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Observatory

MIDLANDS ENGINE SUPPLY RESEARCH REPORT INDUSTRIAL SUPPLY CHAINS

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Leveraging supply chains to create competitive advantage for the Midlands region:

A systematic review



BACKGROUND

This report is based on research conducted by WMG Supply Chain Research Group (SCRG), University of Warwick as a part of the 'Supply Chain Analysis' programme funded by the Midlands Engine.

The aim of this project is to provide a holistic view of industrial supply chains in the Midlands region and identify potential practice and policy interventions for building a clear pathway to increased sustainability, productivity and prosperity.

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60 second overview

Supply chains (SCs) have their roots in manufacturing, and is the glue that links all firms in the business to deliver value to end customers through operational synergy. Industry has long recognised that ‘it’s SCs that compete not individual firms’. This is especially true when it comes to solving the productivity puzzle in the UK, an issue that is caused by the ever-widening gap between firms/regions. If firms can collaborate and cooperate towards the improvement of SC productivity (the aggregated productivity of all entities across the end-to-end (E2E) SC), then the regional productivity can be improved and sustained in the long term.

Global disruptions such as COVID-19 and Brexit make it more difficult to achieve this goal, as it requires a high level of resilience (an ability to bounce back after external disruptions). In simple terms, SC resilience and productivity are interlinked and, if done effectively, can enable firms to retain operational continuity (high resilience) to deliver value to end customers at the lowest possible cost (high productivity).

Our research (a Systematic Literature Review (SLR) and two interactive workshops) focused on exploring how the Midlands region can compete through SCs to create sustainable competitive advantage.

Our findings show that the region faces four critical SC challenges in the current setting: the shortage of resources (i.e. skilled labour, financial investment and infrastructure) in the physical SC network, and the three ensuing issues – visibility, integration and sustainability within the supply chain management (SCM). Without effective solutions, these challenges can significantly inhibit the SC resilience of the region and therefore undermine the overall productivity.

To improve the region’s SCs, we have provided a set of practical and political considerations. At the firm level, there are six SC resilience practices – planning, visibility, collaboration, buffer management, supply flexibility and adaptability, which can be adopted to create a high degree of SC flexibility in terms of SC network configuration and SCM. The key to this is to build SC integration within and across SC entities, so that business activities can be managed by taking a coordinative approach.

At the regional level, local enterprise partnerships (LEPs) and the Midlands Engine can take a coordinator role to leverage resources across different stakeholders (i.e. government, academia and funding agencies) to provide support around SC investments, skill upscaling (particularly expertise around SC planning and management and digital adoption), and infrastructure development (both physical and digital). To grow sustainably in the long term, the adoption of a Circular Economy (CE) provides the biggest opportunity to tackle rooted issues, such as resources sacrifice and carbon emissions, by encouraging the reuse, remanufacture and recycling of existing materials, rather than mining from the ground.

The report is structured as follows. We first highlight the productivity and resilience problems facing the Midlands region and the role that the SC can play. Then we provide an overview of the current state of regional SCs by identifying the key stakeholders and issues/challenges within the current ‘system’. Following this, a set of recommendations is developed to lay out multiple considerations for the development of the region.

Executive summary

Productivity and resilience in the Midlands region – Why the supply chain matters

Since the Global Economic Crisis, the UK has faced a ‘productivity puzzle’. Whilst other countries have experienced a productivity slowdown, the decline in the UK has been more dramatic. The key to solving this problem is to bridge the widening gap between firms; large global frontier firms are often more productive whereas non-frontier firms (i.e. small- and medium-sized enterprises (SMEs)) are less productive. This variation completely undermines the productivity improvement at the country and region levels. Compared with other regions, the productivity of the Midlands region is lagging behind as it has the longest tail of low productivity firms.

To improve the regional productivity, the SC plays a critical role in bridging the productivity gap between the large firms and SMEs. This requires firms to focus on improving the productivity of the entire SC, in which everyone’s productivity is considered and improved through joint commitments. Following the disruptions of Brexit and COVID-19, the importance of SC resilience has been well recognised (e.g. panic buying during COVID-19 and new Customs processes under the Brexit deal). Having a high level of resilience ensures operational continuity, which, if done effectively, can help firms retain productivity advantages during turbulent times.

Defining supply chain and its value

When considering the value that SCs add to the region at the firm level, a resilient and effective SC can reduce costs, which in turn increases profits and, ultimately, competitive advantage. A resilient, effective SC is also beneficial at a regional level, creating social value through skill development and employment opportunities, attracting more foreign direct investment (FDI) and therefore boosting regional productivity and generating more economic value. To build cooperation between regional and firm levels, a ‘regional SC goal’ could be established. This could be a regional SC productivity goal, comprised of the aggregated productivity of individual firms across E2E SCs. This goal could be used to enable collaboration and cooperation between firms in the region, to compete through the region’s SCs rather than individual firms.

Current state of the regional supply chains

When disruptions occur, an SC is only as strong as its weakest link. This was exemplified by the two major disruptions that affected the Midlands in 2020 – Brexit and Covid-19 – which continue to generate extra costs and reduce market opportunities, with devastating effects for firms with limited resilience. This study identifies that the region currently faces various challenges in both the physical SC network and the way it is being managed (supply chain management (SCM)).

Within the SC network, multiple resource issues were identified which include shortage of skilled labour, lack of SC investment, poor cash flow, early adoption of digital infrastructure, outsourcing to low cost countries, and low variations in customer and supply base.

From the SCM perspective, visibility, integration and sustainability are the key challenges in managing the regional SCs. Poor visibility was caused by limited access to real-time data and underdeveloped digital capabilities. A low level of SC integration was found as most firms are organised by business functions, which creates many silos in the SC that create barriers to

forming integration within and between SC entities. Sustainability issues were caused by trade dependency (increasing carbon footprints) and a linear business model (material reuse and recycling are overlooked).

'Build back better' – The changing nature of manufacturing

To help the Midlands region and its businesses rebound from the current SC disruptions and protect them in the future, a set of recommendations has been provided from both a firm's and a region's perspective.

At firm level, six *SC practices* are proposed to create structural and dynamic flexibility in response to disruptions at different stages.

- Before the disruption occurs, *SC planning* and *visibility* are required to enable effective co-ordination with customers and suppliers to mitigate potential changes that may impact demand or supply.
- During episodes of disruption, *buffer management* (rightsizing capacity, inventory and time) is an approach which could be used to better cope with SC disruption, enabling firms to respond to fluctuating demand or supply more effectively. SC reconfiguration could also be used to develop *supply flexibility* in SCs. Right-shoring (i.e. creating a local supply base) should be considered as a long-term strategy for different approaches to this practice.
- Finally, having *adaptability* (the ability to transform the SC to meet dynamic demands) will empower firms to reconfigure the physical SC network in case of disruption.

Building resilient SCs in the region requires a co-ordinated approach across a range of stakeholders to provide the financial support, skills development, regional SC collaboration and public policies to enable the region's SCs to deliver economic and social value. In all cases this requires stakeholders to work together.

- The region also has a role to play in co-ordinating and leveraging skills development across the region, to create a holistic offering that focuses on SCs and not just firms.
- Skills development can be achieved by an integrated skills development system across the region. Core skillsets, such as SC planning, modern manufacturing management (particularly flow management and lean/agile production) and data analytics, are essential to support the improvement of manufacturing productivity in the region.
- Government support is required to underpin investment in new infrastructure to enable better connectivity, both physically and digitally.
- Financial support from central government needs to be provided to the region through incentives to encourage the development of new technologies, particularly in energy and high-value manufacturing.
- Finally, the biggest opportunity of all comes from the region considering the benefits of being at the forefront of the Circular Economy (CE) (i.e. reducing the consumption of primary materials), and focusing on the opportunities of repair, reuse and remanufacture as well as primary manufacturing.

Introduction: Productivity and resilience in the Midlands region – Why the supply chain matters

Key to solving the UK's productivity issue is to bridge the growing gap between firms...

Productivity (growth value added per employee) is a key economic indicator to measure how a country/region/industry/firm is performing against its peers. Since the global economic crisis, the UK's productivity has grown at a lower rate than other EU countries, such as Germany and France, which has attracted enormous attention to solving this so-called 'productivity puzzle' [1]. The widening gap between large global frontier firms and non-frontier firms (SMEs) is the root cause of the productivity decline, which drives regional disparity in this country. Outside London, most cities have been underperforming, with no exception in the Midlands region (15% below the national average productivity in 2018), which has the longest tail of underperforming firms [2].

Regional disparity between the West Midlands and East Midlands presents growing opportunities...

The Midlands region is known as the home of large manufacturers in the automotive and aerospace sectors, which include many global frontier firms, e.g. Jaguar Land Rover, Rolls-Royce, and Bombardier. Such a strong manufacturing base makes the region the top contributor (generates 16% of outputs, i.e. higher than the average of 10%) to the UK's manufacturing. Within the region, a disparity gap was found between West Midlands (6th in the national productivity ranking) and East Midlands (10th in the national productivity ranking) [3]. However, this does not simply mean that the former is better than the latter, especially during this turbulent time.

- In the West Midlands, the top three subsectors of manufacturing are transport equipment (36.8%), metal products (15.4%) and machinery equipment (10.8%) [3]. However, such an industry structure makes the region less resilient when faced with external disruptions, such as the automotive and aerospace being hit the worst by COVID-19 last year [4]. Moreover, those sectors tend to have SCs that span multiple countries, and this has been significantly affected by Brexit [5, 6]. Although the West Midlands has high productivity, the level of resilience is low due to the density of heavy manufacturing (i.e. more capital intensive and less consumer oriented).
- In contrast, the East Midlands has relatively lower productivity but high resilience due to a high level of sector diversity, including food and drink (22.9%), transport equipment (12.2%) and rubber, plastic and non-metallic minerals (10.8%) [3].

The emergence of Brexit and COVID-19 has presented both challenges and opportunities. Now is a critical time for the Midlands region to take stock and consider how it can grow towards increased resilience and productivity as a whole. This is where the SC plays a critical role in linking the development goal at the firm and regional levels; therefore, our research (an SLR and two interactive workshops) focuses on:

- Understanding the value created by the SC at both the firm and regional levels
- Identifying the operational challenges/issues in the current regional SCs
- Developing a set of practical and policy recommendations for the future regional growth

About our methodology

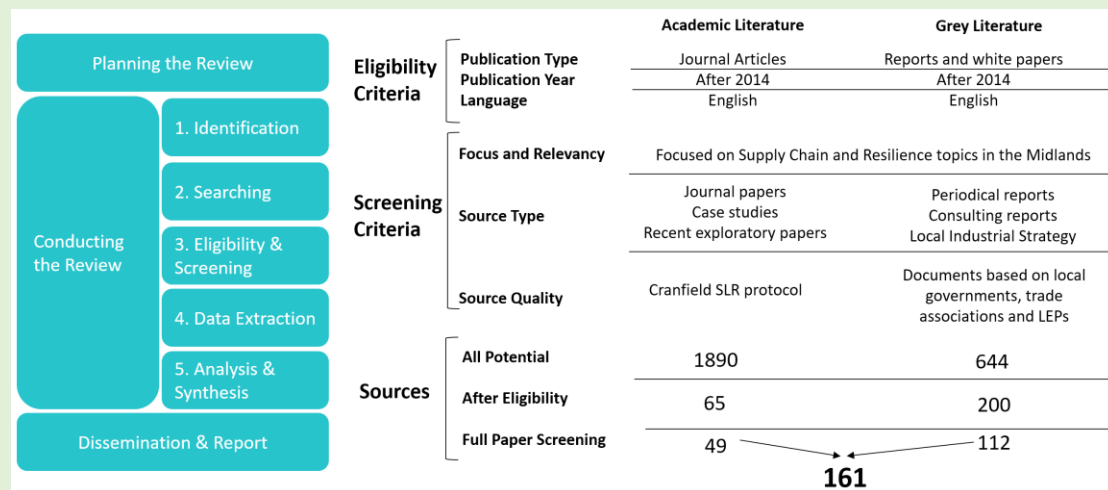
To provide a holistic overview of industrial SCs in the Midland region, the WMG Supply Chain Research Group (SCRG) has conducted a systematic review project, in which a four-stage approach was adopted.

Stage 1: Mapping the industrial landscape in the region

Establishing an overview of the region by conducting background research and identifying key stakeholders in the region.

Stage 2: Evidence gathering

Two work streams (a systematic literature review (SLR) and an interactive stakeholder workshop) were carried out to understand the current state of the regional SC from six perspectives: value creation, vulnerabilities, de-risking, building resilience, governance and public policy options.



Note: A list of papers is included in Appendix 1.

Figure 1. A five-step SLR approach was adopted

Stage 3: Analysis and synthesis

Both descriptive and thematic analyses were conducted to draw insights from the SLR and workshop.

Stage 4: Validation

Findings were presented to the regional stakeholders for feedback.

Overview of supply chain research within the region

SC research by a range of different stakeholders in the Midlands region has grown significantly over the last eight years (Figure 2).

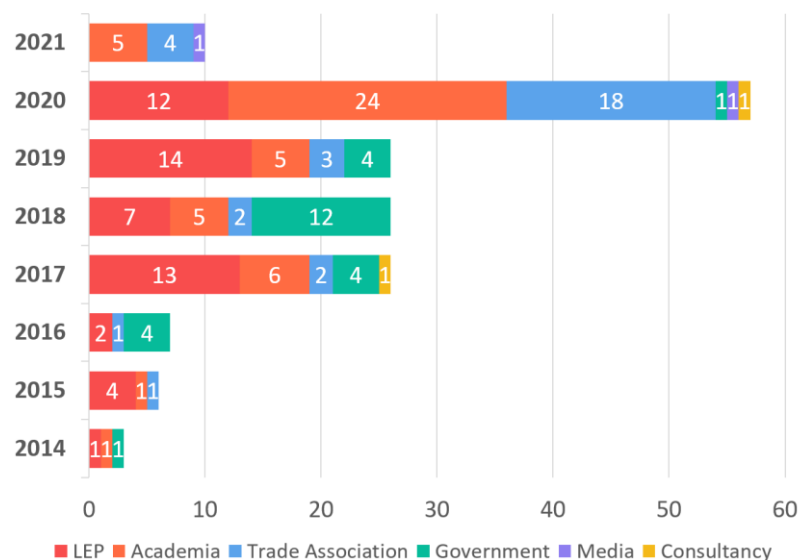


Figure 2. Regional SC research by organisation type and year

Through an SLR, 2,504 publications including academic (i.e. journal publications) and grey (i.e. white papers and reports) literature were initially identified that generally discussed SC in the Midlands region. After the screening process, a total of 161 papers were located for the analysis. Authorship was predominantly by LEPs, academics, trade associations and government.

As the study aims to provide a holistic view of the regional SCs, considering the implications of recent major disruptions (Brexit and COVID-19) on regional SCs, the located studies cover the timeline from 2014 (one year prior to the Brexit referendum) until 2021.

In the first three years, the number of publications remained low with less than ten publications each year. In 2017, the publications started to increase sharply to 26/annum. This could be in response to the launch of the 'Industrial Strategy – Building a Britain Fit for the Future' [7] in November 2017, in which industrial SCs were posited as a key enabler. The result of the Brexit Referendum in 2016 could also be considered as a catalyst for increased interest in SCs as the region started to consider the implications of different Brexit scenarios.

In 2020, the COVID-19 pandemic caused unprecedented challenges to businesses all over the world. Global SCs were severely affected from both demand (i.e. volatile demand) and supply (i.e. operations shutdown and supply shortage) perspectives. Exacerbated by the pending Brexit deadline, much attention was focused on the region's SCs, and this is reflected in a doubling of publications to 57 in 2020. The trend has continued into 2021, with 10 publications in the first quarter.

90% of studies focused on industries that have a physical SC; 19% of studies were sector deep dives, including automotive, manufacturing, construction and food. This report focuses on providing a holistic overview of manufacturing SCs in the Midlands region.

Defining supply chain and its value

Three lens through which to view SCs...

