SEM0012)

learning. Forecasts failed to predict the high levels of demand which materialised once vehicle manufacturing fully resumed, and there was no additional capacity amongst suppliers of semiconductors to fulfil that renewed demand.[68]

38. A wide range of other industries, processes and initiatives have been affected. To take just two domestic examples: Energy UK told us that the rollout of smart meters in the UK had been affected,[69] and the British Electrotechnical and Allied Manufacturers Association (BEAMA) warned that statutory regulations which require domestic and workplace electric vehicle charge points to include smart functionality would lead to an increased need for semiconductors "that may be practically impossible to meet".[70]

39. Even with fabs now operating at full capacity, they have not been able to meet demand, resulting in product lead times of six months or, in some cases, more than 12 months. Semiconductor manufacturers are vulnerable to economic, environmental and social shocks, as they operate a 'just-in-time' model where they produce what is ordered and no more. They may become exposed to what is known as the 'bullwhip effect', whereby small changes in demand at the retail level are amplified as the effect passes through the supply chain, placing great strain on manufacturers.[71]

Long-term risks

40. While some fluctuations in supply have one-off causes (such as the pandemic) or may simply indicate a lag between supply catching up with demand, geopolitical factors have the potential to dislocate supplies over the longer term. For instance, Russia's invasion of Ukraine has affected the supply of essential materials, including rare earth metals. Ukraine supplies around 70% of the world's neon gas, which is used in the development and creation of semiconductor materials, and Russia exports approximately 40% of the world's supply of palladium, also used in manufacture of chips.[72] The risk of China invading Taiwan and disrupting the export of semiconductors is also a distinct potential threat. Such an act, coupled with the combined dominance of the Chinese and Taiwanese semiconductor markets, poses a material risk to the global economy and military and defence production capabilities.

Concentration of production

41. The supply chain for the design and production of semiconductors is remarkably fragmented. The need for high levels of knowledge and expertise, and for substantial capital investment, have led to disaggregation of vertically integrated supply chains over time. The usual model now is one of local specialisation, and the development of geographical concentrations of certain supply chain elements and competencies,[73] and of associated concentrations in computer chip manufacturing. Different supply chains are required for different types of semiconductor, and a wide range of companies will be involved in creation of a semiconductor and its integration into an electronic system in

68 Mr Banks Q24, Professor Young Q50, Mr Lemos Q52
69 Energy UK (SEM0063)
70 Electric Vehicles (Smart Charge Points) Regulations 2021, SI 2021 No. 1467. See BEAMA submission (SEM0055)
71 World Economic Forum, What's the 'bullwhip effect' and how can we avoid crises like the global chip shortage?, 12 May 2021
72 MRL Consulting Group (SEM0034). Palladium is required for the lasers used to create the most complex computer chips. See also Ms Hughes Q32.
73 See Q61

the end product.[74] No one country has an end-to-end semiconductor supply chain for any one industry, and it would be immensely challenging for any single country to have one.[75] Industries which rely upon semiconductors or chips have as a result become highly susceptible to interruptions in supply.

42. DCMS's written submission set out examples of where particular processes or products had become concentrated in different parts of the world,[76] and witnesses provided further detail. Whereas in 1990, 80% of manufacturing was in the US or in Europe, the balance had changed, and 80% of production overall is now in Asia.[77] The US share of semiconductor manufacturing capability has decreased by 10% in the last eight years, because of production incentives in other countries and consolidation of the industry. Most advanced computer chip manufacturing (less than 10 nm) takes place in Taiwan and South Korea,[78] with the Taiwan Semiconductor Manufacturing Company (TSMC) dominant and Taiwan alone producing 92%.[79] Taiwan and Korea account for 83% of global processor chip production and 70% of memory chip output.[80] Alan Banks, the CEO of TechWorks, told us that if Taiwan were "to lose its ability to supply chips around the world, it would take three or four years for the whole world to be able to create what comes out of Taiwan".[81]

International approaches to safeguarding supply

43. The risks inherent in the concentration of production and bottlenecks in supply have been widely recognised internationally, and large financial commitments are being made globally to strengthen sovereign capabilities over more of the semiconductor supply chain and to diversify the location of semiconductor manufacturing facilities.

44. In March 2022, President Biden referred to semiconductors as "so critical to our national security… that we're going to create rules to allow us to pay a little more for them if they're made in America".[82] In July 2022, the US Congress passed a CHIPS[83] Act with bipartisan support, earmarking US $52 billion for chip production in the US, through manufacturing grants, research investments, and an investment tax credit. US technology firms that receive funding under the Act will not be able to construct fabs in China for a decade.[84]

45. In February 2022, the European Commission published a draft "EU Chips Act" in an attempt to ensure the European Union's security of supply, resilience and technological leadership in semiconductor technologies and applications. The aim is to double the EU's current 10% share in the semiconductor market by 2030. The Act "mobilises" over 43 billion euros in public and private investment to strengthen research capacity, enhance production capacity and facilitate access to finance for start-ups.[85] The US and EU

74 Ms Hughes Q33
75 DCMS (SEM 0080). See also Ms Hughes Q33 and Mr Williamson Q104
76 DCMS (SEM 0080), paragraph 13
77 Q123
78 Taiwan is worried about the security of its chip industry, *The Economist,* 26 May 2022
79 DCMS (SEM 0080), paragraph 13
80 Geopolitical Spotlight Shifts To Semiconductors - The New Oil, TS Lombard, 10 February 2021
81 Q42
82 Are Semiconductors a National Security Issue? *The Diplomat,* April 2022
83 CHIPS: Creating Helpful Incentives to Produce Semiconductors for America
84 US bans 'advanced tech' firms from building facilities in China for a decade, *The Guardian*, 7 September 2022
85 Digital sovereignty: Commission proposes Chips Act (europa.eu). See also Mr Banks Q45

announced a joint initiative to avert a "subsidy race" for computer chips at the second meeting of the US-EU Trade and Technology Council on 23 May 2022.[86] A number of companies have announced plans to construct semiconductor fabs within the EU.[87]

46. The Semiconductor Industry Association estimates that the Chinese government has invested up to US $73 billion in its domestic semiconductor industry (not including grants, equity investments and low-interest loans, which together exceed US $50 billion).[88] China's 14th Five Year Plan (2021–2025) specifically identifies compound semiconductors as an area where China could take the lead.[89] China's largest chipmaker, Semiconductor Manufacturing International Corporation, declared that it had managed to reach 7nm node size semiconductors, despite limited access to the most advanced semiconductor manufacturing equipment.[90]

47. Other countries have launched initiatives to increase resilience in the supply chain:

- South Korea recently unveiled the "K-Semiconductor Belt" strategy, aimed at building the world's largest semiconductor supply chain by 2030;[91]
- Japan commenced a US $338 million semiconductor research initiative in 2021[92] and has approved US $6.8 billion in funding for domestic semiconductor investment to double domestic chip revenue to US $114 billion by 2030;[93]
- India plans to spend US $30 billion to make it a foundation of the semiconductor supply chain and manufacturing.[94]

We also note that the main manufacturer in Taiwan, TSMC, is now starting to invest in and operate from sites outside of Taiwan.[95]

Implications for the UK

48. The UK, like other countries, does not have an end-to-end supply chain for semiconductors. In the UK, there is no large-volume silicon semiconductor fabrication, no source of certain key base materials, limited capability in outsourced semiconductor assembly and testing (OSAT),[96] and limited capacity in advanced packaging. There is also a mismatch between the output from UK fabs, which are relatively few in number and which commonly use older technology to produce niche products, and the requirements of

86 EU will seek to head off subsidy race over chip production, official says, Reuters, 16 May 2022
87 Intel is planning to invest over €33 billion in its initial wave of European R&D and manufacturing, including €17 billion for a "leading-edge semiconductor fab mega-site" in Germany, and a € 12 billion expansion of its existing Ireland fab. as part of a total of €80 billion invested in the EU over the next decade. Spain recently pledged to spend €12.25 billion on building chip plants as part of its Covid-19 recovery plan. France revealed a €30 billion plan to invest into robotics, semiconductors, electric cars and nuclear/renewable energy sources in 2021 up to 2030. In response, semiconductor companies STMicroelectronics and GlobalFoundries have undertaken to build a €5.7 billion fab.
88 SIA Whitepaper: Tacking Stock of China's Semiconductor Industry, Semiconductor Industry Association, July 2021
89 China's 14th Five-Year Plan (2021–2025): Spotlight on Semiconductors, *Covington*, 26 April 2021
90 China's chip breakthrough poses strategic dilemma, *Financial Times*, 16 August 2022
91 SMMT (SEM0035)
92 ITPro, Japan funds $338 million TSMC chip development project, 1 June 2021
93 SMMT (SEM0035)
94 SMMT (SEM0035)
95 Mr Docherty Q45; Imperial College London (SEM 0016)
96 Q95

UK manufacturing or technology firms for which semiconductors are vital components. On the other hand, manufacturers may not be fully aware of what can be acquired within the UK.

