Developing Greener Supply Chains

Industrial Strategy Council

Research Paper

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About the Industrial Strategy Council

The Industrial Strategy Council ('the Council') is an independent non-statutory advisory group established in November 2018. It is tasked with providing impartial and expert evaluation of the government's progress in delivering the aims of the Industrial Strategy. Its membership is comprised of leading men and women from business, academia, and civil society.

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Executive Summary

This paper is the first in a series which aim to evaluate the role of industrial polices in delivering a productivity enhancing, inclusive, transition to net-zero. The Industrial Strategy aims to maximise the advantages from the global shift to clean growth – through leading the world in the development, manufacture and use of low carbon technologies, systems, and services. The UK was the first major economy to commit to net-zero emissions by 2050.

Delivering net-zero emissions will require a significant economic transition and the continued focus of both government and businesses. By 2018, total emissions had fallen by 44% from 1990 levels, driven partly by industry and sharp reductions in emissions from power generation. However, progress in reducing industrial emissions stalled in 2018.

Most of the emissions produced by businesses stem from their supply chain. For UK industries, such as the manufacture of food products, supply chain emissions make up the majority of their emissions. Businesses can and must play a part in reducing emissions by integrating green supply chain management across all parts of the supply chain, selecting sustainable suppliers, and implementing new business models to extend product life cycles and reduce environmental impact.

Many business leaders have announced commitments to become carbon neutral. Setting out a strategy and practical steps to reduce supply chain emissions will be vital to achieving this.

This paper explores the business motivations for supply chain greening, the current challenges facing supply chains, recent developments in creating greener supply chains, and finally where progress has been made and what more can be done.

Some businesses are starting to recognise that the development of greener supply chains can result in commercial as well as environmental benefits. More efficient processes and resource use, along with higher retention of environmentally driven employees, increases profitability. Responding to customer demand for sustainability and safeguarding against climate-related risks can retain or expand market share and avoid reputational damage. Greater visibility and alternative suppliers across supply chains, will better equip businesses to anticipate and absorb shocks, maintain supply, and reduce price risks. Decarbonisation commitments will help drive decisions to invest in greener supply chains and may improve access to green finance. However, if the demand for vital inputs fails to keep pace with supply, shortages and high prices may hinder progress.

Supply chains face many challenges, both short-term and long-term. Covid-19 led to the temporary closure of many firms and international markets, culminating in shortages and delivery delays. In addition, decades of integration of UK businesses with the EU has contributed to complex supply chains. Changes to the UK's trading relationships could increase costs in several ways. **Climate change is forcing businesses to consider the risks that extreme weather events pose in terms of supply chain disruption, quality of inputs, and transportation.**

Technology is supporting the move towards green and resilient supply chains. Smart and autonomous systems and better data and tracking can make the supply chains more efficient and give a better picture of transparency. Specialised technologies can improve energy efficiency and reduce emissions. Improved access to product information and greater awareness of climate-related business risk, will help drive change.

Despite the positive developments and opportunities highlighted, the reality is that progress is not being made fast enough. **This paper proposes:**

- **Improved alignment of incentives and mechanisms to increase adoption.** The market is not currently delivering the incentives needed to deliver the required scale and pace of change.
- **Business leaders set ambitious plans to reduce emissions across their supply chain, with commitments and metrics published on an annual basis.** Clear actions reflected in operational plans and measured using globally accepted metrics.
- **Investment in the knowledge and skills needed to deliver greener supply chains is scaled up significantly.** Options to support this could include allowing unused apprenticeship levy funds to be passed down the supply chain to support greening and additional investment in sector skills partnerships.
- **Made Smarter technology adoption support, which is currently only available in the North West, should be scaled up to help improve SME supplier competitiveness and reduce emissions, as should the Manufacturing Made Smarter Industrial Strategy Challenge Fund from the current £147 million to boost supply chain innovation.** The British Business Bank could also more explicitly support supply chain innovation. New collaborations between governments, civil society and private sector will help accelerate supply chain greening.
- **Behavioural change across the economy needs to underpin the above, facilitated by aligned incentives which value natural capital appropriately.** In such challenging and uncertain times, business will need a compelling commercial reason to invest in the required change, and for society as a whole, change needs to be affordable.

Why Supply Chains Matter

Global temperatures are rising.[1] Climate change is causing rising sea-levels, changing weather patterns, and extreme weather events which are affecting countries and communities across the world. For businesses, climate change and associated resource scarcity increases the risk of shortages and transport disruptions and reduces the quantity and quality of inputs. Increased awareness of organisational environmental practices is leading to greater scrutiny from customers, investors, the government and environmental organisations. These factors are encouraging businesses to become more active in reducing their emissions.

Supply chains are activities required by businesses to deliver goods and services to the consumer. Most of the emissions produced by businesses stem from their supply chain activities, such as product sourcing, manufacturing, and logistics. While traditional supply chain practices considered the cost and efficiency of producing the final product, they did not consider its environmental impact. More recently, there have been increased efforts to integrate green practices into supply chain operations (See Box 1).

Businesses are recognising that developing greener supply chains can result in commercial as well as environmental benefits. These include:

- **Increased profitability**: Reduced production costs through reduced wastage and lower resource use and/ or more efficient production methods.[2] The adoption of new business models that can extend the life of a product or increase recycling, in which materials can be used to produce new products at lower cost. Becoming more environmentally conscious may allow businesses to serve new customers and expand their existing market share.[3] Some businesses will see this reflected in their share price.[4] [5]
- **Improved staff retention and worker satisfaction:** A more environmentally conscious working environment may increase employee satisfaction, leading to increased employee retention and productivity.[6]

[1] NOAA. (2019). *Global Climate Report - Annual 2019*.
[2] Mollenkopf et al. (2005) *Assessing the viability of reusable packaging: a relative cost approach*. Journal of Business Logistics.
[3] Hart (1995). *A Natural-resource-based View of the Firm*. Academy of Management Review.
[4] Wong, C. W., K.-H. Lai, K.-C. Shang, C.-S. Lu, and T. Leung. (2012). *Green Operations and the Moderating Role of Environmental Management Capability of Suppliers on Manufacturing Firm Performance.* International Journal of Production Economics.
[5] Golicic, S. L., and C. D. Smith. (2013). *A Meta-analysis of Environmentally Sustainable Supply Chain Management Practices and Firm Performance*. Journal of Supply Chain Management.
[6] Delmas, Magali & Pekovic, Sanja. (2013). *Environmental Standards and Labor Productivity: Understanding the Mechanisms that Sustain Sustainability*. Journal of Organizational Behavior.

Box 1: Green Supply Chain Management (GSCM)

Green Supply Chain Management (GSCM) involves integrating green practices into the supply chain, including:

- **Purchasing:** implementing green procurement strategies to purchase raw and natural materials from sustainable sources. This includes circular models such as reuse, recycling, and remanufacturing,[7] [8] as well as reducing waste and use of hazardous substances.[9]
- **Product design:** using the life cycle approach to analyse where emissions and other environmental impacts are produced throughout the product's life, from extraction, production, transportation, distribution, use, re-manufacture, recycle, and disposal.[10] [11] In addition, it involves designing products to last longer by incorporating robust and recyclable materials.
- **Marketing**: promoting products or services based on environmental credentials.
- **Packaging and operations:** reducing the number of materials and energy embedded in packaging. Designing more space efficient packaging for storage and transportation and considering how inputs and final goods are transported.[12] [13] Also can involve additional mitigation strategies, such as shifting from goods to services.
- **Production**: conservation of natural resources, such as water and mineral use, as well as resources, such as energy, in production.[14] [15]
- **Reduced waste**: enabling materials and products to be used again (resource recovery) in some form within the production process.[16] [17]

[7] Varnäs, A., Balfors, B. and Faith-Ell, C. (2009). *Environmental consideration in procurement of construction contracts: current practice, problems, and opportunities in green procurement in the Swedish construction industry.* Journal of Cleaner Production.
[8] Amemba, C.S., Nyaboke, P.G., Osoro, A. and Mburu, N. (2013). *Elements of green supply chain management*. European Journal of Business and Management.
[9] S. Liang and W. Chang. (2010). *An Empirical Study on Relationship between Green Supply Chain Management and SME Performance in China.* International Conference on Management Science and Engineering.
[10] Hagelaar, G.J. and van der Vorst, J.G. (2001). *Environmental supply chain management: using life cyce assessment to structure supply chains.* The International Food and Agribusiness Management Review.
[11] Gungor, A. and Gupta, S.M. (1999). Issues in environmentally conscious manufacturing and product recovery: a survey. Computers & Industrial Engineering.
[12] Carter, C.R. and Rogers, D.S. (2008). *A framework of sustainable supply chain management: moving toward new theory.* International Journal of Physical Distribution and Logistics Management.
[13] Zailani, S., Jeyaraman, K., Vengadasan, G. and Premkumar, R. (2012). *Sustainable supply chain management (SSCM) in Malaysia: a survey.* International Journal of Production Economics.
[14] Halldórsson, Á. and Kovács, G. (2010). *The sustainable agenda and energy efficiency: logistics solutions and supply chains in times of climate change*. International Journal of Physical Distribution & Logistics Management.
[15] Despeisse, M., Ball, P.D., Evans, S. and Levers, A. (2012). *Industrial ecology at factory level – a conceptual model.* Journal of Cleaner Production.
[16] Carter, C.R. and Rogers, D.S. (2008). *Op cit.*
[17] Amemba, C.S. et al. (2013). *Op cit.*

- **Protection against reputational damage**: As supply chains become increasingly transparent, businesses that implement a green supply chain strategy can avoid reputational damage and loss of environmentally minded customers to more sustainable competitors.[18] [19]

- **Continuity of supply**: Businesses with transparent, green supply chains will be better able to absorb and overcome shocks, maintain production, and adapt to shifting consumer demands. In addition, those with a range of suppliers will be less exposed to shortages and therefore price risks, which could impact profitability.[20]

- **Informed investment decisions:** Businesses that implement green supply chain management will be best placed to understand which aspects of their supply chain contribute most to emissions and implement strategies to reduce them. Maintaining or increasing market share, securing green investors, or reducing the impact of carbon pricing in future, are all potential investment benefits.

What do we know about supply chain emissions?

To achieve net-zero emissions by 2050 and realise the commercial as well as environmental benefits, businesses must take urgent action to reduce their carbon emissions. By 2018, total emissions had fallen by 44% from 1990 levels. The reduction in industrial emissions has been largely driven by improvements in energy intensity, where efficiency improvements and fuel switching have played a part in reducing energy consumption. In addition, the changing composition of the UK economy, away from manufacturing and towards services, including the off-shoring of economic activity, has also contributed to the reduction in energy consumption. While progress has been made in reducing industrial emissions since 1990, progress has now stalled.[21]

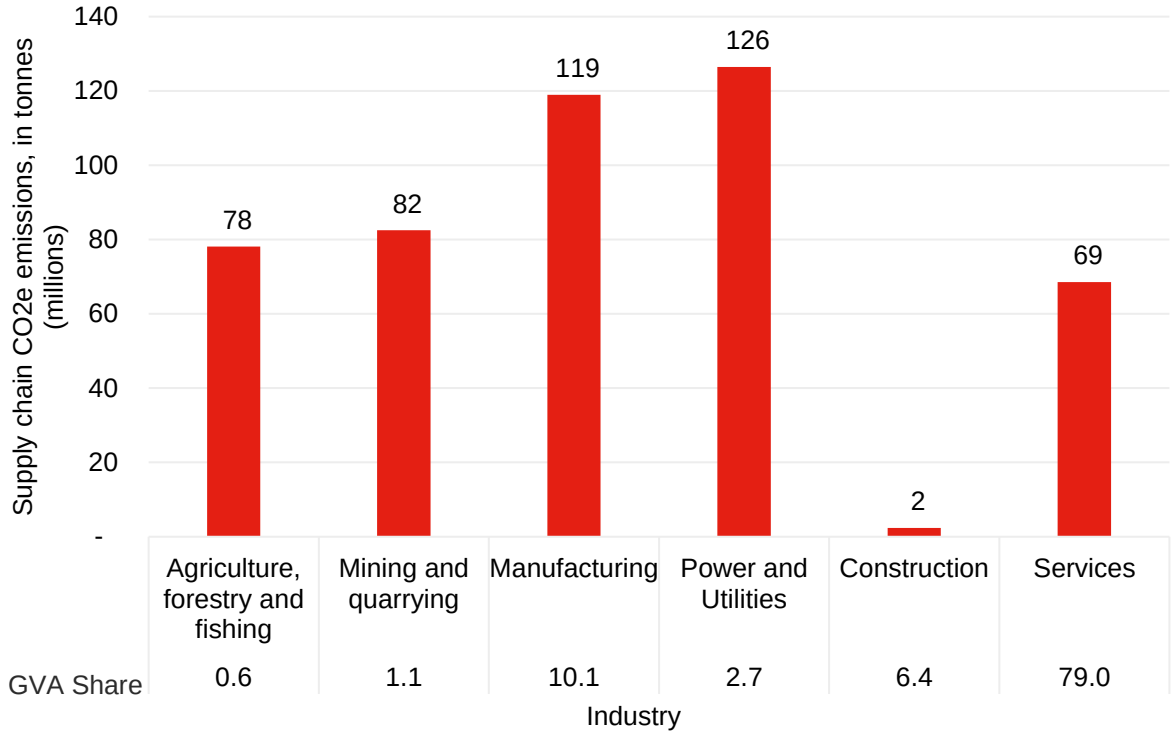
Many goods and services produced by industries feed into other industries in the economy, either as final or intermediate goods. Because of this, businesses need to be aware of the emissions generated by the goods and services they purchase from other industries within their supply chains. This is where the greatest environmental impact takes place.

Figure 1 shows an estimate of supply chain emissions by industry.[22] Supply chain emissions are emissions produced from electricity purchased and used, as well as emissions from the goods and services purchased from organisations they do not

[18] Ellen, P.S., Webb, D.J., Mohr, L.A., (2006). *Building corporate associations: consumer attributions for corporate social responsibility programs*. Journal of the Academy of Marketing Science.
[19] Wu,Y., H. Li, Q. Gou, and J. Gu. (2017). *Supply Chain Models with Corporate Social Responsibility*. International Journal of Production.
[20] The Guardian. (2013). *Why sustainable supply chains make business sense.*
[21] CCC. (2020). *Reducing UK emissions: progress report to parliament*.
[22] Data is provided to us by Professor John Barrett at the University of Leeds.

own or control. The power and utilities industry produces the largest amount of supply chain emissions, followed by manufacturing and services.

