

Supply chain challenges, lessons learned and opportunities

July 2020

1. Introduction

The COVID-19 crisis has put supply chains under severe pressure, revealing both strengths and weaknesses. **Supply chains are complex and refer to the networks between companies and suppliers to produce and distribute specific products.** This network includes different activities, people, entities, information, and resources. The supply chain also represents the steps it takes to get the product or service from its original state to the customer.¹

The engineering perspective on supply chains offers an opportunity to consider wider systemic challenges alongside sector-specific challenges. **It is vital that we understand how these pressures affect the supply chain, so we can confidently navigate our way**

through the remainder of the pandemic and learn lessons for a more resilient future.²

The Royal Academy of Engineering completed an information-gathering exercise across the engineering profession with the help of partners in the National Engineering Policy Centre (NEPC). This exercise posed a series of questions about the current and future supply chain challenges including mitigation efforts and shortages.

This paper draws together the evidence collected through the information gathering and presents a high-level summary of lessons learned and opportunities for transformation, and current and future cross-cutting challenges.

2. Information gathering

Information gathering exercise that was conducted was broken down into three activities, which are illustrated in Figure 1.

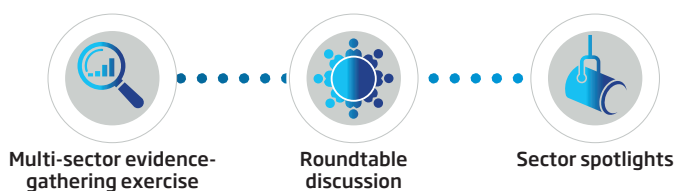


Figure 1

- a. **Current and future challenges gathered from a multi-sector evidence-gathering exercise:** This exercise also captured efforts to mitigate supply chain challenges.
- b. **Gap analysis that emerged from a roundtable discussion on the current and future challenges:** This was attended by representatives with supply chain expertise across sectors.
- c. **'Sector spotlights':** This includes interviews that capture industry expertise in procurement, logistics and finance on the following sectors: food, electronics, telecommunications, transport and energy.

1 Kenton Will. Supply chain. Business Essentials, Investopedia. 2020 February

2 The Royal Academy of Engineering. Engineering a resilient future. 2020 June

3. Multi-sector evidence gathering

More than 60 responses were received, with just over half from large organisations and the remainder from small and medium enterprises (SMEs) and micro-organisations.

See Figure 2. Most responses represent industries in England and Scotland, with nearly all large organisations (c. 50% of respondents) operating globally.³

Inputs came from different sectors including: Energy, transport, food, manufacturing, civil engineering, water and wastewater, construction, oil and gas, nuclear, education, defence, pharmaceuticals, and medical devices.