SC has its roots in manufacturing, which is often understood as a **network** that connects multiple entities in a business to turn raw materials into final products that can be delivered to end customers (Figure 3) [8]. Within the SC, firms are connected by **flows** of material, cash, information in terms how they pass on materials to each other, how the payment works and how the information is exchanged [9]. Within each firm, the SC should be managed as an E2E business **process**, which facilitates general management and decision makings around four functional areas [8]:

- *Plan* – demand forecasting, sales and operations planning
- *Source* – purchase resources from external suppliers to support internal operations
- *Make* – turn raw materials into deliverable products
- *Deliver* – order management, warehousing and transportation

Four roles that SC manager can perform...

The goal of the SC is to deliver maximum value for end customers at the lowest possible cost [8], therefore the fundamental principle of SCM is to balance demand and supply, and create SC flows by (Figure 3) [10]:

- Establishing and managing relationships across multiple functions and suppliers
- Integrating and coordinating the flow of material, information and finance between entities
- Monitoring and optimising buffers (i.e. inventory, production capacity and time) as a mechanism to balance the demand and supply

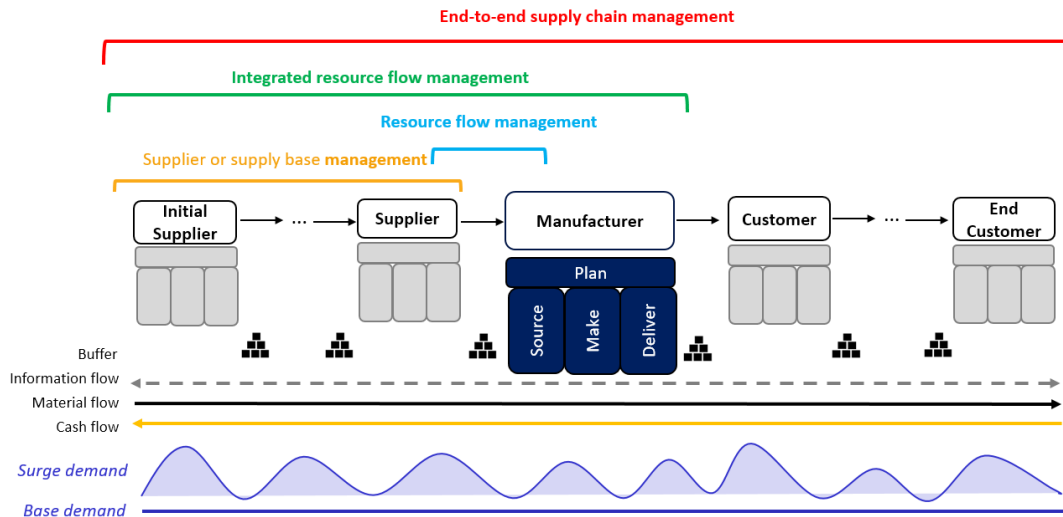


Figure 3. Managing a typical manufacturing supply chain

In manufacturing, there are four different types of role that SCM can play within the business (Figure 3) [11]:

Regional studies highlight that firms within the automotive, aerospace and construction industries mainly focus on **supplier or supply base management**, which is all about managing relationships with suppliers and monitoring their performance. This suggests that the source (procurement) function plays a dominant role, which, if managed effectively, can reduce overall operating costs [8, 12].

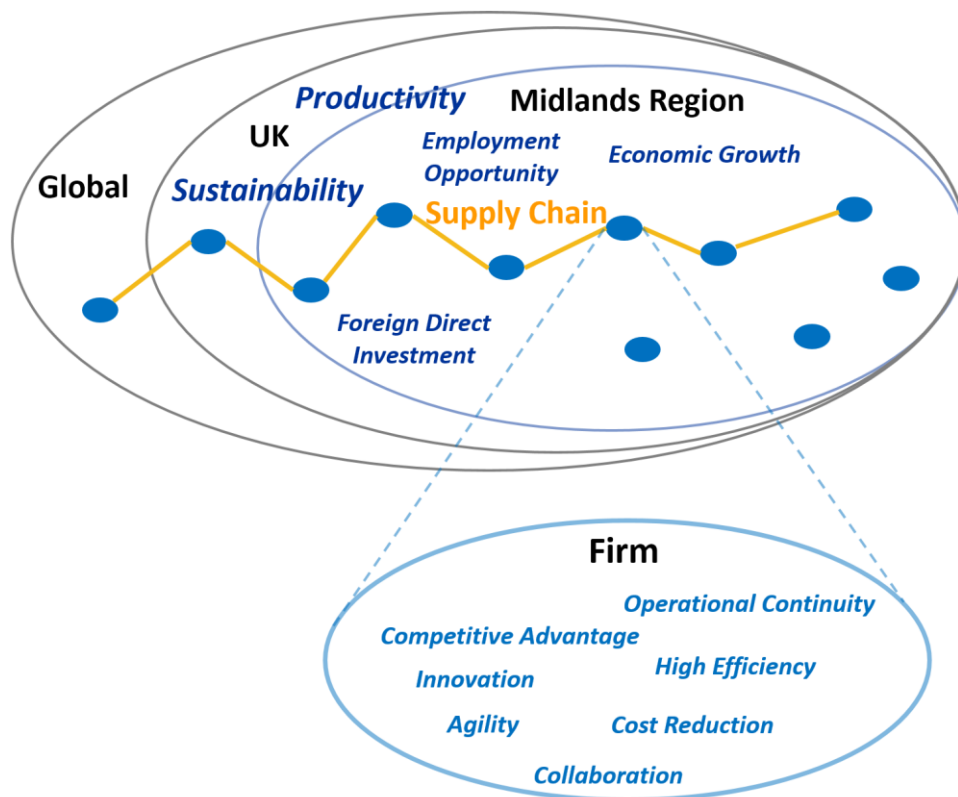
Resource flow management emphasises creating a swift even flow of material, cash and information between the Tier 1 supplier and focal firm (i.e. manufacturer), which reflects the level of coordination between the firms; the flows are lumpy and slow (meaning low efficiency) if firms are not taking a coordinative approach to manage SCs.

Integrated resource flow management takes a unified approach to managing both the supply base and SC flows.

Adopting an **E2E SC management** requires considerations of the other three approaches, which enable firms to gain overall visibility of the entire SC and identify opportunities to improve efficiency through multi-firm collaborations.

SC connects the development goal at the firm and regional levels...

Values created by SCs are perceived differently at the regional and firm levels (Figure 4).



Note: Please see Appendices 2.1 and 2.2 for additional evidence.

Figure 4. The supply chain is the link that connects the different levels

SC creates different sets of values for the firm and regional development...

From the firm perspective, the physical SC network and SCM are positioned as enablers to turn value propositions into products/services that can be delivered to end customers [13]. Effective management allows firms to reduce operating costs by eliminating waste (i.e. time and material) during daily operations, therefore increasing overall efficiency (often measured in terms of time, cost and quality) and becoming more competitive than its rivals [8]. With the rapid growth of global SCs, competing on low cost becomes more difficult for firms based in the UK due to high operating costs (i.e. labour costs, business rates and energy price), therefore firms have been seeking new pathways to retain profitability [14]. During the COVID-19 outbreak, operational continuity and agility have become key competitive factors, as consumers are looking for businesses that can deliver to their promises under extreme disruptions. Those values can be delivered by effective SCM. Moreover, the SC is the glue that connects firms in the region, which enables them to collaborate on innovation in terms of business model and technology development [9].

From the regional perspective, the development of regional SCs creates social value by creating additional employment opportunities in industries that require a physical SC, such as

construction, aerospace and automotive [15, 16]. More importantly, that development has the potential to make vital contributions to economic growth by bringing SC to the local area [2, 17], which could be beneficial to the long-term growth of SMEs if their customers (often large manufacturing firms) are willing to support them in terms of finance, skill development and innovation [18, 19]. If the performance of each single SC entity is increased, the regional productivity is likely to be increased as well, which makes the region more appealing to FDI [20].

Developing a 'regional SC productivity goal' closes the gap at different levels...

Understanding what value the SC brings to individual firms and regions reveals that there is a clear gap between the firm and regional levels in terms of development goals [10, 19]. Our study shows that many firms in the Midlands region have commonly adopted **supplier/supply base management** and **resource flow management** (Figure 3), which only allows them to closely engage with Tier 1 suppliers and hence hardly gain any visibility into further upstream [2]. This is because firms are often working in functional silos which focus on improving their own performance rather than considering the entire SC. This 'silo thinking' has been identified as one of the root causes that undermine the UK's productivity improvement [10], as the power asymmetry between large firms and SMEs gives more productivity advantages to the former than the latter [2]. For example, in the automotive SC, car manufacturers are large global frontier firms, who are customers of SMEs in the chain. To achieve an adequate level of customer service, the manufacturer often inserts buffers (i.e. inventory, production capacity and delivery time) (Figure 3) to mitigate demand uncertainties, which creates greater demand volatilities to suppliers further down the chain. This improves the productivity of the large firms but at the expense of their suppliers [21], and therefore drags down the productivity of the entire SC.

To bridge the productivity gap between the firm and regional levels, a 'regional SC productivity goal', comprised of the aggregated productivity of individual firms across E2E SCs, should be established to create alignment between firms in the Midlands region [2, 10, 22]. To turn this vision into reality, this requires coordination at different levels:

1. Large firms (i.e. manufacturers) should take an **E2E SC management** approach, in which they take a lead role in recognising different demand patterns and coordinating with SMEs to develop tailored SC practices to respond to each demand type [9, 23].
2. Regional coordinators (i.e. LEPs, Midlands Engine) are responsible for aligning the development goals of West and East Midlands to build a regional synergy [18].

Current state of the regional supply chains

To identify opportunities for building SC resilience in the Midlands region, having an overview of the current state of regional SCs and relevant stakeholders would be the critical first step.

Eight types of stakeholders in the regional supply chains

Eight groups of stakeholders were identified in the Midlands region (Figure 5).

1. **SC Owners** are entities that are a part of the SC, which can be further divided into SC Owners OEMs (original equipment manufacturers – often large global frontiers) and SC Owners SMEs.
2. **SC Transformers** are firms that assist SC Owners in increasing their efficiency and productivity, such as infrastructure suppliers (e.g. airports and Network Rail) and professional service providers (e.g. law firms and consulting firms).
3. **Customers** are the recipients of the SC owners' services or products.
4. **Knowledge providers** are organisations such as universities and research centres that provide knowledge and education programmes to other stakeholders in supporting regional growth.
5. **Policymakers** are responsible for developing policies that regulate and support business activities in the region.
6. **Advisors or facilitators** are organisations such as LEPs and the Midlands Engine that provide support to other stakeholders and coordinate activities across the region.
7. **Cash providers** are organisations that offer financial support (i.e. funding and business loans) to firms.
8. **Employees** make up the workforce that supports all types of stakeholders.

To understand the connection between stakeholder groups and their influence on the regional SCs, stakeholder mapping (Figure 6) was conducted to understand some potential SC issues that are covered in the next section, such as power asymmetry between OEMs and SMEs, skill shortages, insufficient SC investment and consumer buying behaviour.

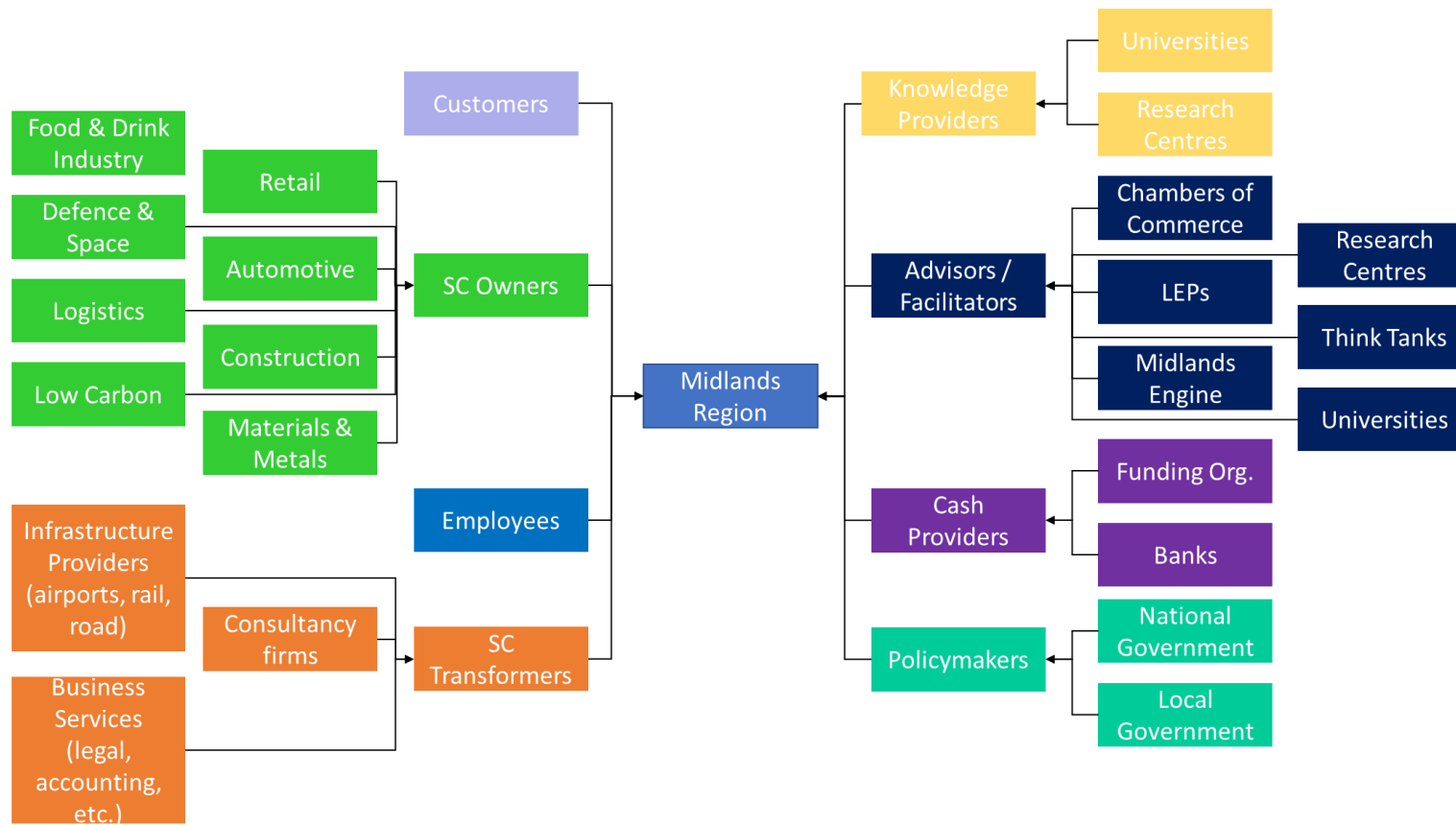
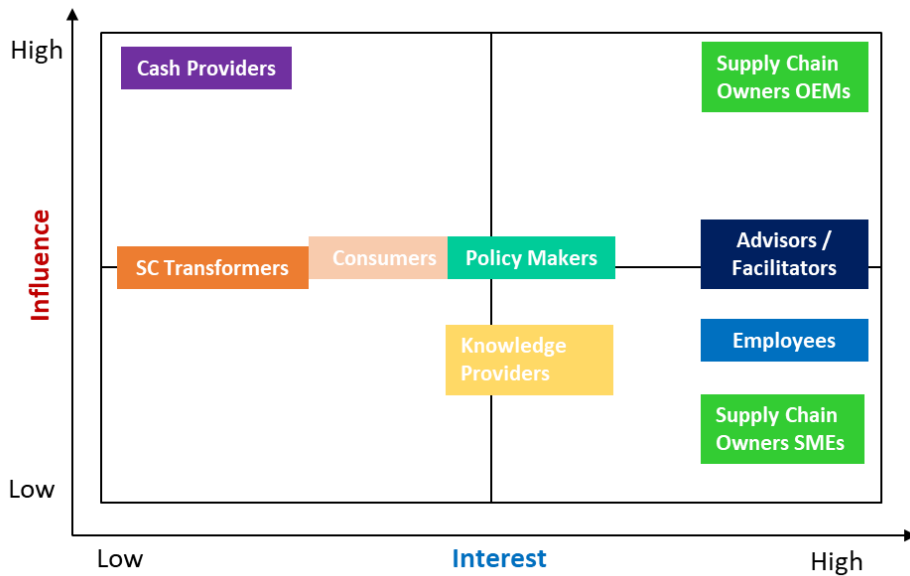


Figure 5. Eight types of stakeholders in the regional SCs

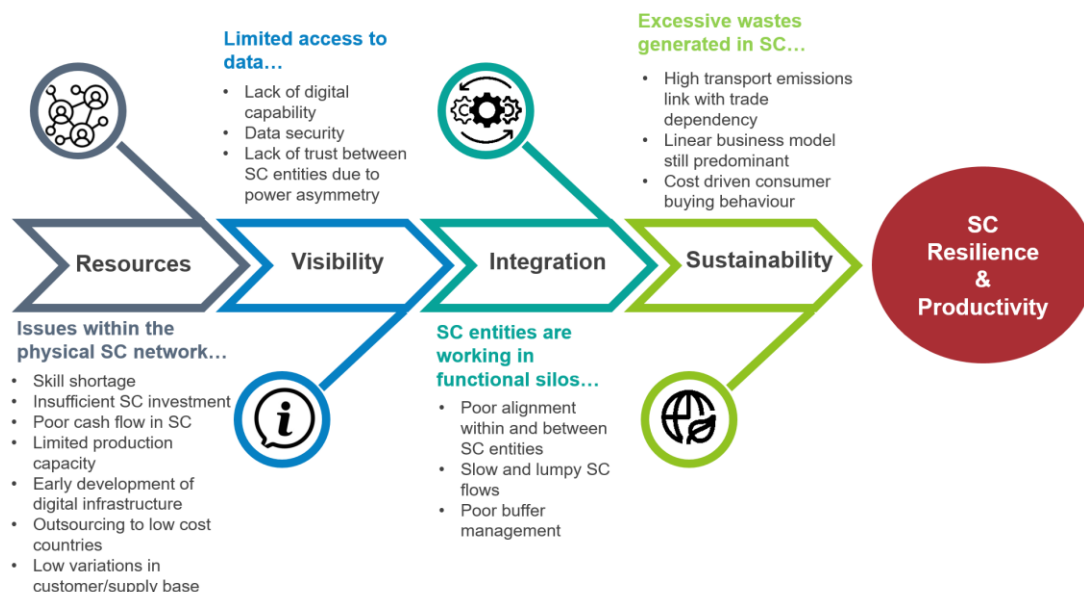


Note: This map was plotted based on the findings of workshop discussions.