Figure 1: Supply chain emissions and GVA by UK industry, 2018

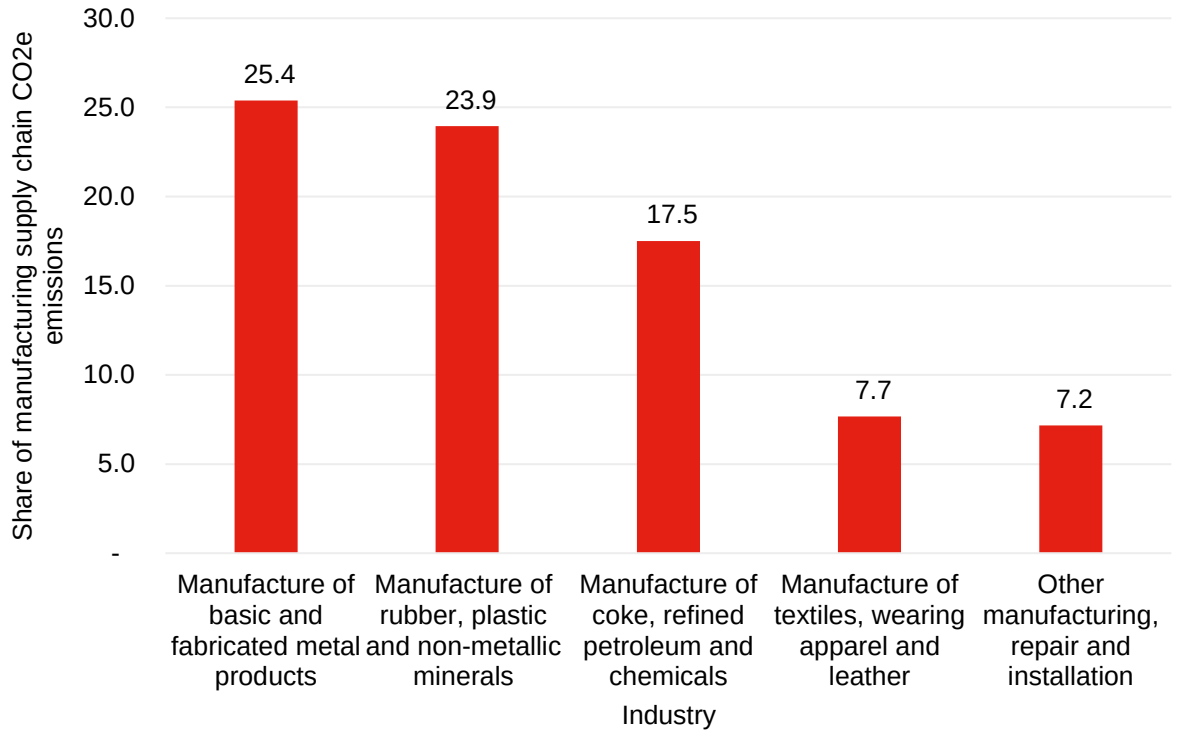


Source: University of Leeds / ISC calculations

Notes: Supply chain emissions are generated from the use and purchase of electricity, heat, or steam from a utility provider, and from the activities not owned or controlled by the reporting organisation but by organisations they purchase goods and services from. Supply chain emissions estimates are emissions generated from the UK and outside-UK supply chains, including emissions generated from the consumption of products from the same industry outside of the UK. Estimates are based on consumption emissions. Consumption emissions equal production-based emissions minus the emissions from the production of exports, plus the emissions from the production of imports. Emissions include the following greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6).

Within the manufacturing industry, the combined supply chain emissions from the manufacture of basic and fabricated metal products and, rubber, plastic, and non-metallic products accounted for 50% of total supply chain emissions (see Figure 2). Most of the indirect emissions from these two industries stem from emissions generated in other manufacturing industries, as well as the cultivation and extraction of raw materials both within and outside the UK.

Figure 2: Share of manufacturing supply chain emissions by selected UK manufacturing industries, 2018



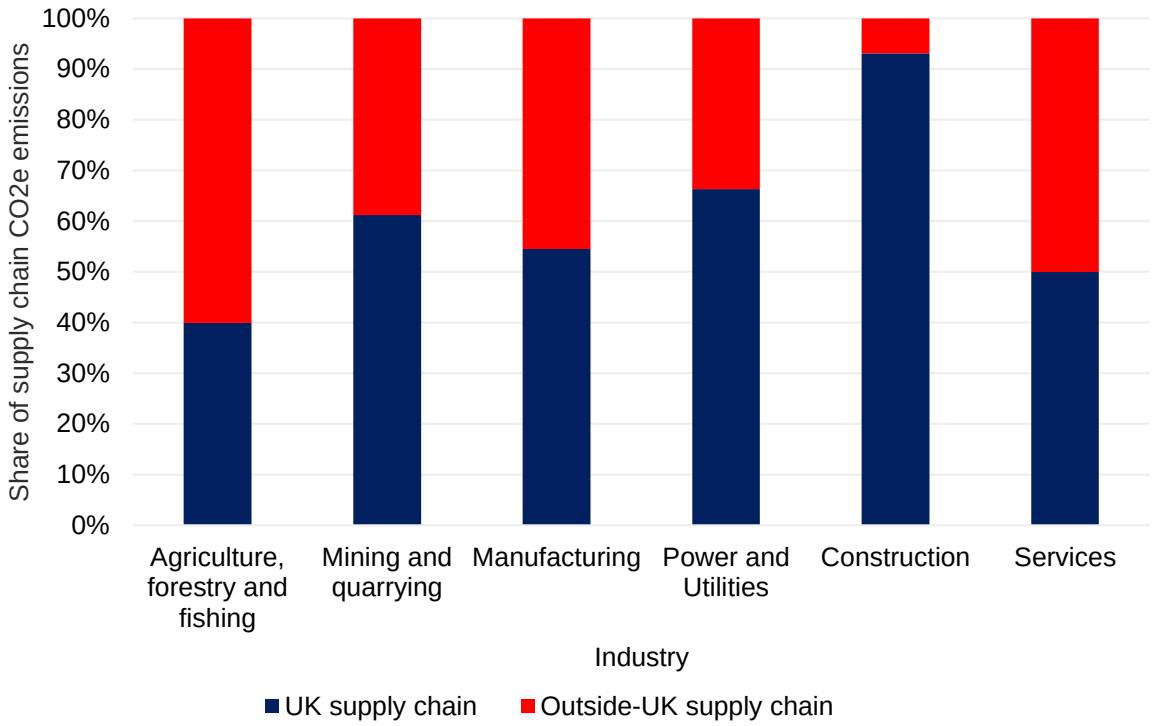
Source: University of Leeds / ISC calculations

Notes: Supply chain emissions are generated from the use and purchase of electricity, heat, or steam from a utility provider, and from the activities not owned or controlled by the reporting organisation but by organisations they purchase goods and services from. Supply chain emissions estimates are emissions generated from the UK and outside-UK supply chains, including emissions generated from the consumption of products from the same industry outside of the UK. Estimates are based on consumption emissions. Consumption emissions equal production-based emissions minus the emissions from the production of exports, plus the emissions from the production of imports. Emissions include the following greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6).

55% of all UK supply chain emissions originate from UK-based supply chains. However, there is significant variation between industry; for example, most indirect emissions from the agricultural industry comes from international-based supply chains, while for construction, they mostly stem from UK-based supply chains.

Over 90% of supply chain emissions from the manufacture of textiles, apparel, and leather originate from international-based supply chains, whereas only 3% of supply chain emissions from the manufacture of pharmaceuticals are produced internationally.

Figure 3: Share of supply chain emissions from the UK and outside-UK by industry, 2018



Source: University of Leeds/ ISC calculations

Notes: Supply chain emissions are generated from the use and purchase of electricity, heat, or steam from a utility provider, and from the activities not owned or controlled by the reporting organisation but by organisations within its supply chain. Outside-UK supply chain emissions estimates include emissions generated from the consumption of products from the same industry outside of the UK. Estimates are based on consumption emissions. Consumption emissions equal production-based emissions minus the emissions from the production of exports, plus the emissions from the production of imports. Emissions include the following greenhouse gases: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6).

How climate change can impact supply chains

Many businesses will be left vulnerable to climate change, some more than others. When managers were asked which of their supply chain functions would be most impacted by climate change, responses indicated that the supply and delivery of goods would be most impacted (see Figure 4). This is most likely due to concerns over extreme weather events impacting the quantity and quality of inputs and causing disruption to existing transport routes.

Figure 4: Responses for most impacted supply chain functions due to climate change

Source: Er-Kara, M., Ghadge, A. and Bititci U.S. (2020)[23]

The Climate Change Risk Assessment (CCRA2) published in 2017 (a five-yearly requirement under the Climate Change Act 2008), highlights the climate risks posed to businesses, including their supply chains. Adapting to climate change is expected to increase the demand for some products and services and reduce demand for others. This appears to be particularly relevant for adaptation-related goods and services within the following sectors: engineering and consulting, agriculture and food, tourism, insurance, and other finance products. Resilient infrastructure, in particular ICT, power, fuel supply, transport and water, is also crucial in enabling businesses to minimise disruptions to their operations from climate change risks. [24]

[23] Er-Kara, M., Ghadge, A., and Bititci U.S. (2020). *Modelling the impact of climate change risk on supply chain performance*. International journal of Production Research.
[24] UK.GOV. (2017) *Climate Change Risk Assessment*

Challenges Facing Supply Chains

Achieving net-zero emissions imposes many challenges to businesses across the economy. The need to understand where emissions are being generated, obtain information about the sustainability practices of suppliers, and monitor progress towards environmental targets, will all incur costs. Businesses may also be subject to increased government regulation, which may include carbon taxes or disclosure requirements around emissions and plans to reduce them.

In addition to identifying which aspects of their supply chain contribute most to overall emissions, businesses will need to assess how extreme weather conditions which are the consequences of such emissions, might disrupt the supply and price of vital inputs to their supply chain.

UK businesses were already grappling with the supply chain implications of a new trading relationship with the EU when the Covid-19 crisis exposed further supply chain vulnerabilities. What follows is a more detailed discussion of some of the challenges facing businesses in developing greener, and more resilient, supply chains.

Climate Change and Extreme Weather

Climate change is forcing many businesses to consider the potential risk of extreme weather events and the ripple effects across their supply chains. Global warming is increasing the likelihood and intensity of climate-related events such as storms, floods, heatwaves, droughts, water scarcity, and land degradation.[25]

Extreme weather events can disrupt local and global supply chains by damaging critical infrastructure, such as roads and bridges. The temporary closure of ports and shipping routes, or impaired operations at airports, all have the potential to cause major disruption to supply chains.[26] If such events become more frequent, or the risks are deemed too high in terms of delayed production costs, businesses will need to consider how to make their supply chains more resilient.

Other critical infrastructure, such as energy generation, may also be impacted by extreme weather events, contributing to production delays and potential exposure to volatile energy costs.[27] Natural resource production could be severely affected, with

[25] IPCC. (2018). *Changes in Climate Extremes and their Impacts on the Natural Physical Environment.*
[26] OECD. (2017). *International trade consequences of climate change*.
[27] IAEA. (2019). *Adapting the energy sector to climate change*.

output variations also resulting in greater price volatility, and shortages delaying production and increasing costs.

The UK Climate Change Risk Assessment provides further details on some of the climate change risks facing the UK, outlined in Figure 5.[28] [29]

Figure 5: Climate change risks for the UK

Flooding and Coastal changes

Climate change will increase the risk of flooding and accelerate coastal changes, such as erosion, impacting businesses and communities. The increased risk of flooding may lead to a permeant loss of business locations, impacting industries clustered around coastlines, such as transport services and tourism. Damaged caused by flooding is expected to cost the UK over £1 billion by the 2050s.

Higher temperatures impacting health, well-being, and productivity

Higher temperatures will increase risks to health and well-being, as well as reduce productivity. Increase threat of heatwaves may increase the number of people dying from climate change, as well as reduce labour productivity.

Water shortages

Water shortages will impact agriculture, energy generation, and industry. UK industries such as chemicals and chemical products, basic metals, food, and beverages are at higher risk of water scarcity, which may impair business operations and reduce quality of inputs.

Reduction in natural capital

Increased risk to natural capital, including clean water, carbon storage, and cultural benefits. The change in temperature and rainfall may increase soil aridity and wildfire risks. In addition, changes to the shift from cold to warm water plankton species could have implications for the entire marine food chain.

Supply chains

Impact domestic and international supply chains. These impacts can be short-term, such as impaired business operations, as well as long-term, such as damage to brand reputation and increased regulatory scrutiny. UK Industries such as food, clothes, and electronic equipment are at higher risk from supply chain disruptions, compared to other industries.

Source: ASC synthesis of the main areas of risk and opportunity within the chapters of the Evidence Report.

Adapted from: CCC UK Climate Change Risk Assessment 2017 Synthesis report.

[28] CCC. (2017). *UK Climate Change Risk Assessment 2017 Synthesis report: priorities for the next five years.*
[29] GOV.UK. (2017). *UK Climate Change Risk Assessment 2017.*

Resource Scarcity

Pressure on raw and natural materials is expected to increase, driven by population growth and urbanisation, requiring changing lifestyles and habits.[30] In addition, climate change is reducing the number and the quality of resources available in certain geographical locations.

Some resources are already seen as either globally or locally scarce, such as water, oil, and minerals.[31] The scarcity of water is contributing to regions becoming more water-stressed over time. In the absence of more water-efficient production methods, businesses will find it increasingly difficult to source inputs such as agricultural products, and water shortages may affect their own production processes. Businesses may be forced to use lower quality resources or seek out substitutes, adapting their production processes or final products accordingly.[32]

The transition to net-zero will increase demand for rare elements needed to produce renewable energy and clean, efficient technologies. The demand for electric batteries has driven up the price of raw materials such as cobalt and lithium.[33] If raw minerals become prohibitively expensive due to their limited supply, this could impede the development of clean tech businesses and result in supply chains greening at a slower pace.

Exiting the EU

Decades of integration between UK and EU businesses have created complex supply chains and a network of subsidiaries across the EU. Consequently, changes to the previous trading relationship between the UK and EU will cause supply chain disruptions in the form of higher input costs, higher costs associated with regulatory compliance and administration, and potential delays resulting from customs checks. Regulatory divergence from EU standards is likely to lead to increased costs and delays. For example, regulatory divergence in auto manufacturing, which exports around 56% of its output to the EU, will necessitate compliance checks at the border.

On the 30th December 2020, the EU and UK signed the Trade and Cooperation Agreement (TCA), which will allow the movement of goods between the UK and EU to be free from tariffs or quotas. It will also include provisions to support trade in

[30] Satterthwaite, D. (2011). *How urban societies can adapt to resource.* Philosophical transactions of the Royal Society a mathematical, physical, and engineering sciences.
[31] Bell, J.E., Autry, C.W., Mollenkopf, D.A., and Thornton, L.M. (2012). *A natural resource scarcity typology: theoretical foundations and strategic implications for supply chain management.* Journal of Business Logistics.
[32] Duclos, S. J., J. P. Otto., and G. K. Konitzer. (2010). *Design in an era of constrained resources. Mechanical engineering magazine.* Mechanical Engineering.
[33] Azevedom, M., Campagnol, N., Hagenbruch, T., Hoffman., Lala, A., and Ramsbottom, O. (2018). *Lithium and cobalt: A tale of two commodities.* Mckinsey & Co.

services (including financial services and legal services), support the mobility of UK professionals to continue doing business across the EU, and end the EU State Aid regime. A summary of the agreement can be found here. This paper does not attempt to set out the full impact of the agreement on UK supply chains but the agreement will still have some impact on supply chains relative to previous arrangements.

Geopolitics and Protectionism

Since the 2008 financial crisis and recession that followed, trade liberalisation has halted and protectionist policies have re-emerged, with trade wars between countries becoming more common. The share of world trade facing some sort of trade distortion has increased from around a third to over two-thirds over the past decade.[34] These trade distortions can have significant implications for supply chains.

During the Covid-19 crisis, many countries implemented protectionist policies in the face of severe shortages, which saw medical equipment and medicine exports halt, and in some cases, deliveries diverted to other countries.[35] In addition, social distancing measures led to the temporary closure of many firms and overseas markets, limited the availability of vital inputs and caused some industries, such as automotive, to shut down operations.[36] It is currently very uncertain how long-lasting some of the adverse effects will be.

