UNIVERSITY OF CAMBRIDGE

Cambridge Industrial Innovation Policy

Why manufacturing supply chains matter and how to revitalise them

The role of supply chains in achieving socio-economic missions

REPORT FOR THE DEPARTMENT FOR BUSINESS AND TRADE (DBT) (FORMERLY DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY (BEIS))

Cambridge Industrial Innovation Policy, University of Cambridge

FEBRUARY 2023

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About this report

This report was commissioned by the Department for Business and Trade (DBT) (formerly Department for Business, Energy and Industrial Strategy (BEIS)) Advanced Manufacturing Directorate to refresh the current evidence base and inform the development of new and existing policy options to support UK manufacturing supply chains.

The report findings are based on the authors' interpretation and analysis of the evidence reviewed, including insights and data shared by the DBT External Expert Group on Supply Chains. However, these findings do not necessarily represent the joint view of the Expert Group; nor do they imply the expression of any opinion on the part of DBT.

Names of countries and territories follow widely accepted conventions and do not imply the expression of any opinion whatsoever on the part of the authors, their affiliated institutions or the client concerning the legal status of any country, territory, city or area, or its authorities. Any mention of firm names or commercial products does not constitute an endorsement by the authors, their affiliated institutions or DBT.

Contributors

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Delivered through IfM Engage, Institute for Manufacturing, University of Cambridge

Key messages

Supply chains are in the news when we experience shortages like those of the personal protective equipment and other critical items during the COVID-19 pandemic. However, supply chains are not just about getting goods from the factory to the customer; nor are they only about problems. Supply chains are a vital part of the economy and well-functioning supply chain businesses drive economic growth.

In modern industries, manufacturing supply chains are critical enablers of innovation and value creation. Firms in the supply chain are a source of not only parts and components but also new technologies, knowledge-intensive services, and ideas. Policy interventions to revitalise manufacturing supply chains are needed not just to be better prepared for the next crisis but also to ensure the long-term prosperity of UK industries.

Why do supply chains matter?

To understand the real value of supply chains – and what the government can do to support them – it is important to understand how they contribute to a broad range of policy goals.

First and foremost, supply chains are critical to supplying the goods we need. Manufacturing supply chains provide goods that are critical to life and national security, such as food, drink, medicines and medical goods, clothing, and fuel. They also supply critical materials, components and equipment that keep factories running. In addition, supply chain firms provide machinery, components, systems and engineering services that enable the operation of critical infrastructure such as transportation, electricity generation, communications and defence. The COVID-19 pandemic has clearly demonstrated that, in times of large-scale disruption, manufacturing supply chains that were previously functioning well can be affected significantly, potentially magnifying the human and economic costs.

Supply chains support job creation and impact the trade balance. Low use of UK-manufactured parts in some UK sectors has contributed to a long-run national trade deficit, despite a remarkable increase in service exports in recent years. Estimates suggest that 70% of manufactured parts used in the UK are sourced domestically, compared with 88% in services. Increasing domestic sourcing would contribute to capturing supply chain jobs and retain the associated skills, while increasing the gross domestic value added of manufacturing sectors. Investments by international firms attracted by local supply opportunities result in increased FDI, as do the investments of lead firms attracted by the local availability of suppliers.

Supply chains increase the reach of innovation and its benefits. The broad benefits of innovation, be they economic, environmental, or societal, only accrue when new technologies – including low-carbon and digital technologies – are diffused widely across entire supply chains. However, this may not happen through market forces alone. Even when new technologies are available in the market, many firms in the supply chain, in particular (but not only) small and medium-sized enterprises (SMEs), fail to exploit opportunities as a result of a lack of internal resources or leadership and management capability.

Similar supply chain businesses often cluster together to create local growth and employment opportunities. Firms benefit from proximity to other firms with which they exchange input and the associated skilled labour and know-how. **Local clustering** allows firms to share knowledge, collaborate on supply opportunities and reduce lead times, transportation costs and their carbon footprint. In the automotive industry, for example, “leaner” and more flexible operations

are possible when suppliers are located close to the vehicle manufacturing plant, particularly in some of the premium segments where UK firms operate.

The UK aerospace industry, for example, is characterised by a number of place-based clusters, including: Airbus and its supplier base around Filton and Broughton; Leonardo and its supply chain companies in the South West; Spirit Belfast (formerly Bombardier Shorts), which drives growth across its supply base in Northern Ireland; Rolls-Royce and its predominantly Midlands-based supply chain, made up of thousands of suppliers in the region; and Boeing's actuation factory in Sheffield, which is seeing a number of small local suppliers, such as Maher, Mettis, Aeromet and MetLase, scale up.

Strong local supply chains allow a country to capture more of the benefits of local R&D activity. Developing next-generation products often involves the introduction of new technologies and processes for which firms require external supplier expertise. Countries and regions hosting a critical mass of suppliers, human resources, R&D know-how, process development and engineering skills are better positioned to exploit the benefits of ideas produced by their research and technology base. Conversely, the hollowing out of supply chains can lead to a vicious "invented here, produced elsewhere" circle, where the loss of key skills and know-how results in the inability to commercialise innovations emerging from the research and science base.

Revitalising supply chains

With the goals of both avoiding the supply chain failures that make the news and strengthening the overall health of supply chains that contribute to the country's prosperity, policymakers face a complicated task. Governments around the world are increasingly paying attention and designing supply chain interventions to achieve specific policy outcomes, rather than just addressing short-term problems. This report provides an overview of international supply chain interventions, providing a useful context to inform the design of future interventions in the UK.

The report makes the following policy **recommendations**:

1. **Supply chain interventions should be designed to address activities and capabilities in the supply chain that are critical to (1) security of supply; (2) job creation, increased domestic value added, improved trade balance; (3) adoption and diffusion of innovation; (4) sector and place competitiveness; and (5) R&D commercialisation and technology scale-up.**
2. **Build the evidence base on supply chain challenges and opportunities, and assess whether the government capability to generate and disseminate this evidence can be improved.**
3. **Formalise functions and responsibilities across government for identifying and addressing supply chain vulnerabilities of critical goods and sectors on an ongoing basis.**
4. **Develop regional institutions to deliver supply chain support, and strengthen support for SMEs.**
5. **Work with industry to formulate sector-specific supplier development plans to exploit existing and emerging opportunities.**
6. **Ensure public procurement decisions support the government's strategic objectives for the health of the UK's supply chains and economy.**

1. Introduction

This report aims to improve understanding of supply chains and how they contribute to policy outcomes and national socio-economic missions.

Supply chains receive significant attention when consumers and businesses experience shortages of essential goods and components.[1] The COVID-19 pandemic resulted in lockdowns and restrictions to movement that affected integrated, complex manufacturing supply chains spread across the world. Some supply chains came to a halt, while for others supplier delivery times and freight costs dramatically increased.[2] Acute shortages were driven by sharp increases in the demand for essential supplies such as personal protective equipment (PPE).[3] And as the world shifted to working and learning from home, a surge in demand for consumer electronics led to a global shortage of semiconductors, impacting automotive, communications, consumer electronics and many other producers.[4]

Dealing with supply chain disruptions and addressing the shortages must be a priority. However, there is a risk that policy reactions miss opportunities if the contribution of supply chains is not fully understood.

Supply chains are not only about the physical movements of goods from factories to customers. They are complex systems that involve activities upstream and downstream of the factory, providing inputs that are integrated into goods and services. Supply chain firms are not only a source of parts and components but they also provide knowledge-intensive services and develop new technologies and ideas.

Supply chains are critical enablers of competitiveness and innovation. To develop new products and services, firms often require external suppliers to develop new parts and components and to provide expertise on new technologies and processes. As recognised in the Net Zero Strategy,[5] the UK will only capture the benefits from public investments in green technology sectors such as hydrogen, offshore wind, and electric vehicles if it can exploit rapidly growing supply chain opportunities in these sectors and develop the associated skills and jobs.

Given the complexity of modern supply chains, it is not a surprise that the analysis of recent publications and engagement with experts found that supply chains cannot be fully captured within a single definition. Supply chains can involve firms from many countries, operating in different sectors and technology areas that are constantly evolving. As such, it is difficult to obtain a comprehensive picture of their structure, their interdependencies, and the different types of market failure that may constrain their functioning.

It is against this background that the Department for Business and Trade (DBT) (formerly Department for Business, Energy and Industrial Strategy (BEIS)) Advanced Manufacturing Directorate commissioned this report to refresh the current evidence base and inform the development of new and existing policy options to support UK manufacturing supply chains. The report has benefited extensively from insights, data and guidance provided by the DBT External Expert Group on Supply Chains. In-depth discussion sessions with DBT policy and analytical leads provided insights into how supply chains are defined by different stakeholders and the typical issues reported.

An important contribution of this report is the framework that sets out to link different supply chain elements to government objectives, market failures and potential interventions. Bringing these building blocks together can inform the strategic rationale for any type of government intervention aimed at improving supply-chain-related policy outcomes.

[1] Institute for Government (2021). Supply chain problems.

[2] Notteboom, T., Pallis, T. and Rodriguez, J. P. (2021). Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008–2009 financial crisis. *Maritime Economics & Logistics*, 1–32.

[3] World Health Organization, WHO (2020b). Shortage of personal protective equipment endangering health workers worldwide.

[4] Vakil, B. and Linton, T. (2021). Why We're in the Midst of a Global Semiconductor Shortage. *Harvard Business Review*. [5] HMG (2021). Net Zero Strategy: Build Back Greener.

Structure of the report

The report is structured as follows:

- **Section 2** discusses *what* supply chains are and *why* they are important for achieving key policy outcomes and socio-economic missions.
- **Section 3** discusses *what* the key challenges and opportunities are that face UK manufacturing supply chains.
- **Section 4** discusses *how* supply chains can be revitalised, providing examples of UK and international supply chain interventions.
- **Section 5** provides policy recommendations.

2. What are supply chains and why do they matter?

This section discusses the key terms related to supply chains and the variety of suppliers that can be found within them. The section then explores the importance of supply chains to achieving a broad set of policy outcomes and socio-economic missions, drawing examples from the UK government's Net Zero Strategy.

2.1 What are manufacturing supply chains?

There is no single agreed definition or model for a supply chain (see Box 1). Many high-value, high-technology products such as cars, aircraft and medical devices – as well as the advanced machinery used to produce them – are complex systems.[6] To put them together, a range of firms contribute to components, subsystems and specialised equipment, as well as specialist services.[7] Competitiveness and innovation in modern industries is thus determined not only by what companies do on their own but also by entire ecosystems of firms sharing input, technologies and ideas.

As previously noted by the UK government, a supply chain is not just a hierarchical chain of businesses supplying tangible components to make up a final product: "The whole supply chain system also includes the functional areas of planning, design, purchasing, manufacturing, distribution, sales, recovery and recycling. Understanding the whole system provides major opportunities for innovation and value creation, and points to the need to ensure that the right skills, leadership and process systems are in place as well as the materials required to form the end product."[8]

Members of the DBT External Expert Group on Supply Chains emphasised that it is important to avoid narrow definitions of supply chains and consider the broad ecosystem of suppliers (and their capabilities) required to enable competitiveness, innovation, and value capture. They highlighted that supply chains encompass all stages of designing, making, selling, and distributing goods and services. This includes specialised high-tech manufacturing services and the broad set of engineering capabilities enabling R&D and product design.

Furthermore, members stressed that supply chain interventions should not be limited to SMEs.[9] This is because in some sectors (e.g. aerospace) the lower-tier suppliers (e.g. raw materials) are very large companies, whereas the first tier might be small family companies.

However, it is important to recognise that most firms in any economy are SMEs.[10] At the start of 2021, SMEs accounted for over 99% of all UK businesses, approximately 61% of all private-sector employment and 52% of turnover. Within manufacturing, SMEs accounted for 99.1% of total firms, 55.5% of employment and 33.4% of turnover.[11]

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[6] Tassey, G. (2010). Rationales and mechanisms for revitalizing US manufacturing R&D strategies. *Journal of Technology Transfer*.
[7] Castellacci, F. (2008). Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Research Policy*, 37(6–7), pp. 978–994.
[8] HM Government (2015). Strengthening UK Manufacturing Supply Chains: An Action Plan for Government and Industry.
[9] The UK government defines SMEs, according to their employment size, as follows: micro enterprises (1 to 10 employees); small enterprises (11 to 49 employees); medium-sized enterprises (50 to 249 employees). Source: Ward M. (2021). Business statistics. House of Commons library, briefing paper n. 06152.
[10] The OECD SME and Entrepreneurship Outlook 2019 report remarks that SMEs represent 99% of all businesses, generating about 60% of employment and between 50% and 60% of value added in the OECD area. Source: OECD (2019). OECD SME and Entrepreneurship Outlook 2019.
[11] All data from: BEIS (2021). Business Population Estimates for The UK and Regions 2021.

Besides supply chains, other related terms are useful to describe the way in which modern industrial systems are structured (Box 1). It is useful to review these concepts, not only because they are widely used in international policy practice but also because they are helpful to understand the complexity of supply chains and the different ways in which they can be analysed.

BOX 1 WHAT ARE MANUFACTURING SUPPLY CHAINS?[12]

While the term "supply chain" has been used as a shorthand for the ecosystem of interdependent firms, other related concepts are widely used in government, industry, and academia. Some of the most common ones are discussed below.