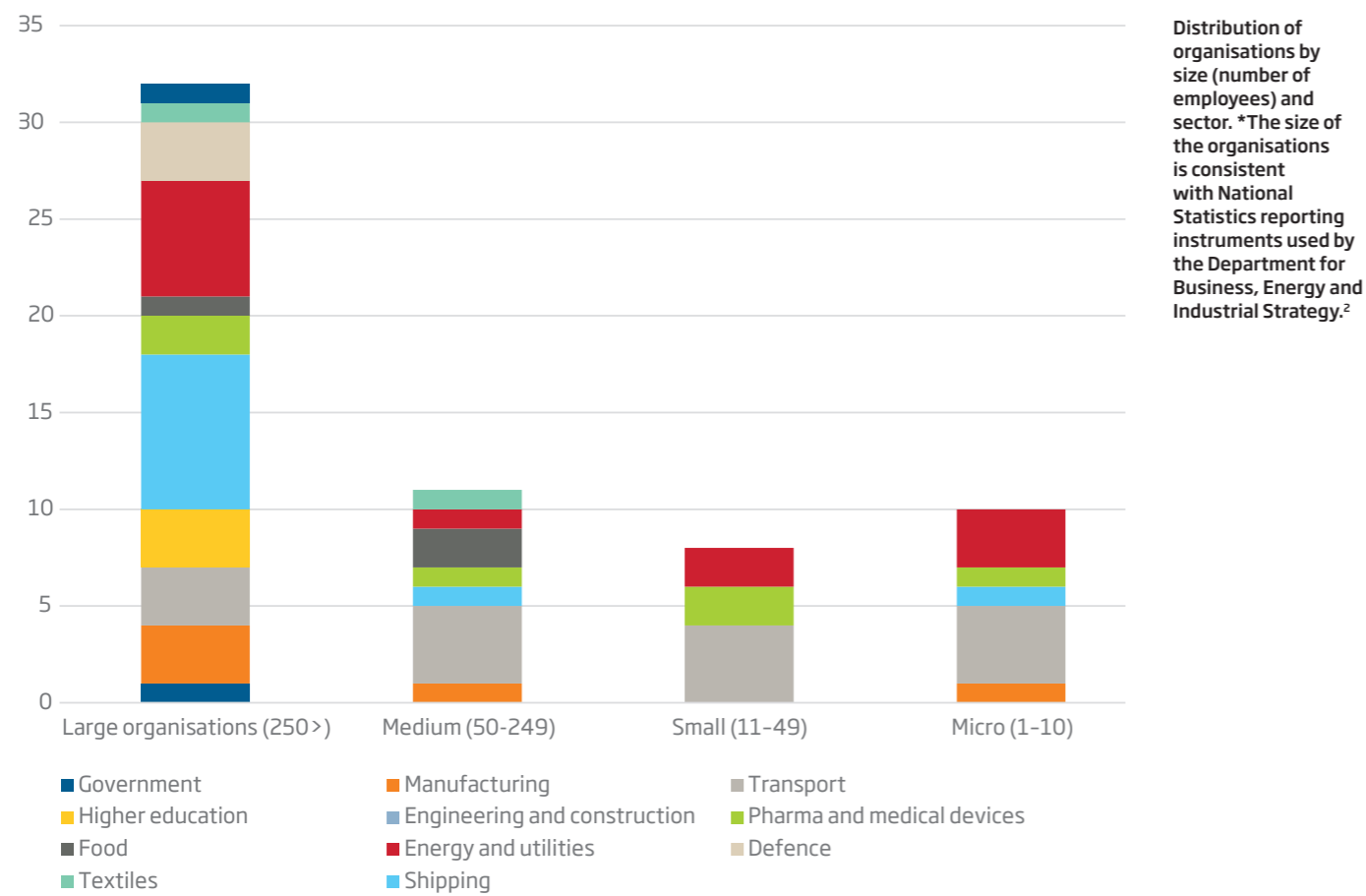


Figure 2 | Organisations by size (number of employees) and sector

³ Categorisations for company size consistent with Department for Business, Energy and Industrial Strategy: Business population estimates for the UK and regions: 2019 statistical release (HTML). 2020 January 14. www.gov.uk/government/publications/business-population-estimates-2019/business-population-estimates-for-the-uk-and-regions-2019-statistical-release-html

4. Influencing factors

Implications of supply chain challenges shared by respondents differ across certain characteristics. These include, but are not limited to, the following:

- Role in the chain:** Disruption passed up and down the chain in both directions: Some companies faced failures due to lack of supplies or credit, while other suppliers faced failure as their clients went out of business or reduced their orders. Supply chain issues are just one element of the wider business continuity challenges arising from or exacerbated further by COVID-19.
- Size of the organisation:** SMEs and micro organisations experienced different challenges to large Tier 1 or Tier 2 organisations.⁴
- Global reach:** Organisations with an international presence experienced a range of supply chain risks, which included blockages, lack of access to raw materials and/or challenges in the wider supply networks (communication, coordination, agility).
- Position in the chain:** There are challenges caused by 'blocked supply chains' where goods or materials are either in short supply or because they cannot be delivered. There may be other critical interdependencies that stop the supply chain functioning at its best. For example, delay in maintenance for critical infrastructure may slow down the whole network in which the supply chain sits.
- Sector:** The nature of the sector and whether the organisation is providing goods or services will influence the demand and response.