Figure 6. Mapping SC stakeholders to identify underlying issues

Supply chain challenges facing the Midlands region

SCs are often complex due to the number of entities involved in the chain and the number of areas that need to be managed in each entity. Empirical evidence shows that industrial SCs in the Midlands region face four challenges that are associated with both the SC network and the way it is being managed (SCM) (Figure 7). To improve the overall resilience and productivity of regional SCs, key stakeholders need to understand the implications of those challenges and collaborate for effective solutions.



Note: Please see Appendix 2.3 for additional evidence.

Figure 7. Midlands region face multiple SC challenges

Resources in the SC network are vital for firms to 'make a living'...

Within the SC network, both tangible (i.e. skilled labour and infrastructures) and intangible (i.e. knowledge and relationships) resources are vital to support the SC operation. In the current regional SC network, multiple challenges were identified that are related to:

Skill shortage – Local firms, particularly SMEs, have been struggling to recruit and retain experienced professionals due to less competitive employee benefits (i.e. career prospect and salary) compared to large firms in the same industry [24, 25]. SMEs are more likely to be dependent on immigrant labour, which can lead to higher staff turnover due to higher mobility [16, 26]. The rapid development of some sectors (e.g. High Value Manufacturing (HVM), life science, low carbon energy) have high demands for skilled labour, for which local firms are struggling to access the talent pool [2, 27].

Insufficient SC investment – Firm level investments significantly increase the gap between OEMs (often large global frontier firms) and SMEs [28, 29]. OEMs have better access to financial support, government incentives for research and development (R&D) and lower interest rates. This provides OEMs with advantages to improve productivity of their own but at the cost of their suppliers, and therefore undermines the regional SC goal [18].

Poor cash flow in the SC – Cash flow is an enduring issue in the SC that is often caused by poor buffer management (i.e. too much stock), late/slow payment by customers and other uncertainties (i.e. machine breakdown, supply shortage) [4, 30]. Poor SC flow has bigger impacts on SMEs in terms of normal operations (i.e. employee salary) and future growth (i.e. investment for business expansion) as they have less working capital [4, 31]. For example, a long payment term in the manufacturing SC often increases the interest rate of SMEs and leads to higher operating expenditure. The cash flow can be improved through the adoption of SC finance, such as reverse factoring. Reverse factoring results in a win-win situation for the involved members (i.e. OEMs, suppliers and banks) by improving their net working capital and liquidity, strengthening their relationships with the SC members and reducing the probability of their bankruptcy [32].

Production capacity – Firms need sufficient cash to expand their production capacity, such as building new plants or upgrading production facilities to support product innovation and low carbon initiative. However, insufficient investment potentially constrains the business growth of SMEs that supply to global manufacturing SCs, which inhibits the competitiveness of regional firms when competing with global rivals [18, 33].

Early development of digital infrastructure – Industries are in a transition to Industry 4.0, which requires incremental changes to support the digitalisation [2]. However, the adoption of digital technologies, such as Artificial Intelligence, Digital Twin and Internet of Things (IoT), is still in the early stages, and needs further development [34, 35].

Overseas supply base – Many firms have been outsourcing to low-cost countries to minimise overall operating costs, which potentially increases the trade dependency that leads to high transport emissions. To address this issue requires firms to reconsider the design of the SC network and to consider other potential options such as reshoring – create supply base in the region [17, 25]. However, this requires a long-term vision in understanding how the SC can help firms sustain competitive advantage. For example, to overcome the shortage of Personal Protective Equipment (PPE) during COVID, the SMEs in the region pivoted SCs to fulfil the local

demand, but this may no longer be needed in the future and hence firms switch back to the supply base in low-cost countries.

Low variations in customer/supply base – Most firms tend to compete on economies of scale (i.e. the cost advantage obtained due to volume of output), in which they serve fewer market segments with a limited range of products and services. This limits the number of customers and suppliers that they work with. Moreover, this could be a critical inhibitor to SC resilience, especially when both the demand and supply side are disrupted in an unforeseen situation. Therefore, firms are urged to compete through economies of scope (i.e. efficiencies due to variety of output rather than volume) by serving multiple markets with diverse offerings in order to be more competitive in the global market [2]. This requires changes at the SC and regional levels. For the former, OEMs play a critical role in developing diverse offerings, whereas suppliers are supporting them to deliver these value propositions to multiple markets. For the latter, the disparity between West Midlands (high productivity, low resilience) and East Midlands (low productivity, high resilience) presents an opportunity to leverage resources across the region to serve diverse markets.

From the SCM perspective, visibility, integration and sustainability are three enduring challenges facing firms in the Midlands region.

Limited access to data inhibits the E2E SC visibility...

Having a high level of **SC visibility** enables firms to monitor the live status of the E2E SC and make management decisions based on real time data [36]. However, a recent study shows that although most UK manufacturing firms have established visibility in 'a small portion' of the SC, they struggle to develop visibility beyond Tier 1 suppliers/customers [37]. The main root causes include:

Underdeveloped digital capabilities – Firms often struggle to recruit and retain technical experts to support the adoption of digital technologies and data interpretation [38, 39].

Data security – SC data are collected from multiple sources and stored in a virtual platform which all SC entities can access. However, some firms may be reluctant to share data considering the impacts of cyber security issues [40].

Lack of trust in SC relationship – Intense competition in the market creates relationship barriers in buyer-supplier relationships, which is often the result of a lack of trust and poor communication being the two critical inhibitors to SCM [33].

Firms need to move away from 'functional thinking' to build SC integration...

Firms have long recognised that **SC integration** is an effective solution to most the SCM challenges, but struggle to implement it in reality [9, 41]. This is because most manufacturing firms are organised by functional silos, which creates a barrier to the cross-functional engagement between SC (i.e. plan, source, make and deliver) and non-SC functions (i.e. marketing and new product development) within the firm [13]. Moreover, the power asymmetry in the SC gives OEMs more bargaining powers and allows them to force down the price on the supplier side through exploited procurement practice [42]. These powers significantly inhibit the **SC integration internally and externally (with customer and supplier)**. The direct consequences of poor SC integration are **lumpy flows of cash, information and material** (low efficiency) and **poor buffer management** (i.e. high inventory costs if buffers are too big/long lead time if buffers are too small)[9, 10].

Improving sustainability requires incremental changes in the current business model...

Sustainability has become a key differentiator in the global competition as there is an increasing demand for ‘green’ products. This regional study identifies that there are three issues in the Midlands region.

The biggest threat to the regional SCs in the Midlands is trade dependency; in particular the aerospace and automotive businesses have high export volumes each year, which produce large amounts of **carbon emissions during transportation**.

More importantly, most firms in the region have adopted a **linear business model**, which focuses on turning raw materials into products that can be delivered to consumers with little consideration for reuse and recycling [43, 44]. To make a transition from linear economy to CE, this requires SC entities to collaborate on product innovation (e.g. adopt the concept of ‘design for recycling’) and optimise resources throughout the entire SC. This requires a high level of SC visibility by using data to identify wastes in the current system, and integration to enable everyone to work towards a shared business goal – growing sustainably.

In addition, **consumer buying behaviours** are often driven by low cost, rather than factors, such as recyclability and carbon emissions embedded in products [43]. Therefore, establishing an E2E SC visibility and making the SC data of products more transparent may drive the market demand for sustainable products. This enables us to fully utilise recyclable materials rather than mine for them from the ground.

When disruptions occur, an SC is only as strong as its weakest link...

Apart from the above SC challenges in normal operations, firms need to watch out and prepare for different types of external disruptions. Over the past decades, global SCs have been challenged in different ways (Figure 8). In the UK, COVID-19 and Brexit tested the resilience of local SCs to the limit, during which firms had to deal with different operational challenges (no time to prepare for COVID-19 vs. plenty of time to prepare for an unknown Brexit deal).

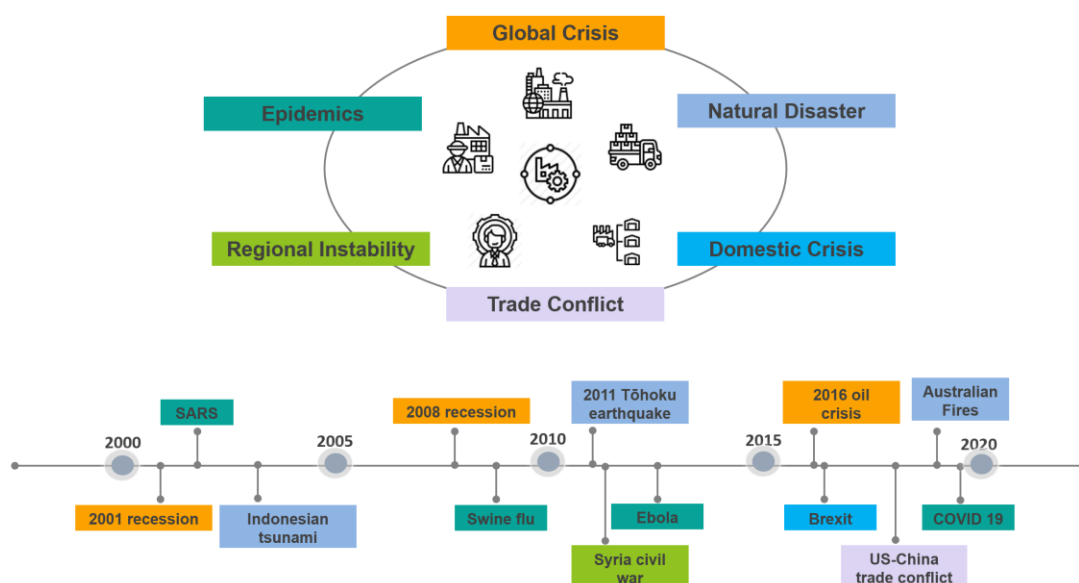


Figure 8. Overview of global disruptions from 2000 – 2020 [45]

Brexit

Although the Brexit decision was made in 2016, the deal between the UK and EU was in suspension until December 2021. During that time, firms needed to plan for various scenarios broadly referred as 'deal or no deal'. A study by MakeUK highlights that 64% of manufacturing firms expressed that this uncertainty had huge impacts during the Brexit process [46]. From the regional perspective, the Brexit potentially aggregated the SC challenges in the Midlands from four aspects (*see Appendix 2.4 for additional evidence*):

Tariffs – Increasing export/import tariffs will raise operating costs for firms in the Midlands as most of the regional SCs are closely linked with the EU [31, 39]. Additional costs may be absorbed by redeveloping the SC network by building supply bases in the UK to reduce transportation costs and tariffs. However, this may not be an option for critical sectors such as automotive, aerospace and pharmaceuticals, as it is harder for them to find 'eligible' specialist suppliers [5]. Hence, they have to work with suppliers to explore possible cost-effective options. In addition, the increasing tariffs may lead to a reduction in export volumes as the UK suppliers could become more expensive than their rivals. This links to another issue, i.e. that firms should not compete through economies of scale but economy of scope to be more resilient in responding to the dynamic market.

Legal – Potential legal changes (e.g. rules of origin and product certification) from Brexit can impact regional SCs in two ways [5, 6]. First, the existing contracts between firms and EU suppliers may no longer be viable, which requires immediate attention to review and comply with the new regulations. Second, the immigration rule is likely to affect regional firms, especially those who have EU employees, which will make the identified skill shortage issue even worse.

Customs – A new Customs border between the UK and EU has direct impacts on regional SCs in terms of costs and delivery time [47]. Additional transaction costs would be incurred if products need to go through a Customs declaration process, and this could make the UK less attractive to multi-national firms in the future [48]. For example, if a Chinese firm trades with UK firms through a distribution centre in the EU, the SC costs are certainly higher than before Brexit. Therefore, firms need to understand how the new system works and identify a route that is cost effective and sustainable (low carbon).

Lead time – Longer lead time is inevitable with the implementation of the updated Customs system between the UK and EU [5, 31, 47]. This causes huge challenges for retail sectors, in particular those that sell products with short shelf lives (i.e. fresh food). To maintain good customer service levels, firms may have to stock more than actually needed to avoid stock shortage, hence increase cash flow issues (i.e. cash tie up when buffers are too big). To address this, an E2E SC planning system is essential to establish SC visibility and coordinate activities to rightsize the buffers of time, inventory and production capacity [10, 48].

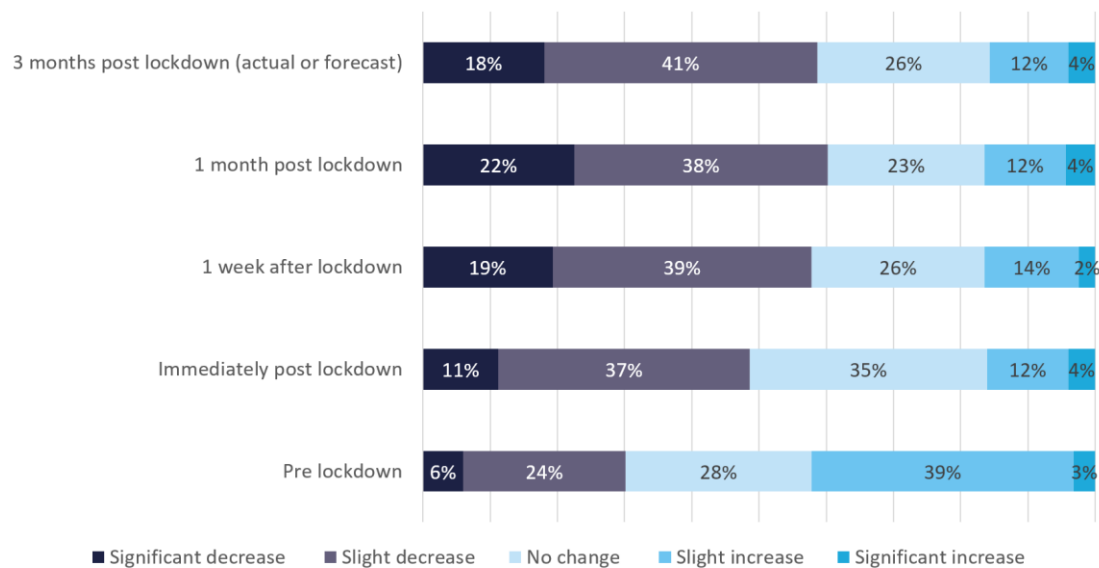
COVID-19

Unlike Brexit, COVID-19 was not predicted and thus a window of preparation could not be provided for this disruption. This caused massive uncertainties for both supply (e.g. panic buying) and demand (e.g. supply shortage and delivery delay) sides (*See Appendix 2.4 for*

additional evidence). A recent survey of 250 UK manufacturing firms [45] identifies several critical insights:

- 65-75% of firms experienced significant demand fluctuations before, during and after the first lockdown (Figure 9). There was increasing demand prior to the first lockdown and then it dropped significantly during the lockdown but was unable to recover after three months post-lockdown.
- Manufacturing firms stated that they were generally more effective in responding to an increase in demand. This was done by utilising buffers in the SC (55% responses), multiple sourcing strategy on key products (50% responses), visibility across the SC network (49% responses) and a risk management approach (45% responses).
- Firms emphasised that enabling a smooth cash flow and building SC flexibility are key to overcoming the remaining consequences of COVID-19.