- The basic definition of a ***supply chain*** is "the sequence of processes involved in the production and distribution of a commodity".[13] Broader definitions go beyond the flow and transformation of materials across firms, seeing a supply chain as "a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances and/or information from a source to a customer".[14] Or, similarly, a "link or strand of operations that provides goods and services through to end-customers".[15]
- Intermediary producers may feed into several different supply chains, forming ***supply networks***.[16] Some researchers prefer the term "supply networks", noting that the linear metaphor of the "chain" has limitations because inter-firm relationships and interdependencies are embedded in complex networks.[17]
- In industry, a ***supply base*** is defined as "the portion of a supply network that is actively managed by a buying company". The buying company, often referred to as the "focal company", manages the suppliers in the supply base through contracts and the purchasing of parts, materials and services.[18] The focal company (e.g. a final automotive assembler) might be served by several supply chains (including the supply chain of the engine and a different supply chain of the entertainment system) but from its perspective it only has one supply base.
- The concept of the ***value chain*** complements that of supply chains by placing an emphasis on the processes of value addition alongside the set of activities involved in creating a product or service. This helps us to think about those activities that underpin the competitive advantage of firms and industries. A broad definition of a value chain would be "the interconnected set of firms and wider activities that together create the value added of the product".[19] These activities include research and development, design, logistics and after-sales services.
- The term ***industrial commons*** has become influential in the international policy debate. It describes a common set of suppliers and human resources available to manufacturing firms in a given region, including: R&D know-how; advanced process development and engineering skills; and manufacturing competencies related to a specific technology. These industrial resources provide a shared benefit to

[12] For a more detailed discussion on supply chain and related definitions, see: Policy Links (2017). New industrial capabilities for new economic growth: a review of international policy approaches to strengthening value chain capabilities. A report for the Department for Business, Energy and Industrial Strategy (BEIS).
[13] *Oxford Dictionary* (2017). Supply chain.
[14] Mentzer et al. (2001). Defining Supply Chain Management. *Journal of Business Logistics*, Vol 22, No. 2.
[15] Slack et al. (2013). *Operations Managements*. 7th edition. Pearson
[16] Ibid.
[17] Kito, T., Bintrup, A., New, S. and Reed-Tsochas, F. (2014). The Structure of the Toyota Supply Network: An Empirical Analysis. Saïd Business School Research Papers.
[18] Choi, T. Y. and Krause, D. (2006). The Supply Base and Its Complexity: Implications for Transaction Costs, Risks, Responsiveness, and Innovation. *Journal of Operations Management*, 24(5)(5), 637–652.
[19] UNIDO (2009). Value Chain Diagnostics for Industrial Development. Building blocks for a holistic and rapid analytical tool. UNIDO Working Paper. United Nations Industrial Development Organization.

multiple companies and provide "a foundation for innovation and competitiveness".[20] The concept of industrial commons emphasises that, despite the global nature of modern industries, the close proximity of this set of suppliers and human resources has a key role to play in fostering technological and industrial innovation.[21]

The concepts presented in Box 1 help us to identify a variety of suppliers typically found in modern supply chains. These suppliers are interrelated, but it is useful to discuss them separately for our analysis:[22]

- **Suppliers of product ideas, design, prototypes and R&D services.** These suppliers are involved in the "idea to product" journey. To turn an idea into a new product, manufacturing firms require a series of steps, including research, design and prototyping, which could be carried out in collaboration with their suppliers or clients. Suppliers in this category support the processes of innovation management and new product introduction.
- **Suppliers of manufacturing equipment, tools, and specialised engineering services.** These suppliers are involved in the "factory" or "production capability" journey. Once prototypes are developed, firms need to develop the capability to manufacture the goods with the quality, price and flexibility required. To do this, they often draw capabilities and resources from suppliers that develop and integrate the required equipment, tools and systems within the factory. These suppliers include equipment vendors and engineering service firms that may integrate mechanical, biological, electronics and software systems to develop new process lines and upgrade existing ones.
- **Suppliers of raw material, parts, components, and subsystems.** These suppliers are involved in the "material transformation" journey. They are mainly related to the range of physical parts and components, subsystems that come together to form the final product. These suppliers can be readily identified from analysis of the bill of materials.[23] When a trade disruption occurs, these suppliers are most immediately affected, hindering the ability of factories to operate just-in-time and produce at the volume required.
- **Suppliers of transport and logistics services.** These include suppliers used to transport intermediate and finished goods within and across supply chains, in both domestic and global supply chains.
- **Suppliers of after-sales services.** These include suppliers that perform a range of activities after the goods are sold to the end-user, including not only repair and overhaul but also activities related to the circular economy such as remanufacturing and recycling services.

[20] Pisano, G. and Shih, W. (2012). *Producing Prosperity. Why America needs a Manufacturing Renaissance*. Harvard Business Review Press.
[21] As noted by Pisano and Shi (2012), industrial common resources "may be embedded in a large number of companies and universities. Software knowledge and skills, for instance, are vital to an extremely wide range of industries (machine tools, medical devices, earth-moving equipment, automobiles, aircraft, computers, consumer electronics, defense). Similarly, capabilities related to thin-film deposition processes are crucial to sophisticated optics; to such electronic products as semiconductors and disk drives; and to industrial tools, packaging, solar panels, and advanced displays. The knowledge, skills, and equipment related to the development and production of advanced materials are a commons for such diverse industries as aerospace, automobiles, medical devices, and consumer products. Biotechnology is a commons not just for drugs but also for agriculture and the emerging alternative-fuels industry."
[22] O'Sullivan, E. (2018). Towards a better understanding of how industrial systems are actually structured: Re-conceptualizing manufacturing "sectors" for industrial policymakers. Industry Studies Conference (ISA 2018, Seattle).
[23] A bill of materials (BoM), or product structure, lists all the components and parts required to produce one unit of a finished product, or end-part. It is often represented as a tree structure with hierarchical relationships among different components and materials. [Source: Cinelli M, Ferraro G, Iovanella A, Lucci G, Schiraldi MM (2017). A network perspective on the visualization and analysis of bill of materials. *International Journal of Engineering Business Management*.]

These different types of supplier not only enable manufacturing sectors to produce the output required to address market demand but also underpin their competitiveness and ability to innovate. Manufacturing sectors cannot address market demand without the continuous supply of parts, components, and subsystems. The development of many new goods and services is only possible thanks to supplier firms providing ideas and supporting their development. And factories are only possible with the suppliers of the equipment, tools, and specialised engineering services.

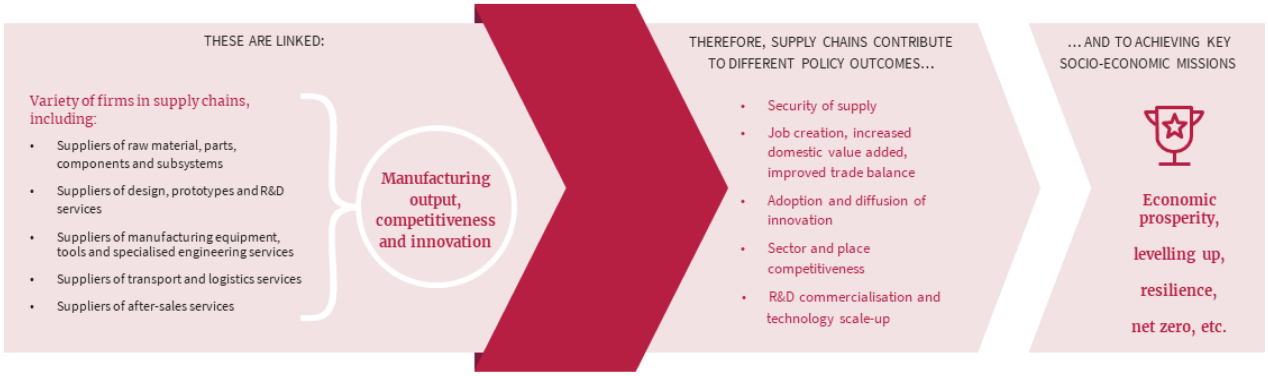
Not surprisingly, there are differences between industries. In discrete industries that involve just-in-time assembly of many components (to put together products such as computers and cars), the performance of suppliers in the “material journey” (in terms of quality, on-time delivery, and ability to deal with fluctuations in demand) is particularly important in the ability to remain competitive. But these suppliers are also often sources of innovation and, in fact, participate in the development of next-generation products and related services. In the automotive and aerospace industries, for example, primes partner with first-tier companies to co-invest in the development of new product models in order to spread risk and costs. First-tier companies may do the same with second-tier companies, and so on. This is not to say that other suppliers are not relevant. On the contrary, the activities of discrete industries cannot be understood without suppliers providing equipment, tools and systems (and related expertise) to set up the production lines where components and subsystems are put together to create the final goods.

In some research-intensive process industries, such as speciality chemicals and pharmaceuticals, specialised firms providing research and development services and other professional, scientific, and technical activities are an integral part of the development of new products. At the same time, suppliers of highly specialised capital equipment (such as bioreactors) are key sources of innovation in the sector.

2.2 Why should policy makers pay attention to supply chains?

Box 2 presents a selection of statements, found in UK policy documents, on the importance of supply chains from various perspectives – ranging from jobs and sustainability to trade and innovation. In this section we explore the importance of supply chains to achieving a broad set of policy outcomes (Figure 1).

FIGURE 1 WHY SHOULD POLICY MAKERS PAY ATTENTION TO SUPPLY CHAINS?



- **Security of supply**. Manufacturing supply chains enable the production of goods that are critical to life and national security, such as food, drink, medicines and medical goods, clothing, and fuel. They supply critical materials, components and equipment that keep factories running. Suppliers also provide machinery, components, systems, and engineering services that enable the operation of critical infrastructure such as transportation, electricity generation, communications, and defence.[24] A disruption in manufacturing supply chains could therefore result in a significant national economic impact and shortages that cascade across multiple critical infrastructure sectors and regions. The COVID-19 pandemic clearly showed that, in times of large-scale disruptions, manufacturing supply chains that were previously functioning well can be affected significantly, potentially magnifying the human and economic costs.
- **Job-creation, increased domestic value added, and improved trade balance.** In the past, the government has recognised that UK supply chains in a number of sectors remain relatively weak and/or vulnerable, with lower levels of domestic sourcing than competitor countries.[25] Estimates suggest that 70% of manufactured parts used in the UK are sourced domestically, compared with 88% in services.[26] Low UK content in some UK sectors has contributed to a long-run national trade deficit, which, despite a remarkable increase in service exports over the last few years, stood at £12 billion in 2020.[27] Increasing domestic sourcing would contribute to capturing supply chain jobs, increasing the gross domestic value added of manufacturing sectors and reducing the trade deficit. Furthermore, investments by international firms attracted by these supply opportunities result in increased FDI, as do the investments of lead firms attracted by the local availability of suppliers.
- **Adoption and diffusion of innovation.** The broad impacts of innovation, be they economic, environmental or societal, only accrue when new technologies – including low-carbon and digital

[24] López-Gómez et al. (2021). Adding the resilience dimension to industrial policy: lessons from COVID-19. Background Paper for the United Nations Industrial Development Organisation.
[25] HMG (2015). Strengthening UK manufacturing supply chains. An action plan for government and industry.
[26] Data refers to 2018 and is based on: OECD (2021) Trade in Value Added (TiVA) database.
[27] House of Commons Library Economic Indicators.

technologies – are adopted widely across entire supply chains.[28] According to the UK Innovation Strategy, supporting adoption and diffusion, alongside research and development, would have a major positive impact on the UK's overall economic performance and would create jobs, growth and productivity gains across the country.[29] For example, the Made Smarter Review[30] found that many businesses in the UK, particularly those with fewer than 250 employees, lag behind in adopting digital technologies. The net impact is low levels of investment, poor levels of productivity, and ageing capital stock.

- **Sector and place competitiveness.** Firms benefit from proximity to other firms with which they exchange input and the associated skilled labour and know-how.[31] Local clustering[32] allows firms to share knowledge, collaborate on supply opportunities, and reduce lead times, transportation costs and carbon footprint. In the automotive industry, for example, "leaner" and more flexible operations are possible when suppliers are located close to the vehicle manufacturing plant, particularly in some of the premium segments where UK firms operate.[33] The competitiveness of regions from an industrial perspective is therefore determined by the quality and mix of capabilities and linkages within the local ecosystem of suppliers. It is well known that large anchor firms attract smaller supplier firms. In fact, the UK aerospace industry is characterised by a number of place-based clusters, including: Airbus and its supplier base around Filton and Broughton; Leonardo and its supply chain companies in the South West; Spirit Belfast (formerly Bombardier Shorts), which drives growth across its supply base in Northern Ireland; Rolls-Royce and its predominantly Midlands-based supply chain, made up of thousands of suppliers in the region; and Boeing's actuation factory in Sheffield, which is seeing a number of small local suppliers scale up – firms such as Maher, Mettis, Aeromet, MetLase, among others.[34]
- **R&D commercialisation and technology scale-up.** Developing next-generation products often involves the introduction of new technologies and processes for which firms require external supplier expertise. Countries and regions hosting a critical mass of suppliers, human resources, R&D know-how, process development and engineering skills are better positioned to exploit the benefit of their research and technology base.[35] Conversely, the hollowing out of supply chains can lead to a vicious "*invented here, produced elsewhere*" circle – the loss of key skills and know-how results in the inability to commercialise innovations emerging from the research and science base. Influential studies conclude that the ability to innovate the next generation of products – in industries including semiconductors, electronics, advanced materials and energy production – is

[28] Shapira, P. and Youtie, J. (2017). Institutions for Technology Diffusion and the Next Production Revolution. In The Next Production Revolution: Implications for Governments and Business (pp. 243–275). Organisation for Economic Co-operation and Development.
[29] BEIS (2021). UK Innovation Strategy – Leading the future by creating it.
[30] Made Smarter Review 2017.
[31] Rosenthal, S. and Strange, W. (2004). Evidence on the Nature and Sources of Agglomeration Economics.
[32] Clusters can be viewed as a group of firms and organisations working in related activities and concentrated in the same geographical location. Michael Porter defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and other institutions—such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations—that provide specialized training, education, information, research, and technical support." Porter M. (1998). Clusters and the New Economics of Competition. *Harvard Business Review,* November–December; see also, OECD (2009). Clusters, Innovation and Entrepreneurship.
[33] Automotive Council (2013). Driving success – a strategy for growth and sustainability in the UK automotive sector.
[34] Examples provided by Expert Group member Balaji Srimoolanathan from the Aerospace Growth Partnership.
[35] Pisano and Shih (2012). *Producing Prosperity. Why America needs a Manufacturing Renaissance.* Harvard Business Review Press.

lost when local supply capabilities are "hollowed out".[36] Concerns have been raised that, without a "healthy" ecology of domestic suppliers, automotive technologies developed in the UK might be taken abroad for industrialisation.[37]

BOX 2 IMPORTANCE OF SUPPLY CHAINS – SELECTED POLICY STATEMENTS

> The Integrated Review Security, Defence, Development and Foreign Policy committed to "a resilient UK able to withstand and proactively tackle the challenges of today and the future", including a specific focus on supply chain resilience, committing to "using all our economic tools and our independent trade policy to create economic growth that is distributed more equitably across the UK and to diversify our supply chains in critical goods". **Cabinet Office (2021).** Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy.
>
> The process of innovation is rarely a factory-like, linear, mechanical process… The system is complex given the range of innovation-intensive businesses – from the large businesses pulling innovation through their supply chains to stimulate organic growth; to high-growth start-ups and scale-ups; and those smaller businesses who are adapting and using innovation to remain competitive.
>
> Vibrant business clusters attract investment and talented workers and enable companies to grow. Strong and innovative supply chains influence the location and success of global corporations. This can all lead to further investment in the skills of local people, quality jobs and opportunity. Working together in a local cluster or supply chain to innovate and do things differently can improve productivity and enrich local economies. **BEIS (2021).** UK Innovation Strategy – Leading the future by creating it.