⁴ Tier 1 suppliers supply the main company, for example, an original equipment manufacturer and Tier 2 suppliers supply Tier 1 suppliers; Tier 3 suppliers supply Tier 2 and so on throughout the supply chain

5. Lessons learned and opportunities for transformation

Several lessons learned and opportunities emerged from a review of the critical challenges and sector spotlights. These include:

a. **Strength of existing networks:** Existing networks in supply chains are underpinned by existing relationships, knowledge and experience, which make it possible to identify where help is most needed. In the sectors explored in this study, rich networks enabled organisations in the supply chain to identify and successfully address the gaps in the supply of components, services, or skills.

For example, a manufacturer trying to source a component in short supply can be connected to a supplier whose current client base has been reduced by the pandemic. Similarly, these networks can support workforce planning, for example by helping those people with critical skills who have been made redundant to find opportunities for retraining or redeployment. The sector interviews for electronics and the oil and gas sector provide current examples of where these networks have been best leveraged. See Boxes 2 and 3.

b. **Communication around supply chains connected to critical resources and infrastructure:** To limit the impact of a potential second wave of COVID-19 or other shocks on global supply chains, there is a need for clear communication and guidance for industries in the wider network of critical supplies. Critical resources and infrastructure providers were deemed essential and were given clear guidance while others that are

equally important for the smooth running of a supply chain were not given clear instructions. These supply networks include component manufacturers for supplies, transport and logistics, and the workforce. See Box 5.

c. **Building back better and greener:** It is vital that recovery moves us forward not backwards. We need a future supply chain that is more resilient and greener, with a strong capacity for innovation. This will require evolution and alignment of multiple regulatory regimes, and consideration of risk, ethics and security issues. Given the right circumstances, technologies can reduce vulnerabilities yet this will involve regulatory alignment across multiple policy areas that may be affected. For example, a shift to more digitised food supply chain may have implications for regimes that regulate transport, telecoms, health and safety, and more.

d. **Agile responses in a crisis:** To respond quickly and in an agile way during a crisis, a supply chain must be resilient. There are many lessons to be learned from the response to COVID-19, for how to achieve this.

a. The pandemic has emphasised the importance of supply chain networks and how digital technologies can enhance visibility of available capacity across the supply chain. Policy needs to be established to ensure 'critical national capability', which may require changes to operation of some vital manufacturing and supply chains.

b. A diversity of suppliers and timely information about their capabilities can enable pivoting during a crisis and/or in developing new ways of delivering existing supplies. For example, understanding the network of possible suppliers globally can inform alternative plans to source materials. Knowledge of how suppliers, for example, have found new ways of transporting goods can also demonstrate the different stages of the supply chain where innovation is taking place.

c. Although supply chain efficiency over the last decade has led to productivity, consolidation of supply has, in some cases, led to one supplier becoming a single point failure. The crisis has exposed how challenging it is to pivot away from such failures without a diversity of suppliers to draw upon. Having a diversity of suppliers and up-to-date information about their capabilities can enable pivoting during a crisis.

e. **A systemic, sector, sub-sector and firm level view:** Understanding the supply networks at a systemic, sector and at a sub-sector level is required. With information at a systemic level, we can understand how shocks propagate to other parts of the system and how multiple disruptions are caused. A sector view can capture factors affecting stakeholders in relation to a product or service. It also is sensitive to industries (supply side) and markets (demand side) that share similar characteristics. A sub-sector view can inform how these shocks and disruptions affect organisations at a firm level. These are nested within one another as shown in Figure 3.

For many firms and organisations, the challenges are wider than the supply chain itself and require understanding of how value is created at different stages.