What changes in demand has your organisation experienced?



Note: Data were collected as a part of the WMG Supply Chain Resilience project, which consists of 250 responses from the UK manufacturing industry. The time frame covers the 1st lockdown in 2020.

Figure 9. 65-75% of products saw demand fluctuations [45]

The survey findings have a direct link with some of the issues (e.g. poor cash flow, lack of capability to serve multiple markets when faced with a demand decline) identified in the current regional SCs, which enables us to understand how challenges are interlinked and how they can be solved more effectively.

Overall, the key findings of this study indicate that the regional SCs are vulnerable due to potential issues in the current SC network as well as in the management practices. The disruptions brought by Brexit and COVID-19 have forced us to rethink what the next ‘normal’ would look like and what we can do as a community to move towards a more resilient and productive future.

'Build back better' – The changing nature of manufacturing

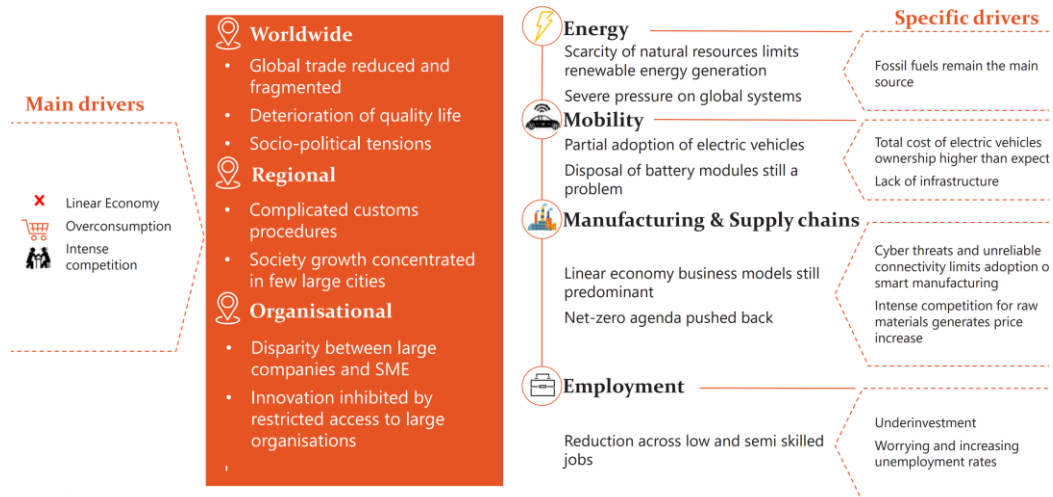
To support the Midlands growing towards increased resilience and productivity, this section first lays out the visionary future – 'A flourishing world' (where we want to be) and then provides a set of recommendations for future growth at the firm and regional levels (how we get to the future that we want).

What would the future look like for the region?

Two scenarios in 2035...

A recent study conducted by WMG, University of Warwick in conjunction with Blue Yonder explores the sustainability and CE practices that firms can adopt to grow in a sustainable way. Findings identify that there two possible scenarios depicting the two extremes of how the world will look in 2035 (Figure 10).

2035: A world on the edge



2035: A flourishing world

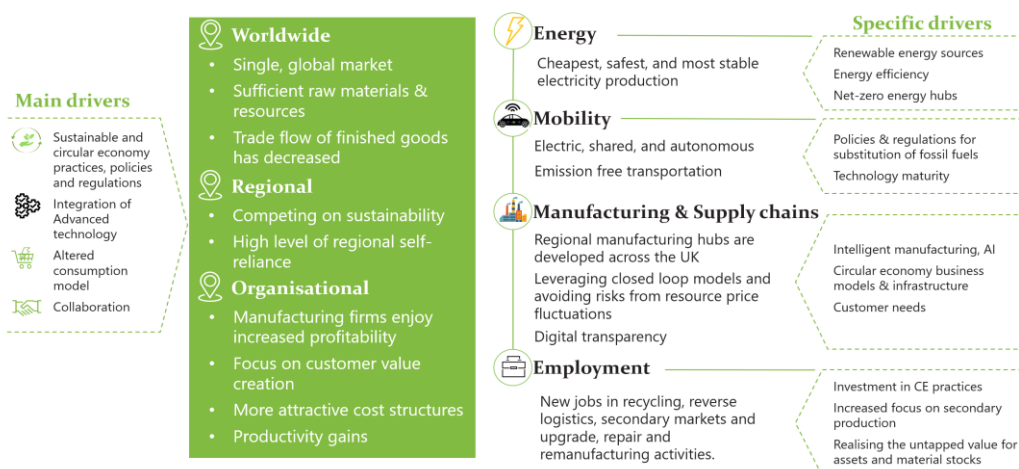


Figure 10. Two scenarios in 2035 [43]

“A world on the edge” is more likely to arrive if the challenges in the current regional SCs will not be addressed in the next decades. *“A flourishing world”* is the ideal state driven by sustainability goals. Through this vision, the Midlands can be viewed as a factory with a high level of self-sufficiency, and the region should achieve a balance between resilience, productivity and sustainability. Through the study [43], there are a number of opportunities that have been identified to address the persistent challenges of regional SCs:

The only way forward is with circular business models...

Adopting circular business models rather than the current linear business models will be a mandate to allow the region to realise the untapped value of assets and material stocks. SCs, in particular, will be able to use closed loop models to avoid risks such as resource price fluctuations and raw material scarcity as they arise.

Technology shift will boost distributed manufacturing as the norm...

Furthermore, innovative technologies such as 3D printing will enable OEMs to shift from the conventional manufacturing model (i.e. mass production) to distributed manufacturing (i.e. customisation). This enables future SCs to be modular, flexible, adaptable and digital, which can be deployed at different levels of distribution. This will also bring innovations in SC finance. For example, *deployed only in your neighborhood*, suggests that community-based investment may be a more appropriate funding mechanism than our current definition of Cash Providers. As a result, new thinking about the role of regional SC stakeholders will be required to adapt to the needs of these new business models as they emerge; for example, the financial investment at the SC level will be needed to set up infrastructure and support business expansions.

‘Green’ growth means new employment opportunities...

To compensate for the inevitable loss of “old” industries, more job opportunities will be created, along with the adoption of CE. Job opportunities in recycling, reverse logistics, secondary markets, and upgrade, repair, and remanufacturing will increase as the region enters the CE. All of the above will necessitate more skilled SCM professionals as well as technical experts in recycling (e.g. disassembly of end-of-life products and scrap sortation).

Start competing as a single regional supply chain, not as individual firms...

SC integration is one of the key firm-level challenges identified; however, in *“a flourishing world”*, regional manufacturing hubs will be established across the UK, enabled by intelligent manufacturing and driven by customer demand, necessitating a different level of coordination and planning. As a result, the **Midlands region has an opportunity to compete not through individual firms within the region, but through its SCs collectively**. This will necessitate a shift in mindset on the part of both regional Advisors/Facilitators, such as the Midlands Engine, and the SC Owners within it. During this process, regional stakeholders will decide who will be in charge of centrally coordinating the E2E SC in order to increase its resilience and implement the regional growth strategy.

Setting up the infrastructure for an aspiring future...

Firms should not compete as independent entities; instead, they should be part of a network that, in collaboration with partners in the SC network, can form a robust and well-communicated SC. Technology, specifically SC connectivity, will enable this by providing

visibility of the E2E SC, establishing effective collaborations, and increasing the level of resilience and flexibility required. As a result, investment should be focused on developing infrastructure in both hardware and software, as these are the backbones of the IoT and, consequently, connectivity.

The region's success will be dependent not only on improving SC flows, but also on doing so in the right way. Following this viewpoint, low-carbon technologies are inextricably linked to “a flourishing world”. The successful use of renewable energy sources, improvements in energy efficiency for a variety of sectors, and the development of net zero energy hubs will provide the most affordable, safe, and stable electricity production. Furthermore, maturing technologies and the substitution of fossil fuels through policies and regulations will result in zero-emission transportation for people and goods using electric, shared, and autonomous vehicles.

‘Supply chains compete, not individual firms’

A productive SC is exhibited when products/services are delivered on time and at the lowest possible costs; SC resilience is critical to retain the continuity of operations and ultimately contribute to the regional SC productivity goal [49, 50]. This section offers practical guidance for firms to enhance their SC resilience (See Appendix 2.5 for additional evidence).

SC resilience can be achieved through the adoption of six practices...

SC resilience is the ‘capability of the firm to be alert to, adapt to and quickly respond to changes brought by a SC disruption’ [51]. A recently developed SC resilience framework [52] (Figure 11) provides practical guidance for firms on how to utilise six SC practices to improve firms’ overall resilience.

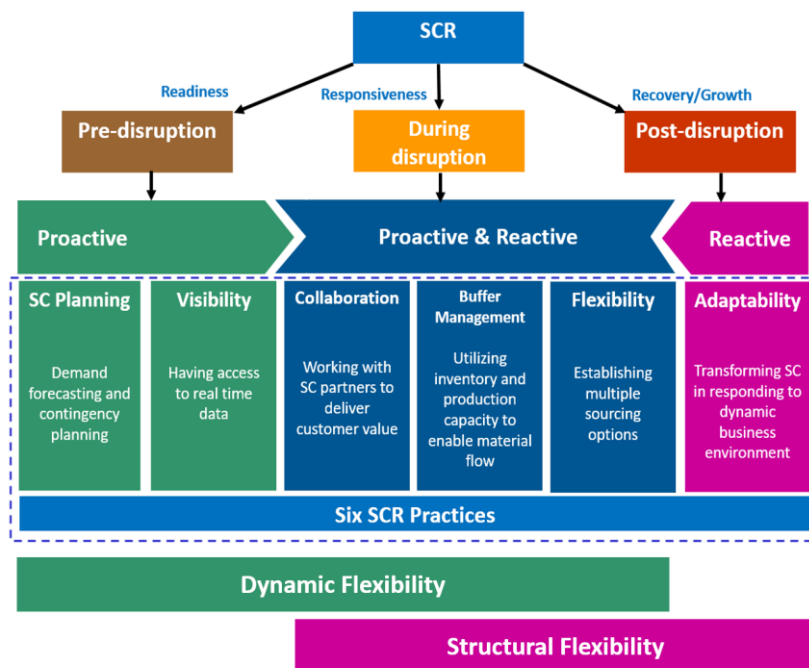


Figure 11. SC resilience framework [52]

Disruptions often occur in three different phases – **pre-disruption, during disruption and post-disruption**, during which firms need to focus on building **readiness, responsiveness and recovery/growth** respectively.

Two strategies – **proactive and reactive**, can be adopted either individually or collectively in different phases to support SC operations.

There are six SC resilience practices that can be utilised:

SC planning enables firms to coordinate business activities based on historical data therefore create swift event flows among different entities...

In terms of **demand planning**, there is an opportunity to develop SC planning as a ‘control tower’, in which large firms (i.e. OEMs) take a coordinating role in recognising different demand signals through the adoption of demand profiling¹ and reducing demand volatilities for SMEs in the upstream [10, 53]. This helps SMEs to optimise buffers of inventory and therefore improve cash flows [21]. In the long term, SMEs should develop their own planning capability, which can reduce their over-dependency on the downstream customers.

Scenario planning enables firms to prepare for potential disruptions, which has proved to be quite effective in some sectors, such as pharmaceuticals [4]. An effective scenario planning lays out the best, mostly likely and worst scenarios for the firm, for which the potential business changes can be identified and prioritised to form an action plan [54].

Visibility allows SC entities to identify burning issues in the E2E SC and make decisions based on real time data...

The adoption of digital technologies could offer solutions to some of the visibility issues (in Figure 7) in the current regional SCs, which generally cover four areas [55]:

- *Connectivity* – collecting real-time data throughout the E2E SC (e.g. IoT, Platforms, Virtual reality).
- *Automation* – automating processes and flows (e.g. Robotic process automation, Cobots and 3D printing).
- *Prediction* – exploiting data to improve forecast and segmentation (e.g. Machine learning, Digital twin).
- *Security* – securing data and flows (e.g. Block chain and Cybersecurity)

Collaboration (essentially integration) within and across SC entities is key to delivering customer values...

Improving collaboration in the current regional SCs requires firms to rethink how they connect with their suppliers and customers. This requires a paradigm shift from ‘functional thinking’ (a root cause of SC integration, in Figure 7) to ‘process thinking’ to build E2E SC integration [9]. Adopting process-oriented thinking allows firms to view the SC as a business process that connects different business functions/entities as a whole system, rather than working in silos. This enables everyone to work towards the same ‘SC productivity goal’ rather than individual performance, which eventually brings four benefits [10]:

¹ Demand profiling is an SC planning approach that can be adopted to categorise demand signals into different types based on product volume and variabilities. Firms can then develop tailored SC practices to fulfil different demand types.

- *Seamless process* can be achieved by redesigning the organisational structure at firm level
- *Integrated business planning* ('control tower') can be developed between entities
- *Better visibility* across the SC
- *Taking a coordinative approach* in rightsizing buffers and enabling SC flows

Buffer management enables firms to optimise inventory level, production capacity and lead time to respond to external disruptions...

Buffer management has proved to be an effective practice for manufacturing firms to respond to both COVID-19 and Brexit [52]. It is critical for firms to understand that buffers have to be rightsized [56], otherwise it can be a potential SC risk. Having buffers in the SC network enables firms to respond to changing demands (i.e. panic buy during COVID-19) effectively, but this always comes with a cost. On the other hand, firms who have taken out buffers (common practice in a lean SC) may fail to deliver and hence expose their SC to risks.

Supply flexibility can be achieved by establishing multiple sourcing options in the SC network...

Low supply variations in the current regional SCs (in Figure 7) make the Midlands vulnerable when facing any external disruptions such as COVID-19 and Brexit. There are multiple options to address this:

Reshoring: Having a supply base in low cost countries may no longer be an option as the total hidden cost (i.e. transportation, Customs process and tariffs) and carbon emissions could be higher than using local suppliers [17, 57]. More importantly, having a local supply base make the SCs more resilient during extreme disruptions such as COVID-19, during which the overseas supply can be easily interrupted. Therefore bringing SCs back to the UK may create value for both the firms and the region (e.g. employment opportunities and economic growth) [2, 25].

Circular economy: Overconsumption of raw materials has put a lot of pressure on the ecosystem. At the same time, the 'Net Zero' 2050 goal also urges firms to think about how to compete in sustainable not just low cost SCs. Recent studies [14, 58] on the UK steel industry highlight that the SC plays a critical role in the sustainability agenda all the way from new product development (e.g. designing for recycling), planning (e.g. optimising the use of primary and secondary resources), making (e.g. reducing carbon emission by adopting innovative steelmaking technologies), delivering (e.g. eliminating transport emissions) and returning (e.g. recycling and reusing scrap for new steels). More importantly, there is an opportunity for steel manufacturers to work with customers in different sectors (automotive, construction and aerospace) and for scrap suppliers to build a circular scrap steel SC in the UK, which can largely reduce the consumption of virgin ores and coals imported from overseas. Adopting a circular business model enables us to recover materials from the current system through reuse, remanufacture and recycling, hence reducing both the consumption of non-renewable resources and carbon footprints.