> We must take advantage of the once-in-a-generation opportunity to build a world-leading EV supply chain in the UK and improve air quality in our towns and cities. We have committed up to £1 billion to support the electrification of UK vehicles and their supply chains, including developing "gigafactories" in the UK to produce the batteries needed at scale. **HM Government (2020).** The Ten Point Plan for a Green Industrial Revolution Building back better, supporting green jobs, and accelerating our path to net zero.

> We want to see UK suppliers retain significant market share in mature, high-value sectors such as automotive and aerospace, and to slow the growth in imported components. And we want to establish collaborative, strong, long-term supply chains in emerging, strategically important sectors like offshore wind, nuclear new-build, shale gas and advanced materials.
>
> A loss of UK suppliers can lead to a vicious circle – a loss of key skills and know-how results in more companies sourcing overseas… A recent report by the CBI estimated that a £30 billion opportunity could be realised, with wider benefits including a reduced trade deficit, regional rebalancing and a boost to our exports.
>
> Strengthening our UK supply chains will safeguard UK jobs. It has been estimated that reshoring a new generation of goods and services to the UK could create 100–200,000 extra UK jobs by the mid-2020s. This is not about repatriating low-value jobs but about creating skilled jobs as a result of the UK's reputation for high-quality, advanced manufacturing. **HM Government (2015).** Strengthening UK Manufacturing Supply Chains: An Action Plan for Government and Industry.
>
> If primes are to meet ambitious sustainability targets, efficiencies must be spread through the supply chain.
>
> Suppliers are increasingly being seen by primes and tier 1s as a source of innovation. Half of the respondents to a recent survey said that partnerships, rather than in-house R&D, would be key to future innovation activity. **Department for Business Innovation and**

[36] Ibid.
[37] Automotive Council (2013). Driving success – a strategy for growth and sustainability in the UK automotive sector. HM Government.

Skills (2014). Strengthening UK Supply Chains: Good Practice from Industry and Government.

2.3 Contribution of supply chains to socio-economic missions

The previous discussion on the contribution of supply chains to various policy outcomes serves as a framework to think about the role of supply chains in achieving higher-level socio-economic missions. Take **net zero** as an example:

- **Security of supply.** Access to suppliers of critical minerals such as lithium, nickel and cobalt and other materials is required to produce batteries for electric vehicles and other low-carbon technologies and products.
- **Capturing supply chain jobs, increasing domestic value added and improving trade balance**. Domestic opportunities for UK suppliers are growing in areas such as heat pumps and electric vehicles driven by regulation and changes in demand; and there might also be export opportunities for UK suppliers as these industries grow in other countries.
- **Adoption and diffusion of innovation.** The rapid development and deployment of low-carbon technologies is required across all supply chains in order to achieve decarbonisation targets**.**
- **Sector and place competitiveness.** The local availability of suppliers can support the competitiveness of the UK (and specific regions) as an industrial location to produce low-carbon products and services.
- **R&D commercialisation and technology scale-up.** The scale-up of technologies such as hydrogen will require the development of new suppliers and the diversification of existing ones.

In fact, statements found in the recent Net Zero Strategy could be analysed through these lenses, as shown in Table 1.

TABLE 1 THE ROLE OF SUPPLY CHAINS – STATEMENTS FROM THE NET ZERO STRATEGY[38]

Policy outcome	Role of supply chains
Security of supply and resilience	The transition to net zero will change the nature of the UK's critical supply chains. Our aim is to help ensure that supply chains critical for the transition to net zero are secure, ensuring that we have access to the materials, minerals and chemicals that our growing green economy will need. Critical minerals are metals and non-metals that are vital for a defined economic activity and for the well-being of the country, yet whose supply may be at risk because of geological distribution, a lack of substitutes and/or other factors. Such minerals provide materials that are essential for components in many of today's rapidly growing clean-energy technologies – from offshore wind turbines to electric vehicles.
Job creation, increased domestic value added and improved trade balance	Estimates suggest the UK's low-carbon economy could deliver up to £170 billion in export sales of goods and services by 2030. The UK will seek to improve market access for green goods and services through our trade policy, our growing array of free trade agreements (FTAs) and our seat in the World Trade Organization (WTO). Our target of 1 GW floating offshore wind by 2030 is a stepping stone to further growth in the UK, which will also develop jobs and opportunities in the associated industrial supply chain, putting us at the forefront of this new technology that can

[38] HMG (2021). Net Zero Strategy: Build Back Greener.

	utilise our North and Celtic Seas. We will build on this with £380 million for our world-leading offshore wind sector, investing in supply chains, infrastructure and early coordination of offshore transmission networks, securing jobs and benefiting communities across the UK. We will publish a refreshed Export Strategy by the end of 2021, which will help to deliver jobs and growth and maximise export opportunities for green UK technologies and innovation.
Adoption and diffusion of innovation	There are a range of ways in which net zero could be achieved in the UK. Our exact route will depend on the availability and deployment of key technologies, supported by long-term market growth, as well as the extent to which individuals and businesses adopt green choices. Deployment of energy-efficiency measures and low-carbon heating in domestic and non-domestic buildings, in line with the ambitions and outcomes in the Heat and Buildings Strategy, will drive up to £6 billion in gross value added (GVA) per year by 2030. We are also committed to additional measures to promote the uptake of low-carbon fuels in the freight, maritime and aviation sectors, and we will work with stakeholders to develop a longer-term low-carbon fuel strategy for the deployment of low-carbon fuels across different transport modes to 2050.
Sector and place competitiveness	There is a global race to develop new green technology, kick-start new industries and attract private investment. The countries that capture the benefits of this global Green Industrial Revolution will enjoy unrivalled growth and prosperity for decades to come – and it is our job to ensure that the UK is fighting fit. As the world moves to tackle climate change, new opportunities will arise for UK companies in domestic and international markets. Updated analysis, based on the BEIS Energy Innovation Needs Assessment (EINA), suggests that key net-zero-aligned sectors in the UK could contribute up to £60 billion in gross value added (GVA) per year by 2050. These opportunities show that net zero and levelling up go hand in hand. Delivering net zero allows us to boost living standards by supporting jobs and attracting investment in the green industries of the future, which can be in areas that need this the most. Crucially, delivering net zero also involves supporting workers employed in high-carbon industries that will be affected by the transition by giving them the skills they need to make the most of new opportunities in the green economy. But the link between net zero and levelling up is wider than just the economy; net zero can deliver wider benefits for people and communities across the UK by helping to spread opportunity and restore pride in place.
R&D commercialisation and technology scale-up	We are building a globally competitive UK zero-emission vehicle supply chain to ensure that our automotive sector is at the forefront of the transition to net zero. Since 2020, the government has been actively supporting the transformation of the automotive supply chain to electrification through the Automotive Transformation Fund (ATF). We are allocating a further £350 million of up to £1 billion ATF commitment to support the electrification of UK vehicles and their supply chains. The development of resilient, efficient and competitive supply chains will be a collaborative strategic endeavour. To support this, in May 2021 we published the CCUS Supply Chain Roadmap, which sets out how government and industry can work together to harness a strong UK supply chain, and we have committed to publishing a hydrogen sector development action plan in 2022, which will outline how the government will support companies to secure supply chain opportunities, skills and jobs in the sector. To ensure that the system is reliable, intermittent renewables need to be complemented by known technologies such as nuclear and power CCUS, and flexible technologies such as interconnectors, electricity storage and demand-side response. These flexible technologies can help to minimise the amount of

	generation and network capacity needed to meet our demand needs, for example, by matching new sources of demand to renewable generation, both nationally and locally. To do this, the new critical supply chains for these technologies also need to be resilient to ensure that the UK can build the capacity it needs for a reliable system.

3. What are the challenges and opportunities for UK supply chains?

This section discusses the challenges and opportunities for UK supply chains across the policy outcomes identified earlier. While some of these opportunities and challenges affect the whole of manufacturing, efforts are made to discuss the implications for supply chains. It is also important to note that some of the challenges and opportunities may be relevant to different policy outcomes. However, we have tried to categorise them for consistency with our previous analysis. Table 2 has been informed by input from the Expert Group, supplemented by the analysis of previous government reports and additional academic and industry sources.

TABLE 2 OPPORTUNITIES AND CHALLENGES FOR UK SUPPLY CHAINS

Policy outcome	Opportunities and challenges
Security of supply and resilience	**THE OPPORTUNITIES** More secure and resilient supply chains are essential to enhancing a country's ability to withstand disruptions during emergency events. The COVID-19 pandemic has disrupted global supply chains, production activities and demand across industries and countries and drawn attention to the important role of manufacturing supply chains in social and economic resilience in national economies. UK manufacturing supply chains have suffered significant adverse effects from the disruption caused by the pandemic, curtailing the UK's ability to produce and sell final products. After the outbreak of the pandemic, the pharmaceutical industry, for example, has been affected by shocks to both supply and demand. On the supply side, disruptions happened to the manufacture of medicines and vaccines, the majority taking place in India, and to the manufacture of active pharmaceutical ingredients (APIs), substantially concentrated in China. The medical supplies (equipment and consumables) sector has also been affected in a similar way, because of the concentration of manufacturing capacity in China and the suspension of production in India and Northern Italy.[39] The pandemic also demonstrated that the existing strengths and capabilities of UK supply chains are not always sufficient to mitigate the negative effects of external shocks. The proposed vision for the National Resilience Strategy[40] highlights opportunities to further improve UK resilience through a more in-depth understating of critical sectors such as incident-critical infrastructure, sensitive technologies, and critical supply chains.

[39] House of Commons International Trade Committee (2020). The COVID-19 pandemic and international trade. First Report of Session 2019–21.
[40] Cabinet Office (2021). The National Resilience Strategy A Call for Evidence.

Access to competent local suppliers allows firms to minimise the risks associated with external shocks by being more responsive to market demand fluctuations.

The transition to net zero will increase the demand for materials needed in the manufacture of components in rapidly growing clean-energy technologies – from offshore wind turbines to electric vehicles. The transition to a lower-carbon economy also means that supply opportunities in these sectors are growing. Countries are already competing to capture the associated skills and jobs.

The Net Zero Strategy aims to ensure that supply chains critical for the transition to net zero are secure, and that the UK has access to the materials, minerals, and chemicals that the growing green economy will need.[41]

The recovery process is pushing firms to conduct in-depth reassessments of the structure of supply chains in terms of location, production capacity and the management of material and information flows among stakeholders to identify weaknesses and eventually reconfigure the supply chain structure.

Resilience and efficiency in domestic supply chains can be pursued in a variety of ways, from supporting diversification and localisation, to developing closer networks and clusters. Measures can also include: building in "redundancy" (overcapacity); stockpiling; creating trusted partnerships; sourcing from nearby countries; international collaboration; and reducing reliance on "just-in-time" production when possible.[42]

THE CHALLENGES

There have been significant changes in the international trading landscape in recent times as a result of the UK's Trade and Cooperation Agreement with the European Union and the COVID-19 pandemic. These events have exposed UK firms to considerable levels of uncertainty and supply/demand shocks in global supply chains.

International climate change action has catalysed substantial growth in the clean-energy sector, resulting in an increased demand for the critical raw materials needed for various technologies (e.g. rare earths for magnets; cobalt used in lithium ion batteries; platinum group metals used in catalytic converters).[43]

However, access to these materials is restricted by a range of geological, economic, technological and political factors, with production usually concentrated in a limited number of countries (e.g. rare earths mostly extracted from China; niobium mostly extracted from Brazil; and platinum group metals mostly extracted from South Africa and Russia).[44] Critical materials underpin future supply chains in the automotive, energy-generation, robotics and electronics sectors.[45]

The transformation of global supply chains in recent decades has led to geographic concentrations of key supply chains (i.e. intermediate and capital

[41] HMG (2021). Net Zero Strategy: Build Back Greener.
[42] House of Commons International Trade Committee (2020). The COVID-19 pandemic and international trade. First Report of Session 2019–21.
[43] University of Birmingham (2021). Securing technology-critical metals for Britain.
[44] USGS (2019). Mineral Commodity Summaries 2019. United States Geological Survey.
[45] University of Birmingham (2021). Op. cit.

	goods) in a few nations. This increases the vulnerability to disruptions because firms rely on a less geographically diversified network of suppliers.[46]
Job creation, increased domestic value added and improved trade balance	**THE OPPORTUNITIES** Increasing domestic sourcing would contribute to capturing supply chain jobs, increasing the gross domestic value added of manufacturing sectors and reducing the trade deficit. For example, the Automotive Council estimates that opportunities for local sourcing in tier 1 amount to £4 billion annually. This includes opportunities in engine components, steering systems, trim and metal pressing. The Net Zero Strategy also highlights the importance of investing in the "green economy and its supply chains". The strategy suggests that new high-skilled supply chain jobs will be created for workers in a number of sectors, including construction, manufacturing, engineering and nature conservation. Overall, the Net Zero Strategy estimates that the 'green industrial revolution' can support up to 190,000 jobs by 2025, and up to 440,000 jobs by 2030.[47] The UK government estimates that 56,000 jobs have already been created since the publication of the Ten Point Plan. Programmes have been implemented to ensure the development of green industries and their supply chains, to include the offshore wind supply chain (through the Offshore Wind Manufacturing Investment Support scheme), low-carbon hydrogen production (through the Net Zero Hydrogen Fund) and automotive manufacturing through the Automotive Transformation Fund that supports the electrification of UK vehicles and their supply chains.[48] **THE CHALLENGES** Low UK content in some UK sectors has contributed to a long-run national trade deficit despite a remarkable increase in service exports over the last few years. Differences exist across supply chains in terms of the share of input supplied from abroad. In the automotive sector, for example, the average UK content in British-built cars increased from 36% in 2011 to 44% in 2017. Oil and gas production, automotive, chemicals, aerospace and steel/commodities all have a relatively high share of input supplied from abroad. The net effect of increased exporting remains limited without strengthened onshore supply chains.[49] As UK investment in the domestic industrial base has declined, competitor countries have adopted strategic programmes to advance competitiveness in global supply chains. For example, the European Union (EU) has adopted policies to stimulate domestic production of electric vehicles and lithium-ion batteries

[46] Lopez-Gomez et all (2021). *Adding the Resilience Dimension to Industrial Policy: Lessons from COVID-19.* Background paper prepared for the Industrial Development Report 2022. Vienna: United Nations Industrial Development Organization.