49. While a dependence on external supply is a risk for any business, in certain sectors the dependence on semiconductor supply from outside the UK could pose threats of a higher order. CSConnected warned us that:

> there are numerous national security concerns and vulnerabilities within the current UK semiconductor supply chain, ranging from minimal control over most of the large-scale manufacturing of semiconductor chips within the UK, to the forced outsourcing of our most sensitive defence-related chip designs to overseas manufacturers, posing a real and present threat to the UK's national security.[97]

50. It would not be realistic for the UK to attempt to onshore the entire semiconductor supply chain in all its forms. The route towards increasing resilience and reducing dependence lies instead in focusing on strengths and co-operating with trusted, secure long-term partners, as advocated by a number of contributors to our inquiry.[98] IQE told us that

> having strategic footholds in the industry is more important in the near term than creating end-to-end supply chains. Such footholds create influence and establish resilience and security of supply, as well as representing commercials and political bargaining chips.[99]

Rina Pal-Goetzen, Director of Global Policy for the Semiconductor Industry Association, based in the US, told us:

> A resilient supply chain has to look like countries co-operating. Right now the problem we have is that there is intense competition between countries that are not very co-operative. This is creating a national security issue for many places. We call it friend-shoring here [the US], because no country can really develop all these things on its own.[100]

51. As for where the UK might look for international co-operation, Trish Blomfield, UK Country Manager for Intel, noted a "reinvigorated European supply chain" which could offer greater resiliency and which could "allow for a made in Europe and designed in Europe supply chain as well".[101] The Bessemer Semiconductor Manufacturing Group suggested that "to strengthen its position, the UK could help coordinate a Five Eyes equivalent for the semiconductor and advanced electronics industry which extends the traditional definition of national security beyond military defence into protection of the

97 CSConnected (SEM0023)
98 For instance School of Electronic & Electrical Engineering, University of Leeds (SEM0056); Mr Banks Q20, Ms Pal-Goetzen Q121
99 IQE (SEM0075)
100 Q130
101 Q123. See also evidence from Welsh Government (SEM0040), Nexperia (SEM0054), Make UK (SEM0012) paragraph 22

most sensitive parts of the economy”.[102] Trish Blomfield pointed to the WTO, G7 and G20 as fora for international agreements, noting that the UK had “a really important seat at the table for international collaborations”.[103]

52. ***The UK is an important part of global semiconductor supply chains, but it is reliant upon other countries. The UK alone will not have an end-to-end supply chain for semiconductors, but it has tradeable strengths. The Government should work more closely with allies in the EU and US, and elsewhere, to safeguard security of supply, both of finished products and of the materials needed for production in the UK. The Government should at the same time be working to represent the UK’s expertise and to entrench and expand the UK’s role in global semiconductor supply chains.***

53. ***We ask Ministers to consider whether the above recommendation, on closer working between the UK and allies in the EU and US, can be effectively delivered by requesting that the UK be invited to take part in relevant parts of the EU-US Trade and Technology Council. We further ask Ministers to set out the Government’s position on whether a new multi-lateral organisation for industrial collaboration between allied democratic countries is required and, if not, which existing multi-lateral organisation provides the opportunity for this important work to be undertaken.***

Other national security risks

54. Taking steps to bring more elements of the supply chain within the UK and a trusted network of allies would not in itself satisfy national security concerns. In written evidence, the Department for Digital, Culture, Media and Sport told us that:

> Due to their importance for national security and defence purposes, some actors may attempt to use economic engagement to acquire UK semiconductor technologies which can present national security risks to the UK.[104]

55. Several contributors to our inquiry expressed fears about foreign acquisition of intellectual property or means of production. We were told that struggling small businesses in the UK were sometimes acquired by overseas firms, and that intellectual property was lost to the UK as a result.[105] Dr Ron Black highlighted the strategic importance of semiconductors, maintaining that “any semiconductor asset that exists today in the UK is critical and a risk if sold unless and until proven that it is not”.[106] Others made points in similar vein.[107] But a number of firms which are central to the UK semiconductor industry and which make a significant contribution to the UK economy are ultimately foreign-owned.[108]

102 Bessemer Semiconductor Manufacturing Group (SEM0074)
103 Q125
104 DCMS (SEM 0080)
105 Mr Banks Q39
106 SEM0049. Dr Black was formerly CEO of Imagination Technologies and is now CEO at Codasip, a supplier of processor IP
107 See for example Imperial College London (SEM0016) on national security concerns; also CSConnected (SEM0023)
108 Arm, a key semiconductor and software design company in the UK, is owned by Softbank, a Japanese group. The Newport Wafer Fab is owned by Dutch company Nexperia, a subsidiary of Wingtech Technology, a Chinese firm. The fabrication facility in Newton Aycliffe is owned by the American company II-VI (now renamed as Coherent Corp.)

56. Some foreign acquisitions of UK semiconductor firms—or attempted acquisitions—have gained notoriety. Imagination Technologies, a UK semiconductor design company, was acquired by Canyon Bridge, a US-based private equity firm, whose largest investor is China Reform Holdings Corporation, a Chinese state-owned investment company. In 2020, China Reform Holdings sought to appoint four directors to the board of Imagination, but the attempted takeover did not proceed, following pressure from a number of select committees (including this committee)[109] and intervention by the Government.

57. A further example is Arm, a semiconductor and software design company based in the UK, which was acquired in 2016 by SoftBank, a Japanese investment group. In 2020, SoftBank attempted to sell the company to Nvidia, a US multinational technology company. The deal was abandoned following an investigation by the Competition and Markets Authority in the UK, and opposition from the US Federal Trade Commission on the grounds that the merger would give Nvidia too much market power.[110]

58. Controversy currently surrounds the acquisition of the Newport Wafer Fab (NWF) in 2021 by Nexperia, a company registered in the Netherlands but owned by Wingtech Technology, a Chinese firm. Nexperia maintains that it saved Newport Wafer Fab from bankruptcy and secured jobs at the plant.[111] However, the takeover is regretted by those who had hoped to see an open access fab established at the Newport site, providing a route by which fabless companies could manufacture compound semiconductors in the UK.

59. Objections to the takeover, on national security grounds, were raised by the Foreign Affairs Committee in its report *Sovereignty for sale: The FCDO's role in protecting strategic British assets*. In that Report, the Committee said:

> The takeover of Newport Wafer Fab by Nexperia represents the sale of one of the UK's prized assets to a strategic competitor, at a time when global chip shortages means that the products manufactured by NWF are of vital national importance. Failure to conduct a detailed assessment of this transaction under the National Security and Investment Act would indicate that the Government continues to hold an unrealistically optimistic understanding of the Chinese government's intentions and is prioritising short-term commercial interests over the long-term security of our country.[112]

On 25 May 2022, the then BEIS Secretary of State announced that the takeover would be called in for investigation under the National Security and Investment Act (described below). This followed an earlier review of the acquisition by the National Security Adviser, at the request of Prime Minister Boris Johnson, which began in July 2021 and is understood to have lasted several months.[113]

60. On 16 November 2022, the Secretary of State issued a Final Order under the Act, requiring Nexperia to sell at least 86% of its 100% shareholding in Newport Wafer Fab (formally "NNL"). The grounds for his decision were that:

109 https://committees.parliament.uk/publications/653/documents/2763/default/
110 Nvidia's $40bn takeover of UK chip designer Arm collapses | Technology sector | The Guardian
111 Q84
112 *Sovereignty for sale: The FCDO's role in protecting strategic British assets*, Third Report of the Foreign Affairs Committee, Session 2021–22
113 For more information on the examples cited above, see Semiconductors in the UK: Searching for a strategy, Policy Exchange, June 2022

- There was a national security risk relating to technology and know-how that could result from a potential reintroduction of compound semiconductor activities at the Newport site, and the potential for those activities to undermine UK capabilities; and
- There was a risk that the location of the site could facilitate access to technological expertise and know-how in the South Wales Cluster, and that the links between the site and the Cluster could prevent the Cluster being engaged in future projects relevant to national security.[114]

61. Nexperia issued a statement expressing dismay at the decision, criticising the Government's handling of the case, rejecting the finding that there were potential national security concerns, and announcing that it would exercise its right under the Act to appeal against the decision.[115]

National Investment and Security Act and export controls

62. The Government seeks to protect sensitive technologies, goods and services from malign foreign influence or acquisition. In its written evidence, the Department for Digital, Culture, Media and Sport told us that:

> To robustly manage these risks, the UK has a number of tools at its disposal, including export controls which the government strengthened through the enhanced military-end user controls introduced in May 2022, and the new National Security and Investment Act which commenced on 4 January 2022.[116]

63. The National Security and Investment Act 2021 allows the Secretary of State to review certain acquisitions of control that may give rise to a risk to national security. Whilst the powers cover all areas of the economy, acquisitions of voting rights or shares above certain thresholds in 17 particularly sensitive sectors must be notified to the Secretary of State and receive approval before completion. If, following scrutiny, the Secretary of State believes that a risk to national security has arisen or may arise, the Secretary of State may make a final order imposing conditions on acquisitions, or blocking them from completion or, if the acquisition has already taken place, unwinding the acquisition.[117]

64. The Government's export control system is based upon lists of products, software and technology which are deemed to have strategic value and which require a licence for export. Applications for licences are considered by the Export Control Joint Unit (ECJU), the Government's regulatory authority for export licensing of strategic goods. Goods not listed may still need a licence if they are likely to be sent to an end-user where there are concerns that they might be used in a weapons of mass destruction programme.[118]