Consumer Preferences

More informed consumers are aware of their environmental footprint and are choosing to purchase more sustainable products. 43% of consumers are choosing brands because of their environmental values, with 34% choosing brands based on their ethical credentials.[37] [38] Increased public disclosures from businesses coupled with more accessible information, are helping consumers to make more informed decisions on what they purchase and from whom.[39]

[34] Baldwin, R. and Evenett, S. (2020). *COVID-19 and Trade Policy: Why Turning Inward Won't Work*. CEPR Press.
[35] Financial Times. (2020). *Covid-19 is bringing out protectionist instincts*.
[36] ECLAC. (2020). The effects of the coronavirus disease (COVID-19) pandemic on international trade and logistics.
[37] Deloitte. (2020). *Shifting sands: How consumer behaviour is embracing sustainability.*
[38] According to the Gfk Consumer Life Survey 2019, while concerns regarding sustainability has jumped ten places in consumer value rankings between 2018 and 2019, other values are more important to consumers, such as 'having fun', 'excitement', and 'thrift'.
[39] Purchasing is a complex issue, where increased information does not necessarily lead to change. According to a survey published by BBMG, GlobeScan, and SustainAbility, two-thirds of consumers want to consume less and consume more sustainably, and yet most fail to act on this expressed preference. A summary can be found here.

Box 2: Examples of product information initiatives for consumers

- **Eco-labelling** informs consumers that products and services meet high environmental standards across the lifecycle. This encourages manufacturers to reduce waste and emissions during the production process, as well as develop products which are durable, easy to repair and recycle.[40] Examples are:
  - Food labels, such as LEAF Marque and Marine Stewardship Council.
  - Energy labels, such as Energy Saving Recommended and Energy Star
  - Product-specific labels, such as Volatile Organic Compounds (VOCs).[41]
  - Sustainability accreditation and membership, such as Bluesign.[42]
- **Smartphone apps** help inform more 'environmentally' conscious consumers about whether products come from a sustainable source. For example, Giki allows consumers to scan the barcode of products, providing them with information such as whether the product has high animal welfare standards or a low carbon footprint.[43]
- **The EU Farm to Fork strategy** is about transitioning to a more sustainable food system.[44] This includes a proposal for sustainable food labelling framework integrating nutrition, climate, environmental, and social aspects.[45]

Businesses that fail to respond to growing consumer demand for sustainable products may face a loss of market share, reputational damage, and weakening stock market performance. Businesses need to both encourage and meet the demand for sustainable consumption. This includes embracing reuse, repair, and remanufacture to extend product life, supporting consumer campaigns to promote reusable alternatives and appropriate disposal at end of use. [46] A more extensive list of what businesses can do can be found here.

Over 90% of UK consumers are still meat eaters, but our dietary habits are changing.[47] Figures vary, but there has been some reduction in meat consumption in UK diets, particularly red and processed meat.[48] There is a greater willingness to consider eating less meat and a growing awareness of the health and environmental

[40] European Commission. *EU eco-label*.
[41] Defra. (n.d.) *A shopper's guide to green labels understanding environmental labels on products*.
[42] Bluesign.
[43] Giki. Giki.
[44] European Commission. *Farm to fork strategy – for a fair, healthy and environmentally-friendly food system*.
[45] European Commission. *Questions and answers: farm to fork strategy - building a healthy and fully sustainable food system*.
[46] UK GOV. *Resources and waste strategy for England.*
[47] IGD. (2020). *Appetite for Change*.
[48] Public Health England. (2019). *National Diet and Nutrition Survey*

benefits of doing so. In 2019, 65% of consumers tried meat-free foods, up from 50% in 2017.[49]

Producers and suppliers will need to monitor and anticipate trends better if they are to minimise supply chain disruption and respond with agility.

Food safety concerns such as animal disease, food contamination, the use of anti-biotic and growth hormones in animals, and genetically modified crops, have also led retailers to take a more careful look at their supply chain. The long and complex nature of some supply chains has made it difficult for businesses to track the inputs that are being used in their products. The 2013 horse meat scandal in the UK highlighted a weakness in UK supply chains. The loss of confidence in the food industry was still felt six months after the scandal, with just under half of survey respondents having trust in the food industry to provide safe food, and just under 40% undecided.[50] [51]

Stakeholder Pressure

While some businesses are moving towards greener supply chains on their own (see Box 3 for some examples), stakeholders can play an important role in developing and encouraging sustainable practices. Businesses are facing increased pressure to align their corporate objectives with sustainability targets and develop new goods and services to meet the growing demand for more sustainable products.

Financial institutions are increasingly focused on the Environmental, Sustainable, and Governance (ESG) credentials of their portfolio, as investors factor environmental concerns into their investment decisions. For example, Barclay's shareholders voted to phase out the financing of fossil fuel and utility companies that are not aligned with the Paris climate goals.[52] In addition, the UK government has announced the end of financial support for new crude oil, natural gas, or thermal coal projects.[53] As a result, carbon-intensive businesses may find it increasingly difficult to access the capital they need. Such firms could be left with stranded assets, which will impact suppliers and communities closely connected with these industries and sectors. [54] [55]

[49] Mintel. (2020). *Plant-based push: uk sales of meat-free foods shoot up 40% between 2014-19.*
[50] Which. (2013). *Horsemeat scandal dents consumer confidence in food industry*.
[51] Mintel. (2013). *Just half of brits trust the food industry to provide safe food to eat.*
[52] Independent. (2020). *Shareholders call on Barclays to end fossil fuel investment in landmark climate crisis resolution.*
[53] UK GOV. (2020). *PM announces the UK will end support for fossil fuel sector overseas.*
[54] Investments that are no longer able to make an economic return.
[55] Robins, N., Tickell, S., Irwin, William., and Sudmant, A. (2020). *Financing climate action with positive social impact. How banking can support a just transition in the UK*. LSE: Grantham Research Institute on Climate Change and the Environment.

Businesses will also be challenged by their competitors if they fail to adopt sustainability practices or adapt to changing consumer preferences.[56] As more companies act, pressure for other companies to do the same will increase.

Non-government organisations are also influencing the development of greener supply chains. Many private and public organizations have been introducing environmental regulations and standards to promote green practices. Organisations such as Greenpeace have been critical of the green practices of large multinational businesses. This led to their "Slaughtering the Amazon" campaign which successfully forced Nike to stop the using leather from cattle raised in the Amazon, which is the one of the largest drivers of deforestation in the world.[57]

Box 3: West Africa Cocoa supply chains and deforestation

The increasing demand for cocoa, combined with increased risks to supply from climate change and other factors, may continue to increase the disparity between the demand and the supply of cocoa.

Around 60% of all cocoa originate in Côte d'Ivoire and Ghana, where climate change is expected to negatively impact the conditions in which cacao trees thrive.[58] [59] Some cocoa-producing regions, such as Lagunes and Sud-Come in Côte d'Ivoire, are expected to become unsuitable for cocoa production in the next 30 years.[60]

The production of cocoa in Côte d'Ivoire and Ghana is contributing to climate change. Historically, cocoa production has been a major contributor to deforestation, and has contributed, along with other agricultural production, to the loss of 17 and 13 % of their forest cover, respectively, from 2001 to 2017.[61]

Businesses are working with the government of Ghana and Côte d'Ivoire, and international non-profit organizations, to produce more sustainable supply chains.

- **Mars** has committed to support farmers with planting materials, fertilizers, and best-practice training. In addition, they have also committed to forest preservation and to achieve a deforestation-free cocoa supply chain by 2025.[62]
- **Barry Callebaut** will increase the transparency and traceability of its cocoa supply chain by publicly sharing information about the location of

[56] Hart (1995). *Op cit.*
[57] Brindis, D. (2009). *Slaughtering the Amazon*.
[58] International Cocoa Organization. (2020). *Statistics.*
[59] ENGAGE the CHAIN. (n.d.) *Cocoa.*
[60] Läderach, P., Martinez-Valle, A., Schroth, G. et al. (2013). *Predicting the future climatic suitability for cocoa farming of the world's leading producer countries, Ghana and Côte d'Ivoire*. Climatic Change.
[61] World Coca Foundation. (2018). *Is the End of Cocoa-Related Deforestation Within Reach?*
[62] MARS. (2020). *Progress Toward a Deforestation-Free Cocoa Supply Chain*.

cooperatives and buying stations. This will include suppliers in Côte d'Ivoire and Ghana.[63]

- **Nestlé** has developed the Nestlé Cocoa Plan, which will aim to empower women, eliminate child labor, and address deforestation issues in the cocoa supply chain. Nestlé has committed to sourcing all cocoa through this plan by 2025.[64]

Government Requirements

The scale and urgency of the net-zero target will require government regulations and incentives to encourage businesses to reduce greenhouse gas emissions and other environmental impacts more rapidly.

'Greening Government Commitments' (GGCs) sets out the actions required for government departments and their agencies to reduce the environmental impact from their own estates and operations. This includes commitments to purchase more sustainable and efficient products and services, requiring government suppliers to become greener.[65]

Environmental policies and innovation policies are encouraging the development and adoption of affordable renewable energy to tackle carbon-intensive manufacturing. For example, under the Non-Domestic Renewable Heat Incentive (RHI), the Government provides financial incentives to businesses that install renewable heat technologies, such as biomass boilers and combined heat and power (CHP) systems.[66] In addition, the Industrial Strategy Offshore Wind Sector Deal, will expand support for the sector to increase renewable energy generation – decarbonising energy usage across supply chains.[67]

The 25-year Environment Plan sets out how the government plans to maintain and enhance the natural environment. This includes using resources more efficiently and from sustainable sources, reducing food supply chain emissions and waste, as well as zero-deforestation supply chains.[68]

As necessary environmental regulations are likely to impose additional costs to business, at least in the short-run, this could impact profitability. It is estimated that the implementation of carbon taxes could increase prices for the whole economy by 0.9%.[69] However, the extent to which these costs are passed down the supply chain

[63] Barry Callebaut. (2020). *Our progress towards ending deforestation and restoring forests in Côte d'Ivoire and Ghana.*
[64] Nestlé. (2020). *Cocoa.*
[65] UK GOV. (2020). *Greening Government Commitments Annual Report April 2018 to March 2019*
[66] UK GOV. (2020). *The Non-Domestic Renewable Heat Incentive: Ensuring a sustainable scheme*
[67] UK.GOV. (2020). *Policy paper: Offshore wind sector deal.*
[68] UK.GOV. (2019). *25 Year Environment Plan*
[69] Grover, D., Shreedhar, G., and Zenghelis, D. (2016). *The competitiveness impact of a UK carbon price: what do the data say?* Centre for Climate Change Economics and Policy and Grantham Research Institute on Climate Change and the Environment.

and onto customers will be dependent on how productive and open to competition these industries are, how quickly they are able to invest in affordable clean technologies and processes to reduce their emissions, and on differences in carbon pricing across geographical locations.

As carbon taxes are expected to increase in line with environmental targets over time, this will impose further costs on carbon-intensive industries and may increase the range of industries required to pay the carbon tax. The recent announcement of the Energy White Paper sets out the government's plan to cut emissions from industry, transport, and buildings over the next decade. This includes the implementation of a net-zero carbon cap and trade market, aligning the cap with an appropriate net-zero trajectory.[70]

Environmental regulations, such as disclosure requirements, could impose substantial policy and administrative costs on firms. It is estimated that the direct cost of DEFRA environmental regulations on business is around £6 billion.[71] For example, under new government plans, large UK businesses will be expected to show their products are sourced from regions free of illegal deforestation.[72] Businesses will need to carry out due diligence to ensure they have sourced their products according to relevant local laws. This will include evaluating new and existing suppliers, as well as changing transport requirements, which could increase compliance costs and result in fines for those who do not comply.[73]

[70] HM Government. (2020). *Energy White Paper: Power our net-zero future.*
[71] Defra. (2015). *Emerging Findings from Defra's Regulation Assessment.*
[72] GOV.UK. (2020). *Forests: reducing deforestation in UK supply chains.*
[73] Defra. (2020). *Due diligence on forest risk commodities.*

Recent Developments in Greening Supply Chains

To reduce the impact of climate change and meet environmental regulations and standards, businesses must reduce their emissions by making Green Supply Chain Management (GSCM) integral to their business, adopting existing and emerging technologies as well as new business models.

Technologies and data analytics are helping businesses to track their products across the supply chain, providing them with information in near-real time. This allows businesses to monitor and map out their supply chain, optimising each part to reduce their environmental impact. This includes sourcing from sustainable producers, optimising transportation routes, and increasing recycling rates.

Other technologies such as Carbon Capture, Usage, and Storage (CCUS), are helping carbon-intensive industries to transition to low carbon and providing the necessary raw materials needed to expand it. Bioplastics are also helping to reduce the environmental impact of packaging while improvements in existing technologies, such as additive manufacturing, may encourage supply chains to be shorter and closer to consumption.

New business models are also emerging as a result of changing consumer habits and businesses commitments to reduce their carbon footprint. This is helping to extend product life as well as increase the rates of recycling at end-of-life.

Technology

The use of smart technologies in machines and processes, is allowing information to be generated and analysed, improving supply chain capabilities, and allowing businesses to better forecast demand and manage inventory, reducing excess storage or wastage. Cloud computing is supporting information sharing and storage, increasing collaboration and competition between suppliers, resulting in improved sustainability and quality. In combination with these technologies, data analytics, artificial intelligence, and machine learning are facilitating improved product design to reduce material use, increasing efficiency and reliability of machinery, as well as integrating environmental considerations into transportation decisions.

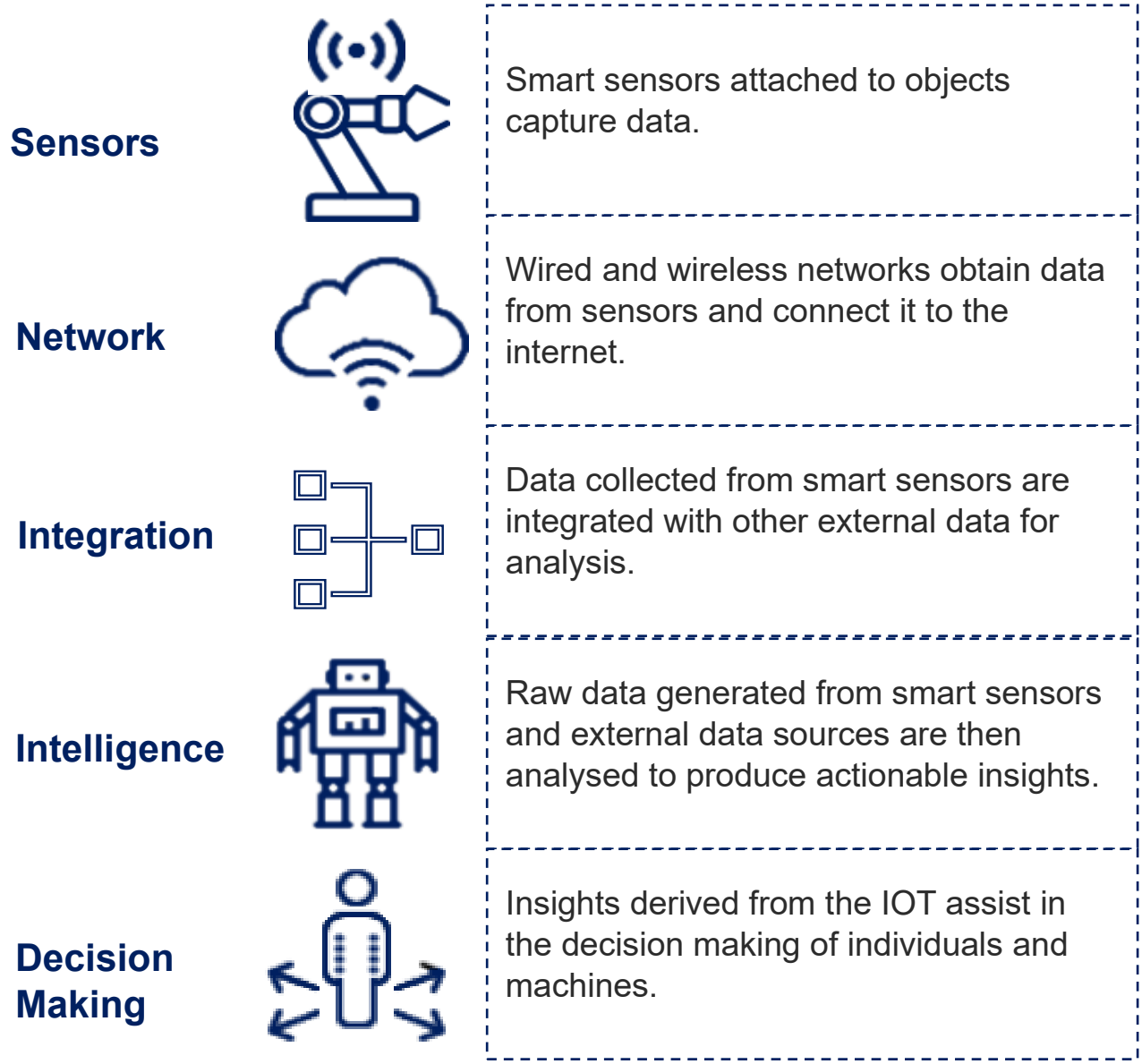
Other technologies can help support the greening of supply chains. Additive manufacturing can bring production lines nearer to the point of consumption, thereby reducing emissions generated from transportation and shipping. Carbon Capture, Usage and Storage (CCUS) can be used to remove emissions from the atmosphere,

as well as embed emissions in products produced by carbon-intensive industries, such as concrete. The use of bio-degradable plastics can reduce the environmental impact of synthetic plastics by reducing lifetime emissions and toxic pollutants which linger in the environment.