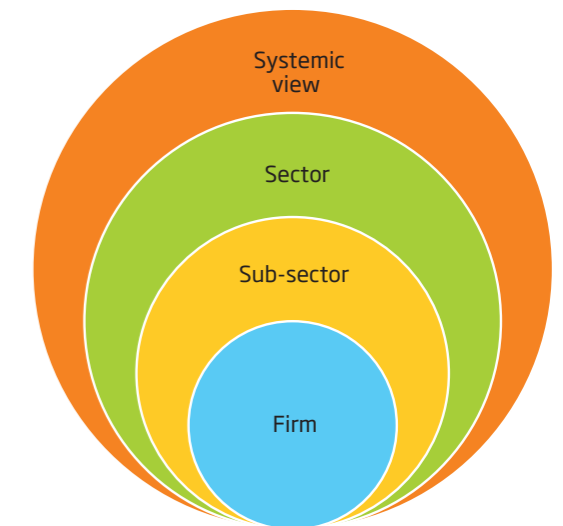


Figure 3 | View from systemic, sector, sub-sector and firm level

6. Cross-cutting challenges and sector spotlights

The following section presents results from the information-gathering exercise on cross-cutting challenges that have disrupted supply chains since the pandemic started. Sector spotlights listed in Figure 4 illustrate the wider points.



Figure 4 | Sector spotlights

NOTE: This paper does not give an exhaustive account of difficulties and strengths across each sector. It instead includes several 'sector spotlights' to illustrate cross-cutting challenges and experiences. These were chosen in consultation with government partners based on critical services and supplies that need to be delivered despite the continued challenges the pandemic presents and are presented in section six.

- a. **Trends in cash flow** were raised in nearly half of all responses to the information-gathering exercise (oil and gas, automotive, power and aerospace, design and manufacturing). In design and manufacturing, an increase in customer requests for longer repayment time frames and/or severe drops in demand led to significant cash flow issues. This also inhibits inventory-holding upstream by the original equipment manufacturer (OEM).
- b. **Uncertainty about social distancing** in workplaces and its implications on workforce availability, due to restricted travel or shielding/isolation, was a concern for construction, manufacturing, energy, and transport. For construction, the gradual lifting of lockdown required clear guidance on how to implement social distancing safely for workers. For manufacturing, the application of social distancing in the workplace on an ongoing basis will present capacity constraints if demand is to be maintained. How social distancing is currently being implemented and shifts, for example the move from 2 metres to 1 metre over the medium term, and how demand evolves in the coming months have to be monitored to inform future plans.



SECTOR SPOTLIGHT | ENERGY

Social distancing and implications for staff health from the offshore wind sector

This perspective highlighted supply chain challenges related to the availability of the workforce, ensuring the health of the workforce, and maintaining certifications of staff. Different stakeholders within the sector shared concerns about the health of staff and maintenance of the network, including issues such as:

- **Moving existing staff and deploying new staff** (developers, OEM personnel, CTV operators, drone inspection providers)
- **Monitoring the health of staff** (service providers, developers, CTV (crew transfer vessel) operators)
- **Validity of staff certification** (developers, CTV operators)
- **Monitoring available resource** (OEM personnel access systems, CTV operators, developers)

Managing the health and certification of the current workforce is a significant factor in ensuring maintenance of the network. These challenges are linked as the availability and safety of a healthy workforce is critical for carrying out maintenance and smooth operation of the network.

In anticipating future challenges, a potential second wave could have implications for the workforce, resulting in delays to maintenance of energy networks. Over the next couple of months there will be a widening gap in skills that will need to be urgently addressed. In the interim, opportunities for more imaginative and flexible arrangements for fast-tracking remote inspections and granting exceptional extensions to certification as the lockdown lifts may help meet immediate health, safety and maintenance needs.

- c. **Shortage of PPE and testing** was raised by many sectors including, but not limited to, oil and gas, pharma and medical devices, construction and utilities. For oil and gas, for example, the unavailability of PPE prevented provision of site-facing services to clients, who were themselves facing challenges in supply, which delayed the restart of businesses. Pharmaceutical and medical device sectors worldwide continue to have shortages in PPE supply in healthcare settings.