65. Industry figures who gave evidence to our inquiry acknowledged the case for controls in the interests of national security.[119] One witness (Mr Beresford-Wylie, CEO at

114 Newport Wafer Fab decision: notice of final order (publishing.service.gov.uk)
115 Statement by Nexperia, 16 November 2022
116 DCMS (SEM 0080)
117 National Security and Investment Act 2021 Annual Report 2022, DBEIS June 2022
118 UK Strategic Export Control Lists
119 For example Ms Blomfield Q133

Imagination Technologies) described the export control regime in the UK as "good" and "very tightly and narrowly focused".[120] Toni Versluijs, Country Manager for Nexperia UK, recognised that "matters of national security need to be investigated in a good and diligent way", although he believed that investigations needed to be conducted swiftly.[121] Mr Beresford-Wylie made a similar point about the pace of the export control process, which he thought took "an awfully long time" and which he said had led to losses in sales to competitors in the US, China and even the UK.[122]

66. **The exercise of controls under the National Security and Investment Act is still at an early stage. We note reservations about the speed of some assessments under the Act and under the export control process, and we will be conducting scrutiny of how powers under the National Security and Investment Act are being used via our National Security and Investment Sub-Committee. Nevertheless, it is our view that the overall purpose of the Act in monitoring acquisitions with a view to safeguarding national security is sound. We believe that it has the potential to help meet concerns about hostile access to intellectual property, knowledge and expertise within the semiconductor industry, and such powers should be used to avoid this.**

67. ***We will further consider the Nexperia case, via the National Security and Investment Sub-Committee, once the period for appeal has expired. In the meantime, the Department should work proactively to ensure a successful transfer of the Newport site to a new owner. Ministers should update the Committee on progress made.***

Critical national infrastructure

68. In written evidence to our inquiry, NCC Group questioned whether "the semiconductor should be formally established as critical infrastructure". It argued that "in doing so, the Government would ensure that the industry is held to the same security and resilience standards as the likes of energy, transport and healthcare are currently".[123]

69. The Government has designated thirteen national infrastructure sectors and has defined Critical National Infrastructure (CNI) as "those critical elements of infrastructure (facilities, systems, sites, property, information, people, networks and processes), the loss or compromise of which would result in major detrimental impact on the availability, delivery or integrity of essential services, leading to severe economic or social consequences or to loss of life". It seeks to reduce the vulnerability of CNI to threats and hazards, and to improve its resilience by strengthening its ability to withstand and recover from disruption.[124] In many cases semiconductors are integral to technology or essential systems which underpin those sectors—communications, health and defence being perhaps the most obvious examples.

70. ***Semiconductors play a hidden but highly significant role in many parts of the UK's critical national infrastructure. We request that the Government sets out which elements of the semiconductor supply chain constitute critical national infrastructure.***

120 Mr Beresford-Wylie Q100

121 Q89 and Q90. See also Mr Thomas Q92

122 Q100 and Q101

123 NCC Group (SEM0038). NCC is a cyber security and software resilience business

124 Public Summary of Sector Security and Resilience Plans, Cabinet Office 2017

4 Role of Government

71. Semiconductors are manufactured by private firms and are sold on the open market. But because of their significance for industries which are fundamental to the UK economy and to our security and wellbeing, and their role in underpinning much of the country's national infrastructure (including critical national infrastructure), central government does not—and should not—entirely stand aside and let market forces determine the health of the UK semiconductor industry and the security of supply. This chapter examines the support which the Government currently offers in various forms.

72. The Government, in its Innovation Strategy, has designated electronics, photonics and quantum technologies as a "family" in which the UK has globally competitive research and development capability and industrial strength. "Families" are a starting point for prioritisation. The Government says that:

> Attempting to lead in every technology within each family will likely prevent us attaining a world-leading edge in any one area. We will need to prioritise investments at a granular level, considering factors like UK comparative advantage, transformative potential, and security and societal need. Learning from the success of vaccine development we must be decisive in backing these priorities and be agile in reviewing those we back where circumstances change.[125]

73. The Government is clear that semiconductors offer significant potential:

> The UK is already a leader in the design of semiconductors, and with sufficient support it has the potential to become a leading designer and manufacturer of compound semiconductor chips and technologies. This would allow the UK to capitalise on increased global demand for semiconductor chips and support domestic production in critical sectors like health, telecoms and automotive. By the mid-2030s UK companies, including those based at established clusters in Wales, Bristol and Cambridge, could play an increasingly central role in a supply chain of acute geopolitical importance.[126]

Government responsibility

74. Although the Department for Digital, Culture, Media and Sport (DCMS) is taking the lead on producing a semiconductor strategy, it is doing so in close collaboration with other government departments.[127] Many departments' interests intersect in this field, including:

- DCMS, which owns the Government's Digital Strategy,[128] designed to encourage innovation, skills and growth in the digital sphere;

125 UK Innovation Strategy, page 85. The UK Innovation Strategy sets out the Government's vision to make the UK a global hub for innovation by 2035.
126 UK Innovation Strategy, page 91
127 DCMS (SEM 0080)
128 UK Digital Strategy. The Digital Strategy's objectives include strengthening the digital economy and infrastructure supporting innovation, increasing the supply of digitally and tech-enabled workers, and financing digital growth

- the Department for Business, Energy and Industrial Strategy (BEIS), which is responsible for allocation of research funding and mechanisms to support industry, and which owns the UK Innovation Strategy and is developing a UK Quantum Strategy;[129]
- the Ministry of Defence and Department of Health, which are prime consumers of sophisticated technologies ultimately dependent on semiconductors;
- the Cabinet Office, where the Office for Science and Technology Strategy (OSTS) is located. OSTS "aims to strengthen the Government's ability to understand, shape and use critical and emerging science and technology" so as to "boost the UK's prosperity, wellbeing and security in an increasingly connected, complicated and competitive world";[130] and
- HM Treasury, which leads on overall economic growth.

75. The Government's net zero strategy relies heavily on semiconductor technology. Compound semiconductors are essential for power conversion, battery technologies, panels and other renewable power generation methods. Americo Lemos, CEO of IQE,[131] told us that "there is no net zero without compound. You have to realise that. There is no autonomous driving without compound electronics".[132]

76. The Department for Levelling Up, Housing and Communities is another part of government with a distinct interest in leading-edge technology firms, such as semiconductor firms, which can bring high-skill and high-wage jobs to areas which (in the words of the White Paper on Levelling Up) had "faced economic headwinds in the past". Semiconductor "clusters", of firms engaged in semiconductor production and in associated industries, are mostly located outside London and the southeast, sometimes in areas which have suffered a decline in more traditional manufacturing. The Government's White Paper on Levelling Up set out an ambition to "reverse the historic decline in manufacturing in the UK with more of the sort of innovation which characterises economies such as South Korea and Israel". In recognition of the value of locating in close proximity centres of research and business which might draw on that research, the White Paper announced that £100 million would be set aside for investment in three new Innovation Accelerators—private-public-academic partnerships which would "aim to replicate the Stanford-Silicon Valley and MIT-Greater Boston models of clustering research excellence and its direct adoption by allied industries".[133]

129 UK Quantum Strategy: call for evidence (publishing.service.gov.uk). It is envisaged that the Strategy would set out ways of supporting commercialisation and industrialisation of quantum technologies, attracting investment, developing the sector and supply chains, helping the research landscape to evolve, and increasing efforts to collaborate with international partners.

130 https://www.gov.uk/government/groups/office-for-science-and-technology-strategy#about-us

131 IQE designs and manufactures complex compound semiconductor wafers

132 Q67. See also BDJ Group (SEM0017) and Centre for Integrative Semiconductor Materials, Swansea University (SEM0044)

133 Levelling Up the United Kingdom (publishing.service.gov.uk), Executive Summary. See also UK Innovation Strategy, page 72

Where should lead responsibility lie?

77. Some of those who contributed to our inquiry were uncertain about where primary responsibility within Government for the prosperity of the semiconductor industry lay, and to which part of Government they should address concerns.[134] Malcolm Penn, Founder and CEO of Future Horizons Ltd, noted that "two distinct government departments (BEIS and DCMS) both seem to have responsibility but it is unclear to industry exactly who is responsible for what (and thus who to talk to)".[135] PragmatIC suggested that responsibility "most likely sits with BEIS" but it recognised that the Government would need to bring together inputs from other departments and units.[136]

78. Even if responsibility were to be shared between different parts of Government, the industry was clear that it needed the Government to speak with one voice when dealing with the semiconductor industry.[137] Toni Versluijs, Country Manager, Nexperia UK, suggested that engagement might be enhanced if the Government was to designate a taskforce or champion for semiconductors,[138] and CSConnected suggested that an Office for Semiconductors might be created.[139]

79. ***We recognise that many Government departments have an interest in the semiconductor industry, and that these interests may overlap. But, in our view, the value of semiconductors to so many sectors of the UK economy and to UK national infrastructure, combined with the national security necessity of safeguarding semiconductor supply, make it essential that a single Government department takes responsibility for nurturing the semiconductor industry in the UK and for security of supplies. We believe that that department should be BEIS, because of its overarching responsibility for industrial strategy, business support, engagement with industry and policy on research funding, and because of its role in protecting UK industrial assets from undue control by overseas entities.***