Adaptability is all about transforming the SC to meet dynamic demands...

The 'VentilatorChallengeUK' in 2020 has proved that the capability of adapting the SC to meet changing demand is critical, during which OEMs such as Rolls Royce, Smith Group, Penlon, GKN Aerospace repurposed their SCs by leveraging resources (i.e. labour, machines and expertise) to design and deliver ventilators to support the NHS [59]. To be adaptive, firms have

to develop their capabilities in terms of sensing the market changes, developing agile business processes, engaging in the product and in technology innovation [49].

Approach to resilience varies depending on the type of flexibility required...

Reflecting on the global disruptions over the past decades (Figure 8), the SC requires a high degree of flexibility to unleash its power. Configuration of the six SC resilience practices provides firms with two different types of flexibility – dynamic and structural [52].

Dynamic flexibility enables firms to respond to changing demands through the adoption of SC practices such as planning, visibility, collaboration and buffer management to rightsize buffers and smooth flows between firms [60]. For example, this was proved to be an effective strategy in the retail business during COVID-19 as firms (e.g. Tata Global Beverage [52]) were able to buffer against uncertainties within the current network.

Structural flexibility is established when the SC network is reconfigured to build flexible options [60]. This requires a firm's ability to adapt or configure its physical SC infrastructure effectively in response to major changes both in the demand and supply sides. The key to retaining structural flexibility is the SC network design that should allow more options to be accessible to the firm. This may come with costs but it makes the SC more resilient during turbulent times when the supply base is being taken away and other sourcing options are urgently needed to retain operations (e.g. 'VentilatorChallengeUK' during COVID-19 [57], 'Rules of origin' under the Brexit deal [6]).

A growth plan for the Midlands region

The region as a whole is urged to address some of the most persistent challenges in order to move into the future of "a flourishing world".

Determine where you want to compete by analysing sectors and new opportunities...

The D2N2 LEP has identified four sectors that should be prioritised: transportation of the future, life science and health, future food processing and energy, and low carbon development [34]. These efforts should be combined under a centralised authority (e.g., Midlands Engine) to ensure that they are well-aligned with the region's aspirations while also taking into account the region's distinct local needs.

Encourage the development of local HVM capabilities through initiatives and incentives...

A hybrid approach should be pursued in which the Midlands leverage existing manufacturing capabilities by embedding new innovation in them while also looking for ways to attract new investment through reshoring. In both cases, investment in upgrading the existing infrastructure and developing a digital infrastructure is critical to the region's competitiveness. The region should begin with the three areas listed below:

- **Invest in physical and digital infrastructure** to help businesses grow and remain competitive [2].
- Look into incentives (such as tax benefits) that foster a favourable investment environment for increasing local content and **explore reshoring options** and possibilities [54].

- **Address the region's lack of innovation** by providing incentives for companies to develop new technologies [39, 49]

Develop an integrated skills development system in the region to address skill gap...

So far, particular attention has been given to the local industrial strategy developed by the LEPs, but in silos. It is necessary to develop a local strategy that includes all stakeholders and integrates and benchmarks best practices. Knowledge providers such as universities and research institutions should be at the forefront as they have strong capabilities of delivering knowledge through well-established courses and training programmes. There is an immediate need to improve the SCM capabilities of the region to address the current challenges, such as SC planning, SC network design, big data analytics, flow management, and lean and agile manufacturing.

- **Focus on upskilling SMEs, as they are the region's backbone.** A dedicated programme for SMEs has been identified as a critical requirement for resolving management issues (e.g., leadership training, strategic planning, finance and investments, change management) and enabling them to develop new capabilities and capacities (SCM, digital technologies usage, CE practices) [2, 16].

Connecting all stakeholders in the region to achieve synergy...

Taking a coordinative approach in connecting stakeholders in the region is fundamental for the future growth, which can be achieved in two ways.

- Setting an agenda for achieving coordination by involving all stakeholders from the outset so that everyone has an 'interest' in the outcome. This is where LEPs or the Midlands Engine can play a coordinating role to create alignment between other stakeholders.
- Creating a central repository of information sharing in the region. The Advisors/Facilitators can be the means to reinforce and communicate the programmes, funding, networking events, among other factors, to connect all the stakeholders in the chain.

Concluding remarks

SC plays a critical role in the development of the Midlands region, a place with a strong manufacturing base. Drawing on the findings of our research, it is clear the region is now currently facing numerous challenges in the physical SC network (resource shortage) as well as the way it is being managed (the lack of visibility/integration/sustainability). This urges us as a community to rethink how we can compete through more productive and resilient SCs in the long term. To achieve this, a set of recommendations is proposed.

- **The Midlands region should develop a 'regional SC goal' to align the development goal at the firm and regional levels.**

This requires the coordination at two levels: 1. OEMs with strong planning capabilities can act as a 'control tower' in the manufacturing SC to coordinate activities with SMEs. 2. Regional coordinators such as LEPs and Midland Engine should leverage the resources across West Midlands and East Midlands to create regional synergy.

- **Firms should adopt a ‘process thinking’ approach to establish the E2E SC integration, which can lead to better visibility by sharing data and increased sustainability through effective buffer management.**
- **SC resilience can be established through the adoption of the six practices – planning, visibility, collaboration, buffer management, supply flexibility and adaptability, which enable firms to retain either structural or dynamic flexibility in response to future disruptions.**
- **Building a Circular Economy in the region can enable the community to grow sustainably, as this helps to avoid overconsumption of raw materials by ‘mining materials from the current system’ through reuse, remanufacture and recycle, and reducing carbon emissions generated from downstream manufacturing and global transportation.**
- **The future of the Midlands is in the hands of ‘everyone’ (eight types of stakeholders), which requires the establishment of an alignment between businesses, policymakers and academics to focus on:**
 - Creating an integrated skills development system across the region to address skill shortages, in particular SC planning and management, modern manufacturing management (flow management and lean/agile production) and big data analytics.
 - Providing incentives to encourage the development of a physical and digital infrastructure, particularly in energy and HVM sectors.

References

1. Crafts, N. and T.C. Mills, *Is the UK productivity slowdown unprecedented?* National Institute Economic Review, 2020. **251**: pp. R47-R53.
2. Dupont, J., *Powering the Midlands Engine: How to build a local industrial strategy*. 2018, Policy Exchange: UK.
3. MakeUK, *Regional manufacturing outlook 2020*. 2020, MakeUK: UK.
4. Midlands Engine., *Economic impact of Covid-19 2020*, Midlands Engine: UK.
5. Bailey, D. and L. De Propris, *What does Brexit mean for UK automotive and industrial policy*. The political economy of Brexit, 2017: pp. 45-62.
6. Francis, C. and D. McGirr, *How the Brexit deal will affect supply chains*. 2020, Pinsent & Masons: UK.
7. HM Government., *Industrial Strategy: Building a Britain fit for the future*. 2017: UK.
8. Christopher, M., *Logistics & supply chain management*. 2016: Pearson UK.
9. Stevens, G. and M. Johnson, *Integrating the Supply Chain ... 25 years on*. International Journal of Physical Distribution & Logistics Management, 2016. **46**(1): pp. 19-42.
10. Zhang, W., J. Godsell, and N. Driffield, *Supply Chain Productivity: A Missing Link? 2021*, University of Warwick: Coventry, UK.
11. Vrijhoef, R. and L. Koskela, *The four roles of supply chain management in construction*. European journal of purchasing & supply management, 2000. **6**(3-4): pp. 169-178.
12. Lago Da Silva, A., M. Christopher, and C. Roberta Pereira, *Achieving supply chain resilience: the role of procurement*. Supply Chain Management: An International Journal, 2014. **19**(5/6): pp. 626-642.
13. Godsell, J., A. Birtwistle, and R. van Hoek, *Building the supply chain to enable business alignment: lessons from British American Tobacco (BAT)*. Supply Chain Management: An International Journal, 2010. **15**(1): pp. 10-15.
14. Hall, R., W. Zhang, and Z. Li, *Domestic Scrap Steel Recycling – Economic, Environmental and Social Opportunities*. 2021, WMG, University of Warwick: UK.
15. de Ruyter, A., D. Bailey, I. Henry, D. Hearne, D. Li, S. Shishank, and R. Eade, *Regional Transport – a supply chain mapping exercise and Brexit exposure check of automotive, aerospace and rail value dependency in the WMCA region 2020*, Birmingham City University: UK
16. Green, A., *Productivity and Skills Commission Report*. 2018, University of Birmingham: UK.
17. Godsell, J., J. Ignatius, A. Karatzas, J. King, D. Li, and J. Moore, *Realities of reshoring: A UK perspective*. 2016, University of Warwick: UK.
18. Olivas-Osuna, J.J., J.M.C. De Lyon, K. Gartzou-Katsouyanni, A. Bulat, M. Kiefel, D. Bolet, K. Jablonowski, and M. Kaldor, *Understanding Brexit at a local level: causes of discontent and asymmetric impacts*. 2019 London School of Economics and Political Sciences, London, UK.
19. Roper, S., K. Hathaway, and N. Driffield, *Understanding value added per employee in six UK sectors: The insider's view*. ERC 2019: UK.
20. Narula, R. and N. Driffield, *Does FDI cause development? The ambiguity of the evidence and why it matters*. The European Journal of Development Research, 2012. **24**(1): pp. 1-7.
21. Storey, J., P.D. Cousins, Co - editors: B. Lawson, C. Emberson, J. Godsell, and A. Harrison, *Supply chain management: theory, practice and future challenges*. International Journal of Operations & Production Management, 2006. **26**(7): pp. 754-774.

22. Mesa, H.A., K.R. Molenaar, and L.F. Alarcón, *Exploring performance of the integrated project delivery process on complex building projects*. International Journal of Project Management, 2016. **34**(7): pp. 1089-1101.
23. Godsell, J., D. Masi, A. Karatzas, and T.M. Brady, *Using project demand profiling to improve the effectiveness and efficiency of infrastructure projects*. International Journal of Operations & Production Management, 2018. **38**(6): pp. 1422-1442.
24. de Ruyter, A. and B. Nielsen, *Brexit Negotiations After Article 50: Assessing Process, Progress and Impact*. 2019: Emerald Group Publishing.
25. Coyne, A., *Manufacturing 2015: The West Midlands Review*. 2015, The Business Desk. Com: UK.
26. City-Redi, *City-Redi 2020 Review: Supporting inclusive economic growth in the West Midlands and across the UK*. 2020, University of Birmingham: UK.
27. Midlands Engine., *ECONOMIC IMPACT OF COVID-19 ON ENERGY AND LOW CARBON SECTOR*. 2020, Midlands Engine: UK.
28. Adalet McGowan, M., D. Andrews, C. Criscuolo, and G. Nicoletti, *The Future of Productivity*. 2015, Paris: OECD.
29. Sultan, F., S. Khalil, and S. Ali Shah, *The Role of Enterprise Education and Training in the Performance of Small Manufacturing Firms: Evidence from West Midlands (United Kingdom)*. Global Social Sciences Review, 2020. **1**: pp. 260-268.
30. City-Redi, *Birmingham Economic Review 2020 Summary 2020*, University of Birmingham Birmingham, UK.
31. Thissen, M., F. van Oort, P. McCann, R. Ortega-Argilés, and T. Husby, *The implications of Brexit for UK and EU regional competitiveness*. Economic Geography, 2021: pp. 1-25.
32. Chakuu, S. and J. Godsell, *Supply Chain Finance: Increasing Competitive Advantage and Financial Certainty throughout the Supply Chain*. 2019, WMG, University of Warwick: Coventry, UK.
33. Midlands Engine, *The Midlands Engine Independent Economic Review: A Final Report to the Midlands Engine Partnership*. 2020, Midlands Engine: UK.
34. Greater Lincolnshire LEP, *Greater Lincolnshire's Digital Landscape*. 2019, Greater Lincolnshire LEP: UK.
35. West Midlands Combined Authority Authority, *State of the Region 2020*. 2020, West Midlands Regional Economic Development Institute Partnership (WMREDI): UK.
36. Vanpoucke, E., A. Vereecke, and S. Muylle, *Leveraging the impact of supply chain integration through information technology*. International Journal of Operations & Production Management, 2017. **37**(4): pp. 510-530.
37. Gates, D., T. Mayor, and E. Gampenrieder, *Competing for growth: How to be a growth leader in industrial manufacturing*. 2016. p. 36.
38. The Marches LEP, *The Marches Sector Skills Deep Dive 2021*, The Marches LEP: UK.
39. Billing, C., P. McCann, R. Ortega-Argilés, and D. Sevinc, *UK analysts' and policy-makers' perspectives on Brexit: challenges, priorities and opportunities for subnational areas*. Regional Studies, 2020: pp. 1-12.
40. RSM, *UK Cyber Security Sectoral Analysis and Deep-Dive Review*. 2018: UK.
41. Wiengarten, F., H. Li, P.J. Singh, and B. Fynes, *Re-evaluating supply chain integration and firm performance: linking operations strategy to supply chain strategy*. Supply Chain Management: An International Journal, 2019. **24**(4): pp. 540-559.
42. Larsen, J.K., G.Q. Shen, S.M. Lindhard, and T.D. Brunoe, *Factors affecting schedule delay, cost overrun, and quality level in public construction projects*. Journal of Management in Engineering, 2016. **32**(1): pp. 04015032.

43. Godsell, J. *Sustainability and the supply chain: Lighting the path forward*. 2020; SCiP Webiner]. Available from: <https://warwick.ac.uk/fac/sci/wmg/research/scip/networking/event8dec>.
44. Spring, M., *Which business models might ensure UK value from emerging sectors?* 2013, University of Lancaster: UK.
45. Godsell, J., W. Zhang, X. Liu, J. Burdett, J. Gibson, C. Francis, and C. Wyn-Davies. *Supply Chain Resilience: 3 practical things you can do*. 2020; SCiP event]. Available from: <https://warwick.ac.uk/fac/sci/wmg/research/scip/networking/9sept/>.
46. Black Country LEP, *Black Country Local Industrial Recovery Strategy*. 2020, Black Country LEP: UK.
47. Owen, J., M. Shephard, and A. Stojanovic, *Implementing Brexit: Customs*. 2017, Institute for Government UK.
48. PWC, *Supply Chain: Your Brexit Competitive Advantage*. 2017, PWC: UK.
49. Pettit, T.J., K.L. Croxton, and J. Fiksel, *The Evolution of Resilience in Supply Chain Management: A Retrospective on Ensuring Supply Chain Resilience*. *Journal of Business Logistics*, 2019. **40**(1): pp. 56-65.
50. Ramezankhani, M.J., S.A. Torabi, and F. Vahidi, *Supply chain performance measurement and evaluation: A mixed sustainability and resilience approach*. *Computers & Industrial Engineering*, 2018. **126**: pp. 531-548.
51. Ambulkar, S., J. Blackhurst, and S. Grawe, *Firm's resilience to supply chain disruptions: Scale development and empirical examination*. *Journal of Operations Management*, 2015. **33**: pp. 111-122.
52. Zhang, W., X. Liu, and J. Godsell, *Supply Chain Resilience: Three Practical Solutions*. 2021, University of Warwick: UK.
53. Godsell, J., P. Jonsson, T. Diefenbach, C. Clemmow, D. Towill, and M. Christopher, *Enabling supply chain segmentation through demand profiling*. *International Journal of Physical Distribution & Logistics Management*, 2011. **41**(3): pp. 296-314.
54. Fahy, N., T. Hervey, S. Greer, H. Jarman, D. Stuckler, M. Galsworthy, and M. McKee, *How will Brexit affect health and health services in the UK? Evaluating three possible scenarios*. *The Lancet*, 2017. **390**(10107): pp. 2110-2118.
55. Gibson, J., *Industry 4.0*. 2018, Crimson & Co.
56. Christopher, M. and M. Holweg, *Supply chain 2.0 revisited: a framework for managing volatility-induced risk in the supply chain*. *International Journal of Physical Distribution & Logistics Management*, 2017, **47**(1), pp. 2-17.
57. Accenture, *Repurpose your supply chain: Seven ways to support the global response to COVID-19 and reshape supply chains for the future*. 2020.
58. Zhang, W., S. Chakku, J. Godsell, and Z. Li, *Steeling for a sustainable future: How could the UK steel industry compete through the supply chain?* 2021, University of Warwick: UK.
59. Accenture, *Designed, supplied, delivered: Coordinating production of medical ventilators for the UK* 2020: UK.
60. Christopher, M., M. Crum, and M. Holweg, *"Supply Chain 2.0": managing supply chains in the era of turbulence*. *International Journal of Physical Distribution & Logistics Management*, 2011. **41**(1): pp. 63-82.