SECTOR SPOTLIGHT | ENERGY

Navigating uncertainty and mitigating testing and PPE challenges from the oil and gas sector

The oil and gas sector developed guidance for mitigating a lack of PPE and testing in the wake of uncertainty. This included:

- **Development and dissemination of guidance** for testing offshore workers for COVID-19 in the first six to eight weeks of the lockdown. This helped to identify those in the workforce who were asymptomatic and prevent offshore transmission of COVID-19, by implementing social distancing and use of PPE where available.
- **Putting in place protection corridors** to safely move people from their place of dwelling to work and vice-versa.

Future challenges include delays to planned maintenance and overhaul of 50% of the platforms that feed the network for the North Shore pipeline, as well as shortages of available helicopters and crew to deliver materials to sites across the platform.

d. **Issues with restricted access to supplies** from China, the US and Europe were shared by the automotive and aerospace sectors as an immediate challenge in the first weeks of the lockdown. This included reduced access to resources and supplies related to freight and trade restrictions.

There is uncertainty about how Brexit will affect the quantity and affordability of supplies, which depends upon the strength and scope of any deal secured post the UK's departure from the EU (including but not limited to supplies for manufacturing, aerospace, food).



SECTOR SPOTLIGHT | ELECTRONICS

Best practice and importance of networks from electronics

The electronics sector shared some of the following challenges since the onset of the pandemic, related to a mismatch in supply and demand of materials and skills:

- **Precision engineering was in high demand** by several companies who had to furlough staff. There was also a shortage of precision engineering personnel as those available witnessed their demand rise significantly. Mitigation included evidence gathering through networks to source expertise and share contacts to meet rising demand.
- **Products that required materials from a single manufacturer** were particularly vulnerable if that manufacturer could not source raw materials. The decline in availability of metal components from Asian markets in the immediate lockdown is an example of how single sources for raw materials, as well as single manufacturers, are particularly vulnerable to global shocks.
- **Shortage of raw materials** such as refined cobalt for magnets and lithium ion batteries (which are needed for radar systems, radiotherapy systems

Manufacturers have shared concerns related to increased freight costs during the current lockdown and anticipate similar cost increases resulting from Brexit. If these cannot be mitigated, there will be some shortages of goods for consumers. Volatility of exchange rates are also wider concerns as many countries go into recession, as geopolitical tensions rise and economic recovery is navigated.

and battery-powered products) is anticipated to be a big challenge in the future. Identifying ways to source these materials over the next months will be critical given that most of the refined cobalt is processed in Asia and there is a possibility of further global lockdowns. **Cobalt is an example of an essential raw material that will remain a supply risk and will require careful planning and mitigation to sustain production of finished products.**

- **Clarity on 'critical' versus 'non-critical':** Providing clarity to companies beyond those categorised as 'critical' or 'essential' on whether they need to stay open is needed. This may require more information about how different sectors' supply chains are connected to critical systems.

An example of good practice and effective mitigation includes:

- **Sharing information across networks** to route manufacturers reliant upon specific components to new suppliers. The situation is currently stabilising and there are success stories of how members within the supply network have been able to share information and learn through this experience. These networks are having conversations about anticipated challenges and mitigation measures for future scenarios.

e. **Demand drop for products and services** (transport, aerospace, construction). For example, the lockdown resulted in a sharp drop in demand for national rail services and local public transport. Uncertainty about

future demand as social distancing is established as a new normal and perceived safety of public transport will influence future demand.