Internet of Things and Smart Systems

The “Internet of things” (IoT) refers to the connecting of devices to enable data collection and data sharing over the internet.[74]

Figure 6: Internet of Things (IOT)



[74] IBM. (2016). *What is the Internet of Things (IoT)?*

Source: Adapted from Deloitte (2017). Continuous interconnected supply chain: Using blockchain & internet-of-things in supply chain traceability.[75]

When applied to supply chains, the IoT can help businesses source more sustainable products. Information collected and exchanged from **sensors**, can explain how the product was made, from where inputs are sourced, how they were manufactured, and how they are consumed. In addition, these sensors can store and provide information to consumers about how these products should be disposed. **Cloud computing** enables the storage of large amounts of information with access shared between the business and suppliers. This can encourage collaboration and greater transparency through the sharing of information. The integration of **data analytics, artificial intelligence, and machine learning** helps inform decisions over more sustainable materials and efficient production processes, and the optimisation of transportation and shipping to reduce environmental impact.

Sensors

A **Radio-frequency identification (RFID)** is a tag that transmits and receives information. It can be used to identify and track physical objects in real-time through the supply chain and the product life cycle, from sourcing to disposal. It can also provide information to consumers on how products can be disposed or recycled at end-of-life. By providing real-time data on sales, RFID chips can help anticipate demand for inputs and reduce the need to keep large quantities of additional inventory.[76] For example, the implementation of RFID in the retail industry can reduce inventory stock by 10 to 15% on average.[77]

Near-Field Communication Technology (NFC) is a short-range wireless technology that can transfer information between other NFC-enabled devices. This can be especially helpful in the food production industry, where changes in government regulations and standards, can be traced across the supply chain to see if they are being met. NFC is more widely diffused across smart devices, such as smart phones and laptops, compared to RFID. This allows consumers and businesses to assess sustainability.[78] For example, Diego, a multinational alcohol beverage manufacturer, uses NFC technology to track their bottles across the supply chain, in-store, and at the point of consumption.[79]

[75] Deloitte. (2017). *Continuous interconnected supply chain: Using blockchain & internet-of-things in supply chain traceability.*
[76] Denuwara, N., Maijala, J., and Hakovirta, M. (2019). *Sustainability Benefits of RFID Technology in the Apparel Industry*. MDPI.
[77] Goodson, J. (2019). *Sustainability in Fashion Retail*. DETEGO.
[78] Pigini, D. (2017). *NFC-Based Traceability in the Food Chain*. MDPI.
[79] DIAGEO. (2015). *Our new connected 'Smart Bottle' unveiled in Barcelona*.

Cloud computing

Cloud computing is the delivery of computing services such as storage, software, and analytics, over the internet.[80] Cloud computing is essential to the IoT, as it allows large volumes of data generated by smart systems to be stored, shared, and analysed, enabling more effective and timely decision-making.[81] Cloud computing reduces the need to have data stored on-site. Data centres are large consumers of energy and this is expected to increase from around 2% of total energy consumption to around 8% by 2030.[82] As businesses are expected to make greater use of the IoT, cloud computing will help to reduce emissions generated from the storing of data. Google has achieved 100% energy efficiency in 2017, with all new data centres expected to run off renewable energy.[83]

Cloud computing can increase collaboration between businesses and suppliers. For example, the combination of big data, cloud computing and artificial intelligence (AI), can be used to gather, store, and analyse information on the entire process of cattle raising. Information about the cattle, such as age and diet are uploaded to the cloud, and AI can be used to provide each supplier with a score according to supplier selection criteria, such as meat quality and carbon footprint.[84]

Data Analytics, Artificial Intelligence (AI), and Machine Learning (ML)

AI is being used to support product design by processing large amounts of information on the relationships between various elements and processes, and to improve existing materials and develop new ones.[85] AI can reduce the need to run multiple tests in the "real" environment, saving time, resources, and energy, previously devoted to the development of prototypes. Toyota, the Japanese car manufacturer, is using AI to develop advanced materials for its next generation battery.[86]

ML presents many opportunities for businesses to drive and accelerate new scientific discoveries. DeepMind, a UK-based AI company, recently announced that it can predict how proteins fold. This has the potential to speed up the discovery of new and more 'personalised' drugs, more nutritious crops, and enzymes that can be used to break down waste.[87]

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[80] Microsoft Azure. *What is cloud computing*.
[81] Lee, I. and Lee, K. (2015). *The internet of Things (IoT): applications, investments, and challenges for enterprises*. Business Horizons.
[82] Andrae S. G. A. and Edler, T. (2015). *On Global Electricity Usage of Communication Technology: Trends to 2030*. MDPI.
[83] Google. (2019). *100 percent renewable energy, for the second year in a row*. Available at:
[84] Singh, A., Kumari, S., Hanif, M., and Mishra, N. (2018). *Big data cloud computing framework for low carbon supplier selection in the beef supply chain.* Journal of Cleaner Production,
[85] Yang, X., et al. (2020). *Development Status and Prospects of Artificial Intelligence in the Field of Energy Conversion Materials*. Frontiers in Energy Research.
[86] Toyota. (2017). *Toyota Research Institute Brings Artificial Intelligence to the Hunt for New Materials*.
[87] DeepMind. (2020). *AlphaFold: a solution to a 50-year-old grand challenge in biology.*

AI is also optimising the movements of delivery vehicles, using information on geography, environment, and traffic to find the best route for delivery.[88] It is also allowing some businesses to optimise routes for cost as well as environmental considerations.[89] The use of AI in logistics is creating shared networks, allowing businesses to combine shipments with other businesses, reducing undesirable fill-rates and empty loads.[90] This can enhance delivery times, reduce costs, and generate lower emissions per unit of cargo transported. Stena Line, a maritime freight business, is working with Hitachi to develop an AI model that would increase fuel efficiency of their vessels, by considering factors, such as wind and current, to determine the optimal route.[91]

The information generated from tracking devices, alongside the use of AI, is helping to predict consumer demand.[92] Businesses are better placed to respond to demand and reduce wastage in the form of resources and energy used in production, distribution, storage, and disposal.[93] [94]

AI can also support recycling and remanufacturing business models. Image recognition technology and robotics can increase the effective recovery of materials, allowing more components to be identified, and better-quality materials to be extracted during the recycling stage.[95] Greyparrot, a tech-start-up, has developed machine learning models that can recognise different types of waste, such as glass, paper, cans, as well as different plastics, helping to increase recycling rates.[96]

[88] DHL. (2013). *Big data in logistics: A DHL perspective on how to move beyond the hype.*
[89] TRANSMETRICS. (n.d.) *How Artificial Intelligence Can Improve Sustainability in Last-Mile Delivery*
[90] NESTA. (N.D.). *Cargonexx.*
[91] Hitachi. (2019). AI Captain: The future of Ship Navigation Inspiring Stena Line to Embrace AI Technology.
[92] Sanders, N.R., Boone., T, Ganeshan, R., and Wood, J.D. (2019). *Sustainable Supply Chains in the Age of AI and Digitization: Research Challenges and Opportunities.* Journal of Business Logistics.
[93] Ma, S., Fildes, R., and Huang, T. (2016). *Demand forecasting with high dimensional data: the case of SKU retail sales forecasting with intra- and inter-category promotional information.* European Journal of Operational Research.
[94] Acar, Y. and Gardner, E.S. (2012) *Forecasting method selection in a global supply chain.* International Journal of Forecasting.
[95] Ellen Macarthur Foundation. (2019). *Artificial intelligence and the circular economy.*
[96] Techcrunch. (2019). *Greyparrot uses computer vision to improve waste management.*

Box 4: DHL adoption of emerging technologies

The emergence of new technologies has allowed DHL to optimize logistics, improve resilience, and reduce its environmental impact.

- **Resilience360** is a cloud-based platform that supports firms in visualising their supply chain. It tracks shipments across multiple geographical locations and transport modes and allows for real-time monitoring of events that could potentially disrupt the firm's supply chain. The system can monitor over 140 different risk factors, including environmental factors.[97] This has been developed using machine learning and natural language processing, as well as publicly available online data and social media.[98]
- Through its **vision picking program**, workers are provided with smart glasses (Google Glass 2.0), providing workers with the information they need to find, scan, sort and move inventory. The use of smart glasses has improved productivity by 15% on average and reduced error rates.[99]
- DHL is also leading a UK government-funded trial of **truck platooning**, enabling groups of trucks to follow each other on major roads. The proximity of trucks helps to improve aerodynamics by reducing wind resistance, thereby reducing fuel consumption. [100]

Robotics and Autonomous vehicles

The implementation of automation in warehouses can help businesses to make more efficient use of storage space and reduce operating costs. Lower labour costs and lower energy costs in terms of heating and lighting required, contributing to the reduction in operating costs. Lower density warehousing also reduces environmental impact, as fewer construction materials and less land are needed.[101]

The use of autonomous vehicles in the transportation of goods between suppliers and customers ('last mile' delivery') has the potential to decarbonise the most pollutive part of the supply chain. Communication between autonomous vehicles and data exchanges could re-route vehicles during busy periods, allowing for potential

[97] Businesswire. (2017). *DHL Supply Watch: Machine Learning to Mitigate Supplier Risks.*
[98] DHL. (n.d.). *Supply Watch: The advanced early-warning system to mitigate supplier financial, stability and compliance risks.*
[99] DHL. (2017). *DHL supply chain makes smart glasses new standard in logistics.*
[100] DHL. (2018). *platooning: one at the fore, all behind one.*
[101] Inbound Logistics. (2010). *Greening the Supply Chain Through Warehouse Automation.*

energy savings from better traffic flows and travel speeds.[102] Optimal routing and driving at more efficient speeds can also reduce fuel consumption.[103]

Additive manufacturing

Additive Manufacturing (AM) is the creation of objects by adding layers of material until a 3D object is produced. 3D printing can use multiple materials, such as plastics, composites, and biomaterials, to create customised objects. It has many applications in the industrial sector including the production of complicated and lightweight components, such as wind turbine blades. As the offshore wind sector is expected to expand over the next decade, AM can play an important role in the production process.[104] AM can produce wind turbines optimised for different locations, adapting designs to wind and turbulence patterns, as well as support in the end-of-life and repair of wind turbines.[105]

AM offers great potential in reducing the environmental impact across the supply chain. Compared to conventional manufacturing, AM uses fewer materials and resources, and is less polluting. It can shorten supply chains, bringing production lines closer to the point of consumption. In addition, AM provides the opportunity to produce products on demand, reducing inventory and storage space, as well as the associated energy use.[106]

Carbon Capture Use and Storage (CCUS)

Carbon Capture, Usage and Storage (CCUS) is a series of technologies that are used to extract the carbon emissions generated by industries, at source or from the atmosphere. It is then either stored in geological sites, such as oil and gas formations, or the deep seafloor, or can be reused in other industrial processes. Current CCUS technology can reduce carbon emissions by between 85–95%.[107] CCUS could play a crucial role in the transition to a net-zero economy, by reducing the emissions of carbon intensive industries and supporting the greening of supply chains.

[102] Mccarthy, J F. (2017). *Sustainability of Self-Driving Mobility: An Analysis of Carbon Emissions Between Autonomous Vehicles and Conventional Modes of Transportation.* Master's thesis, Harvard Extension School.
[103] Research and Innovative Technology Administration (RITA). (n.d.). *Connected Vehicle Research. RITA - Intelligent Transportation Systems - Connected Vehicle. US Department of Transportation (DOT).*
[104] GOV.UK. (2020). *Policy paper. The Ten Point Plan for a Green Industrial Revolution.*
[105] David. (2018). *Sandia's first 3D printed wind turbine blade mould wins national Technology Focus Award.*
[106] Peng, T., Kellens, K., Tang, R., Chen, C., Chen, G. (2018). *Sustainability of additive manufacturing: An overview on its energy demand and environmental impact.* ELSEVIER.
[107] IPCC. (2005). *IPCC Special Report on Carbon Dioxide Capture and Storage*.

Carbon Capture Usage (CCU) can be used to embed emissions in products from traditional carbon-intensive industries, as well as develop products used in the green economy. This includes:[108]

- **Concrete**: carbon can be captured and stored in concrete, then used to produce houses and infrastructure. In addition, carbon can be used to reduce the amount of limestone needed to make concrete, thereby reducing emissions generated from the extraction of limestone.

- **Carbon-Fibre:** Carbon can be used to create cheaper carbon fibre products. This can support the production of wind turbine blades and develop lighter products such as airplane wings and cars, reducing the weight of components and increasing fuel efficiency.

- **Fuels**: The capture of CO2 emissions and the use of other technologies, such as electrochemical conversion and thermal catalysis, can produce liquid fuels, such as methanol.

The UK government will establish CCUS in two industrial clusters by mid 2020s and aim for four of these sites by 2030. This will capture up to 10 Mt of CO_2 per year.[109]

Bio-degradable Plastics

It is estimated that 40% of the plastics produced in the world are used in packaging.[110] While plastics play an important part in protecting and preserving goods as well as reducing weight in transportation, 48% of plastic waste ended up in landfill in 2018.[111]

The production of plastic creates emissions throughout its lifecycle. Most plastics today are synthetic, which are derived from crude oil, natural gas, or coal, which generates considerable emissions from its extraction. In addition, the refining, manufacture, transportation, and disposal of plastic all generate additional emissions. If plastic remains in the environment, toxic pollutants cause harm to humans, animals, and plants. If incinerated, these emissions are released into the atmosphere.

Better recycling and use of alternative packaging where possible, will help reduce the amount of plastic manufactured and disposed. Where there is currently no fit-for-purpose alternative, bioplastics produced from renewable sources can help reduce environmental impact. Bioplastics are polymers derived from biomass, including

[108] Cho, Re. (2019). *Capturing Carbon's Potential: These Companies Are Turning CO2 into Profits.*
[109] HM Government. (2020). *The Ten Point Plan for a Green Industrial Revolution.*
[110] Plastics Europe. (2017). *Plastics Europe Plastics - The facts 2017.*
[111] Eunomia. (2018). *A Plastic Future – Plastics Consumption and Waste Management in the UK.*

energy crops and animal waste.[112] They produce substantially lower carbon emissions over their lifetime and can biologically degrade over time, although not all bioplastics are biodegradable.[113] [114]

The use of bioplastics for packaging has grown by 20 to 25% per year, and demand is expected to increase as businesses move towards more sustainable packaging.[115] It is estimated that switching from traditional plastic to corn-based PLA plastic could cut industry-wide greenhouse gas emissions by 25%.[116]

Environmental Goods and Services

Industries in this sector are focused on environmental protection or resource management. The environmental goods and services sector can play an important role in supporting the greening of supply chains. The sector is mainly dominated by the disposal of waste and recycling, environmental construction, production of renewable energy, wastewater, and water quality management.