A more co-ordinated voice for the sector

80. In some countries the semiconductor industry has a lead representative body (such as the Semiconductor Industry Association in the US). It was suggested to us that in the UK, where the semiconductor ecosystem is fragmented, there was scope for relevant trade associations to collaborate more[140] and speak with more of a combined voice. Malcolm Penn, Founder and CEO of Future Horizons Ltd, suggested that there were "too many trade bodies for an industry of such relatively small size, all stepping on each other's toes", and he believed that the industry would benefit from a "more rational" structure.[141] CSConnected has recommended the creation of a Semiconductor Leadership Group to "provide intelligence and independent advice to UK Government".[142]

134 Mr McHugh Q12, Mr Versluijs Q98.
135 Malcolm Penn (SEM0064). Future Horizons Ltd provides analytical and consulting services on the global semiconductor industry. See also Compound Semiconductor Applications Catapult (SEM0029)
136 PragmatIC (SEM0053). PragmatiC is a semiconductor company which manufactures in the UK.
137 See for instance Mr McHugh Q12
138 Q98
139 CSConnected (SEM0023)
140 Mr Lemos Q98
141 Malcolm Penn (SEM0064)
142 CSConnected (SEM0023)

81. **While it is for those in the semiconductor industry to decide how to champion its causes, we believe that there is scope for the sector to play its part in improving the clarity of communication between the industry and Government, for instance through a collective voice for the sector.**

DCMS Semiconductor Strategy

82. DCMS told us that it had been reviewing its approach to the semiconductor sector and that it planned to publish a semiconductor strategy in autumn 2022. The strategy would have three main objectives:

- Ensuring the UK has a reliable supply of semiconductors
- Ensuring an assured supply of semiconductors for the UK, and
- Protecting and growing UK capability, and seizing opportunities

It added that "for the domestic sector, [the strategy] will explore how to increase communications, research, innovation, coordination and, in conjunction with the Digital Strategy, support the development of a strong talent pipeline."[143] We note that a recent statement by the Government on the forthcoming strategy made no mention of autumn publication, so we are in some doubt as to when the Strategy will in fact be published.[144]

83. The DCMS strategy has already been nearly two years in the making, and there was some frustration in submissions to our inquiry about the pace of the work and the need for the Government to get on with support for the sector and to help attract inward investment.[145] CSConnected argued that a lack of national policy related to semiconductor technology "undermines the credibility of the activity as a priority sector for FDI [Foreign Direct Investment] and economic action".[146] MaxPower Semiconductor UK said that "compared to other major economies, the UK lags considerably in providing clarity and direction on semiconductor strategy";[147] and Rockley Photonics made the same point.[148]

84. The delay in producing a strategy matters. Rina Pal-Goetzen, representing the Semiconductor Industry Association (based in the US), told us in July that decisions were being made "right now" by companies on where to locate manufacturing over the next five to ten years, and that it was "very urgent" that each country should consider whether or not it wanted to be part of the supply chain.[149]

85. ***The Government was correct in its decision to instigate a review of its approach to the semiconductor sector and in heralding a new strategy. The industry has waited for the strategy and will base crucial decisions upon it. The Government should lose no more time and should publish its Semiconductor Strategy immediately.***

143 DCMS (SEM 0080)
144 HC Written Answers, 74747, 3 November 2022
145 For example Mr Beresford-Wylie Q106
146 CSConnected (SEM0023)
147 MaxPower Semiconductor UK (SEM0021). MaxPower is a "fabless" semiconductor company.
148 Rockley Photonics (SEM0032)
149 Q120

What should be in the Semiconductor Strategy?

86. The remainder of this report considers what should be in the strategy when it is published, and looks at mapping, opportunities for expansion, Government support (including research funding and investment support), and the supply of skills.

Mapping

87. A strategy for an industry sector needs to be based upon a full understanding of the current state of that industry. TechUK, a representative body for the technology sector, told us that the Government "should complete the mapping of the UK semiconductor industry already in process … to ensure it has a thorough understanding of the industry and key growth opportunities".[150] Dr Andrew Rickman, CEO of Rockley Photonics, told us that there was a need:

> to list … individual sectors [of the industry] and to understand each step of the supply chain associated with them from the specific wafer that you might use for that process right the way through to the IP element, the design, the test, how that gets built up and the value chain that is on top of that. You can represent that across each particular sector and you can analyse it in terms of this country's strengths and weaknesses.[151]

Dr Rickman did not believe that he had yet seen evidence of this in Government.[152]

88. Mapping would identify where the UK has areas of strength and areas of weakness in the semiconductor chain, where greater resilience was needed, and where the UK should be focusing its efforts.[153] Technology Scotland listed areas in which it saw the UK as having strengths,[154] observing that "any mapping exercise should develop further granularity, identifying specific product areas or applications where the UK is in a strong position to maintain or build a global presence".[155]

89. Mapping could also provide a picture of linkages to associated industries, the supply of relevant skills, and other factors sought by businesses seeking to establish themselves in the market. Dr Simon Thomas, the Chief Executive of Paragraf,[156] told us that his company had been approached by SelectUSA,[157] which had asked them what they needed to grow their business. In his response to SelectUSA, he had said that "we need infrastructure and potentially we need capital. Capital is not a big concern for us, but talent and infrastructure are big ones". He told us that two weeks later SelectUSA had provided them with "a heatmap of the whole US, which showed us where all the talent [and supply chain partners] is located".[158]

150 TechUK (SEM0065)
151 Q105
152 Q106. Rockley Photonics is a firm producing photonic chips
153 See Mr Banks Q41, Professor Young Q82, Dr Rickman Q105 and Q106
154 Such as compound semiconductors, and older generation silicon and design capability
155 Technology Scotland (SEM0039). Technology Scotland is an industry association for a range of organisations across the technology sub-sector
156 A manufacturer of semiconductors from advanced materials
157 A US government programme aiming to facilitate business investment into the United States
158 Q54

90. Mapping could also usefully identify over-capacity. The Bessemer Semiconductor Manufacturing Group suggested to us that some high-quality facilities were under-utilised because new companies were not always aware of what was available, choosing instead to use scarce investment funding to build new, duplicate facilities.[159] During visits both to Newport and to North East England, the Committee heard of older fabrication equipment that was of no further use to the fabs but which could be used in either academic settings or for fabrication of less complex semiconductor components.

91. ***We recommend that the forthcoming Semiconductor Strategy should include:***

- ***An analysis of the semiconductor production and supply chain, recognising different characteristics for different subsectors of the industry, and areas of strength and weakness;***
- ***A heatmap, showing where different semiconductor industries and niches are located within the UK, and how they are positioned in relation to the supply of relevant skills, equipment, research capability, and in relation to other factors valued by firms in those industries; and***
- ***An account of which industries in the UK and which key products are dependent upon a secure supply of semiconductors at reasonable cost.***

In addition, we recommend that the Government produces a risk and resilience strategy for the semiconductor industry alongside its Semiconductor Strategy, as a matter of urgency.

Opportunities

92. A strategy should look ahead, spot opportunities and set out a plan for developing them, and identify risks and how to mitigate them. Contributors to our inquiry put forward suggestions for areas where there was scope for the semiconductor industry to grow and take a lead internationally, or where weaknesses needed to be addressed in order to develop a fully-fledged and self-sustaining industry and an environment which made the UK a top choice for investment by multinational firms.

93. Areas of opportunity included:

- **Intellectual property and design,** where the UK is already strong and competitive;[160]
- **Supporting the design chain for leading edge node chips**; these costs lie somewhere between £40 million and £300 million but are still significantly less than capital expenditure required for leading edge silicon manufacture;[161]
- **Matching UK manufacturing capability to UK design capability**: as new technologies mature, there is scope to increase UK manufacturing in areas where the UK is strong in design. But Alastair McGibbon, giving evidence on behalf of the Compound Semiconductor Applications Catapult, told us that the semiconductor supply chain is quite often “not recognised” within the UK,

159 Bessemer Semiconductor Manufacturing Group (SEM0074)
160 Ms Pal-Goetzen Q128, Make UK (SEM0012), Compound Semiconductor Applications Catapult (SEM0029)
161 Q128; also Ms Blomfield Q129

and that firms in the chain might not (for instance) take account of the UK's manufacturing capability.[162] The Government and funding agencies could usefully monitor more carefully the risk of duplication when allocating funding;

- **Developing manufacturing processes for silicon semiconductors**: Dr Sellars, representing the Compound Semiconductor Applications Catapult, suggested that there might be benefit in adapting manufacturing processes to enable higher chip functionality, increasing the resilience and security of the UK's share of the industry;[163]

- **Development of existing strengths in compound and advanced material semiconductors, to meet demand in emerging markets.** Americo Lemos, CEO of IQE, explained that "most of what we call the megatrends in innovation require compound semiconductors, more so in volume than the traditional semiconductor products that we see". He added that "in this country, there is an opportunity to do the same thing [as in Taiwan] not in silicon but in compound semiconductors".[164] Mr McGibbon told us that volume of demand for silicon carbide chips was "vastly exceeding capacity" and that there was an opportunity for the UK to acquire a leading position in this new and quickly growing area.[165] Mr Thomas identified products from advanced semiconductor materials as a market which the UK "could take control of right now" with timely investment.[166]

- **Facilitating the construction of new fabs:** We note the lack of an open access foundry in the UK, which limits the ability of design companies to expand into manufacturing, forces some of the process overseas, and may reduce the attractiveness of the UK as a base for multinational firms. Toni Versluijs, representing Nexperia UK, told us that there were "plans" and "ambitions" to use a currently unused building on the Newport Wafer Fab site, and that a viable business case and funding plan was now required.[167] Rina Pal-Goetzen, speaking on behalf of the Semiconductor Industry Association, also saw benefits in opening up foundry capacity.[168] The Government could usefully undertake dialogue with the UK semiconductor industry to determine the scale of demand and requirements for developing an open foundry, possibly in the form of pilot lines, to prove proof of concept at manufacturing scale.