Appendix 1 – List of 161 papers

#	Stakeholder type	Year	Literature	Web link
1	Academic	2020	Blog: The impact of Covid-19 on freight logistics and Supply Chain Management	https://midlandsinnovation.org.uk/Press-Releases-2020/blog-the-impact-of-covid-19-on-freight-logistics-and-supply-chain-management-
2	Academic	2020	Reducing the fragility of our supply chains after Covid-19: time for a policy rethink	http://www.openaccess.bcu.ac.uk/9707/1/Reducing%20the%20fragility%20of%20our%20supply%20chains%20after%20Covid-19%20time%20for%20a%20policy%20rethink.pdf
3	Government	2018	Daventry district - economic development strategy 2018-2021	https://www.daventrydc.gov.uk/EasySiteWeb/GatewayLink.aspx?allId=47365
4	LEP	2014	Derbyshire economic strategy statement	https://www.derbyshire.gov.uk/site-elements/documents/pdf/council/have-your-say/consultation-search/consultation-search-index/derbyshire-economic-strategy-statement-final-pre-publication-draft.pdf
5	Government	2020	WMCA-West Midlands State of the Region 2020	https://www.wmca.org.uk/media/4290/state-of-the-region-2020-final-full-report.pdf
6	Government	2014	2014 Local Economic Assessment for Birmingham	https://www.birmingham.gov.uk/downloads/file/2856/local_economic_assessment_for_birmingham_december_2014
7	Academic	2021	Brexit and Beyond report	https://ukandeu.ac.uk/wp-content/uploads/2021/01/Brexit-and-Beyond-report-compressed.pdf
8	Academic	2020	Brexit and Manufacturing	https://ukandeu.ac.uk/wp-content/uploads/2020/06/Manufacturing-and-Brexit.pdf
9	Academic	2020	Regional Transport – a supply chain mapping exercise and Brexit exposure check of automotive, aerospace and rail value dependency in the WMCA region	http://www.openaccess.bcu.ac.uk/9569/1/Centre%20for%20Brexit%20Studies%20Supply%20Chain%20Mapping%20Exercise%20Report%20.pdf
10	Academic	2017	Brexit and the uk automotive industry	https://www.cambridge.org/core/journals/national-institute-economic-review/article/brexit-and-the-uk-automotive-industry/F3BABDDFB0EDF2420557D600011CE7F8

11	Academic	2019	Brexit Negotiations After Article 50: Assessing Process, Progress and Impact	https://books.emeraldinsight.com/page/detail/Brexit-Negotiations-After-Article-50/?k=9781787697683
12	Media	2020	Looking back over 2020 and towards a new year	
13	Trade Association	2020	Black_country_chamber_industrial_strategy_response	https://www.blackcountrychamber.co.uk/images/Have_Your_Say/Black_Country_Chamber_Industrial_Strategy_Response.pdf
14	Academic	2017	Growing the Automotive SC-local vehicle content analysis	https://www.automotivecouncil.co.uk/wp-content/uploads/sites/13/2017/06/Automotive-Council-UK-local-sourcing-content-research-2017-Final-1.pdf
15	Trade Association	2021	Smmat annual report and business plan 2021	https://www.smmat.co.uk/wp-content/uploads/sites/2/SMMAT-Business-Plan-2021-web-version.pdf
16	Trade Association	2019	UK AUTOMOTIVE PRIORITIES Securing success and competitiveness / September 2019	https://www.midlandsengine.org/wp-content/uploads/Financial-Centre-of-Excellence.pdf
17	Trade Association	2020	Uk automotive trade report 2020	https://www.smmat.co.uk/reports/uk-automotive-trade-report/#:~:text=The%20vast%20majority%20of%20UK,largest%20trading%20partner%20is%20paramount.
18	Academic	2014	Plant closures and taskforce responses: an analysis of the impact of and policy response to MG Rover in Birmingham	http://publications.aston.ac.uk/id/eprint/26168/1/Plant_closures_and_taskforce_responses_impact_of_and_policy_response_to_MG_Rover_in_Birmingham.pdf
19	Trade Association	2020	Preparing for Brexit: deal or no deal	https://www.makeuk.org/-/media/eef/files/reports/industry-reports/make-uk-squire-patton-boggs-brexit-report.pdf
20	Trade Association	2018	Brexit making it work for manufacturing	https://www.makeuk.org/-/media/eef/files/reports/industry-reports/brexit-making-it-work-for-manufacturing-2018.pdf
21	Government	2018	West midlands industrial strategy sector evidence full pack	West Midlands Industrial Strategy Sector Evidence Full Pack
22	Government	2018	Brexit the sector impact: Industrial Strategy - Rail Sector Deal	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790469/beis-rail-sector-deal-accessible.pdf

23	Government	2016	Means of Ascent: The Aerospace Growth Partnership's Industrial Strategy for UK Aerospace 2016	
24	Government	2016	West midlands local industry strategy	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/802092/west-midlands-local-industrial-strategy-double-page.pdf
25	Trade Association	2019	New aerospace sector deal one year on	https://www.gov.uk/government/publications/aerospace-sector-deal/aerospace-sector-deal
26	Government	2016	Uk aerospace supply chain study - 2016	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/536903/bis-16-310-aerospace-supply-chain-study.pdf
27	Trade Association	2020	Annual review 2020	https://innovationwm.co.uk/wp-content/uploads/2020/01/Stakeholder-Consultation-Survey-Report-2019.pdf
28	Consultancy	2017	Brexit: The impact on sectors	https://assets.kpmg/content/dam/kpmg/uk/pdf/2017/03/brexit-the-sector-impact.pdf
29	Government	2018	Midlands engine driving life sciences business	https://www.medilinkwm.co.uk/wp-content/uploads/2018/06/DIT-Midlands-Engine-Lifesciences-FINAL-May-2018-.pdf
30	Trade Association	2019	Inside the black box of manufacturing: conceptualising and counting manufacturing in the economy	https://www.ifm.eng.cam.ac.uk/uploads/Research/CSTI/Inside_the_Black_Box_of_Manufacturing_report_FINAL_120619.pdf
31	Trade Association	2020	Midlands engine regional economic impact monitor	Midlands Engine REGIONAL ECONOMIC IMPACT MONITOR
32	LEP	2018	Energy Strategy for the Marches LEP	https://www.marcheslep.org.uk/wp-content/uploads/2021/01/Marches-Energy-Strategy.pdf
33	Government	2019	The Midlands Engine: a Financial Centre of Excellence	https://www.midlandsengine.org/wp-content/uploads/Financial-Centre-of-Excellence.pdf
34	Academic	2020	Supporting inclusive economic growth in the West Midlands and across the UK	https://www.birmingham.ac.uk/documents/college-social-sciences/business/research/city-redi/city-redi-review-report-brochure-28pp-2020dev9.pdf
35	Trade Association	2020	Economic impact of Covid-19 on energy and low carbon sector	https://www.midlandsengine.org/wp-content/uploads/Economic-Impact-of-COVID-19-on-Energy-and-Low-Carbon-October-2020.pdf

36	Government	2018	Getting the best out of the Professional Business and Financial Services sector	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/663640/CS882h_-_HS2_Regional_Briefing_-_PBFS.pdf
37	Academic	2020	Services and Brexit	https://ukandeu.ac.uk/wp-content/uploads/2020/06/Services-and-Brexit.pdf
38	Trade Association	2021	Transport Strategy Refresh-Challenges, OPP and a call for input	
39	Government	2019	Industrial strategy-offshore wind sector deal	Industrial strategy-offshore wind sector deal
40	Academic	2018	An investigation into the foundations of productivity for business, professional and financial services in west midlands combined authority area	https://www.wmca.org.uk/media/2236/business-professional-and-financial-services.pdf
41	Government	2019	West midlands industrial strategy	https://www.wmca.org.uk/media/2571/west-midlands-industrial-strategy.pdf
42	Government	2018	Productivity and skills comission call for evidence	https://www.wmca.org.uk/what-we-do/productivity-skills-commission/
43	Government	2018	Developing effective local industrial strategies	https://whatworksgrowth.org/public/files/18-06-21_Designing_Effective_Local_Industrial_Strategies.pdf
44	Academic	2019	Brexit, foreign investment and employment : some implications for industrial policy	https://www.tandfonline.com/doi/abs/10.1080/21582041.2019.1566563
45	Trade Association	2021	Midlands engine regional economic impact monitor	https://www.midlandsengine.org/reim/
46	Trade Association	2021	Executive Survey 2021: Building agility in manufacturing	https://www.makeuk.org/-/media/files/insights/reports/make-uk-pwc-executive-survey-2021-building-agility-in-manufacturing.pdf
47	Media	2021	COVID-19 prompts radical rethink of manufacturing supply chains	https://www.eastmidlandsbusinesslink.co.uk/mag/manufacturing/covid-19-prompts-radical-rethink-of-manufacturing-supply-chains/
48	Trade Association	2020	Manufacturing confidence: Midlands Manufacturing Resilience commission	https://www.m2r.org.uk/the-report

49	LEP	2020	Sector strengths	https://www.google.com/search?q=Sector+Strengths+lep&rlz=1C1CHBF_en-GBGB911GB911&oq=Sector+Strengths+lep&aqs=chrome..69i57.1988j0j4&sourceid=chrome&ie=UTF-8
50	LEP	2020	Priorities and Plans	https://www.cwlep.com/priorities-plans
51	LEP	2019	The Economic Competitiveness of the Derby & Derbyshire, Nottingham & Nottinghamshire (D2N2) LEP Area	http://documents.nottinghamcity.gov.uk/download/4093
52	LEP	2018	A Science and Innovation Audit for the D2N2 Local Enterprise Partnership area	https://d2n2lep.org/wp-content/uploads/2020/06/D2N2_SIA.pdf
53	LEP	2020	The d2n2 productivity gap: summary	https://d2n2lep.org/wp-content/uploads/2020/06/D2N2_Kneller_July2017_Productivity.pdf
54	LEP	2020	The marches sector skills deep dive - advanced manufacturing	https://www.marcheslep.org.uk/wp-content/uploads/2021/01/Marches-Sector-Needs-Assessment-Advanced-Manufacturing-Final.pdf
55	LEP	2020	The Marches Sector Skills Deep Dive - Agri-tech	https://www.marcheslep.org.uk/wp-content/uploads/2021/01/Agritech-Deep-Dive-draft.pdf
56	LEP	2017	Black country strategy economic plan 2017	https://www.blackcountrylep.co.uk/upload/files/BC%20SEP/DRAFT%20Black%20Country%20Strategic%20Economic%20Plan%2017.03.2017.pdf
57	LEP	2020	Strategic reset framework	https://www.cwlep.com/strategic-reset-framework
58	LEP	2020	D2n2 local industrial strategy	https://d2n2lep.org/wp-content/uploads/2020/09/D2N2_DRAFT_LIS_FINAL.pdf
59	LEP	2017	Department for Digital, Culture, Media and Sport UK Cyber Security Sectoral Analysis and Deep-Dive Review	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/751406/UK_Cyber_Sector_Report_-_June_2018.pdf
60	LEP	2016	LINCOLNSHIRE'S evolving opportunities	https://www.greaterlincolnshirelep.co.uk/assets/documents/LEP_Annual_Conference_Programme_2019.pdf
61	LEP	2017	Sector Needs Assessment - Advanced Manufacturing and Engineering	

62	LEP	2017	Sector needs assessment - environmental technologies	
63	LEP	2016	Strategic economic plan 2014-2030	https://www.greaterlincolnshirelep.co.uk/assets/documents/Strategic_Economic_Plan_2014.pdf
64	Academic	2021	Weekly economic impact monitor	https://blog.bham.ac.uk/cityredi/west-midlands-weekly-economic-impact-monitor-26th-march-2021/
65	LEP	2019	West midlands local industrial strategy	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/802092/west-midlands-local-industrial-strategy-double-page.pdf
66	LEP	2019	West Midlands Local Industrial Strategy Foundations of Productivity Evidence Base	https://www.gov.uk/government/publications/industrial-strategy-the-foundations/industrial-strategy-the-5-foundations
67	LEP	2019	The black country: annual economic review	https://www.the-blackcountry.com/upload/Annual%20Economic%20Review%202019/29981%20-%20Annual%20Economic%20Review%20Brochure%202018-19_f_(Email).pdf
68	LEP	2017	Derby, Derbyshire, Nottingham and Nottinghamshire Area Review	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/634646/Derby_Derbyshire_Nottingham_and_Nottinghamshire_Area_Review_Report_FINAL.pdf
69	LEP	2017	The marches & mid wales freight strategy	https://www.herefordshire.gov.uk/downloads/file/13544/marches_and_mid_wales_freight_strategy_february_2018#:~:text=The%20overall%20aim%20of%20the,on%20the%20environment%20and%20residents.
70	LEP	2018	Our Routes to Growth	https://www.midlandsconnect.uk/publications/our-routes-to-growth-july-2018/
71	LEP	2020	Black country local industrial recovery strategy	https://www.the-blackcountry.com/upload/Black%20Country%20LIRS%2019052020.pdf
72	LEP	2019	D2n2 local industrial strategy - evidence base	https://d2n2lep.org/wp-content/uploads/2020/06/D2N2_LIS_Evidence_base_v1.7.pdf
73	LEP	2015	The Midlands HS2 Growth Strategy Accelerating the UK's engine of growth	https://www.solihull.gov.uk/sites/default/files/2020-12/The-Midlands-HS2-Growth-Strategy-2015.pdf
74	LEP	2017	Building our Industrial Strategy	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/611705/building-our-industrial-strategy-green-paper.pdf

75	LEP	2018	Local industrial strategies policy prospectus	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/744544/local-industrial-strategies-policy-prospectus.pdf
76	LEP	2017	Sector Needs Assessment - Defence and Security	
77	LEP	2019	Black country strategic companies barometer	Black Country Strategic Companies Barometer
78	LEP	2019	West Midlands Local Industrial Strategy Delivery Plan: Food and Drink Manufacturing	West Midlands Local Industrial Strategy Delivery Plan: Food and Drink Manufacturing
79	LEP	2019	The marches digital strategy	https://www.marcheslep.org.uk/wp-content/uploads/2021/01/The-Marches-Digital-Strategy_FINAL.pdf
80	LEP	2017	Sector Needs Assessment - Food Manufacturing and Processing	https://www.marcheslep.org.uk/download/research/Marches-Sector-Needs-Assessment-Environmental-Technologies-Final.pdf
81	Government	2017	Industrial Strategy - Building a Britain fit for the future	https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future
82	LEP	2017	The marches & mid wales freight strategy technical annex	http://www.tracc.gov.uk/uploads/media/Marches_and_Mid_Wales_Freight_Strategy_Technical_Annex_01.pdf
83	LEP	2020	The Marches Sector Skills Deep Dive - Business and Professional Services	https://www.marcheslep.org.uk/wp-content/uploads/2021/01/Business-Professional-Services-Deep-Dive-draft.pdf
84	Academic	2020	Examination of the sectoral overlap of COVID-19 and Brexit shocks	https://www.gov.ie/en/publication/e2c5f-examination-of-the-sectoral-overlap-of-covid-19-and-brexit-shocks/
85	Academic	2020	Worries for UK Automotive	http://www.open-access.bcu.ac.uk/10262/1/Worries%20for%20UK%20Automotive.pdf
86	Academic	2020	Unlocking challenges and opportunities presented by COVID-19 pandemic for cross-cutting disruption in agri-food and green deal innovations: Quo Vadis?	https://www.sciencedirect.com/science/article/pii/S0048969720348919
87	Academic	2020	Prospects for the uk economy	https://www.niesr.ac.uk/sites/default/files/publications/Prospects%20for%20the%20UK%20economy%20August%202020.pdf