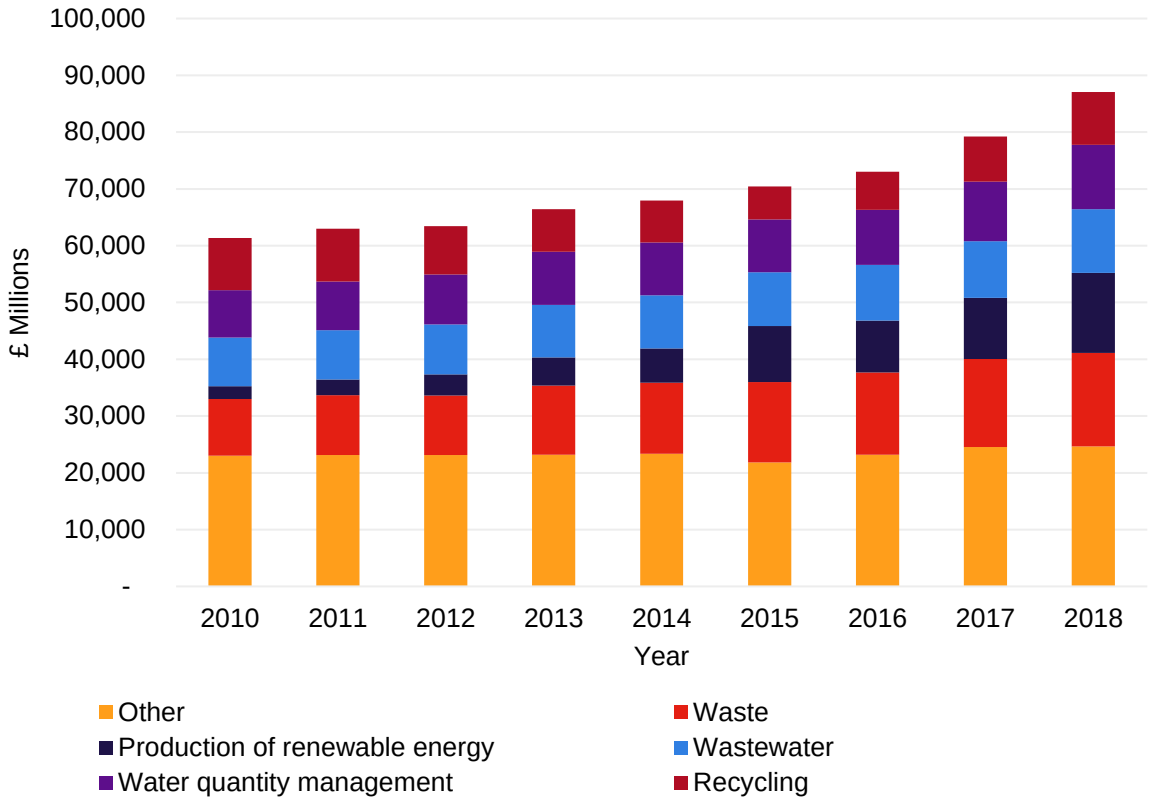
Increased awareness of environmental issues and nature coupled with the implementation of environmental legislation, have all encouraged rapid development of the environmental goods and services sector. The output of this sector has grown by around 42%, since 2010 and accelerated over recent years.

Figure 7 shows that the production of renewable energy accounts for most of this growth. Waste activity has also expanded steadily over this period.

There are several other high growth areas emerging in this sector. While environmental education represents a small proportion of total economic activity within the sector, it has grown by 118% over the past eight years. This activity includes education aimed at environmental protection and management of natural resources.

[112] Wojnowska-Baryła, I., Kulikowska, D., and Bernat, K. 2020. *Effect of Bio-Based Products on Waste Management.* MDPI.
[113] Lopez, J., Vilaseca, F., Barberà, L., Bayer, R., Pèlach, M., and Mutjé, P. (2012). *Processing and properties of biodegradable composites based on Mater-Bi and hemp core fibres.* Resources, Conservation, and Recycling.
[114] Hottle, T.A., Bilec,M.M., and Landis, A.E. (2013). *Sustainability assessments of bio-based polymers. Polymer Degradation and stability.*
[115] Arikan, E.B. and Ozsoy, H.D. (2015). *A review: Investigation of bioplastics.* Journal of Civil Engineering and Architecture.
[116] Posen, D., Jaramillo, P., Landis, A.E., and Griffin, W.M. (2017). *Greenhouse gas mitigation for U.S. plastics production: energy first, feedstocks later.*

Figure 7: Environmental goods and services sector output by activity



Source: ONS

Notes: Environmental goods and services estimate for 2018 are provisional. Other contains output from environmental charities; managerial activities; management of forest ecosystems; insulation activities, in-house environmental activities; organic agriculture; environmental related education; energy saving and sustainable energy systems; environmental consultancy and engineering; environmental related construction; environmental low emission vehicles; carbon capture and inspection and control; and production of industrial environmental equipment. Estimates for the UK EGSS activities of energy-saving and sustainability, environmental consultancy, environmental construction, environmental inspection and control and production of industrial environmental equipment should be treated with caution due to the small sample size and subjective nature of the available data source for these activities.

The climate change resilience market is a rapidly growing one and is an area with significant UK expertise and capability.[117]

Climate science tools and technologies such as the UK Climate Projections 2018 and local projections, will inform planning and decision-making with regard to building climate resilience.[118] Climate-related services and increased investment in infrastructure, will improve the resilience of local communities and businesses, reducing the monetary and non-monetary costs of extreme weather.[119] Increased support for the export of climate resilient infrastructure may help to accelerate the

[117] HM Government. (2019). *Government response to the Committee on Climate Change*.
[118] Met Office. (2018). *UK Climate Projections (UKCP).*
[119] UK.GOV. (2020). *Multi-billion-pound investment as government unveils new long-term plan to tackle flooding.*

diffusion and uptake of environmental goods and services overseas.[120] This could increase resilience in countries most impacted from climate change and protect UK international supply chains.

Box 5: IKEA's IWAY Code of Conduct for suppliers

The IKEA way on purchasing products, services, materials, and components, (IWAY) is a code of conduct which sets out the environmental, social & working condition requirements for all IKEA suppliers and service providers. IWAY guides IKEA's purchasing and procurement, and operational and production decisions with respect to the design and manufacture of products.[121] Businesses are only able to work with IKEA if they meet the minimum requirements set out in IWAY.

IWAY Standards include sections on the environment, chemicals, and waste.

- **Environment:** relates to the compliance of environmental protection by authorities as well as compliance to local laws relating to pollution.
- **Chemicals:** compliance with local laws relating to chemicals, as well as documentation, establish correct storage, handling, and transportation procedures, ensure appropriate labelling and documentation, and provision of employee training.
- **Hazardous and non-hazardous waste:** compliance with local laws and regulations, keeping adequate records of waste, and established procedures for the handling, storing, transportation, and disposal of waste. Use of licensed contractors for waste disposal and adhering to legal requirements for on-site incineration and landfill.

IKEA provides training and support to help suppliers meet new requirements. Regular audits help ensure compliance among suppliers and service providers.

One of the major benefits of IWAY is that the standards mandated to first-tier suppliers are also applied to second-tier suppliers and so on, which helps reduce environmental impact across IKEA's supply chain.

Source: Extracted from IKEA IWAY

Green Finance

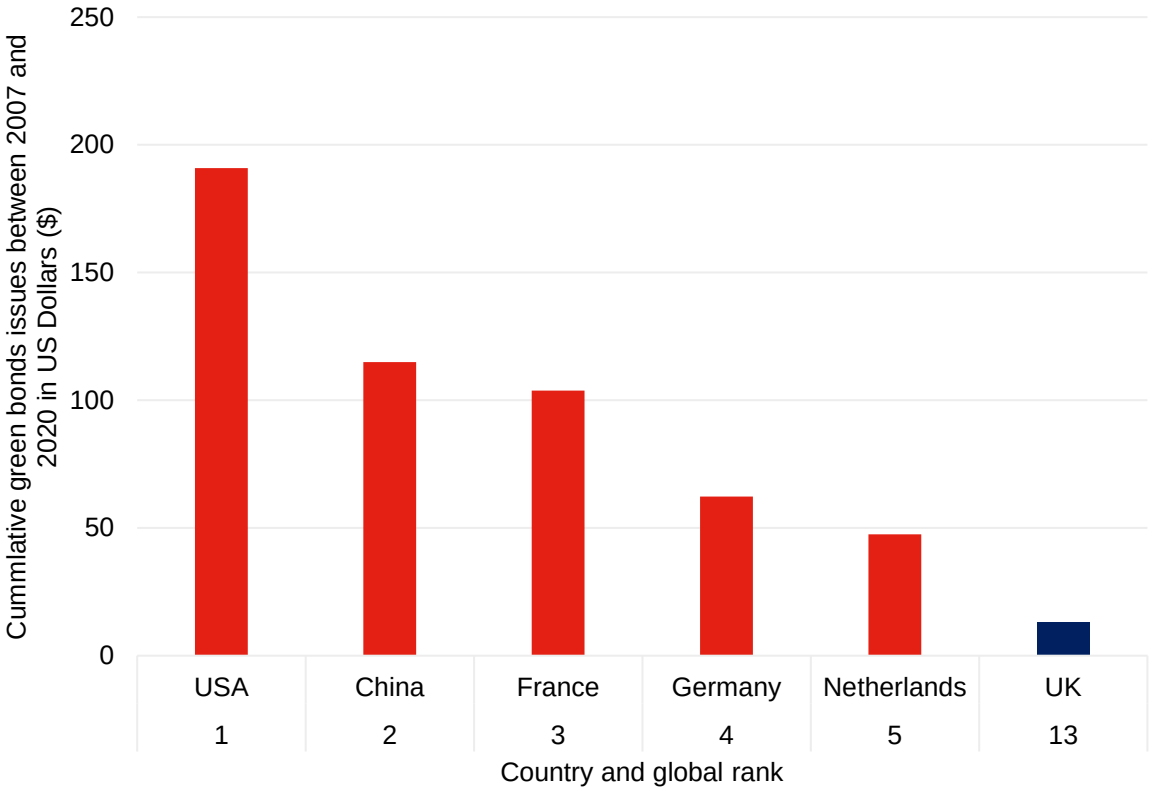
Green finance can come in many forms, such as green bonds, green loans, Sustainability-Linked Loans (SLL), Exchange Traded Funds (ETFs) that track sustainability indexes, and Venture Capital (VC) investment. By 2019, 139 green bonds had been issued, with over $29 billion raised on the London Stock Exchange.

[120] UK.GOV. (2019). *Liam Fox announces export support for UK's climate resilience sector.*
[121] Laurin, F. and Fantazy, K. (2017). *Sustainable supply chain management: a case study at IKEA*. Transnational Corporations Review.

In addition, over 100 ESG indexes and green companies have been setup, with at least 20% of their revenue derived from green industries.[122]

To accelerate the transition to a net-zero economy, green finance provided by banks, non-bank finance, institutional investors, capital markets, as well as public finance, will all be needed. This will include investments into new business models and processes, as well as the innovation and adoption of technologies. For example, SLLs are already being used to finance businesses and bind them to environmental, sustainability and governance-related targets. Britvic, a beverage manufacturer, borrowed more than £400m in SLL and will pay a lower interest rate if it delivers progress against its environmental targets.

Figure 8: Cumulative green bond issued between 2007 and 2020



Source: Climate Bonds Initiative

Notes: Excludes cumulative bonds issued by Supranational entities. Data for each country starts from; 2011 for USA; 2012 for France; 2013 for Germany; 2014 for UK, China, and the Netherlands. Green bonds issued as of 04/09/2020.

While the UK has one of the world's largest financial centres, with a developing green finance sector, it is well behind other countries in relation to green bond issuance. Cumulative green bond issuance between 2007 and mid-2020 put the UK 13th in the world. To stimulate the sector, the UK government will issue its first Sovereign Green Bond in 2021, with further bond issuance thereafter.

[122] The Global City. (2020). *Sustainable and green finance - downloadable factsheet.*

Increased investor appetite for environmental and social returns will ultimately determine to which companies finance flows. In September 2020, BlackRock, an asset management firm, launched three ESG ETFs to provide investors with a "cost-efficient, transparent and sustainable way" to invest in the market.[123] The UN-backed Principles for Responsible Investment (PRI), encourages global investors to incorporate ESG factors into their investment practices.

Regulators and international bodies are already making it easier for investors to direct their investments to more sustainable and more resilient businesses. The Task Force on Climate-related Financial Disclosures (TCFD) has led the way in developing a framework for climate disclosures that promotes more informed investment and insurance decisions and allows stakeholders to price climate-related risk and opportunities. As part of this, businesses are encouraged to produce a series of metrics which indicate their vulnerabilities and resilience to shocks, including supply chain risks.[124]

The UK government has announced its intention to make CFD-aligned disclosures mandatory across the economy by 2025. This will include all listed commercial companies.

Public and private finance

The move towards sustainable supply chains requires investment in new technologies and processes. However, the existence of market failures may impede supply chain greening.

Negative externalities from GHG emissions are born by wider society, polluting firms do not bear the full cost. This is because emissions are not priced by the market, and therefore, market actors have little incentive to reduce emissions without policy intervention. In the absence of carbon pricing and other regulations, companies will underinvest in decarbonisation because the costs of not doing so are too low.

Secondly, the positive externalities to other firms and the wider economy from research and development, in low carbon technologies, for example, tends to exceed the private return recouped by the innovator. This can lead to underinvestment in R&D and innovation.[125]

Finally, the presence of financial constraints can significantly reduce a firm's ability to innovate and is even more prevalent for green innovation. Innovation in low carbon technologies can require large upfront costs, with returns uncertain and emerging much later.[126] Private finance may price this risk as too high, hence the need for

[123] Investment week. (2020). *BlackRock unveils suite of ESG multi-asset ETFs.*
[124] *Task Force on Climate-related Financial Disclosures.*
[125] Jaffe, A. (1986). *Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value.*
[126] Nanda, R., Younge, K. and Fleming, L. (2015) *Innovation and Entrepreneurship in Renewable Energy.*

blended public and private investment to both demonstrate a market, and also help bring about production at scale to make such technologies affordable.

R&D subsidies, tax credits, and grants can help to alleviate financial constraints for businesses and drive innovation forward. For example, initiatives such as the *DECC/TSB Offshore Wind Components Technologies Scheme* provided finance to companies developing component technologies for the offshore wind sector.[127] Alongside other policies, such as the Contracts for Difference reverse auction process, this may have accelerated the reduction in offshore wind costs, making it more cost-effective than fossil-fuel energy production.[128] Moving towards low-carbon energy production has helped to decarbonise the supply chain.