94. ***We recommend that the Government's Semiconductor Strategy consider scope for development of the UK semiconductor industry in the following fields:***

- ***Intellectual property and design;***
- ***Supporting the design chain for leading edge node chips;***
- ***Matching UK manufacturing capability to UK design capability;***
- ***Developing manufacturing processes for silicon semiconductors;***

162 Mr McGibbon Q8 and Q21; see also Ms Pal-Goetzen Q128
163 Q11
164 Q67
165 Q9. See also Dr Rickman Q105, and CSConnected (SEM0023)
166 Q94
167 Q85 and 86
168 Q128

- ***Development of existing strengths in compound and advanced material semiconductors, to meet demand in emerging markets;***
- ***Facilitating the construction of new fabs, including consideration of an open access fab in the South Wales cluster.***

Supporting business growth

95. There are several methods which the Government might use to support growth of businesses in the semiconductor sector. These include incentives for research and development (for instance through grants or tax credits), the creation and maintenance of an environment conducive to private investment, and encouragement of inward investment from overseas.

Research and development

96. UK Research and Innovation (UKRI) is the UK's largest public funder of research and innovation, allocating more than £8 billion in 2021–22 through Research England, Innovate UK,[169] and the seven disciplinary research councils.[170] In March 2022, the Government announced that £39.8 billion had been allocated for investment in research and development over the three-year period from 2022 to 2025, with spending set to increase to £20 billion per annum by 2024–25. The Government has also made a commitment to ensure that total spending on research and development reaches 2.4% of GDP by 2027.[171]

97. We were told that successive governments had devoted approximately £1 billion to funding semiconductor research since 2006.[172] Witnesses told us that the Government had invested nearly £800 million on compound semiconductor research through universities, helping it to become a world leader in the field.[173] Through Innovate UK, it has also funded the Compound Semiconductor Applications Catapult, located in Newport in South Wales.[174]

98. The Government published an Innovation Strategy in July 2021, setting out a long-term plan for delivering innovation-led growth and boosting private sector investment across the whole of the UK.[175] The Strategy noted the establishment of the Advanced Research and Invention Agency (ARIA), which will focus exclusively on projects with potential to produce transformative technological change, balancing the likelihood that most programmes fail in achieving their ambitious aims against the "profound and positive impact on society" which could be achieved by those that succeed.[176]

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169 Innovate UK's aim is to support business-led innovation and to help businesses grow through the development and commercialisation of new products, processes, and services.

170 UKRI Annual Report and Accounts 2021–22, page 24

171 Government announces plans for largest ever R&D budget, DBEIS, 14 March 2022

172 CSA Catapult (SEM0029)

173 Q1 and Q6

174 A "catapult" is an independent not-for-profit organisation designed to bridge the gap between research and industry, by providing a physical environment where businesses, scientists, technical specialists and engineers can work side by side testing ideas and developing their application. See About the Catapult Network - The Catapult Network

175 UK Innovation Strategy: leading the future by creating it

176 See Advanced Research and Invention Agency policy statement, March 2021

99. The Innovation Strategy also noted the diverse but complex nature of the structure of research in the UK. It announced that it would "develop a simpler way for businesses to understand and interact with the UKRI institutional structure". It also announced the establishment of an independent review, led by Professor Sir Paul Nurse, Director of the Francis Crick Institute, to look "across the landscape of UK organisations undertaking all forms of research, development and innovation", highlight the strengths and weaknesses, and make recommendations for addressing them.[177]

100. The Bessemer Semiconductor Manufacturing Group told us that semiconductor innovation was generally "well supported in the UK both through Government support systems and by UK based early-stage technology investors". But it reported concerns from within the industry that later-stage technology was missing out on research funding. Rockley Photonics made a similar point, noting that while such research might not be perceived as "particularly glamorous", it was nonetheless "critical" in bridging the gap to commercial adoption.[178] The Bessemer SMG also told us that some firms believed that EU state aid rules had prevented support for later-stage technology development.[179]

101. Others suggested that the approach to allocation of research funding was not sufficiently discriminatory. Professor Ian Phillips questioned whether there even was a research funding strategy, saying that "the current strategy seems to be to pour money into arbitrary research and leave the market to decide what to take advantage of… The Government has to intervene to make sure that market failure does not cause strategy damage".[180]

R&D tax credits

102. Research and development (R&D) tax credits are intended as an incentive to businesses to invest in R&D by allowing companies to claim an enhanced corporation tax deduction or payable credit on their R&D costs.[181] The work that qualifies for R&D relief must be part of a specific project to make an advance in science or technology. In March 2021, the Treasury consulted on R&D tax reliefs, and it published a report with policy decisions alongside a summary of responses in November 2021.[182] Draft legislation to give effect to some of those policy decisions was published in the summer of 2022. We note that further reforms to R&D reliefs were announced in the Autumn Statement 2022, and that the Government expects that the amount of support provided to innovative businesses through R&D tax reliefs will increase.[183]

103. R&D tax credits are used by the semiconductor industry and have generally been well received. A few points were nonetheless made in written submissions: Make UK told us that the application process was over-complex and that firms often felt that they had to employ agents to secure the credits.[184] TechUK proposed that R&D tax credits should be available for capital expenditure on investment in physical assets.[185]

177 UK Innovation Strategy: leading the future by creating it, page 68
178 Rockley Photonics (SEM0032)
179 Bessemer Semiconductor Manufacturing Group (SEM 0074)
180 Professor Ian Phillips (SEM0025)
181 UK Innovation Strategy: leading the future by creating it
182 R&D Tax Reliefs Report, HM Treasury, November 2021
183 Autumn Statement 2022, paragraph 2.14
184 Make UK (SEM 0012)
185 techUK (SEM 0065); also Make UK (SEM 0012)

104. Research and Development tax credits are a Treasury responsibility, and we note the current inquiry by the Treasury Committee into tax reliefs, which encompasses R&D tax credits. We draw the Treasury Committee's attention to the representations made to us on the subject.

Private investment

105. Venture capital provides finance and operational expertise for entrepreneurs and start-up companies (often in technology-based sectors) which will not yet be making a profit but which have a disruptive business offering with the potential of very strong growth. Venture capital funds act as a bridge between investors seeking high capital growth and innovative companies with high growth potential, seeking to grow their manufacturing and sales operations, enhance their product development and/or expand their business and hire new staff.[186]

106. Another form of private investment is through private equity, which is medium to long-term finance typically offered to support management buyouts and managing buy-ins in mature and potentially high-growth, unquoted companies, in return for an equity stake.[187]

107. The Government supports the provision of venture capital through tax-advantaged investment schemes, such as the Seed Enterprise Investment Scheme (SEIS), Enterprise Investment Scheme (EIS) and Venture Capital Trusts (VCT). Support is also offered through schemes administered by the British Business Bank, such as British Patient Capital and Future Fund: Breakthrough, which (within certain parameters) offer public funds for investment alongside private investors.[188]

108. Total UK venture capital investment in 2020 amounted to £11.9 billion, more than in France and Germany combined; but the UK market lacks the scale and maturity of the US market.[189] Simon Thomas, CEO at Paragraf (a firm manufacturing chips using advanced semiconductor materials), gave examples of firms which had benefited substantially from investment.[190] He told us that the amount of money going into "deep tech" and "hard tech" through venture capital and private equity had grown "massively", and that some the current round of fundraising "would not have been supported as strongly by UK finance as it would have been four years ago". He also noted that some US venture capital firms were setting up offices in London to facilitate investment in the UK.[191]

109. But Mr Thomas also noted that there were limits. Plenty of private investors were ready to invest in the semiconductor industry, and he said that "a fund of $30 to $35 million will be fine"; but the capital-intensive nature of the industry can be something of a disincentive, and he added that "if you go beyond that you need an American lead to come in". He told us of a fund being established through the Bessemer Society to raise capital for investment in infrastructure, including scale-up of manufacturing and packaging facilities.[192]

186 British Venture Capital Association written submission to Treasury Committee, June 2022 and BVCA website
187 British Venture Capital Association website
188 HM Treasury written submission to Treasury Committee, June 2022
189 HM Treasury written submission to Treasury Committee, June 2022
190 Q60
191 Q59
192 Mr Thomas Q59 and Q58, and Bessemer Semiconductor Manufacturing Group (SEM0074)

110. We did not examine in detail the wider issue of Government support for private investment in UK businesses. But we note that the Treasury Select Committee is currently conducting an inquiry into the venture capital market, examining the ability of firms to source financing to scale up, the extent to which start-ups and established industry cooperate, and the effectiveness of Government tax incentives.[193] We draw the attention of the Treasury Committee to the evidence submitted to our inquiry, and specifically to the following points raised in that evidence:

- There should be more focus on Government-led incentives to encourage private investment in later stage funding for more mature semiconductor firms seeking to expand in the UK;
- There should be more effort to build closer relationships between universities, angel investors and venture capital firms, to enable university spinout firms to raise capital quickly; and
- The Government could devote more funding, in partnership with private investment, to enable construction of new facilities which would otherwise be beyond the reach of UK investors and most UK firms.