[47] HMG (2021). Net Zero Strategy: Build Back Greener.

[48] House of Commons International Trade Committee (2020). The COVID-19 pandemic and international trade. First Report of Session 2019–21.

[49] ONS Supply and Use Table analysis provided by DBT.

	through demand support, investment incentives and regulatory tools, at both EU and member-state level.[50] Similarly, Taiwan provides subsidies for fabrication facilities, including: 50% for land costs and 45% for construction and facilities, in addition to R&D investments and other incentives. In the semiconductor sector, South Korea and Singapore provide subsidies that reduce the cost of facility ownership by 25–30%.[51] Another challenge emphasised by the Expert Group relates to the fact that, in many sectors, supply and investment decisions are made by foreign-owned primes, without necessarily taking into account UK capabilities.
Adoption and diffusion of innovation	**THE OPPORTUNITIES** The importance of supporting the adoption and diffusion of new technologies, as well as the generation of new knowledge, has been recognised by the UK Government Innovation Strategy.[52] In the context of rapid technological change, regions and countries with higher rates of new technology adoption are likely to become more attractive industrial locations.[53] Larger firms with higher levels of technological sophistication and financial resources have a role to play in, and can benefit from, supporting technology adoption across their supply chains. Technological advances have significant implications for supply chain businesses that need to respond and adapt in order to maintain their competitiveness and market share. Manufacturers are likely to favour suppliers that are resilient and adaptable to technological change, including the digitalisation of manufacturing.[54] Opportunities exist to address the "long tail" of unproductive firms hindering national industrial competitiveness through improved support for technology adoption.[55] The CBI estimates that SME tech adoption could add around £45 billion to UK GVA in 2030.[56] **THE CHALLENGES** Not all firms have the capabilities to fully engage in, and benefit from, the national innovation system. In particular, smaller firms rarely engaged in innovative activities and have a low contribution to manufacturing R&D.[57] A large proportion of SMEs do not have the time, capacity or funds to partner with universities or research and technology organisations. SMEs also have an intrinsic "innovation fear", as an unsuccessful investment of their limited resources

[50] Ibid.
[51] Ibid.
[52] BEIS (2021). UK Innovation Strategy – Leading the future by creating it.
[53] O'Sullivan, E. and López-Gómez, C. (2017). Manufacturing R&D Policies for the Next Production Revolution: An International Review of Emerging Research Priorities and Policy Approaches. In OECD (2017). The Next Production Revolution: Implications for Governments and Business. OECD Publishing, Paris.
[54] HM Government (2015). Strengthening UK manufacturing supply chains: An action plan for government and industry.
[55] Haldane, A. G. (2017). Op. cit.
[56] CBI (2021). Seize the moment: how can business transform the UK economy?
[57] Policy Links (2017). New industrial capabilities for new economic growth: a review of international policy approaches to strengthening value chain capabilities. A report for the Department for Business, Energy and Industrial Strategy (BEIS).

	in an innovative project can greatly affect their financial performance and even jeopardise their survival.[58] The lack of involvement in R&D and innovative activities of supply chains represents a particular challenge to the long-term competitiveness of advanced industries that require continuous and collaborative innovation. As highlighted by the Bank of England, there large productivity disparities exist in the UK within sectors between leading firms and the rest. Around 1% of companies have seen productivity growth of approximately 6% per year, while one-third have seen no increase since 2009.[59] Slow productivity growth can be linked to limited firm internal R&D and managerial capabilities to adopt the best technologies and operational practices, update production processes and develop new products at a competitive scale.
Sector and place competitiveness	**THE OPPORTUNITIES** The availability of local suppliers has positive impacts by reducing transport costs, the overall carbon footprint of the industry and the risks associated with disruptions such as foreign natural disasters. Access to competent local suppliers allows firms to be more responsive to market demand fluctuations, share resources, enhance collaboration, and reduce inventories. Suppliers also represent a platform for the industries and value chains of the future. In the automotive industry, for example, leaner and more flexible operations are possible when suppliers are located close to the vehicle manufacturing plant. This is particularly important in some premium segments where UK firms operate.[60] Diversification and localisation can play a key role in increasing resilience and efficiency, as being able to draw on multiple suppliers in different locations helps to reduce disruptions by spreading the risk. They can also increase agility, as there are more supplier options to draw upon. As suggested by Make UK, companies have to balance the efficiency offered by streamlined supply chains with the risk of a single point of failure bringing the entire supply chain to a halt.[61] Opportunities to increase competitiveness at sectoral level where supply chains have a role to play include:[62] ▪ **Automotive**: many opportunities exist in low-carbon technologies, including engine efficiency, lightweight materials, hybrids, fuel cells, safety technologies and batteries (with estimated exports worth £18 billion for electric vehicles and vehicle batteries based on CBI estimates). ▪ **Globally powerful brands**: the opportunity to build on motoring heritage and capabilities in premium and specialist segments. Export of engineering and design consultancy. ▪ **Aerospace:** opportunities in emerging technologies, including composite materials, electric power, hydrogen power, homeland security and unmanned aircraft. Focus on international defence markets: the

[58] Ibid.
[59] Haldane, A. G. (2017). Productivity puzzles. Speech given at the London School of Economics. 20 March 2017.
[60] Automotive Council UK (2013). Driving success – a strategy for growth and sustainability in the UK automotive sector.
[61] Ibid.
[62] Modified from PwC (2009). The future of UK manufacturing: observations, analysis and recommendations. PricewaterhouseCoopers; and CBI (2021). Seize the moment: how can business transform the UK economy?.

development of a “home markets” strategy for UK-based companies. Consolidation further down the supply chain to improve the UK’s cost competitiveness.

- **Chemicals**: UK plants have shown the ability to differentiate, succeed and grow, particularly in downstream areas, for example, cosmetics and personal care. Continuing innovation in a speciality is a key short-term priority. Longer term, opportunities exist in developing non-petroleum-based substitutes for traditional bulk chemicals and increasing the use of recycled materials.
- **Green technologies**: a decarbonised economy, winning the global race to net zero, with estimated exports worth £1 billion for carbon capture, usage and storage (CCUS), £8 billion for hydrogen electrolyser production and £3 billion for offshore wind goods and services.

THE CHALLENGES

Improved visibility across supply chains is critical to informing interventions. Make UK analysis suggests that a majority of UK manufacturers only monitor their immediate suppliers (e.g. OEMs only monitoring tier 1 suppliers). Better visibility is required to improve demand forecast and transparency, assess possible supply risks and establish risk-management strategies in collaboration with suppliers.[63]

A concern highlighted by the Expert Group is that the erosion of the UK supply base could have resulted in a loss of industrial capability within the country, including the sophisticated engineering and manufacturing capabilities needed to maintain competitiveness across key sectors.

Data provided by DBT suggests a persistent hollowing out of the UK industrial base. The UK supply base for manufactured parts has declined by nearly 40% over the last 20 years (from roughly 70,000 firms to just over 40,000), including a decline by one-third in the number of mid-sized businesses, to around 6,000.

A key challenge for the design of policies to rebuild the “industrial commons” is the need to better understand the key capability gaps and strengths in the UK and where they are located.

The transition to net zero will affect manufacturing supply chains in different ways, depending on the cost of abatement, their energy intensity and their exposure to additional costs brought about by regulation. In sectors where international competitors are not subject to similar regulations, some UK firms could become less competitive, and some might choose to move to jurisdictions with less stringent climate-change-mitigation policies.[64]

In addition, the Expert Group highlighted that manufacturing firms face higher energy costs in the UK than in competitor counties, which restricts its ability to be competitive.[65]

Therefore, a key policy challenge for the future is to ensure that the shift to a low-carbon economy is done in a way that minimises the cost to UK businesses, taxpayers, and consumers.

[63] Make UK (2020). What can manufacturing supply chains learn from Covid-19?
[64] HM Treasury (2020). Net Zero Review: Interim report.
[65] Data from Eurostat shows that the UK has the tenth most expensive business electricity rates in Europe, at 8.794p/kWh, with Cyprus the highest, at 16.661p/kWh (89.45% higher). Source: Business Electricity Prices (2021). Energy prices and costs breakdown across Europe.

R&D commercialisation and technology scale-up	**THE OPPORTUNITIES** Opportunities exist to develop domestic value chains in strategically important emerging technologies and sectors where the UK has a leading science base, such as net-zero-manufacturing, quantum, synthetic biology, and biopharma. Developing the value chains of the future would require leveraging existing capabilities in the UK supply chain, supporting the diversification of existing firms into emerging supply chains, and supporting the creation of new suppliers. Rebuilding cross-cutting capabilities – the "industrial commons" – supporting UK manufacturing industries can enable the scale-up of next-generation products and services. These "commons" represent "a platform for innovation and entrepreneurship".[66] **THE CHALLENGES** Scaling up R&D is not just about technology innovation. Significant R&D and innovation efforts are also required to develop novel production/process technologies.[67] The scaling-up stage of manufacturing demands the development of a completely new set of capabilities that are not usually available to new entrants. Developing supply chains for new products requires "developing and redistributing manufacturing-related capabilities to support new products, business models and markets".[68] While this common to other economic sectors, it is particularly challenging for manufacturing supply chains, particularly those of high-technology products that usually involve a larger number of components and suppliers. Collaborating with multinational partners has been a solution that manufacturing start-ups have pursued to obtain access to financial resources, scaling capabilities and reaching customers and major suppliers.[69] However, this runs the risk of technologies developed in the UK being scaled up abroad. Another challenge is access to finance. Traditional venture capitalists may invest in the early stages of manufacturing companies; however, they do not usually fund the scaling-up stage, which requires investments of between USD 50 and 150 million. Even the stage of demonstrating viability (pilot scale, market testing, etc.) has been found to be difficult to finance, involving USD 30–70 million investment needs. [70] While venture capital (VC) is a significant source of funding for technology spin-off, it is strongly concentrated in sectors where scaling up usually takes between three and five years, such as: information technology, computers, and

[66] Pisano and Shis (2012). *Producing Prosperity. Why America needs a Manufacturing Renaissance.* Harvard Business Review Press.
[67] O'Sullivan and Lopez Gomez (2017). An international review of emerging manufacturing R&D priorities and policies for the next production revolution. In OECD (ed.), *The Next Production Revolution. Implications for Governments and Business*, pp. 325–360.
[68] O'Sullivan and Lopez Gomez. Op. cit., p. 339.
[69] Berger, S. (2013) Scaling Up Start-Ups to Market. In Berger, S. *Making in America. From innovation to market.* United States of America: MIT Press, pp. 65–89.
[70] Reynolds, E., Samel, H.M. and Lawrence, J. (2015) Learning by Building: Complementary Assets and the Migration of Capabilities in U.S. Innovative Firms. In Locke, R. N. and Wellhausen, R.L. *Production in the Innovation Economy*. United States of America: MIT Press, pp. 81–108.

	telecommunications. While in some sectors innovation cycles from lab to market last five years or fewer, the scaling of technologies in which production plays a critical role, such as biopharmaceuticals and semiconductors, may take ten years or more to bring a product to market.[71] All of these barriers pose challenges to growth and internationalisation of UK suppliers in a context where the demand for customised products and services requires the development and adoption of emerging technological solutions at every stage of the value chain.

In addition to the topics discussed in the previous table, workforce skills was identified by the Expert Group as a cross-cutting challenge identified. This topic has not investigated in detail in this report and warrants further analysis. It is worth highlighting however, that a 2015 report by the UK Commission for Employment and Skills found that, on balance, the evidence suggests that there is no overall undersupply in the labour market of individuals with high level STEM skills. "Rather the issue seems to be one of concentrated pockets of shortages, where employers report insufficient potential recruits with specific skills. Qualitative evidence suggests that reasons for this include a lack of degree courses with the right technical content, a lack of well-rounded candidates with practical work experience and broader competencies, such as mathematical capability." [72]

Similarly, the National Audit Office found that the UK might face STEM "skills mismatch" rather than a simple shortage. A mismatch can include many types of misalignment between the skills needed and those available in the labour pool. According to their report published in 2018, "there are particular shortages of STEM skills at technician level, but an oversupply in other areas, such as biological science graduates, who are then often underemployed in an economy in which they are not in high demand. There is also evidence to suggest that, at graduate level and above, the problem is sometimes one of quality rather than quantity, with people not having all of the employability or practical skills they need to enter the workforce…".[73]

[71] Berger, S. (2013)
[72] UKCES (2015). Reviewing the requirement for high level STEM skills. UK Commission for Employment and Skills.
[73] National Audit Office (2018). Delivering STEM (science, technology, engineering and mathematics) skills for the economy. Department for Business, Energy and Industrial Strategy (BEIS) and Department for Education.