Venture capital is also being used to reduce the financial barriers faced by start-ups, early-stage and emerging companies that have or show high growth potential. Venture capital plays an important role in selecting innovative firms and providing them with the equity funding to grow. It also offers non-monetary benefits including expert advice, networking opportunities, and assistance in bringing products to market more quickly.[129] [130] For these reasons, government have increasingly looked towards venture capital to help channel private finance into high growth areas. The Clean Growth Fund is a venture capital fund joint-funded by the UK government and CCLA investment management, and provides financial capital to start-ups involved in clean tech.[131]

While there is much debate regarding the role of public sector investment in 'crowding out' private investors, public investment in renewable energy technology projects has been shown to encourage private sector investment flows, in both solar and wind technology.[132] Green Infrastructure Banks (GIB) have been effective in addressing investment gaps for low-carbon projects with large upfront capital costs, as well as supporting depressed investment activity during an economic downturn.[133] [134]

As part of the National Infrastructure Strategy, the UK government will continue to invest in the decarbonisation of energy production, including off-shore wind and

[127] HM Government. (2014). *Overview of support for the offshore wind industry.*
[128] BEIS. (2020). *Contracts for Difference.*
[129] Chemmanur, T. J., Krishnan, K., and Nandy, D. K. (2011). *How does venture capital financing improve efficiency in private firms? A look beneath the surface.* Review of Financial Studies.
[130] Hochberg, Y.V., Serrano, C.J. and Ziedonis, R.H. 2014. *Patent collateral, investor commitment, and the market for venture lending.* Journal of financial economics.
[131] GOV.UK. (2020). *Government launches new £40 million Clean Growth Fund to supercharge green start-ups.*
[132] Deleidi, M., Mazzucato, M. and Semieniuk, G. (2019). *Neither crowding in nor out: Public direct investment mobilising private investment into renewable electricity projects.* UCL.
[133] Mazzucato, M. and Penna, C.C.R. (2016). *Beyond market failures: the market creating and shaping roles of state investment banks.* Journal of Economic Policy Reform.
[134] Hall, S, Foxon, T.J., and Bolton, R. *Investing in low-carbon transitions: energy finance as an adaptive market.* Climate Policy.

nuclear technology, as well as set up a new infrastructure bank, to co-invest alongside the private sector in infrastructure projects.[135]

Business Models

New business models can help to alleviate the challenges facing supply chains and create new opportunities for businesses to become greener. The use of intermodal transportation can help businesses to optimise their logistics to consider the most cost-effective and lower emission forms of transportation. Closed loop or circular economy models can help to improve resource and energy efficiency.

Intermodal transport

Intermodal transport is where goods are transported between origin and destination, using a combination of two or more different modes of transport, with each mode of transport subject to a separate contract.[136] The adoption of intermodal transport can encourage the reduction of CO_2 emissions related to the movements of goods across the supply chain.[137] For example, rail can be used to transport full-loads over medium and long distances, optimising CO^2 and reducing environmental impact, especially as most of Britain's freight rail network is already electrified.[138] For short haul, the use of electric vehicles such as lorries and vans, as well as delivery bikes, can be used to deliver goods to their final destination. This will also reduce traffic and emissions generated within cities.

Closed loop or circular economy models

Closed loop or circular economy models are supporting businesses in improving resource efficiency and security, as well as mitigating supply chain risks and increased price volatility. These models can allow much of the original product to be preserved or used again, therefore reducing demand for materials and energy compared to producing a product from scratch.

Product as a service

Product as a service business models involve integrating bundles of products and services, in which the services component is marketed to consumers rather than the product itself. Product as a service can come in many forms:[139]

[135] UK.GOV. (2020). *National Infrastructure Strategy.*
[136] The Geography of Transport Systems. (n.d.). *Intermodalism, Multimodalism and Transmodalism.*
[137] Eng-Larsson, F. and Norrman, A. (2014). *Modal Shift for greener logistics - Exploring the Role of the Contract.*
[138] Worth, J., and Wilding, R. (2020). *The route to NET ZERO 2050 for logistics.*
[139] Tukker, A. (2015). *Product services for a resource-efficient and circular economy – a review.* Journal of Cleaner Production.

- **Product-orientated business models** are mostly focused around selling products in the traditional way but with some additional services attached, such as maintenance contracts and repair with boilers.
- **Use-oriented business models** involve service providers retaining full ownership of the product and consumers paying for temporary access to a product, through either a lease agreement, sharing or product pooling.
- **Results-oriented business models** involve the consumer and the provider agreeing specific outcomes without pre-determining the product involved.

Product as a service business models can create strong incentives for sustainability. Businesses are encouraged to design products with durability in mind, as materials used in the production process will become considerable cost-factors to the firm.[140] [141] Because of this, products are designed to be serviceable, enabling the maintenance and repair of products to extend their lifespan. It also encourages designs to be standardised, allowing components used in one product to be used in others, as well as making disassembly and reassembly easier, supporting refurbishment, remanufacturing, and recycling.[142] [143] Such models can also develop trust and attachment between products and consumers, reducing the likelihood of disposal earlier than the intended lifespan.[144]

Sharing economy

The sharing economy allows under-utilised assets to be used more intensively, either through lending or product pooling. The sharing economy involves the provision of a service, either for free or at a cost, achieved through an intermediary, such as online platform.[145]

- **Co-ownership** models involve the lending of physical goods to others.
- **Co-access** involves allowing other users to be part of an activity which is already taking place.

Sharing economy business models can change consumption and lifestyle habits, supporting sustainable supply chains. As the sharing economy promotes the “use” rather than the “ownership” of assets, it can help to reduce the number of new

[140] Lindahl, M., Sundin, E., Sakao, T. (2014). *Environmental and economic benefits of Integrated Product Service Offerings quantified with real business cases.* Journal of Cleaner Production.
[141] Mont, O.K. (2002). *Clarifying the concept of product-service system.* Journal of Cleaner Production.
[142] F. Mahut, J. Daaboul, M. Bricogne, and B. Eynard. (2017). *Product-Service Systems for servitization of the automotive industry: a literature review.* International Journal of Production Research.
[143] Baines TS, Lightfoot HW, Evans S, et al.(2007). *State-of-the-art in product-service systems.* Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture.
[144] Haines-Gadd, M., Chapman, J., Lloyd, P., Mason, J., and Aliakseyeu, D. (2018). *Emotional Durability Design Nine—A Tool for Product Longevity*. Sustainability,
[145] Hall, S. and Pennington, J. (2016). *How much is the sharing economy worth to GDP?. World Economic Forum.*

products required and the resources and energy used in their production.[146] [147] It can also open up new opportunities for businesses to utilise more cost-effective and environmentally friendly transportation such as trains, by pooling goods together with other businesses and competitors.[148]

Box 6: Example of household appliances as a service

Bundles is a start-up company, offering customers a pay-per-wash model, where customers pay for the service, not the product. Customers choose their washing machine requirements and their expected use. In return, they receive a washing machine with no up-front cost (other than the first monthly fee and a deposit).

As Bundles is responsible for the repair and disposal of the washing machine, there is an incentive for the firm to choose the most efficient and sustainable washing machine manufacturer. Miele, a household appliance manufacturer, uses 100% reusable and recyclable materials, replacing materials such as plastics with stainless steel, to increase the longevity of the product while also reducing its environmental impact.[149] Washing machines can be repaired more easily, and where they cannot be repaired, the components and materials are salvaged and used in the manufacture of new appliances.

As the appliance is connected to the internet, information generated from the washing machine is analysed, enabling customised performance changes to reflect customer use. This improves efficiency and reduces costs, and damage to the appliance. In addition, Bundles provides users with the "Wash App", providing advice on how to conserve energy, water, and detergent.[150]

Source: Bundle

Recycle, Reuse, and Remanufacture

Recycling is the collecting and processing of materials and turning them into new products.[151] Recycling reduces the amount of waste that is sent to landfill or incinerators and allows critical materials to be re-used in new products. This conserves natural resources which would have been used in new products.

Remanufacturing is when a used product or component is returned to its original state, accompanied by a warranty from either a third party or the Original Equipment Manufacturer (OEM).[152] As much of the original product is preserved,

[146] Liu, X,. and Chen, Hongmin. (2020). *Sharing Economy: Promote Its Potential to Sustainability by Regulation.* MDPI.
[147] Dermailly, D., and Novel, A.S. (2014). *The sharing economy. Make it sustainable.* IDDRI.
[148] Mason, R. and Harris, I. (2019). *A review of freight and the sharing economy.* Government Office for Science.
[149] Miele. (2019). *Sustainability Report 2019.*
[150] Circle Economy. (2016). *Bundles: extending the product lifecycle with long-term funding.*
[151] *United States Environmental Protection Agency.*
[152] Ljomah, W. (2002). *A model-based definition of the generic remanufacturing business process.*

remanufacturing uses 85% less energy than conventional manufacturing and fewer resources and materials.[153] Businesses that implement remanufacturing into their product lifecycle can reduce some of the supply chain risks from sourcing inputs more generally and particularly scarce resources.[154] This is especially important when products contain critical raw materials, which may be more difficult to source in future, either because of climate change or other wider trends.

Box 7: Remanufacturing at Caterpillar

Remanufacturing has been part of Caterpillar's business model since 1973. Through the Cat Reman program, customers can return parts (also known as 'cores') at the end of their serviceable life, which can then be exchanged for a 'same as new' core.

One of the biggest barriers to remanufacturing has been encouraging customers to return used cores back to the business. To incentivize customers, Caterpillar asks for an upfront deposit which is paid back once the core has been received. This increases the rate of recovery for used cores, allowing energy and materials embodied to stay within the product and within the organisation's network. This has resulted in very few cores being sent to disposal.

As 65% of Caterpillar's total costs are material costs, the remanufacturing business model has helped Caterpillar to reduce costs and increase competitiveness.[155] In addition, it has also allowed them to preserve 85% of the original energy used within the product, reducing energy and material demand.[156]

Source: Caterpillar

Reuse allows used products to be distributed to new owners, keeping them in circulation. This offers substantial environmental benefits, by reducing the demand for new products and thereby, the need for raw materials and harmful chemicals, as well as the energy used in production.

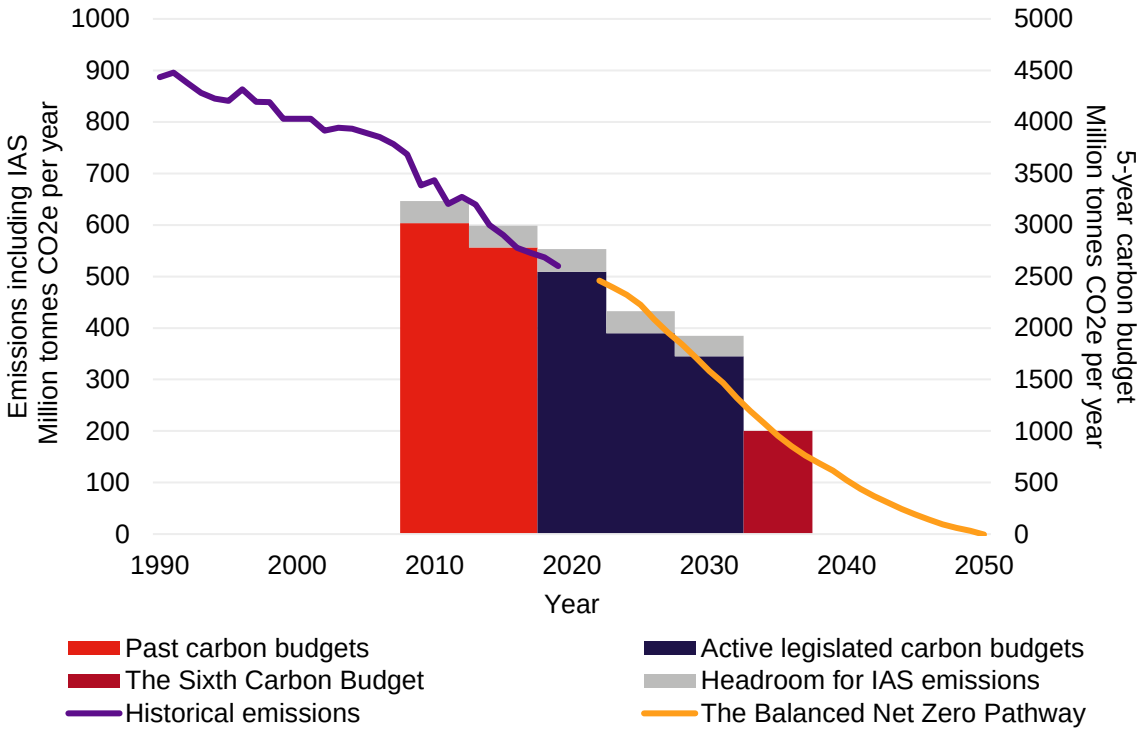
This section has discussed a breadth of options for greening supply chains. Recent developments in technologies are helping to support supply chains to become greener and more resilient. However, some technologies remain more conceptual than others to businesses looking to take action to green their supply chain. It is also possible that some are more relevant to a broader spectrum of industries than others or have been more widely applied and tested than others. The next section will explore the extent to which change is underway, drawing on evidence and supporting policy.

[153] Steinhilper, R. (2006). *Remanufacturing: The Ultimate Form of Recycling*.
[154] Prendeville, Sharon & Bocken, Nancy. (2016). *Design for Remanufacturing and Circular Business Models.* Sustainability Through Innovation in Product Life Cycle Design.
[155] The Engineer. (2016). *The value of remanufacturing.*
[156] Caterpillar. (2016). *Multiple lives: a win-win-win.*

An Assessment of Progress Towards Greener Supply Chains

If Greenhouse Gas (GHG) emissions are to fall sufficiently to meet the net-zero target by 2050, everyone needs to do more (see Figure 9). Under the terms of the 2008 Climate Change Act, the UK sets a carbon budget every five years. The carbon budget is the amount of total GHG emissions permitted over the period, in line with the UK's emissions reduction commitments. While the Climate Change Committee (CCC) reports that the UK has made progress by meeting its first three budgets, it expects emissions to exceed the permitted amount in the fourth (2023-2027) and fifth (2027-2032) carbon budgets based on current policies.[157] The sixth carbon budget report (2032-2037) has recommended a reduction of UK GHG emissions of 63% by 2035 relative to 2019.[158]

Figure 9: Whole economy emissions and indicative trajectory to net-zero target



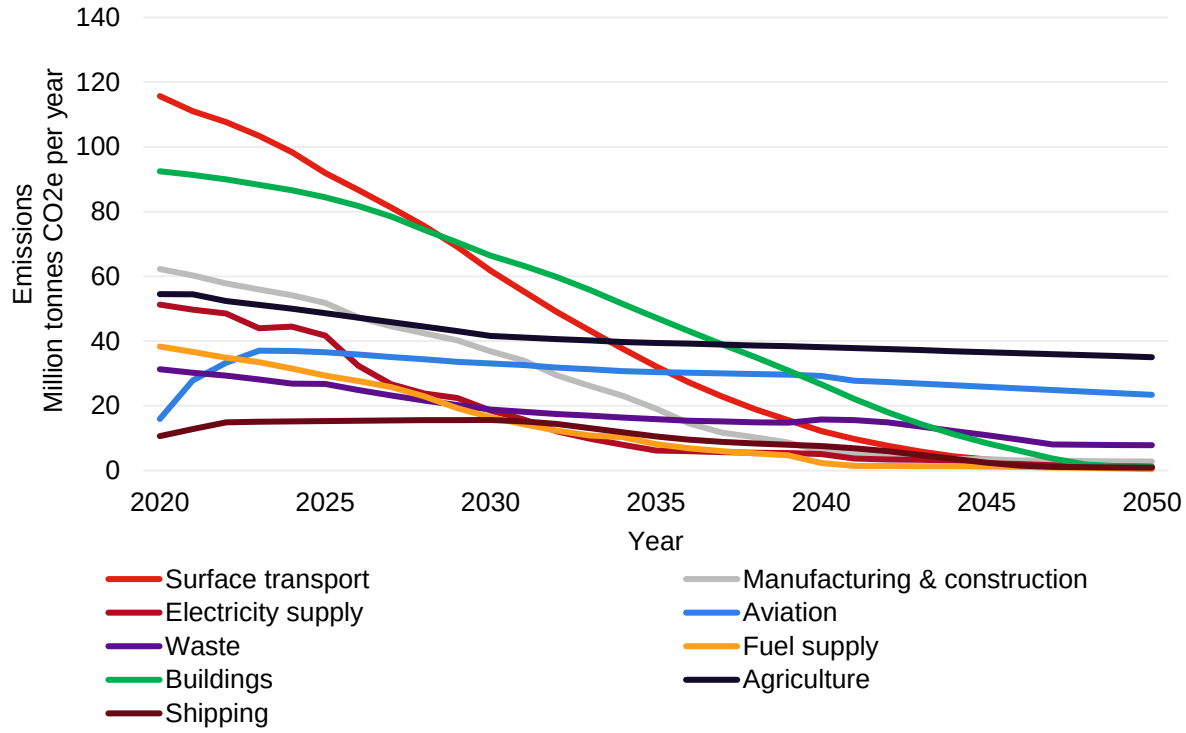
Source: BEIS (2020) Provisional UK greenhouse gas emissions national statistics 2019; CCC analysis.