Direct Government funding

111. The British Business Bank website provides details of Government-funded loans and business grants.[194] In many cases the high levels of capital investment required for facilities in the semiconductor manufacturing industry will be beyond the capacity of such grants. The Future Fund: Breakthrough programme, administered by the Bank and worth £375 million, may have more potential: it aims to accelerate the deployment of technologies which can transform major industries, by offering co-investment alongside private investors in later-stage funding at high-growth, innovative firms in R&D-intensive sectors.[195]

112. Innovate UK, the UK's publicly-funded agency for innovation, offers grant funding and loans to companies seeking financial support through the early stages of idea development. Awards from Innovate UK in 2020/21 totalled £986 million: that sum includes Innovation Loans, which are intended to provide up to £1.6 million for "highly innovative late-stage projects with a clear route to commercialisation and economic impact". A total of £155.7 million of loan commitments had been made by the time that the Innovation Strategy was published in July 2021.[196]

113. Some countries have provided direct funding—either at a federal or a state level—to support semiconductor firms' expansion. China is a prime example;[197] the US is another.[198] But industry witnesses recognised that it would be challenging and very expensive to provide the sort of funding required to establish facilities for advanced silicon chip production in the UK.[199] A more pragmatic approach would be to play to existing

193 Treasury Committee inquiry into the venture capital market: Terms of reference
194 British Business Bank website. See also UK Innovation Strategy, Table 1, page 29
195 UK Innovation Strategy, July 2021, page 28
196 UK Innovation Strategy, July 2021, page 30
197 Q76
198 Q60 and Q77
199 Dr Rickman and Mr Beresford-Wylie Q112

strengths and enable firms to scale up,[200] or to direct investment towards technologies which required less capital investment.[201] We note the view that the expansion of the UK's semiconductor industry had to be industry-led, and that there had to be the will from a company to establish such complex and high-cost capabilities.[202]

Government support for commercialisation

114. Funding is not the only means by which the Government can strengthen the semiconductor industry and help it expand: it can also help bridge the gap between research and successful commercialisation of an idea or product. We note the work of the Fraunhofer institutes in Germany and the Tyndall Institute in Ireland, which are assisted by public funding in providing a contract research service which is responsive to businesses seeking to expand in new technological fields.

115. The UK has no direct equivalent to the Fraunhofer institutes or Tyndall Institute, although it has invested in the nine "Catapults": these are independent not-for-profit organisations designed to bridge the gap between research and industry by providing a physical environment where businesses, scientists, technical specialists and engineers can work side by side testing ideas and developing their application.[203] The Government confirmed in the Autumn Statement 2022 that funding for the nine Catapults would increase by 35% in comparison to the last five-year funding cycle.[204] During our visit to Newport, we learnt of university laboratories which were being fitted with manufacturing equipment, so as to enable a smoother transition to foundries and real-world application.

116. The UKRI Corporate Plan for 2022–25 recognises the importance of supporting commercialisation. UKRI is putting place a new Research Commercialisation Funding Framework and an associated Monitoring & Evaluation Framework, as well as programmes to "empower research teams to explore the best impact routes for the outcomes of their research, including commercialisation and business partnerships".[205]

117. **It is not clear to us that the support currently offered by Government is at anything like the scale which is needed to make a real difference, or in line with a clear strategy from Ministers.**

118. ***The Government must not overlook the semiconductor industry. Whilst we recognise the difficult fiscal picture in the UK, we call on Ministers to set up a new sector deal as the vehicle to work with industry to agree UK priorities and the best use of any public funds or support. This could be via additional funding or guarantees made available via the Compound Semiconductor Applications Catapult, Innovate UK or the British Business Bank. The British Business Bank should lead on scale-up investment and capital investment from public and private sources, whilst the Catapult should continue to bridge the gap between research and industry, to support start-ups.***

200 Ms Hughes Q41
201 Dr Rickman Q112
202 Mr McGibbon Q17
203 See About the Catapult Network.
204 Autumn Statement 2022, paragraph 5.65
205 UKRI Corporate Plan 2022–25 page 18

Encouraging inward investment

119. Imperial College London, in its evidence, said that "ideally, the UK needs to be a destination of choice in the current, possibly time sensitive, diversification of the semiconductor industry".[206] But it appears that the UK is not a destination of choice: for example, the UK Country Manager for Intel told us that the investments currently being made by Intel were "very directly linked to the CHIPS Acts in the US and in Europe, and that the company had "had a lot of support from EU member states".[207] Mr Alan Banks, representing TechWorks (an industry association aiming to promote 'deep tech' capability in the UK) told us that "we do not have companies that are coming into the UK, because they are not really being incentivised to do that".[208]

120. The UK faces intense competition for inward investment. One witness offered an example of a particularly vigorous approach to tempting a firm—Paragraf—to relocate to the US. SelectUSA[209] approached the firm, mapped potential supply chain partners, and offered both infrastructure and a five-year tax rebate.[210] When we asked the Chief Executive Officer of Paragraf whether he was aware of similar efforts being made by the UK Government, he said "no". While he was grateful for Government investment into the firm, he said that there was "no joined-up thinking in the same way that SelectUSA has".[211]

121. ***The UK is missing out on inward investment at a crucial time for the semiconductor industry, and we are competing with other countries. The Government should secure partnerships via the US CHIPS Act, and engage with Taiwanese and other major companies to secure significant inward investment in the UK.***

Skills supply

122. The shift in high-volume semiconductor manufacturing from Europe and the US to Asia in the 1990s and 2000s left a legacy of specialised sites in the UK, and a specialised and ageing workforce.[212] But firms seeking to renew their skills base face difficulties in recruitment and retention, and they report intense competition for talent.[213] Professor Young, Technology Director at the Manufacturing Technology Centre, said that:

> We certainly have bright and clever people coming through. Do we have enough of them? No, definitely not. If I look at the societal challenges we have around net zero and sustainability, that is going to be solved by engineers … If we look specifically at semiconductors, though it is probably true in all industries, we've not just got to be able to make the end product. What we need to do is make the machines that make the end product".[214]

206 Imperial College (SEM0016)
207 Q123
208 Q41
209 The US Department of Commerce federal programme for business investment into the United States
210 Q54
211 Q55
212 See for example Ms Hughes Q36, written submission from IQE (SEM0075); Manufacturing Technology Centre (SEM0027)
213 Ms Blomfield Q126, Mr Beresford-Wylie Q110
214 Q65

Simon Beresford-Wylie, CEO of Imagination Technologies, told us that:

> there is definitely a shortage of engineers here. While there is a pool of talent, we have 161 open vacancies at the moment, and I do not expect to have those all filled this year.[215]

NXP Semiconductors told us that it was running approximately 10% below headcount, despite a major recruitment drive (almost 20% of current employees had started in 2022). It told us that "it is a massive effort to keep recruiting—there is such a gap in numbers of 'skills available' staff".[216]

123. Semiconductor development and manufacture is an intellectually heavy discipline which requires large numbers of workers at post-doctorate level. Demand for the software skills required to programme and integrate chips is growing, fed by a trend towards in-house design of chips by large technology companies and major automotive original equipment manufacturers (OEMs). Simon Beresford-Wylie, CEO of Imagination Technologies, told us that in his forty years in the tech and telecoms sector he had never seen anything like the demand for skilled engineers as there is now, and that other countries (including Germany and India) were facing similar shortages.[217]

124. But the demand for skills applies at other levels and across design and engineering disciplines: The Bessemer Semiconductor Manufacturing Group pointed out that "operator and technician level positions are often overlooked" even though they were vital for the manufacturing of semiconductors.[218] It gave an example of efforts to bridge this skills gap through joint working between firms and a local college, where experienced employees delivered tailored educational modules.[219]

125. There are many links in the chain which ultimately supplies skills to the semiconductor industry. It starts with the take-up of STEM subjects at secondary school level[220] and the choice to specialise in them at tertiary level. IQE[221] told us that:

> Initiatives to attract more diverse talent to the industry via academic study and/or apprenticeships are critically important, as are initiatives that invest in skills development and ongoing learning. Such initiatives could include funding for increased STEM investment for school-aged children, grants for diverse candidates to study STEM subjects at university, training subsidies for science and engineering graduates and enhanced apprenticeship schemes targeted at diverse groups entering STEM careers.[222]

The Government's Innovation Strategy set out the Government's efforts to expand STEM skills through programmes administered by the Government and by UKRI (including the STEM Ambassador programme).[223]

215 Q109
216 NXP Semiconductors (SEM0022)
217 Q110 and Q111
218 See also Ms Hughes Q36
219 South Devon College. See Bessemer Semiconductor Manufacturing Group (SEM0074)
220 See Mr Versluijs Q63
221 IQE designs and manufactures complex compound semiconductor wafers
222 IQE (SEM0075)
223 UK Innovation Strategy, July 2021, page 56

126. Other elements of the chain are:

- Careers advice, and the awareness of the industry itself and the career opportunities which it offers;
- The design of electronic engineering courses at universities, and ensuring that they are attractive and have content appropriate for the development of the semiconductor industry;[224]
- Connections between universities and the semiconductor industry.[225] Several existing semiconductor clusters have links to nearby universities or were built around university spin-off firms. We learnt of examples of successful collaboration, notably between Swansea and Cardiff Universities and the semiconductor cluster in South Wales;
- The factors which aid recruitment and retention in the workplace, including wages, job security, and the ability for suitably qualified workers from overseas to gain permission to live and work in the UK.