4. How can supply chains be revitalised?

Having discussed the importance of supply chains for achieving policy outcomes, and the challenges and opportunities for the UK, this section focuses on what governments can do to revitalise supply chains. The section discusses the need to clearly articulate the rationale behind government intervention and provides examples of market and system failures affecting supply chains. It then identifies potential supply chain interventions to support the policy outcomes identified earlier in the report and provides examples from the UK and other countries.

4.1 Supply chains and the rationale behind intervention

It is critical to articulate a clear rationale for government intervention. While this rationale has traditionally been framed in terms of market failures, recent changes to the HM Treasury's Green Book state that appraisal should be based on social value and welfare economics, and not simply economic market efficiency. This means that while market failures can be used as a basis for the rationale behind intervention, policymakers are not limited to them. The appraisal of any business cases should include all significant costs and benefits that affect the welfare and well-being of the population. For example, environmental, cultural, health, social care, justice and security effects should be considered.

Table 3 presents examples of market and system failures affecting the effective functioning of supply chains and preventing policy outcomes from being achieved. Broadly speaking, these barriers are consequences of the increasing complexity of supply chains and the socio-economic and technological systems where supply chain firms operate. Following the approach of previous studies commissioned by DBT,[74] we include both market and system failures in the analysis.

Understanding market failures and the other welfare and well-being considerations involved in developing the rationale behind government intervention is important but it is only part of the story. Any proposed government intervention needs a strong economic case supported by robust evidence that it will deliver social benefits that outweigh the cost of the intervention. It will also need careful consideration for how an intervention will be delivered, managed, and financed in a way that optimises the social/public value produced by the use of public resources.[75]

The existence of a barrier to the optimal functioning of supply chains does not imply that government intervention is necessary nor that it is the only solution. Each example of a failure needs to be analysed to understand its root causes and its impact on society to determine if, when and how the government (and at which level of government), industry bodies, third-sector organisation, etc. and/or individual businesses could act to address that specific barrier.

[74] Technopolis (2014).
[75] Treasure guidance on business cases for projects and programmes can be found alongside the Green Book. https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

TABLE 3 POLICY OUTCOMES AND MARKET AND SYSTEM FAILURES

Policy outcomes	Examples of market and system failures
Security of supply and resilience	▪ **Information failure** – The increasing complexity of the structure and governance of modern industries[76] means that firms often lack visibility of their buyers and sellers and the vulnerabilities that they might be exposed to. Surveys have found that firms tend to monitor only their most immediate supplier (e.g. OEMs monitoring tier 1 suppliers) and not the whole supply chain.[77] This lack of information means that firms are not able to establish effective mitigation strategies and respond when disruptions occur. ▪ **Information failure** – During an emergency event, producers usually suffer from demand distortion and amplification – the so-called "bullwhip effect" – due to distorted information from one end of the supply chain to the other. As a result of this distorted information, the variance of orders may be larger than that of sales, leading to a number of inefficiencies: excessive inventory, inadequate capacity and transformation plans, missed production schedules and poor customer service.[78] ▪ **Capability/coordination failures** – Resilient supply chains are secure and diverse, with a range of supply sources, adequate stockpiles, safe and secure digital networks, and a manufacturing base and workforce, particularly in key strategic sectors.[79] The local availability and domestic capacity to produce and stockpile critical goods is not always a priority for the private sector, and therefore coordination among firms does not necessarily take place. ▪ **Public good** – The lack of some technologies and capabilities might inhibit the ability to produce goods that are critical to life and national security. There is a public good element in intervention aimed at ensuring that suppliers of these technologies and capabilities exist within the industrial commons.[80]
Job creation, increased domestic value added and improved trade balance	▪ **Information failure** – Large primes are often unaware of the existence of firms that might be able to supply parts, components and services from within the country. At the same time, suppliers are often unaware of potential domestic clients.[81] ▪ **Information failure** – Firms from abroad might not be able to see business opportunities within the country, preventing FDI decisions from being made. ▪ **Capability failure** – Even when domestic companies are aware of domestic supply opportunities, they might not be able to exploit them as a result of lack the resources and know-how to move into a new industry. Diversifying often involves high barriers to entry, especially when new certifications and large investments to scale up production are required.
Adoption and diffusion of innovation	▪ **Information failure** – Even when technologies are available in the market, firms might not be aware of their potential business benefits.[82] Specialised technical and market knowledge is costly and, as a result, not all firms have the basis for making informed technology investment

[76] Gereffi et al. (2005). The Governance of Global Value Chain. *Review of International Political Economy,* 12:1.
[77] Make UK (2020). *What can manufacturing supply chains learn from Covid-19?* Manufacturing Smart Supply Chain project (in collaboration with Oracle)
[78] Lee H.L, Padmanabhan V. and Whang S. (1997). The Bullwhip Effect in Supply Chains. *Sloan Management Review, spring.*
[79] The White House (2021). *Executive Order on America's Supply Chains.*
[80] Policy Links (2017). *New Industrial Capabilities for New Economic Growth: A Review of International Policy Approaches to Strengthening Value Chain Capabilities.* A Report to The Department For Business, Energy and Industrial Strategy (BEIS).
[81] HMG (2015). *Strengthening UK manufacturing supply chains. An action plan for government and industry.*
[82] Ibid.

	decisions. The potential of new technology adoption is often unknown, particularly when relevant technologies have originated in other sectors. ▪ **Capability failure** – Due to weak "absorptive capacity",[83] many firms, in particular SMEs, fail to exploit opportunities offered by technologies available in the market. As a result of limited internal R&D and managerial capabilities, these firms struggle to adopt best technologies and operational practices, to update production processes and to develop new products at a competitive scale. ▪ **Network failure** – Suppliers may be locked into specific technological regimes and find themselves unable to transition into new technologies or businesses. This happens, for example, when the certification to provide a part or component means that suppliers cannot easily change to newer technologies, as this would require going through the certification process again. This is particularly costly in highly regulated sectors such as aerospace and pharmaceuticals.
Sector and place competitiveness	▪ **Infrastructural failures** – Regions and countries might make insufficient human and capital investment in infrastructure that is critical to innovation performance; they might suffer from underdeveloped physical infrastructure or educational systems.[84] ▪ **Coordination failures** – Firms outside business clusters have limited visibility of the market and innovate at higher costs compared to firms within business clusters.[85] Firms outside clusters fail to exploit the advantage of geographical proximity of suppliers. ▪ **Information failures** – Capabilities from other sectors might not be known; applications of new technologies that originated in one sector may be unknown to firms in other sectors. ▪ **Coordination failure** – Innovation efforts that benefit multiple industries and drive economy-wide productivity growth might only be possible through coordinated supply chain efforts.[86] In a number of sectors in the UK, weak communication and collaboration between primes, tier 1s and lower-tier suppliers have been reported.[87]
R&D commercialisation and technology scale-up	▪ **Coordination failures** – Scaling up new technologies often requires large-scale investments and multidisciplinary expertise, and it cannot be tackled by single firms. Alignment of R&D investments, between related fields of expertise, might be necessary to tackle such "grand challenges". In theory, this could happen through private contracting, but high transaction costs and the uncertainty of the market potential might inhibit collaboration.[88] ▪ **Public good/appropriability** – Firms tend to underinvest in R&D because some forms of technological knowledge cannot be patented, and thus they might be exploited by others. Knowledge and skills, generated through R&D by one firm in the supply chain, might benefit others if its workers decide to move to a new employer. ▪ **Network failures –** Underinvestment in R&D collaboration with suppliers is often inhibited for fear of helping competitors, affecting the innovative potential of the supply chain as a whole.[89]

[83] Absorptive capacity is defined as "the ability to recognize the value of new information, assimilate it, and apply it to commercial ends". This capacity is largely a function of the firm's level of prior related knowledge, and it is considered critical to its innovative capabilities. Source: Cohen W.M. and Levinthal D.A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, Vol. 35, No. 1, Special Issue: Technology, Organizations, and Innovation, pp. 128–152.
[84] Technopolis (2014). *The Case for Public Support of Innovation*. A report for the Department for Business, Innovation and Skills.
[85] Porter M. (1998) Clusters and the New Economics of Competition. *Harvard Business Review*, November–December.
[86] Policy Links (2017).
[87] HMG (2015).
[88] O'Sullivan E. and López-Gómez C. (2017). An international review of emerging manufacturing R&D priorities and policies for the next production revolution. In OECD (2017). *Next Production Revolution: Implications for Governments and Business.*
[89] Policy Links (2017).

4.2 Variety of supply chain interventions

Table 4 identifies potential supply chain interventions categorised across the policy outcomes identified earlier in the report. The table is by no means comprehensive, and it is worth noting that some interventions might be relevant to more than one policy outcome. Selected examples from the UK and other countries are included. For a longer list of policy interventions in the UK and abroad, please see Appendix 2. The categorisation presented in Table 4 facilitates thinking about the variety and combination of policy interventions that might be required to revitalise supply chains. It also helps with distinguishing the goals of supply chain interventions from those of broader manufacturing policy measures.

TABLE 4 VARIETY OF SUPPLY CHAIN INTERVENTIONS

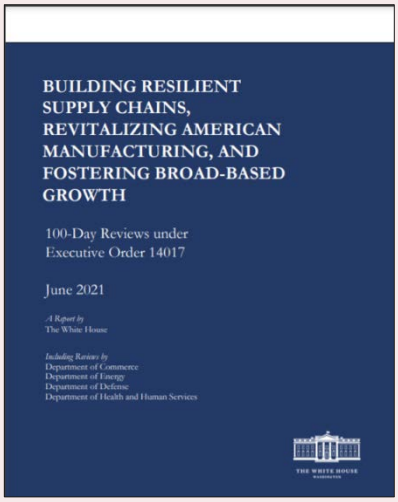
Policy outcomes	Supply chain intervention types	Examples
Security of supply	▪ Studies and projects to identify risks and vulnerabilities in supply chains of critical products and develop mitigation strategies	▪ Project Defend was established in the UK to create an actionable strategy for building resilience in non-food critical supply chains. This has included collating data, intelligence and indicators of potential disruption to the UK's critical supply chains. It has also involved identifying alternative sources of supply. The Department for International Trade (DIT) has also developed a central monitoring system and supported other departments' work to increase supply chain resilience for the long term. ▪ The Global Supply Chains Directorate in the UK Department for International Trade works to increase the long-term resilience of the United Kingdom's critical international non-food supply chains by: strengthening the understanding and monitoring of the UK's critical supply chains; designing policy and guiding strategic interventions to strengthen the long-term resilience of supply chains; and creating and supporting international efforts to strengthen the resilience of critical supply chains. ▪ The Global Supply Chains Intelligence Pilot is being funded in the UK to test the value of combining several government and external data sets, along with big data analytics, to map global supply chains. Participants across government will use real-time visibility and insights to better understand their supply chains, recognise and harness opportunities and proactively mitigate risks. ▪ The US government has carried out a review of critical US supply chains to "identify risks, address vulnerabilities and develop a strategy to promote resilience" (see Box 6). ▪ The 2018 study by the US Department of Defence, Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States, identifies "ten risk archetypes", including sole, single and fragile suppliers.
	▪ Interventions to increase access to critical supplies (e.g. critical minerals and materials), including: targeted trade and cooperation initiatives	▪ Japan's strategy to secure supplies of raw materials aims to increase self-sufficiency in rare metals to 50% by 2030. ▪ Bilateral and multilateral policy dialogues, such as the annual Trilateral US-EU-Japan Conference on Critical Materials for a Clean Energy Future.

	to improve access to international markets; recycling programmes; R&D programmes to develop alternative materials; and stockpiling.	
	▪ Mission-oriented programmes aimed at the rapid scale-up of complete supply chains of critical supplies.	▪ Operation Warp Speed in the US involved vaccine manufacturing forecasting and investing to close any supply chain gaps before they arose. ▪ UK's Vaccine Taskforce and UK PPE Make focused on vaccines and PPE.
	▪ Measures to address supply chain cyber-attacks.	▪ The UK government has produced the Cyber Essentials Scheme, which trains firms in good practices to protect their supply chain and overall cyber-security.
	▪ Incentives for reshoring of selected supply chain firms.	▪ In response to COVID-19, Japan's Program for Promoting Investment in Japan to Strengthen Supply Chains allocated $2.8 billion to support Japanese companies in moving manufacturing capacities with an overreliance on one country (especially China) back to Japan or to Southeast Asian countries. Subsidies initially targeted medical products in short supply, and subsequent rounds targeted critical technology and green goods.
	▪ Supply chain intelligence platforms and resources to enhance preparedness and response during emergency events.	▪ The Supply Chain Control Tower (SCCT) was established in March 2020 to provide visibility in critical medical supply chains to support US government decision-making and actions on planning, acquisition, prioritisation, allocation and targeted distribution to get supplies where they are needed.
Job creation, increased domestic value added and improved trade balance	▪ Interventions to address manufacturing-specific domestic supply opportunities and increase local value added, including supplier development programmes.	▪ The North East England investment promotion agency (now called Invest North East England) is identified as a global pioneer in developing investor development and supply chain programmes at regional level. ▪ Seletar Aerospace Park in Singapore was set up to connect global primes with local suppliers, thereby increasing gross value added and employment in the country's aerospace sector.
	▪ Specialised websites and platforms to connect firms to local suppliers.	▪ The Made Smarter Marketplace, delivered by Swansea University, is designed to optimise manufacturing supply chain networks and create a new industry-wide business model. ▪ The case of CzechInvest is considered a leading example of how the use of a website and specialised sector databases can help to establish linkages with local suppliers and increase the capability of local SMEs to enter the supply chain.
	▪ Targeted FDI attraction programmes aimed at attracting key firms to address supply chain gaps.	▪ Targeted attraction of key suppliers by the Economic Development Board in Singapore in industries such as electronics to address gaps in the "enterprise system".
Adoption and diffusion of innovation	▪ Technology diffusion along supply chain tiers; ▪ Technology demonstration.	▪ The Made Smarter Adoption Programme in the UK supports the diffusion of digital technologies and applications, particularly in SMEs. ▪ The UK's Manufacturing Made Smarter Challenge Programme seeks to support the transformation of UK manufacturing by pioneering the development and integration of new and existing industrial digital technologies (IDTs), including artificial intelligence (AI) and virtual reality. The challenge aims to deliver a