88	Academic	2020	UK analysts' and policy-makers' perspectives on Brexit: challenges, priorities and opportunities for subnational areas	https://www.tandfonline.com/doi/full/10.1080/00343404.2020.1826039
89	Academic	2020	The Role of Enterprise Education and Training in the Performance of Small Manufacturing Firms: Evidence from West Midlands (United Kingdom)	https://www.gssrjournal.com/jadmin/Author/31rvlola2LALJouq9hkR/U6fyfs9KeD.pdf
90	Academic	2020	A Transformational Change Framework for Developing Ecologically Embedded Manufacturing	https://link.springer.com/article/10.1007/s40171-020-00252-8
91	Academic	2020	The Implications of Brexit for UK and EU Regional Competitiveness	The Implications of Brexit for UK and EU Regional Competitiveness
92	Academic	2020	Seeing like a business: rethinking the role of business in regional development, planning and governance	https://www.tandfonline.com/doi/abs/10.1080/21622671.2020.1743201
93	Academic	2019	A stakeholder perspective on Process Improvement Behaviours : Delivering the Triple Bottom-Line in smes	https://www.tandfonline.com/doi/abs/10.1080/09537287.2018.1501809
94	Academic	2020	Regional Rebuilding, the impact of COVID-19 and Brexit	http://www.open-access.bcu.ac.uk/9793/1/Regional%20Rebuilding%2C%20the%20impact%20of%20COVID-19%20and%20Brexit.pdf
95	Academic	2018	Framework for productivity	
96	Academic	2019	The challenges of GSCM implementation in the UK manufacturing smes.	The challenges of GSCM implementation in the UK manufacturing SMEs.
97	Academic	2020	Redefining SME Productivity Measurement and Assessment for a Low Carbon Economy	https://www.cusp.ac.uk/themes/finance/blog-th-ro-pin-report2020/
98	Government	2019	Understanding brexit at a local level: causes of discontent and asymmetric impacts	
99	Academic	2017	Refreshing the D2N2 Strategic Economic Plan: The case for inclusive growth	http://irep.ntu.ac.uk/id/eprint/31620/1/9097_584a_Rossiter.pdf

100	Trade Association	2020	Midlands engine economic impact of covid-19	https://www.midlandsengine.org/wp-content/uploads/Midlands-Engine-Covid19-Monitor-Edition-2.pdf
101	Academic	2018	Lean versus agile production: flexibility trade-offs within the automotive supply chain	https://www.tandfonline.com/doi/abs/10.1080/00207543.2018.1463109?journalCode=tp rs20
102	Academic	2021	HS2 railway, UK – route development to hybrid bill: a collaborative approach	https://www.icevirtuallibrary.com/doi/abs/10.1680/jtran.18.00011#:~:text=Next%20%3E-,HS2%20railway%2C%20UK%20%E2%80%93%20route%20development%20to,hybrid%20bill%3A%20a%20collaborative%20approach&text=In%20January%202012%20the%20UK,was%20consulted%20upon%20in%202011.
103	Academic	2020	Is the Transport Industry Brexit ready?	http://www.open-access.bcu.ac.uk/10208/
104	Academic	2020	Industrial capacity in post covid-19 britain	https://www.bennettinstitute.cam.ac.uk/media/uploads/files/Industrial_stratedy_4_Ind._capacity_in_post_C-19_Britain_3.pdf
105	Trade Association	2017	Implementing brexit: customs	https://www.instituteforgovernment.org.uk/sites/default/files/publications/IfG_Brexit_customs_WEB_0.pdf
106	Academic	2021	Here Comes Brexit's "Damage By a 1000 Cuts"	http://www.open-access.bcu.ac.uk/10739/
107	Trade Association	2020	Building a green stimulus for covid-19	https://neweconomics.org/uploads/files/green-stimulus-covid.pdf
108	Trade Association	2020	UK Regions in Global Value Chains	http://www.cpes.org.uk/dev/wp-content/uploads/2019/09/Session6B_Bart_Los.pdf
109	Trade Association	2020	Post-pandemic recovery: How smart local energy systems can contribute	Post-pandemic recovery: How smart local energy systems can contribute
110	Academic	2020	Pro-environmental business and clean growth trends for the East Midlands 2020	https://derby.openrepository.com/bitstream/handle/10545/625085/EMC%20Pro%20E%20Trends%20Briefing%202020.pdf?sequence=1&isAllowed=y
111	Academic	2020	Diffusion of circular economy practices in the UK wheat food supply chain	Diffusion of circular economy practices in the UK wheat food supply chain
112	Consultancy	2020	1000 companies to inspire Britain 2020	https://www.standard.co.uk/business/1000-companies-inspire-britain-report-2020-b44117.html#:~:text=Register%20here-,The%201000%20companies%20to%20Inspire%20

				Britain%202020%3A%20Annual%20report%20highlights.in%20rebuilding%20post%2DCovid%20economy&text=%22The%20success%20of%20UK%20SMEs.growth%20companies%20achieve%20their%20potential.%E2%80%9D
113	LEP	2017	Midlands matter	https://www.midlandsengine.org/wp-content/uploads/Newsletter-issue-04.pdf
114	Academic	2017	What does Brexit mean for UK Automotive and Industrial Policy?	https://www.regionalstudies.org/wp-content/uploads/2017/01/Bailey-De-Propriis-What-does-Brexit-mean-for-UK-automotive-and-industrial-policy.pdf
115	LEP	2017	Digital landscape summary report	https://www.greaterlincolnshirelep.co.uk/assets/documents/Greater_Lincolnshires_Digital_Landscape_Summary_Report_%28December_2019%29.pdf
116	Academic	2019	Brexit's impact on West Midlands Transport Manufacturing	https://www.bcu.ac.uk/centre-for-brexit-studies/news-and-events/brexit-impact-on-west-midlands-transport-manufacturing
117	Academic	2020	Policy, politics and materiality across scales: A framework for understanding local government sustainable energy capacity applied in England	https://www.sciencedirect.com/science/article/pii/S2214629619306322
118	Academic	2017	Cyber supply chain resilience manufacturing impact on the economic security	https://timreview.ca/article/888
119	Academic	2015	Bargaining for Productivity	https://www.researchgate.net/publication/319989898_Bargaining_for_Productivity_-_UK_The_Sick_Man_of_Europe
120	Academic	2018	Made in the UK: Brexit and manufacturing revisited	https://blogs.lse.ac.uk/euoppblog/2018/07/06/made-in-the-uk-brexit-and-manufacturing-revisited/
121	Academic	2017	The pharmaceutical industry is at risk from Brexit	https://blogs.lse.ac.uk/brexit/2017/07/17/the-pharmaceutical-industry-is-at-risk-from-brexit/
122	Academic	2018	Can Lean and Agile organisations within the UK automotive supply chain be distinguished based upon contextual factors?	https://core.ac.uk/download/pdf/185505044.pdf
123	Academic	2020	The Covid-19 crisis and manufacturing: How should national and local industrial strategies respond?	https://journals.sagepub.com/doi/full/10.1177/0269094220953528

124	LEP	2019	Local industrial strategy economic review - llep	https://llep.org.uk/app/uploads/2020/11/Local-Industrial-Strategy-Economic-Review-June-2019.pdf
125	LEP	2018	Local industrial strategy	http://www.semlep.com/modules/downloads/download.php?file_name=1237
126	LEP	2017	South east midlands where innovation fuels growth strategic economic plan	https://www.semlep.com/modules/downloads/download.php?file_name=742
127	LEP	2018	Semlep local industrial strategy evidence base	https://www.semlep.com/modules/downloads/download.php?file_name=1237
128	LEP	2019	South east midlands local industrial strategy	https://www.semlep.com/modules/downloads/download.php?file_name=1349
129	LEP	2018	Stoke-on-Trent & Staffordshire Strategic Economic Plan	https://www.stokestaffslep.org.uk/app/uploads/2019/01/SSLEP-Strategic-Economic-Plan-April-2018-.pdf
130	LEP	2015	Sap priority sectors evidence advanced manufacturing	https://www.stokestaffslep.org.uk/sap-priority-sector-and-cross-cutting-themes-report/
131	LEP	2015	Sap priority sectors evidence construction final	https://www.stokestaffslep.org.uk/sap-priority-sector-and-cross-cutting-themes-report/
132	LEP	2015	Sap priority sectors evidence logistics final	https://www.stokestaffslep.org.uk/sap-priority-sector-and-cross-cutting-themes-report/
133	LEP	2020	Digital skills business survey 2020	https://www.stokestaffslep.org.uk/app/uploads/2020/01/SAP-Cross-Cutting-Themes-Evidence-Digital.docx
134	LEP	2020	Worcestershire's Strategy for Restart and Recovery	https://www.wlep.co.uk/wp-content/uploads/64733-Economic-Recovery-Plan-Summary-V02-Landscape-V05.pdf
135	LEP	2019	Worcestershire LEP local industrial 2040 final	https://www.wlep.co.uk/resources/document-library/
136	LEP	2019	Worcestershire LEP's SEP & LIS development evidence base	https://www.wlep.co.uk/wp-content/uploads/Evidence-Base-September-2019.pptx
137	Trade Association	2015	The Midlands Engine vision for Growth	https://www.birmingham.ac.uk/schools/business/research/research-projects/city-redi/the-midlands-engine-economic-observatory.aspx#:~:text=Independent%20Economic%20Review,-The%20Midlands%20Engine&text=Completed%20in%20February%202020%2C%20the,50%20of%20our%20region's%20businesses.&text=An%20analysis%20of%20public%20sector%20funding%20across%20the%20Midlands

138	LEP	2020	Midlands engine LEP profiles	https://www.midlandsengine.org/wp-content/uploads/ME-LEP-Profile-Black-Country-October-2019.pdf
139	Government	2018	West Midlands industry strategy consultation document	https://www.birmingham.ac.uk/schools/business/research/research-projects/city-redi/the-midlands-engine-economic-observatory.aspx#:~:text=Independent%20Economic%20Review,-The%20Midlands%20Engine&text=Completed%20in%20February%202020%2C%20the,50%20of%20our%20region's%20businesses.&text=An%20analysis%20of%20public%20sector%20funding%20across%20the%20Midlands
140	LEP	2019	Greater Birmingham & Solihull local enterprise partnership-join scrutiny committee	https://gbslep.co.uk/uploads/2019/12/Appendix-A-GBSLEP-Joint-Scrutiny-Committee-ToR-2019-20-V1.0-1.docx
141	Academic	2020	Wisdom from Arabian networks: a review and theory of regional supply chain management	https://www.tandfonline.com/doi/abs/10.1080/09537287.2020.1796144?journalCode=tpc20
142	Government	2017	Automotive sector report	https://www.parliament.uk/globalassets/documents/commons-committees/Exiting-the-European-Union/17-19/Sectoral-Analyses/4-Sectoral-Analyses-Automotive-Report.pdf
143	Academic	2021	Regional Resilience: The Co-dependence of Business and Regions in Recovery	https://blog.bham.ac.uk/cityredi/regional-resilience-the-co-dependence-of-business-and-regions-in-recovery/
144	Trade Association	2017	Midlands engine strategy 2017	https://www.midlandsengine.org/wp-content/uploads/2017/03/Midlands-Engine-Strategy-2017.pdf
145	Trade Association	2020	Manufacturing confidence	https://www.midlandsengine.org/wp-content/uploads/Midlands-Manufacturing-Resilience-Report-and-Appendices.pdf
146	Trade Association	2020	Midlands Engine Independent economic review	https://www.birmingham.ac.uk/schools/business/research/research-projects/city-redi/the-midlands-engine-economic-observatory.aspx#:~:text=Independent%20Economic%20Review,-The%20Midlands%20Engine&text=Completed%20in%20February%202020%2C%20the,50%20of%20our%20region's%20businesses.&text=An%20analysis%20of%20public%20sector%20funding%20across%20the%20Midlands

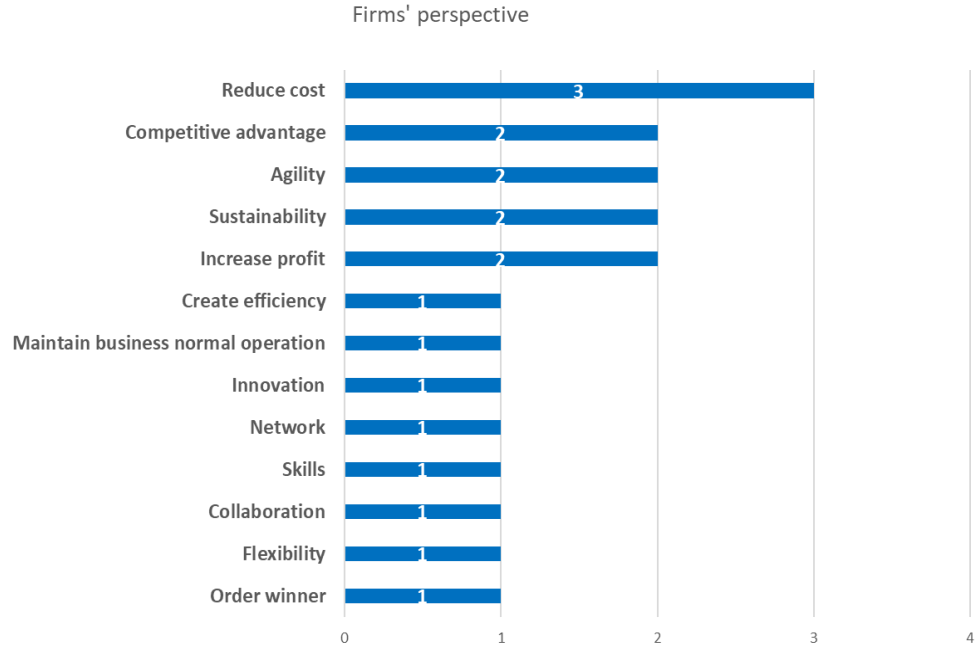
147	Trade Association	2020	Midlands matters issue 1 Feb 2020	https://www.midlandsengine.org/wp-content/uploads/Midlands-Matters-February-2020.html
148	Trade Association	2020	Midlands matters issue 2	https://www.midlandsengine.org/wp-content/uploads/Midlands-Matters-Issue-02.pdf
149	Government	2018	Industry strategy-Life Sciences Sector Deal 2	https://www.gov.uk/government/publications/life-sciences-sector-deal/life-sciences-sector-deal-2-2018
150	Government	2017	Industry strategy. What is the Industrial clusters	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/646547/NIESR_Clusters_Research_BEIS_Format_with_summary_FINAL.pdf
151	Trade Association	2020	Regional scorecards for ICAEW UK Economic Report Sep 2020	https://www.icaew.com/-/media/corporate/files/technical/economy/economic-insight/uk-economic-forecast/uk-economic-outlook-regional-scorecards-september.ashx
152	Government	2018	Growing the Bioeconomy	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf
153	Government	2017	The Impact of Brexit on Birmingham and the West Midlands	https://birmingham.cmis.uk.com/Birmingham/Document.ashx?czJKcaeAi5tUFL1DTL2UE4zNRBcoShgo=H4SHk7RAwBz%2BRyKu4D9RI4rt4fThmBqfdpeo3M3qXuyF6%2Fso52vW5Q%3D%3D&rUzwRPf%2BZ3zd4E7lkn8Lyw%3D%3D=pwRE6AGJFLDNIh225F5QMaQWcPHwdhUfCZ%2FLUQzgA2uL5jNRG4jdQ%3D%3D&mCTIbCubSfXsDGW9IXnlg%3D%3D=hFflUdN3100%3D&kCx1AnS9%2FpWZQ40DXFvdEw%3D%3D=hFflUdN3100%3D&uJovDxwdjMPoYv%2BAJvYtyA%3D%3D=ctNJff55vVA%3D&FgPIIEJYlotS%2BYGoBi5oIA%3D%3D=NHdURQburHA%3D&d9Qjj0ag1Pd993jsyOJqFvmyB7X0CSQK=ctNJff55vVA%3D&WGewmoAfeNR9xqBuxOr1Q8Za60lavYmz=ctNJff55vVA%3D&WGewmoAfeNQ16B2MHuCpMRKZMwaG1PaO=ctNJff55vVA%3D
154	LEP	2019	Construction skills gap analysis for The Marches LEP	https://www.marcheslep.org.uk/download/skills/skills_sector_deep_dives_2/CITB-Construction-Report-The-Marches-FINAL.pdf
155	Trade Association	2018	Brexit Briefing: Brexit - making it work for manufacturing	https://www.makeuk.org/-/media/eef/files/reports/industry-reports/brexit-making-it-work-for-manufacturing-2018.pdf
156	Government	2016	Advanced propulsion centre impact report – APC UK	https://www.apcuk.co.uk/app/uploads/APC_2016_Capability-Report.pdf