SECTOR SPOTLIGHT | TRANSPORT AND LOGISTICS

The role of SMEs supplying the aerospace sector

Many suppliers to major manufacturers are taking this time to adjust their own demand and output schedules. Where major aircraft manufacturers have experienced reduced demand, there will be SMEs within this supply chain whose demand has also plummeted. Cost-saving measures are in place and many businesses are using cash reserves to stay afloat. These measures adopted by suppliers cannot guarantee their long-term survival. Long-term liquidity to ensure firms can continue to operate at reduced demand levels is paramount to the survival of many SMEs. Alternatively, an indication of future constricting of the supply chain and/or sector must be communicated early.

Many suppliers fear the long-term impact on the aerospace sector related to a range of factors: The impact of social distancing; different international quarantine rules; consumer confidence in travel and the wider economic situation; and change in ways of working, for example working from home or virtual meetings. All of these may reduce future demand for business travel and flights.

While many large manufacturers have the means and expertise to prepare, smaller SMEs may need support.

There are benefits to cross-manufacturing sector collaboration, which will be particularly beneficial to SMEs on workplace issues such as implementing social distancing on the shop floor and meeting PPE requirements. Protecting the workforce is a business priority and sector guidance on what level of PPE equipment workers should be using is needed as there are varying levels available and are often in short supply. Managing the PPE supply chain is a concern, particularly if government mandates PPE usage in the wider public.

Some companies are uncertain as to whether they can adopt social distancing measures as short-term emergency measures, or whether to accept that this is an inevitable inefficient permanent fixture albeit a safe mode of operating until a vaccine is in place.

Advanced notice of changes in lockdown measures is also vital to allow companies time to plan and communicate necessary changes to employees. For companies it would allow time for changes to working practices to be implemented and provide an indicator of certainty to firms that are currently making difficult decisions around workforce planning and long-term projects.

- f. **Changing patterns in deliveries, logistics and procurement issues:** Defence respondents considered a reduced level of industrial activity to be related to a range of factors including: logistics challenges, availability of workforce, and containers

having insufficient supply to justify regular shipments. For defence, sourcing materials is not a current problem, but an extension of lead times related to a potential second wave and/or Brexit could lead to cascading problems including delay to projects.



SECTOR SPOTLIGHT | TRANSPORT AND LOGISTICS

Changing consumer demand patterns and innovation in warehousing

Logistics covers large swathes of goods produced by manufacturers for retail, electronics, and many other sectors. Some sectors, such as food, are well understood with strict processing and hygiene standards. Specialty goods, such as automotive or some chemicals, will have a specific logistics and warehousing chain that is point-to-point and vertical. This means the end-to-end chain is overseen by the producer.

- For many retail goods and electronics, logistics and warehousing services include supplying different goods to a variety of retailers, where the workforce is largely unskilled and requires limited specialist training. In a pandemic, forecasting the volume of these goods at any point requires accuracy and speed to generate a profit. For some sectors where the profit margin is 1% or 2%, being able to forecast accurately is critical.

- The surge in online purchases during the pandemic has resulted in a parallel surge in online returns. Even with data analytics, it is challenging to predict the volume coming in and out of warehouses at any given time. Many of these processing warehouses are only paid if they can process the return within 24 hours. The small margin and short processing times require accurate predictions of stock and supplies, the ability to innovate in how space is used in warehouses, and an understanding of where equipment is fixed versus flexible so that staffing levels can meet demand.
- Innovation capability is dependent on developing appropriate skills, knowledge of networks and behaviours throughout supply chains. It is also dependent on the effective transfer of knowledge from universities to businesses. These points are particularly important in the context of firms operating in the logistics service provision (LSP) part of UK supply chains.

- g. **Responses to the pandemic are putting strains on our critical national infrastructure:** Telecommunications has enabled agility and adaptation across all sectors. The shift to widespread remote working has been reliant on continuous

broadband provision. The trend towards digitalisation of many critical sectors has placed greater attention on potential vulnerabilities of critical infrastructure such as telecommunications, which can be influenced by security, resilience and innovation.