		resilient, flexible, more productive and environmentally sustainable UK manufacturing sector. As part of the challenge, the Made Smarter Innovation Digital Supply Chain Innovation Hub aims to develop breakthrough solutions that create supply chains that are fully connected, resilient and sustainable. Delivered through a collaboration led by Digital Catapult, the hub network aims to make innovation more accessible to a wide range of potential businesses, including manufacturers and technology. The hub will provide them with access to clusters of test beds and other practical laboratories. ▪ Singapore Blockchain Innovation Programme (SBIP) is aimed at boosting the adoption of blockchain technologies by Singaporean companies, particularly those operating in trade, logistics and the supply chain.
Sector and place competitiveness	▪ Business and technical support to increase the capability of firms in supply chains.	▪ Scottish Manufacturing Advisory Service (SMAS) provides expert support to supply chain firms. ▪ The UK National Manufacturing Competitiveness Levels (NMCL) is a national, quality-assured, best-practice programme aimed at improving the competitiveness of manufacturing supply chain companies.
	▪ Programmes aimed at exploiting the efficiencies of local clustering of related supply chain competencies.	▪ Science parks sponsored by the Taiwan authorities provide semiconductor companies with access to land, electricity and water and lower operating costs by enabling several members of the semiconductor supply chain to operate within the same facility. ▪ The Industrial Clusters mission is a competition funding research, technology demonstrations, shared infrastructure and research and cluster collaboration. It aims to position UK clusters as top areas for global inward investment and driving demand for low-carbon products and technologies. Improvement activities are delivered by approved providers.
R&D commercialisation and technology scale-up	▪ Mapping supply chains needs for the industrialisation of emerging technologies gaps.	▪ Technical report "Global Carbon Fiber Composites Supply Chain Competitiveness Analysis" produced for the US Department of Energy to "identify key opportunities in the carbon fiber (CF) supply chain", where resources and investments can help to advance the clean-energy economy. The report focuses on four application areas: wind energy, aerospace, automotive and pressure vessels.
	▪ Supplier development programmes aimed at diversification of next-generation products and higher-value-added activities.	▪ Fit4Nuclear: The Nuclear Advanced Manufacturing Research Centre (NAMRC), with support from EDF Energy and Areva, has developed a programme to help UK suppliers get ready to bid for work in the civil nuclear supply chain.
	▪ Innovation funding programmes aimed at developing next-generation supply chains.	▪ The Automotive Transformation Fund in the UK supports commercially led research and development in the design of elements of the electric automotive supply chain. It supports projects focused on technological improvements, as well as those developing new business models. The fund encourages projects that bring new investment and new businesses into the sector in the UK. ▪ The US Small Business Innovation Research and Small Business Technology Transfer competitive programmes support a diverse portfolio of small

		businesses to meet research and development needs and increase commercialisation.

BOX 3 BUILDING RESILIENT SUPPLY CHAINS: REVITALISING AMERICAN MANUFACTURING AND FOSTERING BROAD-BASED GROWTH



In February 2021 President Biden signed an Executive Order (E.O. 14017 America's Supply Chains) and directed the US government to undertake a comprehensive review of critical US supply chains to identify risks, address vulnerabilities and develop a strategy to promote resilience. The review report was released in June.

"As a significant customer and investor, Federal Government has the capacity to shape the market for many critical products… The Administration should leverage this role to strengthen supply chain resilience and support national priorities."

What?	Why?	How?
▪ Four sectors reviewed: ➢ Semiconductor manufacturing and advanced packaging; ➢ Large capacity batteries; ➢ Critical minerals and materials; ➢ Pharmaceuticals and active pharmaceutical ingredients. ▪ Five drivers of supply chain vulnerabilities: ➢ Insufficient US manufacturing capacity; ➢ Misaligned incentives and short-termism in private markets; ➢ Industrial policies adopted by allied, partner and competitor nations; ➢ Geographic concentration in global sourcing. Limited international coordination.	▪ Rebuilding a robust and resilient supply chain and a diverse and healthy ecosystem of suppliers. ▪ Focus on labour as an asset to be invested in to create well-paid jobs. ▪ Foster investment in domestic manufacturing (e.g. semiconductor and key input for semiconductors, pharmaceuticals and active pharmaceutical ingredients). ▪ Enhance international engagement and cooperation. ▪ Encourage private-sector development and implementation of "best practices". ▪ Domestic production of emerging technologies can drive demand.	▪ Rebuild production and innovation capabilities through, among others, transformative investments within the American Jobs Plan: ➢ At least US $50 billion in investments to advance domestic manufacturing of cutting-edge semiconductors and in R&D on next-generation semiconductors; ➢ New incentives to spur consumer adoption of US-made EV, and to support battery cell and pack manufacturing; ➢ US $15 billion in national charging infrastructure to facilitate the adoption of EVs. ▪ Support market development: ➢ Expansion of critical minerals production and processing in the US; ➢ Improved transparency throughout the pharmaceuticals supply chain. ▪ Leverage the government's role as a purchaser of and investor in critical goods: ➢ Strengthening of federal Buy American procurement requirements, with additional preferences for a list of designated products; ➢ US $5 billion to electrify the federal fleet with US-made EVs. ▪ Work with allies and partners to decrease vulnerabilities in global supply chains: ➢ Expansion of multilateral diplomatic engagement, including a new Presidential Forum, to strengthen collective supply chain resilience; ➢ Increased capacity for the US Development Finance Corporate and other international finance tools to invest in production capability for critical products. ▪ Monitor near-term supply chain disruptions as the economy reopens from the COVID-19 pandemic: ➢ Establishment of a Supply Chain Disruptions Task Force to provide an all-of-government response to near-term supply chain challenges to economic recovery.

Source: White House (2021). *Building Resilient Supply Chains: Revitalizing American Manufacturing and Fostering Broad-Based Growth.*

4.3 The External Expert Group perspective

Overall, the Expert Group discussion highlighted that, while addressing the challenges and opportunities identified in this report should be a priority, it is important to do so through a coherent and integral policy agenda to avoid fragmentation of efforts and maximise cross-sectoral impact.

Some of the specific supply chain interventions suggested by the Expert Group include:

- Expanding the **advice available to SMEs**. In particular, the need for a national programme, with an open-access helpline to assist firms to meet their carbon-zero aspirations, was identified.
- Creating a cross-sectoral high-level **Supply Chain Council** in charge of developing a national supply chain demand model across all sectors was suggested. This council would create a "UK Manufacturing PLC" bill of materials to identify supply chain opportunities where both private and public sectors could focus.
- Creating IUK-funded specific programmes to **close the gaps in UKM PLC supply chains**.
- Establishing **public procurement programmes** based on a deep understanding of the complexity of supply chains via detailed mapping, to promote localisation of supply chains by aggregating demand and pooling volume that would generate supply opportunities.
- **Strengthening the support offered by Innovate, HVMC and KTN** in terms of collaborative clusters and innovation support. This may involve tweaks to the direction of, for example, HVMC to engage more with SMEs, and greater funding support for their activity with SMEs.
- Increasing the supply of **technology demonstrators** that highlight technology, both existing and emerging. These should revolve around net-zero technologies, hydrogen and other decarbonising technologies.
- Working more closely in partnership with sector **trade associations**, which have unrivalled knowledge of their sectors and access to their members.
- The UK Government or the British Business Bank could offer an **SME performance bond to allow competent SMEs to take on larger contracts** and underwrite some of the risk to larger firms in sourcing with UK companies.
- Implementing **carbon tax** for products, considering the true environmental impact and ethical outcomes of the goods being produced.
- Developing **communities and clusters** within manufacturing sub-sectors to facilitate the transfer of best practice and collaboration.
- Innovation calls through Innovate UK that are focused on green technologies, with a focus on **scale and automation** (products must be produced at prices that consumers can afford).
- Supporting structured **"challenge-led" innovation events/workshops** with local partners, bringing together LEPs, universities, research institutes and business support organisations to help to identify solutions to enhance/improve local supply chains.
- Supporting structured business improvement/excellence programmes to **assist local businesses with transitioning into a new supply chain**. Good examples include Fit4Offshore Renewables Norfolk and Suffolk (with ORE Catapult and supported by New Anglia LEP assisting non-energy-sector business such as engineering/manufacturing businesses into the offshore wind supply chain) and the national Fit4Nuclear programme (led by Nuclear AMRC).
- Supporting the **promotion of the pipeline of major projects and contracts in advance** to local business networks within regions via chambers, growth hubs, LEPs, sector groups, for example, to raise awareness of future supply chain opportunities in order for businesses to prepare and get the right advice on their capabilities and competencies well in advance.

5. Policy recommendations

Recommendation 1: Supply chain interventions should be designed to address activities and capabilities in the supply chain that are critical to (1) security of supply; (2) job creation, increased domestic value added, improved trade balance; (3) adoption and diffusion of innovation; (4) sector and place competitiveness; and (5) R&D commercialisation and technology scale-up.

Policy interventions to revitalise manufacturing supply chains are needed not just to be better prepared for the next crisis but to ensure the long-term prosperity of UK industries.

While recent discussions on supply chains have focused on shortages of goods and disruptions of supply routes, supply chains are not just about getting goods from the factory to the customer nor only about problems. Firms in the supply chain are not only a source of parts and components but also new technologies, knowledge-intensive services, and ideas.

Supply chains in modern industries are made up of "ecosystems" of firms providing both physical and intangible input – including specialised high-tech manufacturing services – that contribute to the health of UK sectors.

Therefore, supply chain interventions should not be limited to particular tiers of the supply chain, suppliers of physical input or firms of a certain size.

Instead, the scope of supply chain interventions should be framed in terms of those activities and capabilities in the supply chain that are critical to underpinning competitiveness and innovation of UK sectors. In addition, there is a need to ensure that supply chain interventions support value capture within the UK economy. Section 2.2 identifies five socio-economic missions to which the contribution of supply chains is critical.

INPUT FROM THE EXTERNAL EXPERT GROUP

"It is important to recognise the fundamental point that supply chains are about the process across all stages of designing, making, selling and distributing goods and services."

"The supply chain can be companies of all sizes. Do not approximate to SMEs only. Do not approximate by supply chain tiers. In some sectors (e.g. aero) the lower-tier suppliers (e.g. raw materials) are huge companies, whereas the first tier to Rolls-Royce are small family companies."

Suggestions made during expert group consultation

These suggestions could be further explored, refined, and prioritised as part of future work.

- Creating new IUK-funded programmes to **close gaps in UK PLC supply chains**.
- Additional innovation calls through Innovate UK that are focused on green technologies, with a focus on **scale and automation** (products must be produced at prices that consumers can afford).

Recommendation 2: Build the evidence base on supply chain challenges and opportunities, and assess whether the government capability to generate and disseminate this evidence can be improved.

Because supply chains cut across technologies, sectors and geographies, and are constantly being reconfigured, economic statistics provide limited insights into their challenges and opportunities.

Given that supply chains are relevant to achieve a variety of policy objectives, and are constantly changing, a strong and evolving evidence base around supply chains is needed to support decision making.

For example, supply chains of critical goods need to be better understood to identify failure points. In addition, this might require mapping of supply chain to understand the likely future patterns of sector reconfiguration (e.g. the reconfiguration of the automotive supply chain driven by the transition to electric vehicles) to support technology scale up.

The evidence base should not be limited to opportunities for local sourcing in existing industries but also provide forward-looking analysis of demand, technology and regulation trends likely to shape future opportunities.

Efforts have been made to capture such information in the past (e.g. studies on local sourcing opportunities in the automotive industry[90]). However, this could be expanded on with more systematic gathering of evidence to inform the design of supply chain policy interventions.

INPUT FROM THE EXTERNAL EXPERT GROUP

"There are opportunities to create a 'UK Manufacturing PLC' bill of materials to identify supply chain opportunities where both private and public sectors could focus."

"Where a government has a stated ambition and the supply side of the economy has neither the capacity nor capability to deliver, a supply chain opportunity can be identified (e.g. zero-emission vehicles for public transportation; heat-pump manufacturing at scale)."

Suggestions made during expert group consultation

These suggestions could be further explored, refined, and prioritised as part of future work.

- Creating a cross-sectoral high-level **Supply Chain Council** in charge of developing a national supply chain demand model across all sectors was suggested. This council would create a "UK Manufacturing PLC" bill of materials to identify supply chain opportunities where both private and public sectors could focus.

[90] See, for example: Automotive Council (2015). Growing the Automotive Supply Chain: the Opportunity Ahead; Automotive Council (2017). Growing the Automotive Supply Chain: Local Vehicle Content Analysis.

Recommendation 3: Formalise functions and responsibilities across government for identifying and addressing supply chain vulnerabilities of critical goods and sectors on an ongoing basis.

The COVID-19 pandemic has evidenced the need to identify key supply chain vulnerabilities and take preventive actions. This requires achieving end-to-end supply chain visibility for critical sectors and products.

Efforts are required to identify known and potential risks along the supply chain, examine alternate routes and alternate methods of transportation, and analyse any known restrictions of storage, handling and/or transportation.

As risks continue to evolve, this will require periodic reviews and ongoing monitoring of risks critical sectors and products. This intelligence should feed into action, which should consider a range of approaches including reshoring, redundancy, stockpiling, trusted partnerships, sourcing from nearby countries, and international collaboration (Parliament, 2020). In addition to preparatory measures, flexible legislation may be required for emergency situations.

It is not desirable nor feasible to map all supply chains. Instead, vulnerabilities in the supply chain of goods and sectors critical to life and economy should be prioritised. Initiatives such as Project Defend, reviews of critical materials, and the Global Supply Chains Intelligence Pilot are a step in this direction. Following a presidential Executive Order, reviews of risks in the supply chain of four sectors were tasked to relevant Departments in the US government.