We have not examined each of these aspects in detail, and many lie beyond our remit. We set out below, however, some of the evidence on bringing in overseas talent, which we suggest should be taken into account by the Government in the forthcoming Semiconductor Strategy.

Encouraging talent from overseas

127. There is a mixed picture on drawing in talent from overseas. There has been some success: Dr Rickman, CEO of Rockley Photonics, told us that:

> we have found in South Wales that we have been able to attract people from all over the world. Where we have had shortages here, we have been able to make up for them by drawing across the whole of Europe, China and the US. People seem to love coming here.[226]

128. Others reported difficulty in attracting and retaining suitably qualified staff. Alan Banks, CEO of TechWorks, told us that the salaries offered in the US are more attractive, but he added that it was not just about wages. He said that:

> we are seeing quite a lot of international students coming into universities, and the universities welcome them because they are typically higher fee-paying than the UK nationals. The courses that we are offer are good. What happens is that these students, typically, over time, will gradually migrate back to their home countries, so we lose that skill that was created in the UK.[227]

224 Ms Hughes Q36
225 See IQE (SEM0075)
226 Q111
227 Q39. See also Ms Hughes Q38 and Mr Williamson Q103

Some contributors to this inquiry linked recruitment problems in the semiconductor industry to the UK's exit from the EU and to costs of visas and delays in granting them.[228]

129. The Government said in its Innovation Strategy, published in July 2021, that "we are opening our borders to top talent" and that "world-leading innovators should see the UK as the place to make their ideas reality. We are reforming our migration system to be open to them". A new "High Potential Individual" route will be introduced for people who have graduated from a top global university, enabling them to work in the UK, even without a job offer, and to extend their visa and settle in the UK if they meet certain requirements. A new Global Business Mobility visa will also allow overseas businesses greater flexibility in transferring workers to the UK.[229]

130. Recognising the need to address retention difficulties, the Innovation Strategy says that the Government is reviewing the country's capacity "to attract and develop the most outstanding research and innovation talent" and that the Government will assess "whether there are gaps or shortfalls in our offer, and if so, how they can be addressed". The Government says that it "will explore whether we should change duration and types of support, including what role fellowships can play in delivering better support for talented people and their teams".[230]

131. ***We welcome the steps being taken by the Government to encourage talent from overseas, although it has yet to be seen whether they will help to solve the challenges faced by the semiconductor industry in recruiting and retaining workers with the necessary skills. The forthcoming Semiconductor Strategy should not shirk this issue and should set out how the Government plans to meet the very specific skills needs of the UK semiconductor industry.***

228 CSConnected (SEM0023), National Epitaxy Facility (SEM0031), Centre for Integrative Semiconductor Materials, Swansea University (SEM0044), Quantum Dice Ltd (SEM0073)

229 UK Innovation Strategy, pages 53 and 59 to 61

230 UK Innovation Strategy, page 62

Conclusions and recommendations

Supply and demand

1. *The UK is an important part of global semiconductor supply chains, but it is reliant upon other countries. The UK alone will not have an end-to-end supply chain for semiconductors, but it has tradeable strengths. The Government should work more closely with allies in the EU and US, and elsewhere, to safeguard security of supply, both of finished products and of the materials needed for production in the UK. The Government should at the same time be working to represent the UK's expertise and to entrench and expand the UK's role in global semiconductor supply chains.* (Paragraph 52)

2. *We ask Ministers to consider whether the above recommendation, on closer working between the UK and allies in the EU and US, can be effectively delivered by requesting that the UK be invited to take part in relevant parts of the EU-US Trade and Technology Council. We further ask Ministers to set out the Government's position on whether a new multi-lateral organisation for industrial collaboration between allied democratic countries is required and, if not, which existing multi-lateral organisation provides the opportunity for this important work to be undertaken.* (Paragraph 53)

3. The exercise of controls under the National Security and Investment Act is still at an early stage. We note reservations about the speed of some assessments under the Act and under the export control process, and we will be conducting scrutiny of how powers under the National Security and Investment Act are being used via our National Security and Investment Sub-Committee. Nevertheless, it is our view that the overall purpose of the Act in monitoring acquisitions with a view to safeguarding national security is sound. We believe that it has the potential to help meet concerns about hostile access to intellectual property, knowledge and expertise within the semiconductor industry, and such powers should be used to avoid this. (Paragraph 66)

4. *We will further consider the Nexperia case, via the National Security and Investment Sub-Committee, once the period for appeal has expired. In the meantime, the Department should work proactively to ensure a successful transfer of the Newport site to a new owner. Ministers should update the Committee on progress made.* (Paragraph 67)

5. *Semiconductors play a hidden but highly significant role in many parts of the UK's critical national infrastructure. We request that the Government sets out which elements of the semiconductor supply chain constitute critical national infrastructure.* (Paragraph 70)

Role of Government

6. *We recognise that many Government departments have an interest in the semiconductor industry, and that these interests may overlap. But, in our view, the value of semiconductors to so many sectors of the UK economy and to UK national infrastructure, combined with the national security necessity of safeguarding*

semiconductor supply, make it essential that a single Government department takes responsibility for nurturing the semiconductor industry in the UK and for security of supplies. We believe that that department should be BEIS, because of its overarching responsibility for industrial strategy, business support, engagement with industry and policy on research funding, and because of its role in protecting UK industrial assets from undue control by overseas entities. (Paragraph 79)

7. While it is for those in the semiconductor industry to decide how to champion its causes, we believe that there is scope for the sector to play its part in improving the clarity of communication between the industry and Government, for instance through a collective voice for the sector. (Paragraph 81)

8. *The Government was correct in its decision to instigate a review of its approach to the semiconductor sector and in heralding a new strategy. The industry has waited for the strategy and will base crucial decisions upon it. The Government should lose no more time and should publish its Semiconductor Strategy immediately.* (Paragraph 85)

9. *We recommend that the forthcoming Semiconductor Strategy should include:*

- *An analysis of the semiconductor production and supply chain, recognising different characteristics for different subsectors of the industry, and areas of strength and weakness;*
- *A heatmap, showing where different semiconductor industries and niches are located within the UK, and how they are positioned in relation to the supply of relevant skills, equipment, research capability, and in relation to other factors valued by firms in those industries; and*
- *An account of which industries in the UK and which key products are dependent upon a secure supply of semiconductors at reasonable cost.*
- *In addition, we recommend that the Government produces a risk and resilience strategy for the semiconductor industry alongside its Semiconductor Strategy, as a matter of urgency.* (Paragraph 91)

10. *We recommend that the Government's Semiconductor Strategy consider scope for development of the UK semiconductor industry in the following fields:*

- *Intellectual property and design;*
- *Supporting the design chain for leading edge node chips;*
- *Matching UK manufacturing capability to UK design capability;*
- *Developing manufacturing processes for silicon semiconductors;*
- *Development of existing strengths in compound and advanced material semiconductors, to meet demand in emerging markets;*
- *Facilitating the construction of new fabs, including consideration of an open access fab in the South Wales cluster.* (Paragraph 94)

11. It is not clear to us that the support currently offered by Government is at anything like the scale which is needed to make a real difference, or in line with a clear strategy from Ministers. (Paragraph 117)

12. *The Government must not overlook the semiconductor industry. Whilst we recognise the difficult fiscal picture in the UK, we call on Ministers to set up a new sector deal as the vehicle to work with industry to agree UK priorities and the best use of any public funds or support. This could be via additional funding or guarantees made available via the Compound Semiconductor Applications Catapult, Innovate UK or the British Business Bank. The British Business Bank should lead on scale-up investment and capital investment from public and private sources, whilst the Catapult should continue to bridge the gap between research and industry, to support start-ups.* (Paragraph 118)

13. *The UK is missing out on inward investment at a crucial time for the semiconductor industry, and we are competing with other countries. The Government should secure partnerships via the US CHIPS Act, and engage with Taiwanese and other major companies to secure significant inward investment in the UK.* (Paragraph 121)

14. *We welcome the steps being taken by the Government to encourage talent from overseas, although it has yet to be seen whether they will help to solve the challenges faced by the semiconductor industry in recruiting and retaining workers with the necessary skills. The forthcoming Semiconductor Strategy should not shirk this issue and should set out how the Government plans to meet the very specific skills needs of the UK semiconductor industry.* (Paragraph 131)

Formal minutes

Tuesday 22 November 2022

Members present:

Darren Jones, in the Chair

Alan Brown

Andy McDonald

Charlotte Nichols

Mark Pawsey

Draft Report (*The semiconductor industry in the UK*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 131 read and agreed to.