SECTOR SPOTLIGHT | TELECOMMUNICATIONS

Greater visibility of the 5G supply chain during the pandemic and wider systemic challenges

Recent attacks on cell towers point to public concerns about the safety and security of 5G networks. Many towers that are not 5G enabled in the UK were also attacked because of the spread of misinformation on social media and other channels. This response has reinforced the vulnerability and criticality of telecommunication infrastructure that is essential for connectivity prior to and during a time of great need.

Over the last 10 years in the UK there has been a consolidation of telecommunications suppliers, which has led to an aggressive decrease in prices and a scramble to be the cheapest network. With a limited number of suppliers, telecommunications face challenges to resilience, innovation and security. While these are not direct effects of the COVID-19 pandemic, increased public awareness of the importance of critical infrastructure could drive discussion around opportunities for public investment to develop and protect telecommunications.

Resilience and innovation

With a limited number of suppliers, telecommunications run the risk of dependency on other countries who supply or operate different parts of the network. Innovation in the network is a critical component of building resilience to risk.

In order to have a flourishing community of vendors supplying telecommunications equipment, there needs to be stronger scale-up opportunities in the UK. There are telecommunications startups in the UK, but there are limited opportunities for scaling innovations. For this to occur, the path for scaling innovations needs to be more firmly supported through UK industrial policy and mechanisms to support early- to late-stage development.

Security and skills

There is a need to reinforce security of telecommunications networks that is 'aggressively pragmatic', which goes beyond concerns around Huawei's 5G network raised in the press. For example, one option would be to strengthen technical capabilities that enable remote monitoring and maintenance of existing telecommunications. Whether it is Huawei, Nokia or Ericsson, there are many reasons why security will vary from one network to the another, and skills is one area that needs attention.

The skills gap for UK engineers in these networks has led to mobile operators functioning as marketing providers: They outsource these capabilities to Europe, China and India. Education and skills for equipping engineers working on critical infrastructure such as telecommunications must include robust training on security, data privacy and ethics as core requirements (as opposed to its elective status).

h. **Current regulation is not equipped for innovative solutions. Data-sharing can enable closer alignment of multiple regulatory regimes.**

As digitisation of sectors evolves, agile regulation will require data sharing between departments

that oversee multiple policies and issues ranging from health and safety, transport and logistics to telecommunications. This will require efforts among regulators to share information and develop regulatory regimes that can account for cross-cutting issues.



SECTOR SPOTLIGHT | **FOOD SECTOR**

Data sharing across the food supply chain and integrating regulatory regimes

In the food sector, networks had to be quickly reconfigured to cope with a huge COVID-19 related shift in demand patterns at the retail end of the supply chain (for example increased demand for product in shops and online, with a plummeting of demand from restaurants and other food service firms). As lockdown restrictions are lifted, the profile of this demand will change, and supply chains will need to adjust to reflect this. The food and drink sector has broadly held up, yet the pandemic has drawn attention to different parts of the system that can be strengthened to enable supply chains to respond to future shocks.

As lockdown is lifted, there is greater need for enhanced UK shipping company capability to ensure **protected supply chains for food**. One step toward this could be a digital interface that maps and strengthens understanding of connectivity and bottlenecks in supply chains. This could inform a national programme of innovation and acceleration of activities to scale UK capability and growth, upskill supply and demand, and reduce carbon emissions alongside national growth. With the challenges related to dependency on seasonal migrants, there are opportunities to automate food and vegetable picking using robotics, which could help to reduce vulnerabilities. For this to occur, security of

telecommunications, data sharing by stakeholders in the supply chain, and integrating regulatory regimes for data sharing, food and telecommunications need to be examined more closely.