Lessons from such initiatives should be shared widely across government and industry, and the function and capabilities to monitor supply chain vulnerabilities on an ongoing basis should be formalised in government.

INPUT FROM THE EXTERNAL EXPERT GROUP

"[There is a] need to understand the complexity of supply chains via detailed mapping thereof. This will highlight vulnerability, especially when supply chains have recently been exposed to global disruptions (e.g. COVID, global shipping container crisis, semi-conductors etc)."

Recommendation 4: Develop regional institutions to deliver supply chain support, and strengthen support for SMEs.

Opportunities exist to provide further coherence to the landscape of business support in the UK and to increase the focus on supply chain challenges and opportunities.

Policy makers would need to consider where supply chain investment decisions are made and how local capabilities might be leveraged to influence these decisions. All this would also require an understanding of the potential gains from local clustering, including lead-time savings and carbon footprint reduction. In designing delivery of this support, it is important to consider how to build on the networks, capabilities and skills of existing organisations.

For example, Catapults play a valuable function in delivering industrial support. However, they have not reached the level of coverage across all regions and nations and thus do not support technology diffusion throughout the country in the same scale as their international peers (such as the Fraunhofer institutes in Germany, after which the Catapults were modelled). The cost of support and membership are perceived as barriers to SME engagement.

The decision to disband the Manufacturing Advisory Service has left Britain without a nationwide support instrument for SME manufacturers, and many within the industry would support the return of a similar function.

In the UK, learnings may be drawn from the Scottish Manufacturing Advisory Service (SMAS), National Manufacturing Institute Scotland, and the network of Catapults. In the US, for example, the Manufacturing Extension Partnership (MEP) based at the National Institute of Standards and Technology (NIST) supports technology diffusion through its network of nearly 600 offices and centres serving firms in all of the US states.

INPUT FROM THE EXTERNAL EXPERT GROUP

"[There is a need to] expand the advice available to SMEs. A national programme is required; a collaborative, open-access helpline to assist firms to meet their carbon-zero aspirations is needed – government funding would be useful."

"We have played around with regional trials for long enough. There should be a continuing review of what companies themselves see as their barriers and opportunities for development. Sector trade associations should be partners in this programme."

"Outside the North West of England there is no integrated model for [providing technical, process and change management expertise] in relation to industrial digitalisation. Growth hubs in other parts of the country said that they didn't have the ability to provide sufficiently expert advice to support this work. Elsewhere… local authorities, LEPs, universities and others are trying their best, but with limited resources. They often struggle to locate SMEs who need their help and to interact meaningfully with them."

"There is widespread enthusiasm for, and commitment to, increasing the pace and scope of our national efforts to promote industrial digitalisation. But to deliver, we need to build on the Made Smarter North West pilot, and replicate its success in other regions."

Suggestions made during expert group consultation

These suggestions could be further explored, refined, and prioritised as part of future work.

- Review the offer of **advice available to SMEs**. In particular, the need for a national programme, with an open-access helpline to assist firms to meet net-zero targets, was identified.
- **Strengthening the support offered by Innovate, HVMC and KTN** in terms of collaborative clusters and innovation support. This may involve tweaks to the direction of, for example, HVMC to engage more with SMEs, and greater funding support for their activity with SMEs.

Recommendation 5: Work with industry to formulate sector-specific supplier development plans to exploit existing and emerging opportunities.

There was broad agreement among the stakeholders consulted around the potential to increase the participation in current supply chains of a number of sectors, in order to exploit benefits such as increased responsiveness, lower logistics costs and reduced carbon footprint. In the automotive industry, for example, reports suggest that the appetite for local sourcing remains strong.

As industries and their supply chains reshape as a result of changes in consumer demand, technology and regulations, UK supply chains face new threats and new opportunities. For example, the transition to net zero is opening up new opportunities for UK suppliers in industries, including hydrogen, offshore wind and electric vehicles.

Supplier development plans can support the transition by helping UK suppliers to reconfigure existing capabilities and develop new ones. Indeed, the Net Zero Strategy announced that new sector and supply chain development plans will be developed. A systematic approach to formulating such plans across industries is needed, taking into account current and future industry structures, as well as the strengths of UK supply chains in the context of international competition.

Sectors of interest should be identified in line with the government's priorities and evidence around risk, to focus initial activity regarding supply chain development plans.

INPUT FROM THE EXTERNAL EXPERT GROUP

"The supply chain needs to demonstrate structural flexibility. This is the ability to reconfigure, to create new supply chains to fulfil demand. It is easier for supply chains to be structurally flexible, when they are local, rather than global."

"Our focus and approach have been consistent by attempting to wake up the traditional supply chain to the opportunities based on process, competencies and capabilities (PCC). We want organisations to think beyond their current products and consider how they can apply their PCC to net zero (e.g. an exhaust manufacturer makes exhausts, but their key process and competence is based on welding and tube manipulation. Within the battery module and pack, we understand that there will be a significant amount of welding required)."

"Understanding OEM's strategy around batteries will hopefully result in further giga-plant investments, which will consequently attract and identify the supply opportunities."

Suggestions made during expert group consultation

These suggestions could be further explored, refined, and prioritised as part of future work.

- Increasing the supply of **technology demonstrators** that highlight technology, both existing and emerging. These should revolve around net-zero technologies, hydrogen and other decarbonising technologies.
- Working more closely in partnership with sector **trade associations**, which have unrivalled knowledge of their sectors and access to their members.
- Facilitating the development of **communities and clusters** within manufacturing sub-sectors to facilitate the transfer of best practice and collaboration.
- Supporting structured **"challenge-led" innovation events/workshops** with local partners, bringing together LEPs, universities, research institutes and business support organisations to help to identify solutions to enhance/improve local supply chains.
- Supporting structured business improvement/excellence programmes to **assist local businesses with transitioning into a new supply chain**. Good examples include Fit4Offshore Renewables Norfolk and Suffolk (with ORE Catapult and supported by New Anglia LEP assisting non-energy-sector business such as engineering/manufacturing businesses into the offshore wind supply chain) and the national Fit4Nuclear programme (led by Nuclear AMRC).

Recommendation 6: Ensure public procurement decisions support the government's strategic objectives for the health of the UK's supply chains and economy.

A clear message from the consultations carried out during this project has been the need to think more systematically about the role of procurement in supporting the health of UK supply chains.

The UK spends some £290bn on public procurement every year, representing a huge opportunity. As identified in the UK's National Procurement Policy Statement, public procurement should not only be guided by cost but should also consider spill-overs to the local economy.

Such spill-overs may include retaining UK capability, or national security considerations. Building on the recent work in improving Public Procurement, the UK government could look to understand how national procurement priorities can used to strengthen domestic supply chains.

Similarly, the government could challenge the private sector to more carefully consider the hidden costs associated with the purchasing decision, through approaches such as life-cycle costing, zero-based pricing, total cost of ownership (TCO), total acquisition cost (TAC) and transaction cost analysis (TCA).

INPUT FROM THE EXTERNAL EXPERT GROUP

"[Local sourcing] stimulates local manufacturing companies and gives them that little bit of lift to seek opportunities outside of the public sector."

"Procurement teams (OEMs and tier 1s) do not understand or appreciate the importance of looking across the entire supply chain to capture complete costs. They simply focus on the piece price. Better training or education in this area is imperative in order to support localisation initiatives."

"Variables such as quality concerns, requiring a/freights to replenish, carbon footprint, use of one-way packaging etc. need to be factored in."

Suggestions made during expert group consultation

These suggestions could be further explored, refined, and prioritised as part of future work.

- Based on a deep understanding of the complexity of supply chains via detailed mapping, **promote localisation of supply chains by aggregating demand and pooling volume** that would generate supply opportunities.
- Supporting the **promotion of the pipeline of major projects and contracts in advance** to local business networks within regions via chambers, growth hubs, LEPs, sector groups, for example.
- The UK Government or the British Business Bank could offer an **SME performance bond to allow competent SMEs to take on larger contracts.**

Appendix 1: the DBT Supply Chain External Expert Group

The DBT Supply Chain External Expert Group comprises more than sixty experts from the UK government, industry associations and academia.

The table below shows the members of the Expert Group who contributed to this report.

TABLE A.1 DBT SUPPLY CHAIN EXTERNAL EXPERT GROUP THAT CONTRIBUTED TO THE REPORT

Name	Organisation
Balaji Srimoolanathan	Aerospace Growth Partnership, ADS Group
Ed Sweeney	Aston University
Faye Smith	DIT, Northern Powerhouse
Jack Semple	Engineering and Machinery Alliance (EAMA)
Mike Hinton	High Value Manufacturing Catapult
Mike Gillard	Industry Wales
Mukesh Kumar	Institute for Manufacturing
Ben Peace	Knowledge Transfer Network
Peter Clark	Knowledge Transfer Network
Robert Quarshie	Knowledge Transfer Network
Janet Godsell	Loughborough University
Bhavina Bharkhada	Make UK
Julian Munson	New Anglia LEP
Kevin Shepherd	Nuclear Advanced Manufacturing Research Centre
Jane Galsworthy	Oxford Innovation Services, Manufacturing Growth Programme
Nick Shields	Scottish Enterprise
Andy Page	Sharing in Growth
Nick Golding	SWMAS ltd
Robert O'Neil	Welsh Automotive Forum

Appendix 2: UK and international supply chain interventions

TABLE A.2 EXAMPLES OF PREVIOUS AND ONGOING SUPPLY CHAIN INTERVENTIONS IN THE UK

Programme	Sector	Intervention focus
Previous		
Advanced Manufacturing Supply Chain Initiative (AMSCI)	Manufacturing	Designed to improve global competitiveness through R&D, skills training and capital investment. Project could also include reshoring.
Long-Term Advanced Supply Chain programme (LTASC)	Automotive	Diagnostic and business specific improvement plan, designed to address quality, cost and delivery (QCD), R&D capability, and management and employee development. These are core competitiveness measures used across the automotive sector.
Reshore UK	Manufacturing	Reshore UK was set up to spearhead a reshoring campaign and provide a "matching and location" service to help businesses make the right location decisions and help firms repatriate supply chain work with suitable domestic suppliers.
GROW Offshore Wind	Offshore wind energy	GROW Offshore Wind was designed to boost competition and increase UK content. It delivered an England-wide programme to build capacity within the offshore wind supply chain and enable UK SMEs to penetrate the £15 billion UK offshore market and the far-larger international market of circa £500 billion.
Manufacturing Advisory Service (MAS)	Manufacturing	MAS was established in 2002 to provide support and advice to SMEs and funded as a national scheme between 2012 and early 2012. It was managed by Grant Thornton.
CURRENT		
SC21	Aerospace and defence	An improvement programme designed to accelerate the performance and competitiveness of UK aerospace and defence supply chains, focusing on quality, cost, delivery, flexibility, product and technology and customer experience. National programme led by ADS, with more than 300 active companies.
Sharing in Growth	Aerospace and defence	A highly intensive business transformation programme to support key manufacturing growth sectors, including offshore wind, defence and nuclear. The aim is to transfer knowledge and capability in order to help ambitious supply companies grow and compete internationally.
National Aerospace Technology Exploitation Programme	Aerospace	Aerospace Growth Partnership manages a £15 million R&D fund for SMEs to strengthen supply chains in the UK. The grants are supported by expert technical and management mentoring, with (unfunded) sponsorship from an end-customer.
Aerospace Technology Institute (ATI)	Aerospace	ATI provides grants for R&D activity and encourages larger firms to collaborate with one another, as well as with smaller suppliers, research organisations and academia.
Advanced Propulsion Centre (APC)	Automotive	APC enforces a collaborative approach as a condition of funding and providing a lever for supply chain partners to invest their own funds in the project – it is especially focused on the industrialisation of the low-carbon automotive supply chain.
Nuclear Advanced Manufacturing Research Centre (NAMRC) and Fit for Nuclear	Nuclear energy	The Nuclear Advanced Manufacturing Research Centre (NAMRC), with support from EDF Energy and Areva, has developed a programme to help UK suppliers get ready to bid for work in the civil nuclear supply chain.
Hinkley Point C Supply Chain / HMG Benefits Realisation Assessment	Nuclear energy (project-specific)	As part of its procurement strategy for Hinkley Point C, EDF Energy has partnered with the Somerset Chamber of Commerce to manage the Hinkley Supply Chain Team in engaging with businesses in the South West that want to become part of the supply chain.
CompeteFor	N/A	CompeteFor was used successfully by the London 2012 Games authorities and their supply chains; the service continues to be used in the supply chain of major capital infrastructure projects, such as Crossrail.
National Shipbuilding Strategy	Marine engineering and manufacturing	Marine companies are important for their local economies – providing skilled jobs and higher wages.

Made Smarter Technology Adoption Programme	Cross-sectoral	The programme is delivering advice, support and funding to SME manufacturers based in the North East, North West England and West Midlands and Yorkshire and Humber regions. Services provided include advice from digital specialists, digital roadmapping for business, access to digital natives in technology strategy or implementation, digital skill enhancement through dedicated learning hubs, and funding to support the purchase of hardware and software.
Manufacturing Made Smarter Innovation Programme	Manufacturing	A £147 million investment from the UKRI Industrial Strategy Challenge Fund (ISCF) – matched by a minimum of £147 million from industry. It supports the transformation of UK manufacturing capabilities through the adoption of industrial digital technologies. These include projects in smart connected factories; connected and versatile supply chains; adaptable, flexible manufacturing operations and skills; and new ways to design, test and make products.
National Manufacturing Competitiveness Levels (NMCL)	Automotive	Developed by the Society of Motor Manufacturers and Traders (SMMT), NMCL is supported by major trade bodies, industry primes and original equipment manufacturers. It offers capability and competitiveness assessments and improvements, including training, coaching, mentoring and consultancy.
Scottish Manufacturing Advisory Services (SMAS)	Manufacturing	Run by Scottish Enterprise (Scotland's national economic development agency and a non-departmental public body of the Scottish Government), the programme helps companies to improve cost savings and efficiencies, adopt digital technologies, build sustainable change, identify supply chain opportunities through reviews, roadmapping and benchmarking tools.
Welsh Automotive Forum	Automotive	The industry-led initiative represents the automotive industry in Wales, representing over 120 component suppliers to vehicle-makers.
South West Manufacturing Advisory Service (SWMAS)	Manufacturing	SWMAS runs manufacturing support programmes on business strategy, operational efficiency, investment in physical capital, innovation and supply chains – in addition to business support programmes in areas such as coping with COVID-19 and research and development tax credits.
Manufacturing Growth Programme	Manufacturing	A £10 million programme funded by the European Regional Development Fund (ERDF) that supports improvements at manufacturing SMEs in 15 local enterprise partnership (LEP) regions. Services provided include business diagnostics and planning for growth and improvement opportunities; assistance by external experts in implementation; and improvement grants of up to 35% of implementation costs. The programme is delivered by Economic Growth Solutions, part of Oxford Innovation.