Summary agreed to.

Resolved, That the Report be the Fifth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

[Adjourned till Tuesday 29 November at 9:45am]

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Tuesday 7 June 2022

Martin McHugh, CEO, Compound Semiconductor Application Catapult; **Alistair McGibbon**, Industry Expert, Compound Semiconductor Application Catapult; **Dr Andy Sellars**, Strategic Development Director, Compound Semiconductor Application Catapult — Q1–22

Alan Banks, CEO, TechWorks; **John Docherty**, Industry Expert, TechWorks; **Jillian Hughes**, Director, NMI (National Microelectronics Institute) — Q23–45

Tuesday 5 July 2022

Toni Versluijs, General Manager, BG MOS Discretes and Country Manager, Nexperia UK; **Americo Lemos**, Chief executive officer, IQE plc; **Simon Thomas**, Chief executive officer, Paragraf; **Professor Ken Young**, Technology Director, MTC (Manufacturing Technology Centre) — Q46–98

Simon Beresford-Wylie, Chief executive officer, Imagination Technologies; **Dr Andrew Rickman**, Chief executive officer, Rockley Photonics; **Paul Williamson**, Senior Vice President and General Manager, Client Line of Business, Arm — Q99–118

Rina Pal-Goetzen, Director of Global Policy, Semiconductor Industry Association; **Trish Blomfield**, UK Country Manager, Intel — Q119–133

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

SEM numbers are generated by the evidence processing system and so may not be complete.

1 Advanced Propulsion Centre UK (SEM0066)

2 Anonymised (SEM0059)

3 Anthony, Professor (Siemens Professor of Microelectronics, Newcastle University) (SEM0007)

4 BDJ Group Ltd. (SEM0017)

5 BEAMA (SEM0055)

6 Bessemer Semiconductor Manufacturing Group (SEM0074)

7 Black, Dr Ron (SEM0049)

8 British Vehicle Rental & Leasing Association (BVRLA) (SEM0071)

9 Bytesnap Design Ltd (SEM0008)

10 CSconnected (SEM0023)

11 Camlin Group (SEM0015)

12 Centre for Integrative Semiconductor Materials, Swansea University (SEM0044)

13 Clas-SiC Wafer Fab Ltd (SEM0050)

14 Compound Semiconductor Applications Catapult (SEM0072)

15 Compound Semiconductor Applications Catapult (SEM0029)

16 Consumer Choice Center (SEM0014)

17 Crypto Quantique (SEM0061)

18 Department for Digital, Culture, Media and Sport (SEM0080)

19 Deviny, Mr Ian (Business and Technical Lead -Power, Semefab Ltd) (SEM0047)

20 Energy UK (SEM0063)

21 Finchetto Limited (SEM0052)

22 Govier, Mr Joe (CEO, Connect 2 Cleanrooms Ltd.) (SEM0001)

23 Highway Electrical Association (SEM0011)

24 Hopkinson, Professor Mark (Profesor, The University of Sheffield); and Shien Ng, Professor Jo (Professor, The University of Sheffield) (SEM0043)

25 IQE plc (SEM0075)

26 Imperial College London (SEM0016)

27 Inductive Power Projection Ltd (SEM0009)

28 Jawad, Mr Haydar (CTO, Smart Babylon) (SEM0010)

29 Karuna KT, Gandhi (SEM0062)

30 Leonardo UK Ltd (SEM0026)

31 MRL Consulting Group (SEM0034)

32 Make UK (SEM0012)

33 Mawby, Professor Phil (SEM0069)

34 MaxPower Semiconductor UK (SEM0021)

35 MicroLink Devices UK Ltd. (SEM0045)

36 NCC Group (SEM0038)

37 NXP Semiconductors (SEM0022)

38 Nexperia UK (SEM0054)

39 North East Advanced Material Electronics (NEAME); and Business Durham (SEM0060)

40 PEMD Innovations Limited; North East Automotive Alliance; and Driving the Electric Revolution Industrialisation Centers (SEM0033)

41 PTC Ltd (SEM0005)

42 Paragraf (SEM0079)

43 Penn, Mr Malcolm (Founder & CEO, Future Horizons Ltd) (SEM0064)

44 Pentagram Research UK Ltd (SEM0042)

45 Phillips, Professor Ian (Retired) (SEM0025)

46 Photonics Leadership Group (SEM0041)

47 PragmatIC Semiconductor (SEM0053)

48 Qualcomm Technologies International, Ltd (SEM0077)

49 Quantum Dice Ltd (SEM0073)

50 Rockley Photonics (SEM0032)

51 SILC (Sensing Innovation Leadership Council) (SEM0048)

52 School of Electronic & Electrical Engineering, University of Leeds (SEM0056)

53 Seagate Technology plc (SEM0057)

54 Semefab Ltd (SEM0046)

55 Semiwise Ltd (SEM0020)

56 Shaikh, Prof Siraj (Professor of Systems Security, Coventry University); and Parkin, Dr Simon (Assistant Professor, Delft University of Technology) (SEM0028)

57 Technology Scotland (SEM0039)

58 Tetrivis LTD (SEM0036)

59 The GAMBICA Association (SEM0037)

60 The Manufacturing Technology Centre (SEM0051)

61 The Manufacturing Technology Centre (SEM0027)

62 The National Epitaxy Facility (SEM0031)

63 The Society of Motor Manufacturers and Traders (SMMT) (SEM0035)

64 UK Electronics Skills Foundation (SEM0004)

65 Wave Photonics (SEM0002)

66 Welsh Government (SEM0040)

67 techUK (SEM0065)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website.

Session 2022–23

Number	Title	Reference
1st	Pre-appointment hearing with the Government's preferred candidate for Chair of the Competition and Markets Authority	HC 523
2nd	Draft Legislative Reform (Provision of Information etc. relating to disabilities) Order 2022	HC 522
3rd	Energy pricing and the future of the Energy Market	HC 236
4th	Post-pandemic economic growth: state aid and post-Brexit competition policy	HC 759
1st Special	Decarbonising heat in homes: Government Response to the Committee's Seventh Report of 2021–22	HC 208
2nd Special	Energy pricing and the future of the energy market: Responses to the Committee's Third Report of Session 2022–23	HC 761

Session 2021–22

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1st	Post-pandemic economic growth: Industrial policy in the UK	HC 385
2nd	Climate Assembly UK: where are we now?	HC 546
3rd	Post-pandemic economic growth: Levelling up	HC 566
4th	Liberty Steel and the future of the UK steel Industry	HC 821
5th	Pre-legislative scrutiny: draft Downstream Oil Resilience Bill	HC 820
6th	Pre-appointment hearing of the Government's preferred candidate for Chair of the Financial Reporting Council	HC 1079
7th	Decarbonising heat in homes	HC 1038
8th	Post Office and Horizon - Compensation: interim report	HC 1129
9th	Revised (Draft) National Policy Statement for Energy	HC 1151
10th	Draft Legislative Reform (Renewal of National Radio Multiplex Licences) Order 2022	HC 1199
1st Special	Decarbonising heat in homes: Government Response to the Committee's Seventh Report of 2021–22	HC 208
2nd Special	Net Zero and UN Climate Summits: Scrutiny of Preparations for COP26—interim report: Government Response to the Committee's Third Report of Session 2019–21	HC 120

Number	Title	Reference
3rd Special	Uyghur forced labour in Xinjiang and UK value chains: Government Response to the Committee's Fifth Report of Session 2019–21	HC 241
4th Special	Mineworkers' Pension Scheme: Government Response to the Committee's Sixth Report of Session 2019–21	HC 386
5th Special	limate Assembly UK: where are we now?: Government Response to the Committee's Second Report	HC 680
6th Special	Post-pandemic economic growth: Industrial policy in the UK: Government Response to the Committee's First Report	HC 71
7th Special	Post-pandemic economic growth: Levelling up: Government Response to the Committee's Third Report	HC 924
8th Special	Liberty Steel and the Future of the UK Steel Industry: Government Response to the Committee's Fourth Report	HC 1123
9th Special	Pre-legislative scrutiny: draft Downstream Oil Resilience Bill. Government Response to the Committee's Fifth Report	HC 1177
10th Special	Post Office and Horizon – Compensation: interim report. Government Response to the Committee's Eighth Report	HC 1267

Session 2019–21

Number	Title	Reference
1st	My BEIS inquiry: proposals from the public	HC 612
2nd	The impact of Coronavirus on businesses and workers: interim pre-Budget report	HC 1264
3rd	Net Zero and UN Climate Summits: Scrutiny of Preparations for COP26 – interim report	HC 1265
4th	Pre-appointment hearing with the Government's preferred candidate for the Chair of the Regulatory Policy Committe	HC 1271
5th	Uyghur forced labour in Xinjiang and UK value chains	HC 1272
6th	Mineworkers' Pension Scheme	HC 1346
1st Special	Automation and the future of work: Government Response to the Committee's Twenty-third Report of Session 2017–19	HC 240
2nd Special	Future of the Post Office Network: Government Response to the Committee's First Report of Session 2019	HC 382
3rd Special	Safety of Electrical Goods in the UK: follow-up: Government Response to the Committee's second report of Session 2019	HC 494
4th Special	COP26: Principles and priorities—a POST survey of expert views	HC 1000