157	Government	2018	New era of tech-driven legal and financial services to boost productivity and improve customer experience	https://www.gov.uk/government/news/new-era-of-tech-driven-legal-and-financial-services-to-boost-productivity-and-improve-customer-experience
158	Government	2018	HM Treasury analysis-the long term economic impact of EU membership and the alternatives	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/517415/treasury_analysis_economic_impact_of_eu_membership_web.pdf
159	Trade Association	2020	Midlands matters issue 03 2020	https://www.midlandsengine.org/wp-content/uploads/Midlands-Matters-Issue-03.pdf
160	Trade Association	2016	The Midlands Engine Science and Innovation Audit Volume 2: Supporting Annexes Sep 2016	https://www.midlandsengine.org/wp-content/uploads/Midlands-Engine-IER-Full-Report.pdf
161	Trade Association	2020	Building back stronger, better and greener in the Midlands	https://www.brownejacobson.com/training-and-resources/resources/legal-updates/2020/09/public-sector-midlands-engine-roundtable-report-building-back-a-stronger-better-and-greener-midlands

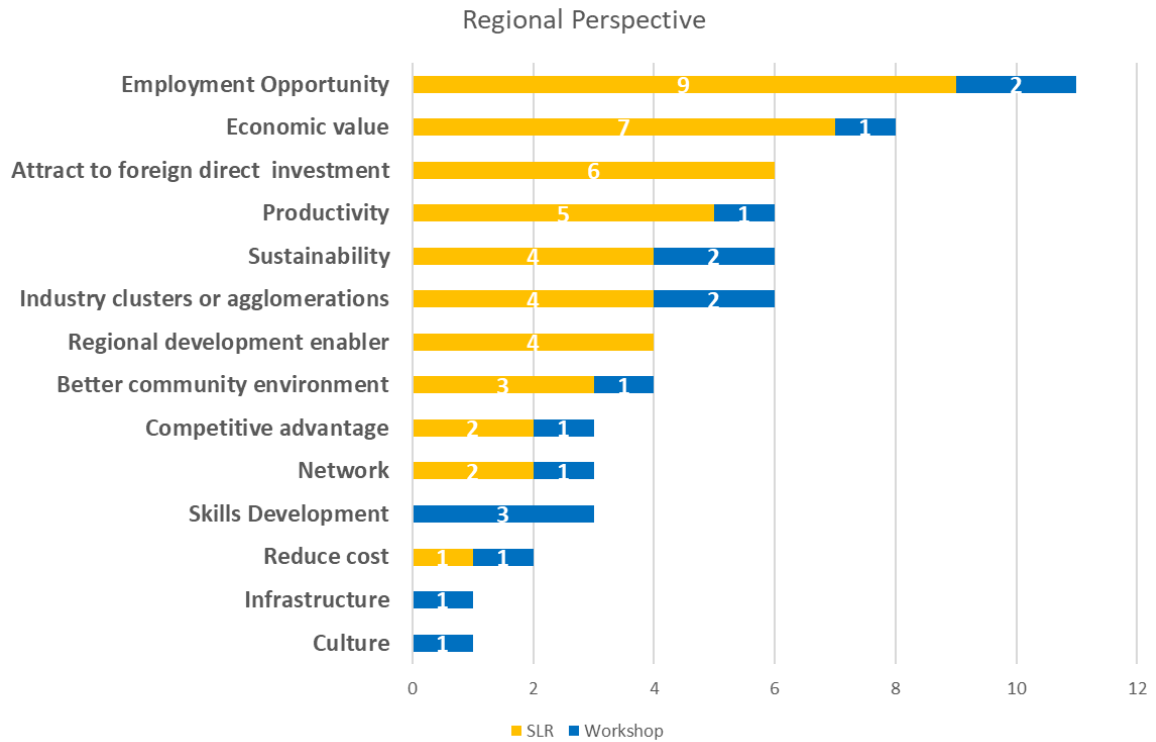
Appendix 2 – Additional evidence

This appendix includes the descriptive findings (from the SLR and two interactive workshops) that underpin the insights highlighted in the report.

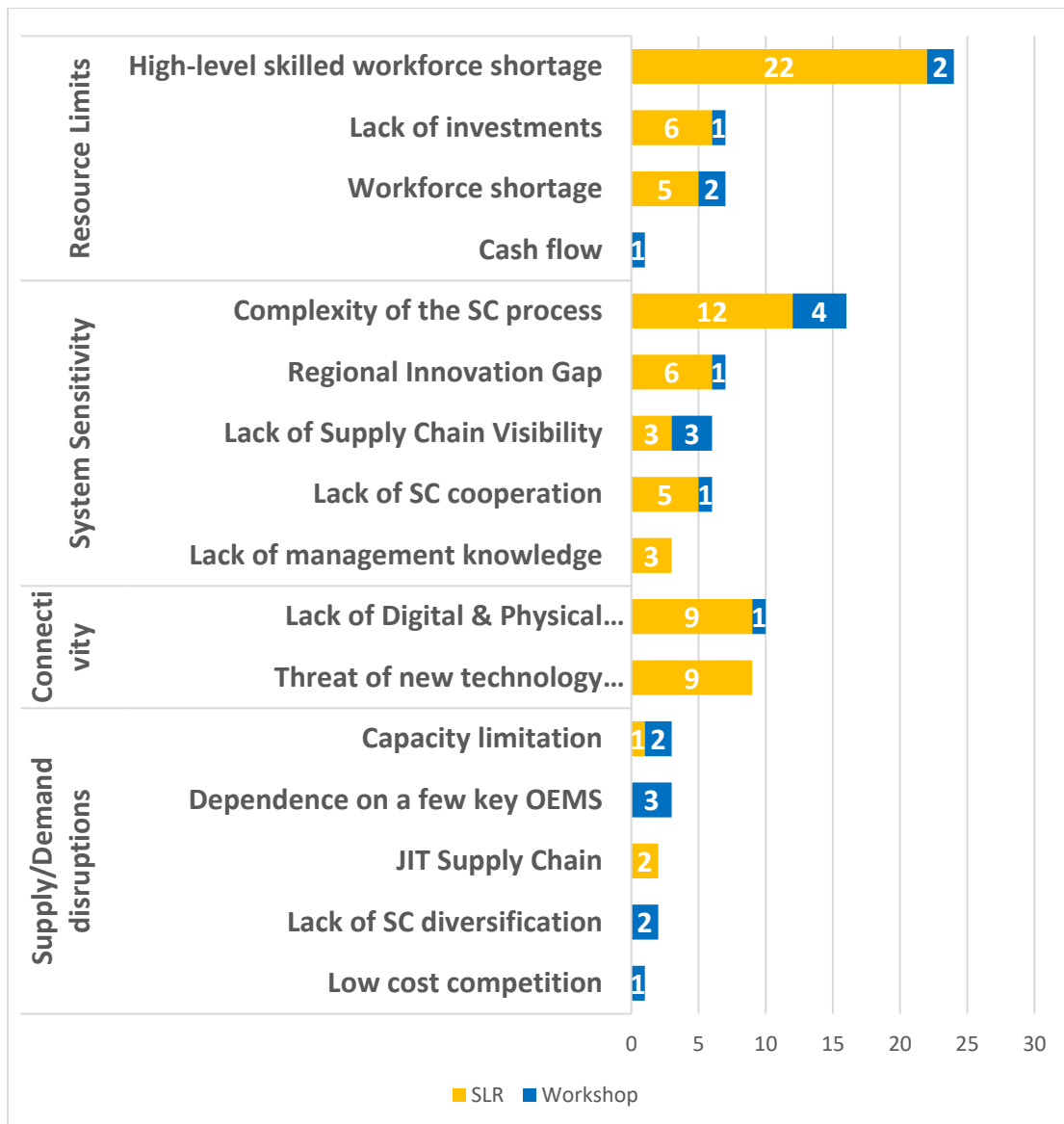
2.1 What value does SC create for local firms?



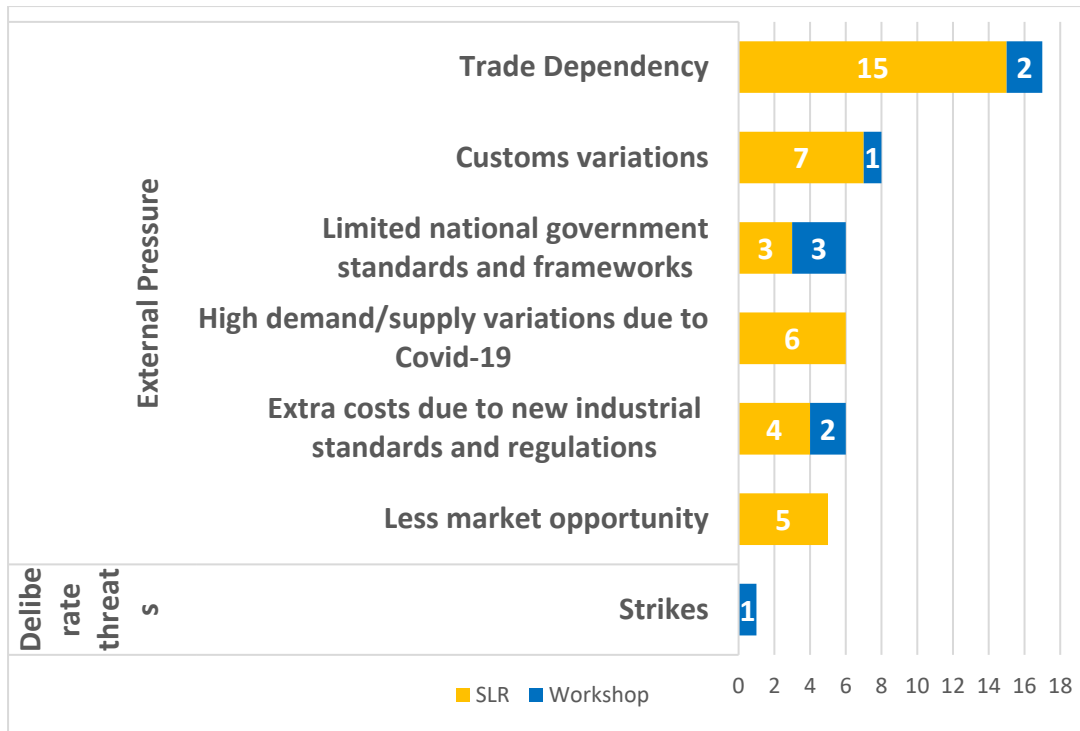
2.2 What value does SC create for the region?



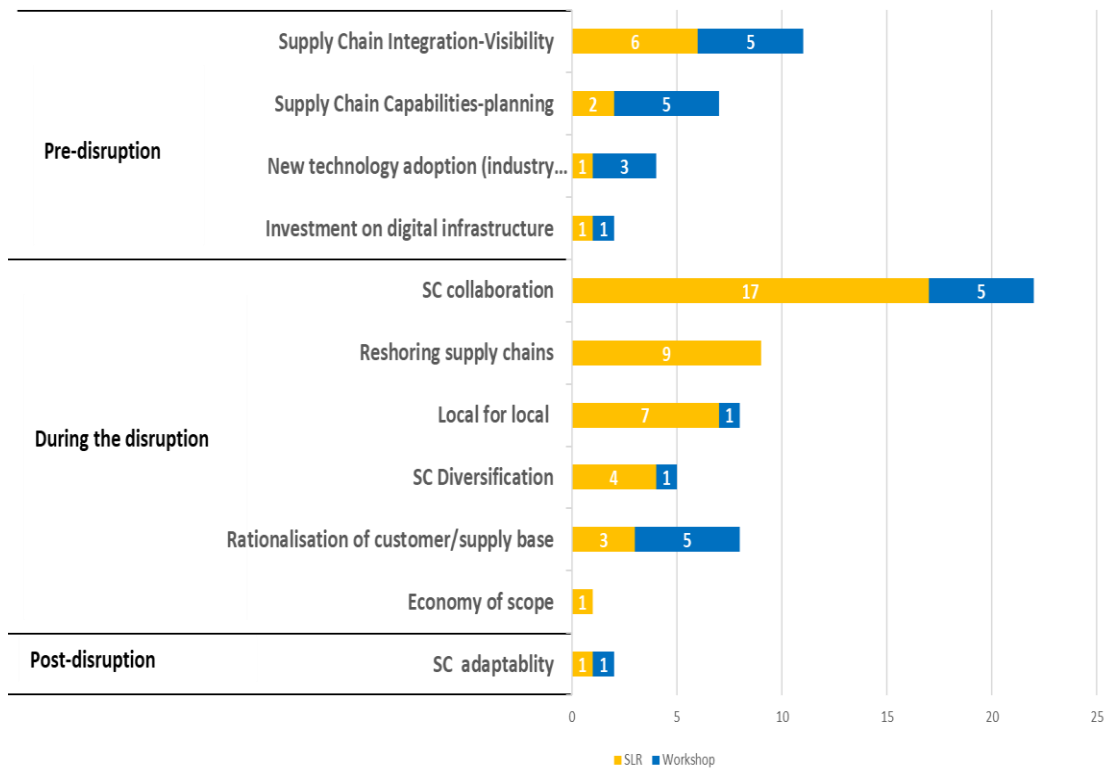
2.3 What are challenges/issues within the current regional SCs?



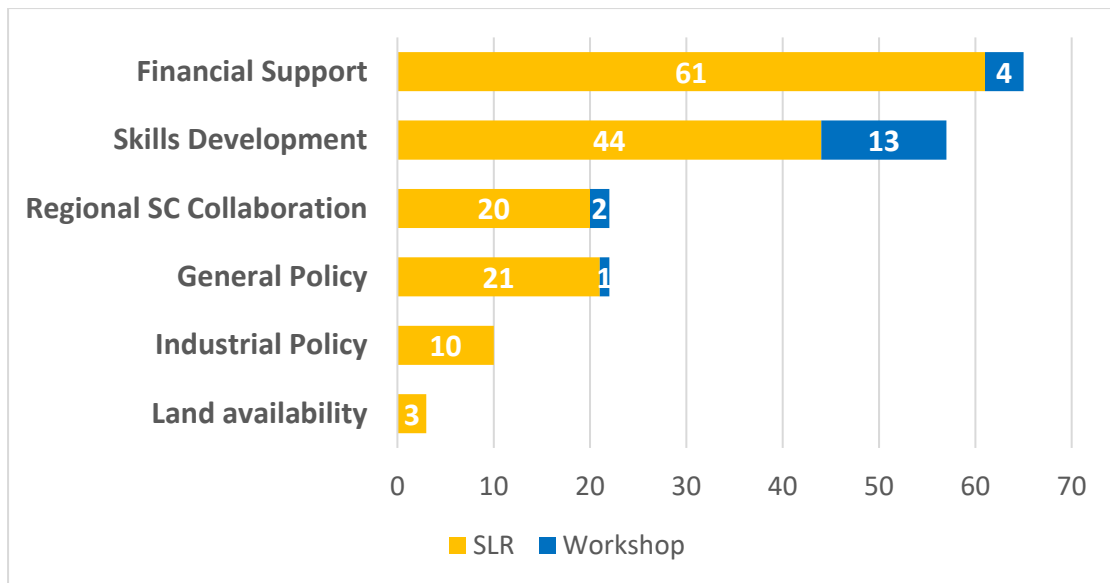
2.4 What are the impacts of COVID-19/Brexit on the regional SCs?



2.5 What can firms do to improve SC resilience?



2.6 What support can the region provide to improve SC resilience?



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