TABLE A.3 POLICY INTERVENTIONS HIGHLIGHTED IN SELECTED INTERNATIONAL POLICY DOCUMENTS

Country/policy document	Policy interventions
US  **National Science & Technology Council (2018). *Strategy for American Leadership in Advanced Manufacturing***	▪ **New business creation and growth.** Capital investments and training provided to small companies to develop new innovative ideas, commercialise new products and enter new markets are provided by federal programmes such as Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR). Collaboration between small and large companies is also supported by The Mentor-Protégé Programme. ▪ **Technology and supplier scouting programmes** to identify domestic sources capable of producing parts identical to those being imported. Buy America and Hire American executive order to support domestic supply chains for both defence and commercial manufacturers. ▪ **Technical assistance grants** for manufacturers developing innovative value-added agricultural products, e.g. USDA Rural Business-Cooperative Service. ▪ **R&D support and investments**. Government R&D support for basic research and early-stage applied research. ▪ **Cyber-security outreach and awareness.** Outreach and education to stakeholders seeking patent protection in the cyber and network security sectors provided by central government agencies. Manufacturing-related cyber-security vulnerabilities are addressed by the Cyber Hub for Manufacturing within the DoD Digital Manufacturing and Design Innovation Institute (one of the Manufacturing USA institutes)
US  **The Executive Office of the President and Department of Commerce (2015). *Supply Chain Innovation: Strengthening America's Small Manufacturers***	▪ **Access to management and technological expertise.** Manufacturing extension partnership designed to offer services in supplier improvement and supply chain optimisation, supplier scouting and business-to-business networks, and supply chain technology acceleration. ▪ **Economic adjustment programme.** Defence Industry Adjustment (DIA) programme that helps manufacturing firms to improve their resiliency in their respective defence industrial bases (assistance for dislocated workers and impacted firms due to demand shocks from changes in defence spending). ▪ **National labs in applied and applied technology** by the Department of Energy, as a forum for an exchange of ideas between regional firms, universities and economic development intermediaries.
US  **Department of Homeland Security (2019). *Supply Chain Resilience Guide***	▪ **Community Lifelines Implementation toolkit** to facilitate purpose and communication among the whole community (Federal, state, local, tribal and territorial governments, and private-sector and non-governmental entities) to enable the continuous operation of government functions and critical business. The seven community lifelines essential to human health and safety or economic security are: (i) safety and security; (ii) food, water, shelter; (iii) health and medical; (iv) energy; (v) communications; (vi) transportation; and (vii) hazardous material.
European Union  **European Commission (2021). *Updating the 2020 New Industrial Strategy: Building a Stronger Market for Europe's Recovery***	▪ **Mapping of strategic dependencies and capacities**. A "bottom-up analysis" based on trade data that provides first insights on the scope of the issues at stake. Out of 5,200 products imported into the EU, the analysis identifies 137 products (representing 6% of the EU's total import value of goods) in sensitive ecosystems on which the EU is highly dependent; in-depth reviews of possible internal dependencies within the Single Market and their impact, linked to a concentration of activities of individual firms, in areas such as raw materials, batteries, active pharmaceutical ingredients, hydrogen, semiconductors and cloud and edge technologies. ▪ **A proposed EU–US Trade and Technology Council** as a platform for cooperation to pool resources and build stronger and more diverse alternative supply chains with the closest allies and partners. ▪ **Industrial alliances in strategic areas** such as raw materials, batteries and hydrogen (already launched); processors and semiconductor technologies; and industrial data, edge and cloud (in preparation); and space launches, and zero-emission aviation.
European Union  **European Parliamentary Research Service (2019). *EU Industrial Policy at the Crossroads***	▪ **Deepening of the Single Market for non-digital services**, including transportation, retail, financial, professional and tourism services. ▪ **Foreign investment control as a key defence mechanism**, with the European Council given the right to decide by a qualified majority vote to block a foreign investment based on national security implications of large non-EU investments or mergers in the EU. ▪ **International procurement instrument** to improve the conditions under which EU businesses compete for public contracts in third countries and the EU negotiates its access to foreign procurement markets. ▪ **Increased public funding for innovation** in the multiannual financial framework (MFF) 2021–2027, not only in basic research but also in making new technologies ready for the market. ▪ **Appropriate conditions and incentives for private investment in R&D,** e.g. the launch of the European Fund for Strategic Investments that has triggered financing for strategic projects across the EU. ▪ **Cross-border industrial cooperation and coordination** through the Strategic Forum for Important Projects of Common European Interest for a number of value chains, including: connected, clean and autonomous vehicles; smart health; low-carbon industry; hydrogen technologies and systems; the industrial Internet of things; and cyber-security.

Country/policy document	Policy interventions
European Union **European Parliamentary Research Service (2019). *Global and Regional Value Chains: Opportunities for European SMEs' Internationalisation and Growth***	▪ **Access finance for investments** through grants, loans, loan guarantees, venture capital, e.g. COSME (the EU Programme for the Competitiveness of SMEs, EIC Accelerator, EIC Fast Track to Innovation, Horizon 2020 INNOSUP). ▪ **Development cooperation aid**, e.g. European Neighbourhood Instrument (ENI) with assistance for partner countries to achieve progressive integration into the EU internal market and enhanced cooperation, including through legislative approximation and investments (the 16 ENI partner countries are Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia, Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine). ▪ **Targeted business support**, e.g. know-how and advice, information and networking opportunities, e.g. the European Cluster Collaboration Platform, an online hub for cluster stakeholders and reference one-stop-shop for stakeholders. ▪ **Development and large-scale piloting of digital industrial platforms**, which are essential for the integration of various key digital technologies into real-world applications, processes, products and services, e.g. the Digitising European Industry (DEI) Initiative.
European Union **European Commission (2017). *Investing in A Smart, Innovative and Sustainable Industry: A Renewed EU Industrial Policy Strategy***	▪ **Investment in infrastructure and new technologies.** European Fund for Strategic Investments to support strategic projects across the continent; The European Investment Bank Group has also developed equity investments. ▪ **The EU Raw Materials Initiative to ensure secure, sustainable and affordable supply of critical raw materials** that are of high economic importance and are associated with a high supply risk. ▪ **EU energy policy**. Sectors at risk receive free allocation of allowances under the EU Emission Trading System; The New Entrants' Reserve (NER) 300 Programme allocated €2.1 billion to 39 highly innovative projects; a Modernisation Fund to support energy sector modernisation in 10 lower-income Member States. ▪ **Industry-led initiatives in value chains of strategic importance** concerning Important Projects of Common European Interest (IPCEI): a strategic forum involving key stakeholders to identify key value chains and investment projects and monitor progress achieved, e.g. in the full EU battery value chain, both for mobile and stationary applications. ▪ **Initiatives to tackle basic skills gap and development of high-level skills in emerging fields**. EU Skills Agenda with ten key actions, a five-year plan to help individuals and businesses develop more and better skills and to put them to use.
Germany **Federal Ministry of Labour and Social Affairs (2021). *Entwurf eines Gesetzes über die unternehmerischen Sorgfaltspflichten in Lieferketten (Law on Corporate Due Diligence to Avoid Human Rights Violations in Supply Chains)***	▪ A new supply chain law to set out clear and realisable requirements for corporate due diligence. The law applies to large companies and will come into force in March 2023: ➢ Companies must adopt policy statements on respecting human rights, carry out risk analyses, engage in risk management, establish a grievance mechanism, implement transparent public reporting and take remedial action in the event of a violation. ➢ The Federal Office for Economic Affairs and Export Control, which is tasked with monitoring compliance with the law, checks company reports and investigates any grievances.
Germany **Federal Ministry for Economic Affairs and Energy (2019). *SMEs Digital: Strategies for the Digital Transformation***	▪ **SMEs Digital services by the Federal Ministry for Economic Affairs and Energy (free of charge):** ➢ A combination of Mittelstand 4.0 Centres of Excellence in all parts of Germany to offer support for digitisation. ➢ Workshops, training sessions, practical tests, webinars and surgeries. ▪ **Teaching and demonstration factories designed to imitate real-life companies**.
Germany **Federal Ministry for Economic Affairs and Energy (2019). *National Industrial Strategy 2030: Strategic Guidelines for a German and European Industrial Policy***	▪ **To offset the disadvantages to efficient German and EU companies due to interventions by other countries**, four action points are required: ➢ Review and reform of existing law on subsidies and competition. ➢ Facilitate time-limited subsidies in areas of innovation with highly innovative ground-breaking impact in which the achievement of competitiveness is in the interest of the economy as a whole. ➢ Take a more effective stance against dumping and abuse of market-dominant positions. ▪ **Facilitate company mergers** in areas in which size is an absolute necessity for entrepreneurial success.
Germany **Federal Ministry for Economic Affairs and Energy (2015). *Future of the German Mittelstand Action Programme***	BMWi has 10 fields of action under its SME Action programme: ▪ **Promotion of entrepreneurship.** ▪ **Strengthening of start-up and growth financing.** ▪ **Tackling skills shortages.** ▪ **Improving, regulating and cutting red tape.** ▪ **Utilisation and shaping of digitisation**. Innovative Digitisation of Commerce platform bringing together companies, associations, trade unions and academia to strengthen SMEs as providers and users of ICT in the digital economy; Industrie 4.0 platform to tap the potential of digitisation for German goods-producing industry, particularly SMEs;

Country/policy document	Policy interventions
	Initiatives under "Mittlestand MDigital – ICT Applications in Commerce" to provide model solutions for SMEs. ▪ **Strengthening of innovative capacities.** Central Innovation Programme for SMEs (ZIM), which supports R&D projects; innovation vouchers to promote consultancy services for SMEs in innovation management, energy cost-cutting and digitisation. ▪ **Support for globalisation of SMEs.** Network of bilateral chambers of commerce; market development programme for SMEs (including fact-finding missions); Ixpos.de, a central reference online point of contact for SMEs on questions relating to export promotion; Germany Trade & Invest to provide information about attractive new target markets for SMEs. ▪ **Strengthening of SMEs in structurally weak regions**. ▪ **Development of new fields of business deriving from the energy transition.**
Japan **Ministry of Economy, Trade and Industry (2020).** ***Program for Promoting Investment in Japan to Strengthen Supply Chains***	Features of the Program for Promoting Investment in Japan to Strengthen Supply Chains: ▪ Subsidies covering half for large enterprises and two-thirds for SMEs of their property acquisition, equipment, system purchasing costs for Project Type A (maximum expenditure: 15b yen (~£97m)). ▪ Subsidies covering half for large enterprises and three-quarters for SMEs of their property acquisition, equipment, system purchasing costs for Project Type B (maximum expenditure: 15b yen (~£97m)). ▪ Subsidies covering three-quarters of SMEs' property acquisition, equipment, system purchasing costs for Project Type C (maximum expenditure: 15b yen (~£97m)).
Japan **Ministry of Economy, Trade and Industry; Ministry of Health, Labour and Welfare; Ministry of Education, Culture, Sports, Science and Technology (2021).** ***White Paper on Manufacturing Industries (Monodzukuri)***	The 2021 White Paper analyses trends that will contribute to the survival strategies of Japan's manufacturing industries in the following directions: ▪ **Resilience: increasing supply chain resilience.** Technological development and constructing and strengthening supply chains in fields such as semiconductors, storage batteries and various upstream materials will lead directly to increased competitiveness of Japan's manufacturing industries as a whole. ▪ **Green: addressing carbon neutrality.** Japanese manufacturers – including suppliers – will have to properly understand and accommodate governments' and global manufacturers' efforts and ideas towards achieving carbon neutrality if they are to ensure steady business continuity into the future. ▪ **Digital: furthering efforts towards digital transformation**. In order for manufacturers to make efficient and strategic digital investments, they must first understand precisely what roles they play in their value chains, and what data those roles mean they need to manage.
South Korea **Office of the President (2021).** ***Remarks by President Moon Jae-in at Presentation of K-Semiconductor Strategy***	Launch of the **K-Semiconductor Strategy** with features including: ▪ Complex, all-embracing support through tax credits, financing, regulatory reform and the expansion of infrastructure, so that corporate investments can be made in a timely manner and production capacity can be expanded rapidly. ▪ By designating semiconductor production, a key national strategic technology, tax incentives for related facility investment will be increased by up to six-fold. It will become possible to deduct up to 50% of R&D investment from taxes. ▪ Low-interest loans for facility investments by operating a special financial support programme backed by more than 1 trillion won (~£638k). ▪ The time required for a variety of licensing and approval will be shortened as much as possible, and electricity transmission lines, water and wastewater recycling facilities will be expanded so that semiconductor manufacturing plants can be built swiftly. ▪ Target over the next ten years to nurture 36,000 semiconductor specialists, and to develop core technologies with high-growth potential (e.g. next-generation power semiconductors, artificial intelligence semiconductors and state-of-the-art sensors). ▪ Proposed enactment of a special act on semiconductors to create regulatory exemptions, train talented individuals and expand support for rapid investment.

About us

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

This report was delivered through IfM Engage, the knowledge transfer arm of the Institute for Manufacturing (IfM), University of Cambridge.

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