Notes: Emissions shown including emissions from international aviation and shipping (IAS) and on an AR5 basis, including peatlands. Adjustments for IAS emissions to carbon budgets 1-3 based on historical IAS emissions data; adjustments to carbon budgets 4 and 5 based on IAS emissions under the Balanced Net-Zero Pathway.

[157] CCC. (2020). *Op Cit.*
[158] CCC. (2020). *The Sixth Carbon Budget – The UK's path to Net Zero.*

Figure 10 shows which sectors of the UK economy account for the most emissions, where progress in reducing emissions has been greatest, and the indicative trajectory to net-zero. While progress has been made in reducing emissions, sectors such as transport and buildings will need to see the largest declines to help the UK meet its net-zero target by 2050.

Figure 10: Sector GHG emissions and indicative trajectory to net-zero target



Source: CCC analysis.

A month before the release of the sixth carbon report in December 2020, the UK government announced the 'Ten Point Plan for a Green Industrial Revolution'.[159] This included the end of new petrol and diesel cars and vans sales by 2030, ten years earlier than planned, and increased investment to make homes and public buildings more energy efficient.

The 10-point plan also included increased investment into clean energy, expanding offshore wind and nuclear energy, as well as hydrogen production capacity and Carbon Capture Usage and Storage (CCUS).

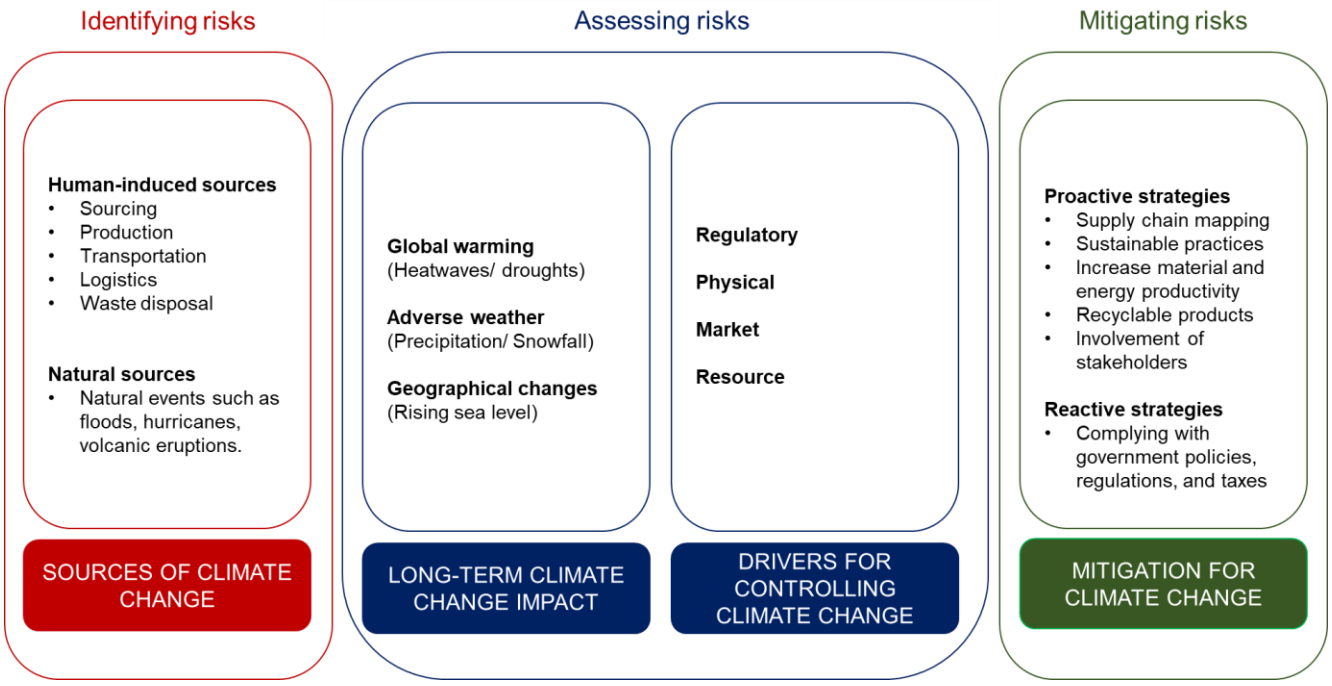
More support will also be directed towards the development and expansion of technologies, industries such as air and maritime transport, as well as developing the City of London to become the global centre of green finance.

Nonetheless, the CCC has highlighted that further commitments are needed to meet net-zero by 2050.

[159] GOV.UK. 2020. *PM outlines his Ten Point Plan for a Green Industrial Revolution for 250,000 jobs*

Understanding Supply Chain Risks

Figure 11: How climate change risks can affect the supply chain



Source: Adapted from Ghadge, Wurtmann, and Seuring (2019).[160]

Among UK CEOs, around two-thirds consider climate change to be a threat to their day-to-day business operations, with a quarter of them considering it to be an extreme risk. Long-term impacts such as global warming, adverse weather, and geographical changes can all cause severe disruptions to supply chains. Increased awareness of these impacts is helping to drive forward action, with 57% of CEOs having assessed the climate change risks they face.[161]

While some businesses have committed to reducing their overall environmental impact, more needs to be done to design and implement a strategy to achieve this. Around a third of UK businesses report they have or will be developing a net-zero strategy in future. However, within this group, just under-half have yet to develop their net-zero plan.[162]

As most emissions generated by business stems from their supply chain, developing an effective and comprehensive net-zero strategy requires an understanding of the entire supply chain. While larger businesses tend to have a better understanding of their supply chains, over 59% of Small and Medium businesses (SMEs) do not

[160] Ghadge, A., Wurtmann, H., and Seuring, S. (2019). *Managing climate change risks in global supply chains: A review and research agenda*. International Journal of Production Research
[161] PWC UK. (2020). *Climate change soars up CEO agenda*.
[162] Mitie. (2020). *Lack of know-how holding back UK carbon reduction, despite a third of UK businesses having a net zero strategy*.

understand all parts of their supply chain, with just over a third having undertaken audits to better understand them.[163]

In a survey conducted by the Economist Intelligence Unit, respondents reported that aside from cost, the biggest barriers to adopting a sustainable supply chain strategy are difficulty in monitoring complex supply chains (29%) along with organisational structures (24%). Businesses also cited lack of internal expertise (18%), lack of support from top management (16%), and lack of government support (16%) as hindering their efforts.

Without the knowledge, data, tools, expertise and practical support, there is a risk that businesses will either be too slow to act or lack the necessary information and expertise to take effective action.

Supporting Conditions

Transparency over supply chain practices

Increased transparency across the entire supply chain, more timely data, and better use of data will enable businesses to consider environmental impact and resilience to climate-related risks at every stage of their supply chain. This will inform purchasing decisions, for example, choosing suppliers with better sustainability credentials, improving existing suppliers through contractual terms, or allowing purchasing managers to source inputs closer to production or consumption. If businesses set out their sustainability requirements, transparent supply chains can increase competition between suppliers and drive progress. It can also optimise choice of transportation. Finally, it can improve understanding of how products are used and disposed of, encouraging the redesign of products to last longer, and measures to make recycling easier.

Progress so far:

Figure 12 sets out some of the government policies and voluntary initiatives that are encouraging the development of transparent supply chains.

[163] Aldermore. (2020). *One in 10 UK SMEs would not survive disruption to their supply chain*.

Figure 12: Supporting initiatives to develop more transparent supply chains

Initiatives	Description
Environmental, Social, and Governance (ESG) disclosure reporting	International regulators, non-profit organisations, and the private sector are encouraging investors and businesses to embed ESG considerations into their strategies. Businesses need to disclose a range of information, including potential climate change risks.
Task Force on Climate-Related Financial Disclosures (TFCD)	Climate-related disclosures will be mandatory for large UK companies by 2025. This will improve transparency, inform the assessment and pricing of risk, and the allocation of capital to more sustainable projects and activities.[164]
Online tools and guidance	Publicly available information is being used to help businesses map out their supply chains. Organisations such as TRASE provide free mapping of supply chains for key commodities. Furthermore, the SDG Compass guides companies in aligning their strategies with the Sustainable Development Goals, mapping the SDGs to their value chain to measure impact.
Forests: reducing deforestation in UK supply chains	The government will introduce a new law through the Environment Bill to prevent illegal deforestation in the supply chains of UK businesses. This will require companies to know where their commodities have come from and if it complies with local laws.

Skills

Clear company strategies are needed to guide recruitment and training choices with respect to attracting and retaining the breadth of skills needed to analyse and make improvements across the supply chain. Hard skills, such as knowledge about carbon products, green production, green logistics, and innovative design, can lead to improvements in product design, production methods and transportation methods. In addition, soft skills, such as leadership and collaboration, will help drive change within and outside the organisation. If these skills are in short supply, businesses need to develop training programmes to build and nurture sustainable supply chain talent. Figure 13 demonstrates the range of skills needed.

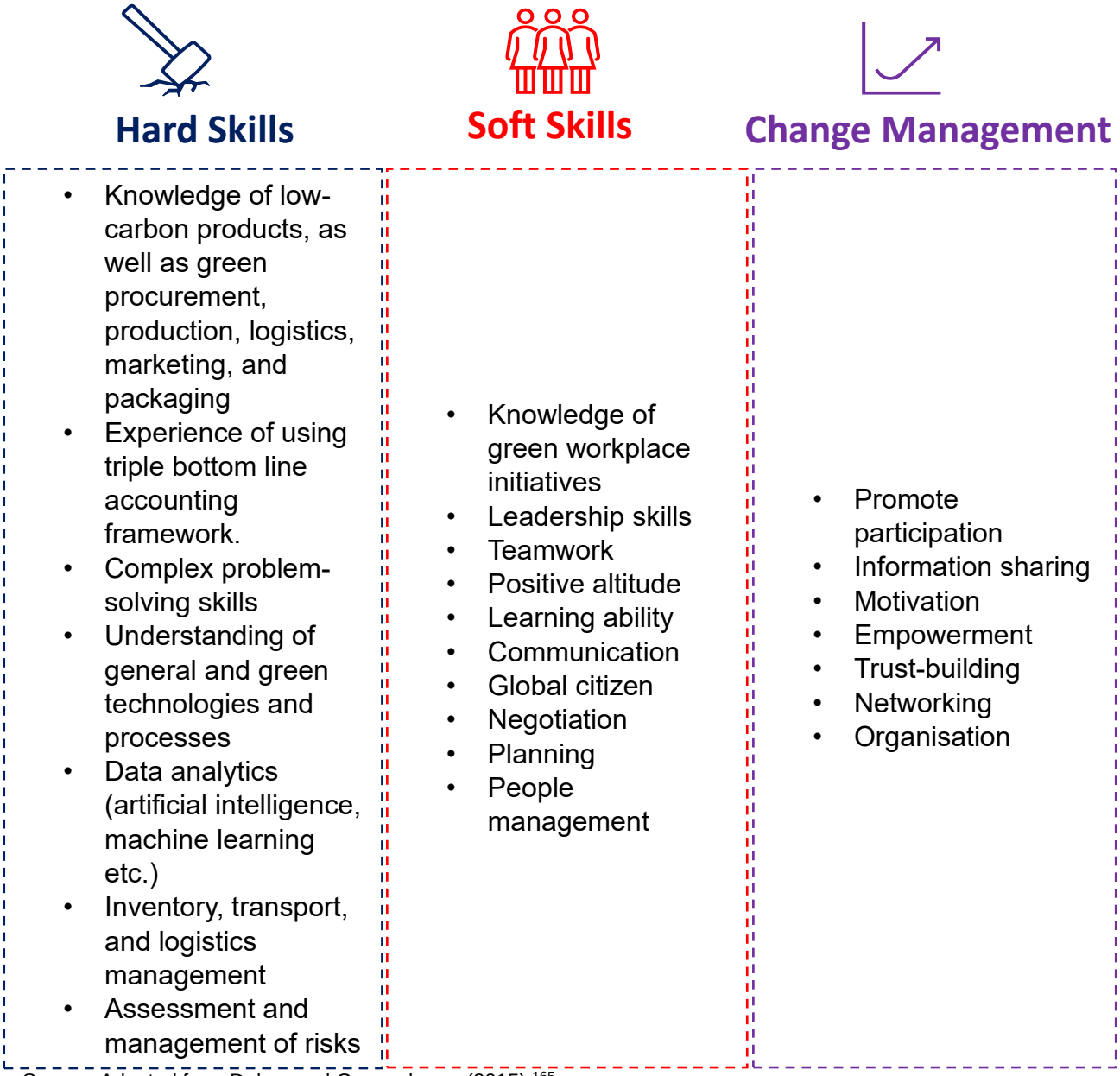
Expert advice, from consultancies and specialist training organisations, can support businesses in their shift towards greener supply chains. These organisations can

[164] GOV.UK. (2020). *UK joint regulator and government TCFD Taskforce: Interim Report and Roadmap.*

assist with mapping business operations, monitoring sustainability practices and emissions, assessing risks, and advising on implementing change.

Further and higher education institutions can collaborate with businesses and specific sectors or green sector experts, to develop a curriculum that aligns with the skills needs of different industries. This might include modules on decarbonisation and sustainability, as well as digital skills, such as data science. Bringing in supply chain experts and sector specialists can help raise awareness of sustainable supply chain management as a profession and encourage more talent into the industry.

Figure 13: Framework for sustainable supply chain talent



Source: Adapted from Dubey and Gunasekaran (2015).[165]

[165] Dubey, R. and Gunasekaran, A. (2015). *Shortage of sustainable supply chain talent: An industrial training framework.*

Progress so far

The supply chain industry continues to face skill shortages. 54% of logistics companies expect skill shortages over the next five years, with software engineers, project managers and executives being most in demand.[166]

Several policy initiatives are already in place to support the development of green skills. 'Skills for a green economy: a report on the evidence', outlines several actions that government has supported to identify green skill needs and associated career options, such as bringing together Sector Skills Councils (SSCs) and improving the quality of information provided by the National Careers Service.[167]

The potential shortfall in STEM skills highlighted in the Council's UK Skill Mismatch in 2030 paper will apply to supply chain greening too. The government has continued to implement policies in this area. The government has already announced the first 12 Institutes of Technology (IoTs) to address technical skill needs, with second wave of IoTs currently out for competition.[168] It also launched The Skills Toolkit in 2020, which offers online learning to help people gain new skills, such as computer coding.[169]

Furthermore, through sector deals and other initiatives, there has been a large expansion in apprenticeships to meet sector skill requirements. The offshore wind industry expects to employ 3,000 new apprentices by 2030.[170] Sector deals should increase the stock of green skills in the economy, some of which will be transferrable to other industries and sectors. This will include both hard skills (knowledge of low-carbon products and processes) and more general soft-skills (such as leadership, collaboration and negotiating skills), which can be used to drive change within firms and sectors.