Sharing data and information in the immediate term can also provide valuable lessons to other areas of the COVID-19 response, potentially for distribution of a vaccine. This will require significant efforts in procurement, logistics, storage, and delivery. Development of these capabilities, alongside vaccine research, is a necessary step. How can lessons learned from the food sector's cold chain contribute to future deployment of a vaccine? Globally, the cold chain is underdeveloped (approximately 10% of the required cold chain in some developing nations exists with 25% of many temperature sensitive foods lost). Vaccine cold chains are by no means comprehensive and up to 25% of vaccines in the developing economy are wasted because of the lack of a suitable cold chain. This frames an important question: **"How will we distribute vaccines across the planet in the shortest possible time, using the existing cold chains?"**

The critical need to distribute large quantities of vaccine and test kits in the future may require the requisition of cold chain assets from the food/pharma supply chain. It is possible that this reallocation of assets may be required at a time when the driver pool has been diminished by illness-related absence.

7. Summary

This section summarises the value in conducting this high-level view of supply chains.

- **Shared learning for better preparedness:** Understanding the supply chain vulnerabilities that emerged early on and throughout the lockdown offers opportunities to capture and share lessons to better prepare for future shocks, which could include a potential second wave of COVID-19. The engineering perspective has provided a context for considering the wider systems and networks of supply chains, which factor in how different sectors and sub-sectors are connected. Examining different sectors will show lessons that can be shared across the engineering profession and across the different systems.
- **Capturing sector examples and case studies:** Where respondents provided insights on critical challenges, mitigation mechanisms and opportunities to build back better, these lessons have been documented to inform the policymaking process. The food sector's experience in responding to sharp increases in demand early on reflects knowledge within the supply chain's network and can inform future efforts to respond to future shocks and/or inform efforts in other sectors. The offshore wind sector's experience of developing guidance in response to limited PPE has led to resources for ensuring the health of the workforce. The pandemic has also inspired efforts to maintain certifications of staff in new ways in the offshore wind and oil and gas sectors.

- **Creating networks:** This understanding of supply chain challenges also shines light on how industry has responded to reduce uncertainty, develop networks for components and skills, and share good practice. The electronics sector's example demonstrates how members within the supply network have been able to share information and learn through this experience to not only source materials in short supply, but to generate relationships for addressing future challenges and mitigation measures for future scenarios.
- **Technological innovation:** The crisis has also created opportunities for innovation and technology adoption that could be supported by policy decisions. The transport and logistics sector shows how innovation capability in forecasting demand is dependent on developing appropriate skills and behaviours throughout supply chains. It is also dependent on the effective transfer of knowledge from universities to businesses. The telecommunications sector, which has been critical in enabling many operations to become fully digital during the pandemic, shows that future strategies for growth must address closing the skills gap and foster an ecosystem that enables stronger scale-up opportunities.

8. Emerging themes and questions

Three strategic themes emerge strongly from the evidence collected in this short study. These themes generate questions that should be considered in future capacity and resilience planning.

- **Communication:** Communication across the supply chain network needs to be effective and capable. This is increasingly IT based with uptake of video conferencing and virtual uptake. To tackle questions regarding future capacity and resilience, will a strategic overview to communication be taken?
- **The role of regulators** in the market as critical stakeholders whose influence has implications for innovation in both products and processes. This may demand something of a culture change: How can this be enabled?
- **Enabling sector knowledge sharing:** Manufacturing and production will vary from sector to sector. How can we transfer learning within and between sectors? Lessons learned from the food

sector's cold chain, for example, could be valuable in future deployment of a vaccine. Automation across many different sectors could also play an important role, however, 'it' must take into account different business models and different ways in which companies operate together with their respective stage in the response to COVID-19. For example, some companies are in the survive stage rather than the thrive stage. How can efforts like this enable or support companies in future resilience planning without getting in the way or putting unnecessary additional pressure upon them?

It is vital that we understand pressures that affect the supply chain, so we can confidently navigate our way through the pandemic. Capturing lessons such as how networks have responded and where communication has been integral can help us not only prepare for future shocks, but foster opportunities for more imaginative approaches to building back a greener, more resilient future.



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Further details about this project please contact

nepc@raeng.org.uk

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Royal Academy of Engineering
Prince Philip House
3 Carlton House Terrace
London SW1Y 5DG

Tel 020 7766 0600
www.raeng.org.uk
@RAEngNews

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