Industry also supports young people to enter the supply chain and logistics industry. Some university courses are aligning themselves with the NOVUS Trust group of companies, offering mentors, summer placements, and year-long industrial placements to young people.[171] However, within organisations, there are little to no training programmes focused on building sustainable supply chain talent.

Figure 14 outlines policies and initiatives which are encouraging the development of green and digital skills which can be utilised for greening supply chains.

[166] UK Logistics Monitor. (2019). *CILT & Statista expert survey – report. 2019*.
[167] GOV.UK. (2011). *Skills for a green economy: a report on the evidence.*
[168] GOV.UK. (2020). *Institutes of technology wave 2 competition*
[169] HM Government. *Skills Toolkit.*
[170] Renewable UK. (2020). *Offshore Wind Industry Council media release – Wednesday 4th March.*
[171] NOVUS is a not-for-profit organisation, part of the Chartered Institute of Logistics and Transport in the UK.

Supporting initiatives in place

Figure 14: Supporting initiatives to develop talent for supply chain greening

Initiatives	Description
Institute for Apprenticeships and Technical Education	Developing green skills by aligning apprenticeships with net-zero and sustainability objectives. Developing guidance for employers on how to incorporate sustainability concepts into apprenticeships.[172]
T-Levels	Improving technical skills in construction, engineering, manufacturing, digital, agriculture, and environmental.[173]
Offshore Wind Sector Deal	Create a curricula and accreditation scheme to deepen the skills base, facilitate skills transfer between industries, strengthen links between employers and providers of technical education, and increase the number of apprentices within the sector.[174]
Nuclear Sector Deal	Enable green skills to be transferred across sectors, expand the National College for Nuclear to other regions, provide additional investment into training centres and PhDs, and dedicated careers champions to improve access to work experience opportunities.[175]
STEM initiatives	Increased funding for PhDs in physical sciences, maths, and engineering, as well as improving science teaching.[176]
Institute of technology and regional bodies	Set up more Institutes of technology (IoTs) to collaborate between further education (FE) providers, universities, and employers, offering specialised higher technical education.[177]
Sector Skills Councils (SSCs)	Independent and employer led SSCs to develop occupational standards and skills solutions for their sectors.
Digital Boot Camps	£8 million for digital skills boot camps, and build sector-specific skills, including software development and data analytics.[178]
Energy White Paper	Sets out the UK governments policies and commitments to decarbonise the energy sector, tackle fuel poverty, deliver four low-carbon clusters by 2030 and at least one net-zero variant by 2040. It also highlights a strategy for upskilling through the 'Green Jobs Taskforce' and a National Skills Fund, to be launched in 2021.
NOVUS Trust	Works with universities to provide students studying supply chains with lectures, mentoring, coaching, and placements.

[172] GOV.UK. (2011). *Skills for a green economy: a report on the evidence*.
[173] GOV.UK. (2017). *T Level panels: membership*.
[174] GOV.UK. (2019). *Industry Strategy: Offshore wind Sector Deal*.
[175] GOV.UK. (2018). *Industry Strategy: Nuclear Sector Deal*.
[176] GOV.UK. (2020). *Multi-million government investment in the future of UK science*.
[177] GOV.UK. (2019). *Institutes of technology*.
[178] GOV.UK. (2020). *National Skills Fund.*

Consumer pressure

Growing consumer and investor demand for sustainable products will encourage businesses to adopt sustainable practices across their supply chain.

Progress so far

Improved access to more detailed product information is enhancing consumer purchasing decisions. Eco-labels enable consumers to see which consumer goods are energy efficient, while certifications such as the Forest Stewardship Council (FSC) inform consumers of which products have been responsibly sourced from a sustainably managed forest.

The importance of sustainability to a growing number of customers is encouraging businesses to seek sustainability accreditation, be part of high-profile campaigns, or retail activism. This involves businesses making a stand on certain issues, such as political, societal, and environmental, and being transparent with their customers. For example, Project Ocean, a partnership between the Zoological Society of London and Selfridges, highlights ocean conservation issues to new audiences. Selfridges ensures that all its food halls and restaurants do not serve endangered fish and its beauty products are free from shark-related ingredients.[179]

Smart-phone apps, such as Giki, are supporting more informed consumer purchasing decisions by highlighting a product's sustainability, or a business' environmental, social, and ethical practices. According to Giki, 80% of the people surveyed reported changing products as a result of Giki badges.[180]

Consumers are also using online petitions to drive change. Online petitions can help to build momentum through increasing awareness of issues and reaching a larger audience. For example, a guardian petition calling for Wellcome Trust and the Bill and Melinda Gates Foundation to ditch their fossil fuel investments, received 100,000 signatures within five days of it being launched.[181] As a response, the Bill and Melinda Gates Foundation announced a $2bn investment into renewable technology initiatives (even if calls to divest from fossil fuel companies were rejected). In addition, the petition led to 220 institutions worldwide to divest.[182]

[179] Selfridges&Co. *Project ocean*.
[180] Giki. (2020). *Giki Zero: Press Pack*.
[181] The Guardian. (2015). *Guardian climate change petition reaches 100k signatures*
[182] The Guardian. (2015). *Bill Gates to invest $2bn in breakthrough renewable energy projects.*

Supporting initiatives in place

Figure 15: Supporting initiatives to inform sustainable product choices

Initiatives	Description
Eco-Labels	Eco-labels appear on product packaging to help customers identify and select products which meet their sustainability criteria. Examples include: Forest Stewardship Council, Marine Stewardship Council, and Energy Saving Recommended.
Retail Activism	Consumer values are encouraging firms to take a stand on certain issues and be transparent with their propositions, such as Project Ocean.
Smart-phone apps	Smart-phone apps are serving as a convenient platform to assist customers in making sustainable purchasing decisions. These include apps such as Giki, Thred up, and Think Dirty.
Online petitions	Online petitions are helping to highlight environmental issues to larger audiences. Organizations supporting online petitions include, UK parliament petitions, Change.org. EarthJustice, and Greenpeace.

Alignment and incentives

Some market-based mechanisms are proving successful in encouraging consumers and businesses to reduce emissions. However, the existence of market failures and barriers are impeding progress and risk the UK failing to achieve its net-zero target.

The use of carbon pricing is helping to internalise the cost of emissions, encouraging firms to implement cost-effective mitigation strategies and reduce consumer demand for higher-cost carbon-intensive products. The UK has confirmed that it will establish its own scheme to replace the EU ETS, the first phase of which will run from January 2021 to 2030.[183] While this policy will apply to all UK-based businesses (meeting a set criteria), it will not affect high-carbon imports coming into the UK. While this may reduce competitiveness and increase the risk of carbon leakages, policies such as the allocation of free allowances, are mitigating this.[184] [185]

Investment into the low-carbon economy is signalling to others the government's intent to reduce emissions and meet net-zero by 2050. Subsidies, grants, loans, and tax credits have been effective in increasing low carbon investment by mobilising and catalysing private sector investment and helping to address market failures and barriers. While subsidising renewable energy is necessary to attract finance and

[183] UK GOV. (2020). *New Emissions Trading System proposal would see UK go further in tackling climate change.*
[184] Carbon leakages is when the costs related to climate policies may persuade businesses to transfer production to other countries with looser emission constraints.
[185] CCC and Catapult (2020). *Industrial Decarbonisation: Net Zero Carbon Policies to Mitigate Carbon Leakage and Competitiveness Impacts.*

achieve scale and affordability at speed, the UK spends much of the £12 billion per year subsiding energy from fossil fuels.[186]

Taxes and other environmental policies are being used to reduce resource use and waste. The UK produces an estimated five million tonnes of plastic waste each year, around half of which is packaging.[187] Only 46% of plastic waste is recycled or recovered.[188] The Resources and Waste Strategy set out several initiatives to invoke the 'polluter pays' principle and extend producer responsibility so that producers incur the cost of disposal for packaging. This includes the introduction of the plastic packaging tax, incentivising businesses to use recycled material and be responsible for the collection of plastic waste.[189]

Supporting initiatives in place

Figure 16: Aligning incentives to develop greener supply chains

Initiatives	Description
Resources and waste strategy	Sets out several policies related to the preservation of material resources, minimising waste, promoting resource efficiency, and moving towards a circular economy in England.
UK Emissions Trading System (ETS).	UK Emissions Trading System (ETS), that will set a cap on the total amount of greenhouse gas emissions that can be emitted from certain sectors.
25 Year Environment Plan	Sets out the UK government's goals and legally binding targets, including clean air, clean and plentiful water, thriving plants and wildlife, reducing environmental hazards, using resources from nature more sustainably and efficiently, and minimizing waste.
Measuring and valuing business impact on natural capital	Organisations are supporting businesses in measuring and valuing its direct and indirect and dependencies on natural capital, including the International Union of Conservation of Nature (IUCN).
Consultation on changes to Supply Chain Plans and the CfD contract[190]	The Government is consulting on proposed amendments to the Contracts for Difference (CfD) scheme ahead of the fourth Allocation Round (AR4). In addition, it also proposes further amendments to the scheme in relation to supply chain plans and changes to the CfD contract to encourage the growth of sustainable and efficient supply chains.

[186] EU Commission. (2019). Report from the commission to the European parliament, the Council, the European economic and social committee, and the Committee of the regions. Energy prices and costs in Europe.
[187] Plastics Europe. (2017). *Op cit.*
[188] UK.GOV. (2020). *ENV23 - UK statistics on waste.*
[189] UK.GOV. (2020). *Plastic packaging tax.*
[190] UK.GOV. (2020). *Contracts for Difference (CfD): changes to Supply Chain Plans and the CfD contract.*

What More Needs to Be Done

In addition to the supporting conditions outlined in the preceding section, improved access to more timely, detailed, and accurate information on suppliers, is encouraging and enabling businesses to factor sustainability into their supply chain decisions and activities. Improved data, transparency and disclosures are also enabling informed investors and consumers to choose businesses with strong sustainability credentials.

Despite the positive developments and opportunities highlighted, the reality is that progress is not being made fast enough. **The market is not currently delivering the incentives needed to deliver the required scale and pace of change.**

Improving alignment of incentives to drive behavioural change

Carbon pricing should be expanded. Any expanded system will need to ensure UK industry can compete by applying carbon pricing to goods coming into the UK and should also cover the international supply chains of UK firms. Energy subsidies and taxes will need to be better aligned to drive the required behavioural change.

Behavioural change across the economy is needed to develop ambitious plans to green supply chains, facilitated by aligned incentives which value natural capital appropriately. In such challenging and uncertain times, business will need a compelling commercial reason to invest in the required change, and for society as a whole, change needs to be affordable. Currently, businesses are able to profit at the cost of the environment, while consumers wanting to limit damage to the environment have to pay higher prices to do so. Businesses should be encouraged to account for the value they derive from natural capital and integrate environmental impacts into corporate decision making.

Strong incentives could be applied to business so that materials used in the production process become considerable cost-factors to a business, as does lack of progress on recycling and reducing product waste.

Building on the government's November announcement around mandated climate-related disclosures, businesses need to **set ambitious plans to reduce emissions across their supply chain, with commitments and metrics published on an annual basis.** This will need to be accompanied by increased investment in training to support businesses in planning and implementing their strategies.

This will help businesses to mitigate and limit their exposure to risks and make faster progress in greening their supply chain - providing businesses have access to the affordable skills and technologies they need to do so.

Leadership and management

Setting out the ambitions and actions of the organisation, as outlined above will help management and leaders to drive sustainable supply chain practices within their

organisation. Managers need a clearly designed strategy from which to make operational, staffing, and training decisions, supported by better systems and use of data to monitor skills needs and training outcomes.

The leadership and management skills needed to drive forward change within and outside the organisation, are in short supply. Previous IS Council research estimates that 2.1 million workers in the UK will be under-skilled in at least one core management skill by 2030.[191]

The lack of knowledge on how to mitigate and adapt to supply chain risk as well as developing more sustainable supply chains, is impeding the development of an appropriate and effective strategy. This partly reflects a shortage of skills and expertise within the industry and **more must be done by senior managers to attract people with the right skills or develop them internally through training programmes**.

Alongside this, **managers and leaders will need to align objectives and co-ordinate activities across the organisation to achieve overall sustainability targets**. For example, businesses can change their procurement policy to source more sustainable products and the marketing department can advertise this to attract consumers with those values.

In moving towards more sustainable supply chains, leadership teams will also need to agree when and where to make significant investments to green their supply chain. **Senior leaders will need to make a compelling case to decision-makers and shareholders, highlighting the need for investment in new technologies and skills needed to achieve their sustainability targets.**

Reducing skill shortages

Prior to the Covid-19 pandemic, firms reported a lack of access to the right skills as the number one threat to the UK economy.[192] Despite this, participation in training remained fairly constant, with average hours of training declining since 2011.[193]

More investment is needed in the knowledge and skills needed to deliver more sustainable supply chains. In addition to green design, production, and logistics skills, STEM and digital skills will be highly relevant to the development and adoption of green technologies and the application of data science and automation along the supply chain.

The apprenticeship levy is already supporting the development of new skills within firms and across the supply chain, but as noted in our Annual Report of 2020, the design of the system could be more flexible. While the uptake of levy funds has increased, there is still considerable scope for initiatives which connect larger firms to

[191] Industrial Strategy Council. (2019). *UK skills mismatch – 2030 – research paper*.
[192] Confederation of British Industry. (2020). *Employment Trends Survey.*
[193] Winterbotham, M., Vivian, D., Kik, G., Huntley Hewitt, J., Tweddle, M., Downing, C., Thomson, D., Morrice, N., & Stroud, S. (2018). Employer Skills Survey 2017. Department for Education.

smaller firms to facilitate levy transfers, or improved partnerships between providers and employers. **Making it easier for apprenticeship levy payers to transfer unused levy funds to firms in their supply chain will help deliver the skills needed for greening supply chains.**

Understanding and addressing future skills needs for developing sustainable supply chains will require increased collaboration between education institutions, local government, and business.

Encourage investment in technologies

The move towards greener supply chains will require investment in new technologies and processes, as well as widespread application and adoption of these advancements across industries and sectors. To encourage investment in green innovation, more must be done to tackle the barriers faced by businesses.

Made Smarter technology adoption support, which is currently only available in the North West, should be scaled up to help improve SME supplier competitiveness and reduce emissions, as should the Manufacturing Made Smarter Industrial Strategy Challenge Fund from the current £147 million to boost supply chain innovation. The British Business Bank could also more explicitly support supply chain innovation. New collaborations between governments, civil society and private sector will help accelerate supply chain greening.

The Clean Growth Fund should scaled up to provide more support for the deployment of innovative clean technologies. Venture capital can help to reduce the financial barriers faced by start-ups and high-growth firms. Such support can help firms bring products to market more quickly and achieve sufficient scale to bring down prices and accelerate adoption.

A clear and stable policy vision is also needed to provide certainty on which to base investment decisions. For example, the global maritime survey asked senior global maritime stakeholders for their views around decarbonisation. They found that regulatory uncertainty was the biggest potential barrier to shipping's decarbonisation over the next 10 years.[194] In support of the industry, the release of the Clean Maritime Plan and the Ten-Point Plan set out the government's policies and commitments to increase investment into hydrogen, support research projects for net-zero ships, and explore options to standardise environmental regulations for vessels. These initiatives can provide the vision, stability, and support needed to encourage investment in industries, especially those struggling to meet net-zero by 2050.

[194] Marsh. (2019). *Deep Dive on Decarbonization of Maritime Industry.*